CNNum
Conseil National du Numérique

Jules Ferry 3.0

Building a fair and creative school system in a digital world

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Part 1:

Teaching in today's digital society

1 – Teaching information technology: a must

The goal of teaching is to help children understand the world around them, find their place in it, both personally and professionally, and make a contribution to it. Can they do that today without IT knowledge? Clearly not. We live, work, play and learn surrounded by machines and systems that process information and knowledge, help us perform our daily tasks, and sometimes even make decisions for us. The digital revolution has affected every sector of our economy, every organisation, every business and most of our everyday activities. It has also affected knowledge itself, and the way in which it is produced, passed on, acquired and implemented in every walk of life. At the same time, research has been transformed by the data mining and production applications that exist, and by computational thinking. The courses we teach should obviously take these changes into account.

In France, we recently became aware that there is a need for this kind of teaching. Things have since taken a positive turn, as both society and policy makers become aware of this need, leading to initiatives such as new baccalaureate courses in IT and Digital Sciences. But more needs to be done. Information technology courses must now be made available throughout the national education system at every level, from primary (where we can teach computational thinking) to middle (computer programming can be taught to students in *troisième* (ages 14-15) onward) and high school via the rollout, already planned, of the IT and Digital Sciences course to all general and technical baccalaureate students. IT should be taught to everyone to ensure we are producing students capable of acting in a digital society, controlling rather than being subjected to the digital transformation taking place.

IT courses offer another advantage: as they are taught in groups on a project basis through trial and error, they open the door to a new way of teaching.

Strong political support combined with knowledge of the limitations (particularly financial) and the energy and commitment of existing and trainee teachers will be required. Teacher training will be a key factor in any implementation.

In 2013, the French Digital Council published an Opinion on IT teaching[1] which proposed contributing to a discussion focusing on how to reach a straightforward target:

> ***"Over the next three years, ensure that IT is taught from primary to secondary level."***

[1] http://www.cnnumerique.fr/enseignementinformatique/

This recommendation is outlined in this report.

Training pupils for life in the digital society

First and foremost, introducing everyone to computational thinking (see Box) is a must, to:

- Understand many everyday objects (e.g. telephones, bank transactions, airport logistics) as well as other concepts in areas such as life sciences, economics, town planning, meteorology, etc.
- Prepare students for the jobs of tomorrow in both digital companies and cutting-edge sectors, and even in other less technical fields that will be transformed through information technology.
- Progress together in a digital economy where innovation and the ability to cooperate are key factors in maintaining competitiveness.
- Not be subjected, as a user or consumer, to decisions made by a programme or IT system without being able to understand the decision, question or discuss it, or even change it if necessary.
- Be able to decode the power plays that occur in a digital society, to protect one's privacy and autonomy, and to take part in collective decisions that will call upon increasing amounts of data and calculations.

These are some of the "commands" outlined in Douglas Rushkoff's[2] "*Program or be Programmed*". The French *Académie des sciences* makes similar recommendations in its 2013 report[3] (entitled "*L'enseignement de l'informatique en France: il est urgent de ne plus attendre")*.

> Computational thinking developed from the analysis of the strength and limitations of IT processes carried out by machines or humans. Through IT methods and models, we are able to solve problems and design systems capable of performing processes that we alone would be unable to perform.
>
> *Jeannette Wing in Bulletin de Specif, December 2008*
> *See also "La pensée informatique" in Interstices[4]*

[2] *Program or Be Programmed: Ten Commands for a Digital Age*, Soft Skull Press, 2011.
[3] http://www.academie-sciences.fr/activite/rapport/rads_0513.pdf
[4] https://interstices.info/jcms/c_43267/la-pensee-informatique

A story of stop and start

The *Plan Calcul* was introduced in 1967 alongside an IT Taskforce by the Ministry of Education. The goal was to look at how to go about introducing IT courses in schools. The Taskforce concluded that high school pupils should be introduced to a new way of thinking based on models, algorithms and organisational structures across all disciplines. This is still valid today.

In France and abroad, IT courses became more widespread in the 1980s, striking a chord among teachers who got involved in their thousands and looked upon it as a way of opening up and modernising the teaching methods that existed at that time. The Logo[5] software application is often mentioned with fondness by the oldest teachers and former pupils who still remember these lessons that enabled them to learn the fundamentals and gain a basic understanding of computational thinking.

Since then, courses on programming logic have been replaced almost everywhere by courses that focus on teaching programming uses. In 1992, the Education Minister stressed the urgent need for teachers to understand the "technological, social and cultural challenges associated with these new techniques so that they would quickly become commonplace and practical everyday tools", and to add an IT module to the IUFM teacher training syllabus. This resulted in the introduction of multimedia teaching policies that did not really do enough to develop actual uses. In addition, the original goal to teach the "new thinking" behind IT was lost. The B2I (*Brevet Informatique et Internet*[6]) computer and internet skills certificate, for which pupils did not sit an exam, focused exclusively on the use of technical applications. Pupils were not required to understand how these applications worked, let alone create or adapt them.

The general rollout of the B2I diploma to baccalaureate students (between 2000 and 2008) aimed at "preparing pupils to use IT and communication technologies responsibly" was restrictive in that it was reduced to usage alone, with a particular focus on accessing "Digital Workspaces". In a way, this led to a very reduced form of IT teaching , with its own applications and resources but one that was completely devoid of any algorithmic thinking and relatively isolated from the rest of the digital world.

For several years, the focus was on developing multimedia courses. This is an important goal which should not be confused with information technology teaching. We have now entered a clarification

[5] Logo is a programming language devised in the 1960s by Seymour Papert at MIT. Papert was passionate about artificial intelligence and education. Famous for its turtle that children could guide to produce graphics using a few simple instructions, Logo is a complete programming language from the same family as LISP, a programming language used extensively in artificial intelligence. Logo's role in education peaked in the 1980s with the arrival of affordable personal computers for "educational entertainment" in primary and secondary schools. It gradually disappeared completely from French education, as teaching focused increasingly on the practical use of office automation software at the expense of learning basic programming skills. Source: Yann Dubois, http://www.yann.com/fr/apprendre-la-programmation-aux-enfants-avec-le-langage-logo-17/09/2010.html

[6] http://eduscol.education.fr/cid46073/b2i.html

stage, and we at last have a genuine opportunity to give IT courses the place that the national education system has been trying to give them since the 1970s.

Progress is being made

As part of the high school reforms introduced at the beginning of the 2012-2013 school year, a new specialised course entitled IT and Digital Sciences was offered to final-year science *baccalauréat* students in certain schools (44% of secondary schools and 8.4% of students). In 2014, a programming course was introduced for students taking preparatory classes for engineering schools. Similarly, the Académie de Montpellier introduced a pilot scheme making the IT and Digital Sciences course available to final year students taking the literature or economic & social *baccalauréat* exams.

Despite these steps in the right direction, the vast majority of pupils still have no access to IT courses. The government's digital roadmap published in February 2013 did not go any further.

Our neighbours that have realised the importance of IT teaching in schools have produced roadmaps that go much further, incorporating the concept of "IT for everyone". In the UK, following on from the Royal Society's 2010 report entitled "Shut down or restart", IT was added to the science curriculum in 2013 and is tested at the same level as physics, chemistry and biology, i.e. it is treated as a fundamental building block of science education. In Germany, information technology is taught in every federal state bar three at secondary level. In Israel, IT has been part of the secondary school curriculum since 1990; the country's digital and IT start-ups are renowned worldwide. The list of strong, targeted measures taken throughout the world to promote IT teaching in schools continues to grow.

In France, awareness is spreading. In their report[7] entitled "*Le développement de l'économie numérique française*" ("Developing the French digital economy"), the MPs Corinne Erhel and Laure de La Raudière argue in favour of introducing IT teaching at primary and secondary level. On 12 February 2014 during the inauguration of the French Tech Hub in Silicon Valley, President François Hollande stated: "*Everything starts with computer programme coding at school. And we are going to help boost this particular area".* Lastly, the *Comité national des programmes* published a report in June 2014 stressing the importance of learning computer programming language among scientific languages, as well as the related concepts, such as coding, algorithms, etc.

French people share this view. According to the BVA-Syntec Informatique 2014 innovation survey[8], 87% of French people believe that it is important that computer programming is taught at school (24% starting in primary school, 41% starting in secondary school). Lastly, according to a TNS-Sofres survey carried out for Inria[9], 64% of French people believe that IT courses should enable students to understand programming languages, while 50% believe students should be taught how

[7] http://www.assemblee-nationale.fr/14/rap-info/i1936.asp
[8] http://www.bva.fr/fr/, Baromètre de l'innovation, May 2014
[9] http://www.inriality.fr/barometre2014/

to programme, and 62% believe courses should cover the production and publication of web content.

Non-profit organisations are introducing a raft of innovative measures in primary and secondary schools. These include *"Coding goûters", "Ateliers bidouille"* by the Petits Débrouillards, to name a few (see appendix for more details). This is a step in the right direction, but these measures reach only a handful of pupils. Although important, they are no substitute for a national education policy.

The stakes are high. We will only be able to reach the goals set by involving teachers, educational pioneers, digital activists, educational publishers, digital startups, nonprofit organisations, unions, and local and regional authorities. The Education Department has opened the door, particularly through the introduction of IT and Digital Sciences to final year baccalaureate students. We must now fully commit to IT teaching, but how exactly should we go about it?

Programme to improve cooperation

What should we teach?

The National Education Syllabus Director asked a group of IT experts from the *Académie des sciences*, the *Société informatique de France* and the *Association EPI* (*Enseignement Public et Informatique*) to draw up an IT curriculum for primary[10] and secondary [11] schools. Both proposals outlined a core knowledge base focused on four main subject areas:

1. Algorithms and computational thinking
2. Programming: writing/changing code
3. Information: processing data/information
4. Computers: understanding how they work

Extracts:

> The *Académie des Sciences* identifies three methods of IT learning which correspond to three successive learning stages which partially overlap. They are discovery, gaining autonomy and fully understanding the concepts. The discovery stage takes place at primary school, the full understanding stage at high school and the gaining autonomy stage at middle school.
>
> At primary school, pupils should be introduced to the basic concepts of computers and information technology. Using language they understand, and based on their daily lives and what they already know from other subjects, they should be taught about data, programming languages, algorithms and computers. It is too often the case that IT teaching at primary level is restricted to the use of computers or software created by third-parties. This approach completely distorts what is a scientific and technical discipline in which abstraction and personal experience play a key role.

[10] General proposals for IT teaching at primary school: http://www.epi.asso.fr/revue/editic/itic-ecole-prog_2013-12.htm
[11] Draft high school IT programme: http://www.epi.asso.fr/revue/docu/d1402a.htm

Acquiring IT knowledge is not about sitting in front of a screen for hours at a time but about learning basic, universal principles. Primary IT teaching should therefore not be related to a particular computer, software application or programming language. It must therefore strike a balance between activities that require the use of a computer and others that do not.

The challenge: teaching IT differently

Adding IT to the curriculum means more than simply adding a new subject, which is one reason why it is so important.

As a scientific and technical discipline, IT is difficult to teach in a classroom situation. Using the blackboard to teach IT in the same way as maths, for example, may result in many pupils switching off from the subject completely. The best results are obtained by taking a group- and project- based approach. Pupils come up against problems during the project and learn how to solve them, while the teacher acts as a guide. Instead of giving a lesson, the pupils are taught how to learn through reading, accessing online teaching material, meeting experts, and above all else through gaining hands-on experience. Adding IT to the curriculum could therefore help to introduce a new approach to teaching:

- Pupils learn better and faster by working with their peers and displaying their knowledge to others. In so doing, they are learning how to work together.
- Pupils take part through trial and error and learn through interaction with the computer. When they make a mistake, pupils often feel as though they have failed. Based on this new approach, they actually feel as though they are learning from their mistakes, which is part of the teaching process.
- Pupils gain in self-confidence when they manage to solve IT problems and gain an understanding of complex technological tools.

IT should therefore not be used as another tool to select the brightest pupils but rather it should be adapted as a tool for teaching skills and knowledge and the ability to deal with technology.

Several successful trials have shown that information technology is an excellent tool for rekindling the interest of pupils who were beginning to switch off. It provides pupils with the opportunity to try things out, correct their own mistakes, learn alongside their peers, and pass on any knowledge they are proud to have acquired. This is possible because they are both interested in the subject and because it is taught in project mode, which gives them a goal to aim for, values trial and error, encourages working together, boosts their self-confidence and ensures that they gain a better understanding of the subject. There is no reason why this approach would not work for pupils studying other subjects.

A cross-disciplinary approach

The digital revolution has produced staggering results, such as the systems behind Google, Facebook and Amazon. But it has also made a societal contribution through, for example, Wikipedia, fablabs, the online swapping of music or films via peer-to-peer sites, etc. Although the paradigm

shift triggered by Internet really took off in the mid-90s, it did not do so simply as a result of its technical superiority but because its business and architectural models chimed with economic and social practices which were looking to form a network.

Given the circumstances, to ensure that everybody understands the digital society we are living in and plays a role in our digital economy and society, information technology cannot be taught without referring to what it gives life to, i.e. the digital world and the new cultures that it is helping to flourish. Our subject-based National Education approach makes a more holistic concept difficult. In the project-based approach that we recommend for IT teaching, multi-disciplinary projects should be promoted:

- In IT classes, by focusing on projects that involve several subjects; if possible, the teachers of these other subjects should get involved in the project.
- In classes teaching other subjects by promoting digital projects; IT teachers should get involved wherever possible.

As information technology is prevalent in our social and economic lives, teaching the subject in our schools would provide an opportunity to open our schools up to the outside world through joint projects with businesses, local and regional authorities or even local nonprofit organisations. Pilot tests in this area again show how training programmes can make it possible to carry out a multitude of projects that can be useful for those living on housing estates, for example.

IT teaching can therefore help to change the education system by growing networks, offering new ways for pupils to express themselves and providing access to knowledge. Adding IT to the curriculum therefore offers the opportunity to shake up the current system, give pupils more control over their learning, and introduce new practices from primary through to secondary level.

A strategy for success

We feel it is important to stress how France must urgently adopt a tangible and proactive IT teaching policy given what is at stake, the complexity of the issue and how far behind our peers we are lagging. The National Digital Council has set the long-term goal of introducing IT teaching from primary through to secondary level, as is currently the case for physics, and life and earth sciences.

Our long-term goal: IT lessons for everyone, from primary to secondary school

Here, we outline the initial, bold steps required to introduce IT teaching along several, parallel paths.

To factor in budget constraints and the numerous problems faced by the Education Department, our proposals also make a considerable effort to:

- Use IT teaching as leverage to meet other targets, such as teaching certain basic principles to primary school pupils, enhancing the secondary school curriculum, helping some pupils renew interest in their studies, developing project-based teaching and working in groups.

- Encourage our education system to value, support and implement innovative on-the-job measures while introducing a proactive policy that includes all schoolchildren.

A targeted approach at every level

Primary school

In primary school, exposure to programming through simple environments such as Scratch[12] teaches pupils basic concepts such as task sequencing, tests, and looping. This provides hands-on experience and exposure to algorithms. There is already a plethora of material for teaching young children programming and information technology. This material enables children to discover information in a digital format, and therefore discuss the emerging digital world. Most importantly, this teaching must not be limited to programming alone. We must also teach computational thinking by taking an unplugged approach to computer science teaching (see Box).

> *Computer science unplugged* is a programme for primary school pupils onwards[13]. Designed by teachers in New Zealand, it takes a fun approach to teaching children the basics of computer science and computational thinking without the use of a computer. It has successfully shown that while it is possible to spend hours in front of a computer without learning anything, it is equally possible to learn a great deal about computers and how they work without actually going anywhere near one.

IT classes should also help to reinforce teaching of "the three Rs" (reading, writing, arithmetic). They can play a key role in this area, helping children learn more, and testing their knowledge in all three. For example, a software application with a spell check function can be a fascinating tool for boosting children's knowledge and understanding of the written word. A simplified spreadsheet can do the same for children's counting skills. However, the aim is not simply to familiarise children with these tools, but to introduce them to other aspects of the three Rs through IT lessons.

Teacher training is key to ensuring that programmes of this kind are a success (see below). To this end, schoolteachers must ensure that they are familiar with the highest quality teaching materials that are becoming increasingly available.

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[12] A free programming language designed and maintained by the Lifelong Kindergarten Group at the MIT Media Lab. It aims to introduce pupils aged 8 and above to fundamental mathematic and IT concepts. It takes a playful approach to algorithms and helps users to create algorithms, work them out, and work together on Internet. Source: http://www.cndp.fr/ecolenumerique/tous-les-numeros/boite-a-outices/apprendre-par-le-jeu/article/article/scratchimagine-programme-partage.html

[13] http://csunplugged.org/

Making the most of extracurricular activities and the non-profit sector

As well as introducing IT teaching gradually, we recommend that the National Education Department and local authorities make the most of after-school activities to boost their IT teaching programmes by involving the many existing clubs and nonprofit organisations that have already been created to teach children computer programming, for example. This inclusive, gradual approach could be network-based, thus ensuring that the teaching materials are shared, the measures introduced are brought to the fore and that everyone learns together about the difficulties encountered and the success stories achieved. Schoolteachers would obviously have to be part of these networks.

Secondary school

There is a significant opportunity to teach IT at this level as hours in the curriculum have already been allocated to IT and many technical studies teachers have already received IT training.

We propose converting the one-year technical studies course at this level into an IT class which would concentrate on teaching pupils basic computer programming and basic algorithms.

The aim is obviously not to diminish the importance of technical studies. At this juncture, it is worth reiterating the links that exist between information technology, a technical subject, and technical studies. However, we also feel that it is important not to get the two mixed up. The one-year IT course should be clearly entitled "information technology" (or IT and Digital Sciences). Although technical studies teachers could teach the course to start with, it should be taught by specially trained IT teachers in the long run (whether they were previously teaching technical studies or not) who have an IT diploma or certificate.

The most appropriate year for this course would be the last year of middle school as this is when pupils must choose which subjects they are going to specialise in when they reach high school.

We must re-examine technical studies teaching at middle school level

There is some disgruntlement among technical studies teachers even though the experts confirm how important it is for pupils to be exposed to the subject from an early age. Science subjects have been taught separately at middle school level since time immemorial. Teachers specialise in maths, physics, or life and earth sciences, and no-one would claim to be able to cover the whole subject range. Nevertheless, we should take a closer look at why we ask our technical studies teachers to cover such a wide spectrum of subjects from mechanical to electrical engineering to information technology or even tertiary sciences and technologies. The rise of information technology, both as a science and a technical subject, show that this situation is untenable.

It would be worth carrying out a survey to ascertain how many technical studies teachers would be interested in becoming IT teachers if they were given training to do so, as was the case for high school IT and Digital Sciences teachers.

Recommendation 1

- Teach the basics of computational thinking using the plugged or unplugged approach at primary school, making good use of extracurricular activities for beginners.
- Teach IT at middle school level. Start by introducing a one-year IT course focusing on basic computer programming skills during the time currently allocated to technical studies.
- Teach IT to every high school pupil through the rapid rollout of the IT and Digital Sciences option.

Teacher training a priority

The success of this proposed syllabus from primary through to secondary level would of course depend on the skills of the teachers involved. Our latest recommendations therefore focus on the main issue: having enough skilled teachers available at every level.

Primary school: IT lessons should be added to the teacher training syllabus, with an IT module being added as soon as possible for new teachers. It should be also made available for existing teachers via online courses, eLearning modules, MOOCS (Massive Open Online Courses), online communities, etc. As we have already mentioned, teachers should be encouraged to learn along with their pupils through the use of suitable teaching materials that are now widely available.

Middle school: initially, technical studies teachers could teach IT classes. We must therefore ascertain as quickly as possible how many technical studies teachers would be willing and have the requisite skills to teach IT as a school subject that covers both basic programming and algorithms. In the longer run, they could, if they so desired, become IT teachers.

High school: it is currently impossible to extend the IT and Digital Sciences option to pupils studying literature, economics or technical subjects due to the lack of qualified teachers. We could call on existing teachers (as we did for the IT and Digital Sciences option for final-year science students) to help out; experience shows that maths teachers are often willing to do so. They must, however, teach information technology from a scientific and technical perspective rather than a purely abstract maths-IT perspective. These teachers normally volunteer to change and often take a very dynamic approach. We must help them get to grips with their new subject by setting up networks and supplying them with appropriate teaching materials, online courses etc. in the longer run. The current system requiring a simple “declaration of skills” must in the longer run be replaced with an official certification process.

Primary and secondary school: the National Education Department and local and regional authorities must work together to tap into alternative sources, i.e. extracurricular nonprofit organisations, IT students and professionals. We must also start making the most of existing online teaching materials as much as possible.

In the medium term, we must have a pool of qualified IT teachers

To teach information technology[14], or any other subject, teachers must be qualified. As students will be increasingly exposed to information technology, having qualified teachers will take on even greater importance. For middle and high schools, teachers must be qualified to degree level both in terms of their knowledge of the subject and their teaching skills (project-based teaching, learning through trial and error, etc.)

The limitations of workaround solutions

Although essential in the short run, the numerous suggestions made to recruit teachers on an ad hoc basis will not be enough to meet the targets set:

- Train existing teachers on a voluntary basis: this is clearly one option that can be explored. In the long run, these teachers can convert to become IT teachers. Generally speaking, the volunteers are middle school technical studies teachers (which fits in with requirements) or high school maths teachers. However, we can question the wisdom of converting maths teachers (mostly for the purpose of teaching IT and Digital Sciences) into IT teachers and further aggravating the lack of maths teachers. We should also take into account the fact that considerable resources would have to be earmarked to provide conversion training for teachers with non-scientific backgrounds.
  In high schools where IT and Digital Sciences has been introduced as an optional subject, the number of volunteers has reached its limit. And the additional training given is often insufficient. We are therefore a long way off being able to cover all of our needs (see later) using this approach.

- Relying on extracurricular activities: these activities are invaluable and offer extremely useful teaching materials, methods and experiences. However, looking upon them as a replacement for standard classes does both them and pupils a disservice. First of all, only a small number of pupils can ever be involved, and the number may vary considerably from one year to the next on a local basis. Second, they are designed to complement the work of the National Education Department, provide back-up and offer an alternative to those pupils who do not find what they are looking for in their own schools. These activities would be worse off if they were integrated into mainstream education and standardised to comply with syllabus requirements, a particular timetable or group of teachers. While in the short run workaround solutions are available, in the medium term we have no other option but to recruit qualified teachers. Which raises two important questions:
- How many positions need to be filled?
- Where will we find all of these teachers?

[14] Our focus here is on training teachers to teach IT in middle and high school. It would also be worth giving some thought as to how the digital revolution could teach the way other subjects are taught, such as French, history, languages and other science subjects, multiplying the number of teaching approaches possible – but that is another subject.

How many positions need to be filled?

There are two ways of quantifying the teaching requirements for middle and high schools: by number of teaching hours or number of schools[15]. The truth lies somewhere in the middle, as teachers may sometimes (but not always) teach in more than one school (depending on the distance that has to be covered, whether the timetables are compatible, the teaching teams work well together, the other school activities held, etc.). We suggest estimating this requirement to obtain a ballpark figure based on two hours of teaching in *troisième* (14-15 years old) and *terminale* (15-16) at secondary school. This figure includes private schools. It is important to note that there will be no change to the number of hours of teaching that pupils will receive. This therefore means making only marginal changes to the total number of teachers and changing how they are allocated among the subjects to be taught.

	Calculation based on number of hours	**Calculation based on number of schools**
Middle school: teach IT in *troisième* *on the basis of the hours allocated to technical studies* (2h/week)	32,000 classes Approximately 3,500 positions[15]	7,200 schools ◊ *Realistic estimate: 5,000-6,000 positions* ◊ *Number of new positions: 10%-15%, around 500-900*
High school: IT and Digital Sciences across the board (2h/week)	12,000 general baccalaureate classes, 1,250 technical baccalaureate classes[16] (ST2S-STL) Approximately 1,500 positions	979 schools ◊ *Realistic estimate: 1000-1200 postes.* ◊ *Number of new positions: 90%, 900-1,100*

Where will we find all of these teachers?

As well as converting existing teachers to IT (for the current IT and Digital Sciences option, around 200 full-time positions), recruiting qualified IT teachers is a must. Our very approximate calculation indicates that several thousand positions must be filled.

[15] These figures are approximate. The National Education Department does not provide enough information that would enable us to produce a more accurate estimate. These figures also apply to a plateau being reached; we are well aware that this could not be achieved in one year.
[16] IT is already taught in the final year of technical baccalaureates (Management Science and Technology, and Industry and Sustainable Development Science and Technology)

There are two target audiences:

- Newly qualified teachers. Teaching IT could interest young, highly-motivated teachers who are good at working in a team. They may be willing to cut their teeth by teaching IT, putting what they learn to good use in the private sector if they decide that is the road they want to go down.
- Qualified professionals looking to switch over to teaching. For example, engineers may be looking for a temporary or permanent move out of business and into teaching, giving them the opportunity to pass on what they have learned.

Will it be possible to attract enough qualified professionals into education? We believe so, if we can offer them (to make up for the lack of a high salary) recognition and professional opportunities inside and outside the National Education Department. The goal is an exciting one: help France's youth learn new, must-have skills while exploring new approaches to teaching.

This brings us immediately to the subject of introducing a secondary school (CAPES) and higher education teaching diplomas (Agrégation) for IT. This idea has been put forward by Corinne Erhel and Laure de La Raudière, both Members of Parliament. It is currently the subject of lively debate. The issue being dealt with is a simple one:

How to quickly find a large number of qualified IT teachers

To recruit people who are already working, alternative forms of training and recruitment other than the traditional secondary school teaching diploma (CAPES) can be used. It makes sense, however, to use the CAPES to attract young graduates as this is the method used to recruit teachers for every other subject. It should now be rolled out to IT.

Attracting teachers capable of teaching two subjects would also offer greater flexibility, which would be essential, particularly during the transition phase. This could result in technical studies and IT teachers in high school, or teachers qualified to teach information technology and mathematics, for example.

Recommendation 2

- During the transition phase, IT would have to be taught in secondary schools by existing teachers. In addition, we would have to look for potential teachers elsewhere, i.e. among the population of computer researchers, engineers or non-formal teaching professions.
- Develop the recruitment of qualified IT teachers, i.e. those who have a Masters degree in information technology or computing science.

Help overhaul the education system

Teaching IT and its related methods offers new ways of adapting our approach to teaching in general. We propose adopting a proactive policy in this direction supported wherever possible by the experience of innovative teachers.

We must promote multidiscplinary projects with a digital slant and a high IT content.

Whenever possible, these projects should be coordinated by several different subject teachers. Students would work individually while supervised and would be given time to work on a project together from start to finish. Through these kinds of projects, IT students could work in conjunction with other students of other subjects, such as maths, French, etc.

These projects would also provide an opportunity to open up to the outside world, i.e. by forging partnerships with the nonprofit sector or local businesses. It could be even more rewarding if students were to work on real problems using real data.

This could apply in particular to projects carried out as part of the final year IT course.

As we mentioned previously, introducing IT in primary and secondary schools must be done using different teaching methods than those used to teach other subjects, i.e. project-based teaching, trial and error, group work, reverse teaching, a multidisciplinary approach, etc. This cannot be put in place by taking a top-down approach via the syllabus but rather will call upon the practical knowledge and experience gained by both the teachers and schools.

Although not unheard of, this kind of approach is still relatively unusual in France, particularly for teaching the more general subjects. Monitoring its results, successes and failures will be a key step in ensuring the continual improvement of IT teaching. Furthermore, if positive results are obtained, this approach could be rolled out to other teaching scenarios and to other subjects.

Recommendation 3

- Place group projects at the heart of IT lessons and give priority to projects that require working jointly with students studying subjects other than IT.
- Set up benchmarks for progress, such as the percentage of students leaving the education system with a "satisfactory" level of IT knowledge.
- Monitor the practices implemented to oversee their improvement or help them feed through to other disciplines.

2 – Introduce digital literacy

The term digital literacy is still relatively uncommon in France, although it is becoming more widespread on a daily basis. Some people prefer to talk about "digital knowledge" whereas others favour "digital and multimedia education".

We selected digital literacy for two reasons:

- It represents a departure from the traditional approach taken by our education system to multimedia learning which meant that pupils were more or less information "consumers".
- It focuses on the following key point: for individuals to be in control of their lives in the digital age, they need a certain amount of knowledge and even more skills and methods

which change the very relationship they have with knowledge itself and how they go about acquiring it.

By their very nature, the knowledge and skills that form the cornerstones of digital literacy are constantly shifting as they keep pace with developments in technology and its uses, both extremely fast-moving. The aim of this report is not to re-design the ideal framework for digital literacy, as it would quickly become obsolete. Instead, we will first look at the existing framework and identify what we feel are three of its weaknesses. We will suggest how changes can be made to form a stronger foundation for digital literacy. Second, we will look at how the digital world can contribute to existing teaching methods, something we feel is essential and will have a liberating effect on our teachers. The aim is not to overload an already full syllabus. As it is more about skills and methods than knowledge, digital literacy represents an opportunity for teachers and documentation specialists to diversify, extend and boost their teaching methods. Digital literacy goes hand in hand with other disciplines and can be taught by taking a cross-cutting approach without eating into the time allocated for learning other knowledge-based subjects (the more technical aspects being incorporated into IT courses; see chapter on information technology).

Given that it leads to a cultural change in the way we approach acquiring skills and learning, digital literacy offers unexpected ways to help the most vulnerable students who are having the greatest difficulty at school. Numerous existing practices show this to be the case.

Changing frameworks

Numerous digital literacy frameworks exist today, including some with an international dimension (see the framework produced by the very prolific Mozilla Foundation).

In France, the B2i (Internet and Information Technology) Certificate provides a framework for digital learning from primary through to secondary level. Established in 2000, its content was updated and significantly improved in 2011 for primary and middle school pupils and in 2013 for high school pupils. Nevertheless, it has several limitations that we would like to take a closer look at here to ensure that they are eliminated during the next update.
They are:

- Its strictly French framework
- Its implementation which is not carried out by a dedicated team of teachers with clearly defined responsibilities
- Its main focus, which is still largely dominated by a non-digital media culture, particularly the primary and middle school versions

If we really want to make digital literacy a genuine tool for teaching, it will have to undergo significant change.

Really teach the frameworks

B2i is not properly integrated in our educational system, and more often than not, there is no designated teacher or team in charge of teaching this subject. Pupils obtain this certificate by doing exercises at home, alone in front of a screen, or in a best case scenario in a technical studies class. There is no clear link between these exercises and the other subjects he/she has been taught.
The certificate is therefore proof that a student acquired knowledge with no real support from teachers. This is the most surefire way of widening the inequalities between those who can learn these skills at home and those who are left to fend for themselves.

There are several points in the framework that are worth taking a closer look at across all disciplines. Digital literacy should therefore be placed in the hands of a qualified team chaired by one of its members reporting to the school's head teacher. The group would make regular checks throughout the school year to ensure that the skills covered by the curriculum were being taught in all subjects and make any necessary adjustments accordingly.

Recommendation 4

- Encourage every teacher to incorporate some aspects of digital literacy into their classes.
- Ensure digital literacy is taught in such a way that every pupil is treated equally. Develop teacher support and group work for pupils.
- Appoint a digital literacy coordinator in each school (teacher/documentation specialist, head teacher, etc.) who will be responsible for teaching of B2i based on the feedback from

teachers regarding the skills acquired by pupils based on the cross-disciplinary approach taken.

Equip pupils with the tools to be digitally creative

The B2i is far too defensive and places too much emphasis on the risks (freedom, copyright, etc.) associated with using digital media rather than the opportunities it offers. Pupils have to wait until they reach high school before they can display their knowledge of the tools on offer and gain experience, albeit theoretical, of working as part of a network. The "Be Responsible" section contains an obviously useful set of skills but makes pupils want to run away from the digital world rather than grasp it (for example, the focus is placed on checking the rights associated with content that the pupil would like to use elsewhere rather than how to choose a licence for their own digital content to decide how it will be distributed).

Pupils are taught to take a critical approach but are not taught how to deal with issues that might arise. For example, although there is a presentation of the CNIL (French Data Protection Authority) and its role, there is no explanation given of the digital economy, how it operates, or the related business models. It seems difficult to explain to pupils why they must be careful when managing their digital footprint if they do not understand the economic reasons for doing so.

We propose adjusting the current frameworks and reworking them around four key skills that are currently missing or skimmed over:

- Equip pupils with the tools to understand the constantly changing digital landscape
- Teach pupils to produce content individually or as part of a group
- Teach pupils how to publish and distribute their work
- Teach pupils how to contribute to the general pool of knowledge

Most of these skills can be acquired when studying other subjects; there is no need to introduce specific courses to teach them.

Understanding rather than being subjected to the constantly changing digital world

Classes given in almost every discipline, including the arts, philosophy, history/geography, economics and social sciences, technical studies and maths, must teach pupils how to think about the role played by science, technology (in general) and digital media (in particular) in changing people's thought patterns, the economy and society at large.
Understanding how the digital economy is built and operates (e.g. disintermediation, the Attention Economy, two-sided markets, etc.), analysing the role of algorithms in our cognitive thought processes, understanding the social ties that are forged or undone via social networks: these are all examples of what pupils should be taught at school.
Helping pupils gain some perspective on the IT ecosystem, outlined in the "Information Technology" section, is a key digital literacy skill to be learned. This includes learning to write code, control a computer or other hardware (e.g. Arduino) via a programme, or design web pages or

video games. Other skills mentioned earlier are also vital in teaching students to think for themselves.

Recommendation 5

- Train teachers, particularly teachers-documentation specialists, about the societal issues raised by the digital revolution at teacher training college and through vocational training.
- Use group work and online methods for teachers' digital literacy vocational training.
- Insert a module dealing with these questions in almost every subject's curriculum and classes.

Produce individually and as part of a group in open mode outside the classroom

Project-based group work should be introduced in every primary and secondary school subject, ideally simultaneously. The project should take the children's age into account and the tools available within the framework of the existing curriculum.
The aim is to teach children how to work in groups as early as possible, i.e. to write a story, learn a particular skill or play a game. Excellent digital tools are available for group work, including wikis, content management systems (CMS) and blogs that can be used to produce images and sound. Group work of this kind may also call upon general knowledge children pick up during their extracurricular activities (e.g. video games, fanfiction, etc.).

Group work may involve the entire class or small groups within it. Alternatively, it could involve two classes working together, one of them foreign, which would be a particularly enjoyable way for children to learn modern languages.

This approach could also provide an opportunity for teachers to look for participants (e.g. a journalist, scientist, craftsperson, etc.) outside school who, without being physically present, could contribute to the project and interact with the students. The whole process, including looking for possible participants by searching online and then making contact, is an educational approach in itself.

Interacting with third parties from outside school puts pupils in a knowledgeable position, which will boost their confidence and help them gain perspective on their own skills and knowledge, as in any knowledge transfer process.

TransiMooc, a MOOC created by and for young people
This MOOC was built by students working together and helping each other. Two hundred students produce video clip content and seven hundred have signed up for the course. Young content producers are benefitting from this connected, interactive approach which is also encouraging their teachers to get actively involved.
Source: http://transapi.fr/transimooc/

i-voix

I-voix is a blog to promote literature-based reading, writing, creative activities and discussions. It is produced by second year literature baccalaureate students from the Iroise High School, Brest (France) and French students from the Cecioni High School from Livorno (Italy) as part of an eTwinning project.

Source: http://www.i-voix.net/

Studying the news with a journalist

Laurence Juin, a teacher in a vocational secondary school, uses various digital applications in her classes (Twitter, Pinterest, Tumblr and Google Drive).

One year she asked her students to study the news, so they launched an appeal via Twitter for articles to be submitted. A journalist from France Bleu La Rochelle answered the call and told the story of a murder that had taken place on Ile de Ré ten years earlier and which she covered at the time. She sent a long text to the class which acted as a starting point for repeated exchanges between them, first via Twitter, before the journalist visited them in class.

Source: Forum des usages coopératifs, Brest, July 2014

Recommendation 6

- Schedule at least one group-based project using digital technology per year for each class.
- Encourage teachers to involve third-parties (e.g. a business, nonprofit organisations, teachers/researchers) in their projects.
- School heads should provide support for these projects, identify newprojects and ensure their long-term development.
- Promote teaching which gives students the initiative and encourages them to contact third-parties outside school as part of their group project work.

Publish on the Web and distribute their work

Whenever possible, class group projects should be made available online.

The aim of doing so is to make pupils aware of the implications of publishing (i.e. making your work available to an audience), i.e.:

– They must pay extra attention to quality, form and content.
– They must be responsible: understand the impact of the material being published.
– Rights management: choose the licence suitable for the publication method selected by the pupil/group of pupils.
– Reputation: how reputation is managed via digital technology.
– Promotion: understand the role played by social networks and how search engines work.
– Conversation: understand how the content they produce may lead to online conversations or other forms of sociability.

– Cost: understand what the work of a digital editor comprises and the related business models (where applicable).

Publishing therefore enables pupils to acquire a significant portion of the skills outlined in the B2i framework.
In addition, it provides an opportunity to master the basics of web publication tools (blogs, style sheets, one-page video introduction, etc).

A relay class in Brest uses Twitter

Monique Argoualc'h, a relay class[17] teacher from Brest, opened a professional Twitter account for each of her pupils when they joined her class. The use of this account is governed by a charter which must be adhered to both in school and at home. Pupils are required to follow basic spelling rules and they all have a standardised account ID starting with DR. Pupils use their Twitter accounts to give updates on class projects, keep the other group members informed of the latest developments as well as the teachers of the class that they left and to which they will return once their stint in relay class is over. They also use the account to communicate with other relay classes. In 2012, they used their accounts to work remotely with a class based in Saint Nazaire on a Twitterature project and in 2013 on a Philotwit project.
The timetable for the week is published on the relay class website. This enables students to plan ahead and get involved. At the same time, it keeps secondary schools and parents informed of the work being performed in the relay class and raises its status.
Source: Forum des usages coopératifs, Brest, July 2014

Recommendation 7

- Encourage schools to publish their work systematically, particularly websites, blogs, sustainable social networks, digital workspaces, etc.
- Train pupils to use open licences (such as Creative Commons) and teach them about the related editorial decisions (re-use, sharing, circulation) and how this applies to the use of documents for which they have exclusive ownership.

Develop the use of shared educational resources

There are three types of resources available in the digital world: 1) proprietary resources protected by copyright whose re-use is subject to negotiation; 2) resources in the public domain which can be freely reproduced as long as the author's moral rights are respected (these resources are open to educational innovation); and 3) shared resources (or common knowledge) to which the creator has attached a free licence.

17 Relay classes are for dropout pupils (those who are passive or disruptive in class, refuse to attend school for irrational reasons, etc.). In 2012, 13,600 pupils attended 440 relay classes in France.

A significant amount of time is often devoted to proprietary resources (e.g. written manuals, use of tablets and digital documents, etc.). Looking at other types of resources during class provides both pupils and teachers with an opportunity to enhance their knowledge in this area. Such an approach would also help improve understanding of intellectual property rights, the challenges they pose and the constraints they place on creative pursuits.

New practices (fanfiction, audio/video remixing, subtitling, literary criticism, etc.) driven largely by youth culture need to relieve this pressure to highlight pupils' creativity and dedication when taking advantage of the new opportunities offered by technological innovations. Each stage of school can offer pupils the opportunity to take part in group projects, such as contributing written material to encyclopaedic websites created by and for children (Wikimini, Vikidia), correcting or adding to a Wikipedia article, contributing to OpenStreetMap during a "cartography party" that could supplement a geography course, collecting nutritional data from the fridge at home which can then be added to the OpenFoodFacts website (this activity could complement Life and Earth Science courses), putting the class computer's calculation powers to use as part of a grid computing research project, posting class photos on Flickr using a Creative Commons licence, etc.

Working alone in the classroom, teachers are often unfamiliar with these types of resources or are reluctant to make their own teaching materials available in this way. The desire to contribute to free educational resources available online, demonstrated by some teaching groups (Clio (history), Sésamath (maths), use of shared presentations on Slideshare, etc.) is held back substantially due to the lack of an efficient, centralised process for making these resources available online.

Copy Party via mobile phone

Karima Kadi, a teacher/documentation specialist at the Raoul Dufy middle school (Le Havre) set up the first Copy Party with a *troisième* class. After checking that all of her pupils had a mobile phone (to ensure that nobody would be excluded), she used the Copy Party to show that it was possible to copy and share texts without breaking the law. This provided her with the opportunity to discuss copyright, and knowledge and skills sharing with her pupils.
http://www.actualitte.com/reportages/le-smartphone-star-de-la-premiere-copy-party-dans-un-college-du-havre-2150.htm

Sésamath

The Sésamath Association aims to make free educational resources and free professional applications available to everyone to teach maths via Internet. The body advises its members and contributors to use free licences to communicate and write documents and educational material.
http://www.sesamath.net/

Recommendation 8

- Train groups of teachers at teacher training college and through vocational training to use and enhance the pool of common knowledge.
- In each digital workspace's list of "educational resources", include all of the workspace's common knowledge, free educational resources and related tools and applications to ensure that they are more easily accessible to teachers.

Build at European level

Digital literacy must by definition be flexible and in constant flux since it must, in a very short space of time, incorporate the successive transformations that occur as a result of the arrival of disruptive technology in our social practices. It is difficult for the French National Curriculum Board (*Conseil supérieur des programmes scolaires*) to keep pace with this change, not to mention its international counterparts.
However, given the streamlining of diplomas and free circulation of students that is taking place, we feel it is now essential to introduce a European framework.
The first European certificate already exists – the European Computer Driving Licence. However, this Licence is not at all suitable to the digital literacy requirements we set out here, and we feel it needs to be overhauled completely.

Member States should obviously still be responsible for their education systems which should continue to be governed by the subsidiarity principle. It is not part of the European Union's remit to oversee the content of school curricula. However, it is increasingly in favour of converging the work of Member States in education, providing support and encouraging the emergence of new, innovative practices[18]. France can therefore benefit from this situation, commit to working within the European Union, invite other interested Member States to get involved and aim to build a genuine digital literacy framework that can be applied throughout the EU.

Recommendation 9
Work with other EU Member States to harmonise France's digital literacy framework with that of other Member States to produce one single, harmonised framework.

Methods, approaches, skills and knowledge

Teaching digital literacy is as much about adopting certain working practices and approaches as it is about acquiring skills and knowledge. Many of these practices and approaches predate today's digital society (e.g. learning how to look for information, building a list of points in favour/against a concept, project-based approach, etc.) but have been given a new lease of life thanks to the digital revolution. Others are inspired from the workings of the digital world (e.g. free software

18 http://eduscol.education.fr/cid47513/politique-europeenne-en-matiere-d-education.html

community cooperatives, hackatons, barcamps, meetups, etc.). One of the main digital breakthroughs relates to the abundance of content which can be reused, appropriated, and is freely available to all users. This transformation offers both an opportunity but requires training in how to reuse or create content, and in distribution methods, management rights and licences for use.

There are three reasons for adopting this stance and these methods. First, it enables users to grasp the basics of the digital world that they can call upon regardless of the technology they are dealing with throughout their life. Second, they will give users the key to being independent, a must in today's professional world that requires individuals to be increasingly autonomous. Third, these methods will be useful for tomorrow's citizens in both their social and private lives.

A new learning culture

Switch from a culture of competition to one of cooperation

The principle of competition has underpinned economic growth in western countries throughout the 20th century. From a liberal viewpoint, it drives individual and group creativity: this includes competition between companies, but also between towns and regions, individuals, etc. The educational system has contributed to this culture, in particular through its system of marking pupils' work and teachers' assessment of their performance. Similarly, schoolchildren's work has, as a result of this cultural model, been based on individual, "vertical" work.

We are now coming up against the limits of this ideology in the form of stalling or faltering economies, growing social inequality, and diminishing natural resources. But cooperative approaches could offer alternatives. Our aim is not to replace one ideology with another, i.e. cooperation with competition, but to take a closer look at how a cooperative approach could lead us in the direction of alternative, more sustainable growth models that may help to boost individual well-being.

Digital technology is open to cooperative approaches as a result of its intrinsic network-based organisation. This is visible everyday in numerous ways, including the working methods employed by companies in the digital sector, the innovative open projects between companies, the emergence of services based on peer-to-peer exchange, or in the construction of shared knowledge databases, all the result of cooperative efforts (e.g. free online encycolopaedias).
By introducing digital culture into teaching, our schools can become a breeding ground for cooperative knowledge, and find ways to take a new approach to pupil assessment which all too often can result in defensive, individualistic behaviour.

Reduce the focus on accumulating knowledge, encourage learning through discovery, reward curiosity

With almost instantaneous access to a wealth of documentary resources, Internet is gradually replacing our memories with digital resources. Certain cognitive psychologists are worried about this trend. They have passed on their concerns to teachers but have not necessarily proposed viable alternatives that would fit in with today's well-developed habits. We do not feel that a defensive approach would be enough to tackle the problem and believe it would make more sense to:

- Acknowledge that each major disruptive technology that has touched upon the field of knowledge, such as printing, has undoubtedly led to a cognitive transformation which was not necessarily a backward step.
- Go one step further by abandoning the accumulation approach, and switch the memorisation process to other objects (methods, correlations, etc.). Western teaching has for a long time limited the role of memory (compared, for example, to book-based religions, or the Chinese education system), and it can now move up to the next level.
- Take advantage of this cognitive decline to focus children's time and attention on other ways of learning, such as making discoveries by accident. Too often decried as Web surfing, learning new facts by accident requires curiosity, a selective critical approach and specific methods to be fruitful. This curiosity and thirst for information can now play a key role in our teaching process.

Today, it is just as important to know how to look for information, to quote sources, build up a critical opinion, find things by accident, and learn to interpret information as it is to acquire knowledge and skills related to a particular discipline. But one cannot be substituted for the other.

Diversify knowledge transfer methods, switch roles and change pupils' self-perception

Online courses and documentary resources now compete with teachers' knowledge. Until now, teachers held a monopoly on the subject being taught and the content made available by publishers.

All too often, this diversification is looked upon as a source of rivalry. It can, however, give teachers greater freedom and more resources, freeing up time that they can now spend helping pupils to learn rather than transferring their knowledge and assessing how much pupils have taken in.

The setup is new for pupils, enabling them to study independently and sometimes acquire knowledge that can them be passed on to other pupils or even to the teacher. Teaching approaches based on reciprocal knowledge sharing[19] have proved their worth over time, both inside and outside school (particularly for children experiencing difficulties since these approaches help to boost their self-confidence, a prerequisite to every child's motivation to learn).

Now that resources are available online, there has been a role reversal and the teacher-pupil relationship has been altered, which for some can be destabilising. The resultant increase in alternative teaching approaches does not call the teacher's authority into question, but does mean

[19] Claire Héber-Suffrin, *Échanger des savoirs à l'école, Abécédaire pour la réflexion et l'action*, Chronique Sociale, 2004

that teachers must now justify their role; being a teacher is now as much about providing pupils with support during the learning process as it is about transferring knowledge. This approach is particularly successful when dealing with pupils experiencing difficulties.

In the years to come, schools must take an approach that looks upon these new online resources as a welcome addition rather than something that will replace traditional teaching materials. Teachers must maintain a central role, and the system should provide both teachers and pupils with support and encouragement during this transition; not everyone will find it easy to adapt.

Digital Media helps reignite pupils' interest – When dropout pupils lead the debate

Five pupils who dropped out of the Pablo Neruda Middle Secondary School in Pierrefitte were asked to discuss the problems they face. After drawing up a self-portrait, Mike, Fiona, Dumy, Melissa and Kenny learned to build and conduct interviews with the head teacher, senior education counsellor, teachers, classroom assistants, pupils that had not attended school previously and business representatives.

This exercise in digital mediation changed their way of looking at school, the teachers, their professional goals, and even themselves. Similarly, it changed the way teachers see them.

http://raccrocherparlesmedias2013.blogspot.fr/

When digital media and innovative teaching feed off each other

Teachers have been looking for innovative approaches and ways of updating their teaching methods long before the digital revolution occurred. Nevertheless, after several decades, it is still difficult to spread the most tried and tested alternative teaching methods throughout the national education system and feed them through to teacher training courses.

Strong ties are becoming apparent between digital literacy and many of these innovative approaches to teaching. The advantages could be two-fold: digital technology can act as a springboard for these new approaches, extending their reach. At the same time, digital literacy needs these new approaches since it depends as much on methods and attitudes as it does on knowledge and skills.

Project-based methods, active teaching methods, institutional methods, role reversal classes, surveys, mapping controversies, content curation, and so on – all of these approaches predate the arrival of digital technology and could easily do without it. But joining forces with technology could be useful on a number of counts:

- Digital technology can provide support. In the case of a role reversal approach, digital media (e.g. videos, digital portfolios, etc.) make it easy to move the teaching part of a lesson out of the classroom and into the home, library or specifically allocated self-study periods.

- Digital technology can provide the means for pupils to take a cooperative or active approach to project building. The use of tools such as Wikipedia, participatory mapping applications, or group word processing tools can make it easier to work as a group either remotely or in the classroom.
- Encouraging pupils to think for themselves and take a critical approach can be supported by the mapping controversies approach. This would help in performing a critical analysis of digital society and understanding its individual and group challenges. At the same time, digital media such as mind maps, software for group writing and public debating tools could all be put to use.
- Subjects relating to the economy and digital society are often rather technical, which may discourage pupils or even teachers. The survey based method could help simplify learning in this area.
- Digital technology is contributing to an exponential growth in the mass of data available. It is difficult for pupils to sift their way through this mass and decide what is useful. The problem is not a new one but has been multiplied ten-fold. Learning how to use content curation applications (e.g. Scoop-it, Seen-this, etc.) would equip pupils with the skills required to deal with this issue.

Content curation in secondary school: carrying out a press review using Flipboard

As part of the "DocTice" MOOC, four teachers from Besançon Academy (Isabelle Kesler, Marie-Claire Giraud, Juliane Eble-Terschlusen and Séverine Cottere) created a full sequence for teaching content curation using the Flipboard application.
http://www.cndp.fr/savoirscdi/societe-de-linformation/reflexion/la-curation/les-pratiques-des-professeurs-documentalistes-en-matiere-de-curation/la-curation-avec-des-lyceens-realiser-une-revue-de-presse-avec-flipboard.html

Recommendation 10

- Add a starter course in new digitally-enhanced teaching practices to teacher training courses, placing the focus on how to involve the most vulnerable pupils.
- For CAPES, CAPET and CAPEPS admission tests, introduce the option for candidates to carry out dissertations based on group learning methodology training programmes.
- Using an online sharing service, provide teaching teams with access to the experience, methodologies and tools documented that they can use to add these metholodogies to their teaching practices.

Alternative ways of assessing teaching

Teachers are currently only assessed in classroom situations where they are the sole teacher giving lessons in their own subject(s). Their role as part of the entire teaching staff is not taken into account.

We are not recommending that teachers no longer specialise. We do, however, feel that taking an interdisciplinary approach could help to offset the silo effect that comes from teaching individual subjects in this way. For this reason, we suggest devoting part of a teacher's assessment (particularly secondary school teachers) to assessing their ability to work on interdisciplinary projects in conjunction with other teachers.

We must encourage and develop teaching projects that enable pupils to participate and cooperate (see I-B2 and I-B3). A portion of teachers' assessment could focus on their ability to develop projects of this kind.
Lastly, sharing course materials on an open platform (see Chapter 4) could also be developed on an incentive basis rather than forced upon teachers.

Recommendation 11

- As part of the teacher assessment process (see above), develop the use of digital media by teachers, particularly in the development of open source teaching materials, the implementation of interdisciplinary digital projects and/or when working jointly with third parties.
- Simplify the publication process and encourage discussions on experience-sharing websites (e.g. *Expérithèque*[20])

Adapt classes to project mode

Classroom equipment should be gradually updated to shift the focus away from the black-/white-/digital-board. All of the equipment must be mobile (tables with wheels, equipment to support creativity, etc.) to adapt to the requirements of the various teaching times and methods used. Having a classroom set up for project work does not require the same layout as for individual work, for example. If, for financial reasons, overhauling all classroom equipment is not an option, any new equipment purchased must take into account these new guidelines (see Appendix).

Recommendation 12

All new classroom equipment must be adaptable, enabling teachers to adapt the classroom layout to suit his/her teaching programme.

[20] *Expérithèque* is a website documenting experimental teaching practices:
http://eduscol.education.fr/experitheque/carte.php

Open up group workspaces

Dedicated group workspaces should become an integral part of our schools. Unlike the library or the study room, both quiet places, these workspaces should be designed to let pupils work together on their projects. This does not require a radical reform but could be set up gradually as and when the need or desire for them becomes apparent. The government must be ready to rise to this challenge.

As outlined in the section on networked schools, schools must open up to the outside world while maintaining certain areas closed off to third parties. These conflicting requirements could be remedied by using the school at different times for different purposes. During classtime, it should remain a space where children learn to grow away from their parents.
After class, schools can be used for social events (this is already the case for some schools whose premises are used on an intensive basis for extracurricular activities). But all too often, these events are held back by significant administrative hurdles.

These workspaces could also be devoted to extracurricular activities. Extracurricular digital activities could be developed further as long as enough supervisors are trained. This training could be provided by digital mediators (see Section 4).

We also suggest using these workspaces to run non-formal digital technology workshops and to enable pupils and parents to work together on digital media.

Using digital workspaces to run non-formal digital technology workshops

As is already the case in some schools, these workspaces can be used to organise extracurricular activities for children. These activities will however be diversified to include digital technology courses, particularly IT. This does not mean that there is no place for digital literacy and information technology in the school curriculum. But as both subject areas evolve extremely quickly, they are also taught outside of the school curriculum as the pace of school teaching is not in line with the pace of technological innovation. Educational associations have a key role to play here.

Smart Kids, non-formal digital education
Smart Kids is an educational association that offers children scientific and technical courses via digital media, including:
- *Edgar le Camtar*: The truck equipped with sensors. Children test their senses using all types of sensors in the truck. What is a sensor? How does it differ from human senses? What kind of sensors should we take with us on a trip to Mars?
- *Georgette la Camionnette*: The thinking van. The van processes data and samples taken from Mars. How can we interpret the data? Under what conditions would life on Mars be possible? Children are taught to make and test their assumptions by carrying out simple and fun experiments.
http://www.futur-en-seine.fr/fens2014/projet/le-science-tour-bus-des-petits-debrouillards/

A space where pupils and parents can improve their digital literacy together

Outside of class time, schools can also act as digital mediators. For example, they could open their doors to parents who may feel shut out by these new digital workspaces, fearing they may have a negative impact on the parent/teacher/pupil relationship or lead to its disappearance altogether. Parents could therefore be given access to all of the IT equipment that their children use during the day.
The arrival of digital technology in our schools should not drive a wedge between certain categories of children and their parents in terms of the knowledge that is acquired.

Digital workspaces and parents
The national survey on the use of digital workspaces in middle schools carried out in 2012 (published in 2013) showed that 86% of parents had not participated in or kept up with the communication and events held in relation to the digital workspace in their children's school, and 93% said that they had never attended training regarding the digital workspace since it was opened.
http://cache.media.eduscol.education.fr/file/ENT/46/6/EVALuENT-synthese-enquete-2012-VF_241466.pdf

Recommendation 13

- Open a co-working space in schools for internal and external use.
- Streamline the associated red tape, ensure that an extra caretaker is always present when necessary outside normal school hours to supervise:
    - Educational associations, non-formal classes in science and technical studies and particularly digital literacy.
    - Those involved in digital mediation providing help to members of the public finding it difficult to master digital technology.
- Budget for the employment of a digital mediator or facilitator.

3. Introduce a new general baccalaureate in digital humanities

A new general baccalaureate

Introducing a new general baccalaureate in digital humanities is one possible solution as to how our education system can get the most from digital technology. The goal may seem a modest one, adding "one more general baccalaureate" to the existing list. However, the goal this time around would be for this baccalaureate to be used as a testing ground and a catalyst for change. At the same time, it would have symbolic value.

The idea would be to create a baccalaureate for "creative individuals in the digital age". It would be the most general baccalaureate of all, positioned at the intersection of science, arts and social sciences, and would break down the barriers between them. Its goal would be to take a more modern approach to the wealth of humanities subjects by focusing on digital sciences and technology.

This degree would include all of the traditional subjects, such as maths, physics and chemistry, life and earth sciences, French, philosophy, history-geography, economics and modern languages.

With a cultural and creative bias, the degree would be accessible to both literature students, and would make up for the division at middle secondary level between literature and maths students by showing that it is possible to successfully study digital technology and sciences without necessarily being good at maths. Unexpected skills would probably come to the fore. Prejudices would fall away, particularly for girls, who from 15 on tend to turn their backs on science and technical subjects. Demotivated students who previously did not feel as if they were learning anything may also find this new degree to their liking. By training a wider variety of profiles using a less rigid format, this new degree could encourage students to take university IT courses (e.g. engineering courses) or more creative jobs (by offering better design, technical and sociological training for jobs in design, graphic design or journalism).

The digital revolution occurred on the back of a stream of disruptive technologies underpinned by inventions and progress in computing science and digital technologies. This new degree would therefore start by teaching computer programming through humanities-inspired projects. The other aspects of digital technology (computers, data, algorithms) would also be taught by placing the focus on how they interact with humanities subjects.

Over and above the scientific and technical aspects, the digital revolution calls other subjects into play, including economics, social, cultural and arts-based disciplines. They must all contribute to enhancing this new degree's content. The focus would be less on covering a dense curriculum, which is totally unrealistic, but more on achieving real goals, such as learning about the world, learning how to learn, or learning how to solve problems in an environment that has changed due to digital knowledge and techniques. Rather than asking teachers to follow a rigid teaching programme or to use specific predefined teaching methods, they would be given general targets and it would be up to them to decide how to achieve them. For example, based on a framework and curriculum, the school's teachers and groups of schools could build the project based on their skills and how they wanted to go about teaching the degree. In addition, they could decide which partners they could work with, if any, based on the local digital presence and strengths.

Without going so far as to say what the framework and curriculum would contain, there would be two main pillars:

- Cultural and creative industries, including an introduction to techniques and lessons on web design, game design, immersive learning experiences, 3D-design, the Internet of Things, techniques for fast prototyping and 3D-printing, data visualisation, etc.
- Big data industries and their related social and technical applications in healthcare, the environment, sciences, politics, business, management, R&D, etc.

The idea is therefore to *teach differently*, using project- and especially group-based methods, role reversals, digital materials (MOOCs), trial and error (a natural approach for IT subjects), and by interconnecting the different disciplines as much as possible. Far from being added on as a subject in its own right or becoming a supplement to the more traditional subjects taught, digital literacy (see previous section) would be taught as a cross-disciplinary subject.

The general humanities baccalaureate would also focus on entrepreneurship, design, social innovation, solidarity based economics, Do-it-Yourself, and empowerment.

Lastly, it would promote a certain number of key values, including:

1. Working together and getting involved through bold, tangible projects.
2. Discovering the world, for example, through partnerships with companies or nonprofit organisations to encourage a creative, innovative approach.

Creating such an ambitious degree would call upon everyone's enthusiasm and hard work, particularly IT teachers (see section 1), humanities teachers and "teaching innovators". It should make it possible to contribute to the future pool of designers, managers and craftspeople who will bring about change and encourage innovation.

Another chance for non-mathemeticians

For this new baccalaureate, we felt the humanities was an important choice as all too often digital technology is associated with scientists and the study of scientific subjects. Every type of student should have access to digital technology. Furthermore, today's Literature baccalaureate has been completely discredited (only 16% of general Baccalaureate students take the Literature option; this number is in decline), even though it offers the type of training that our society still has as much need for. Combining humanities and digital technology studies could be a way of bringing about a much-needed revival in this baccalaureate's status. Research has shown that humanities subjects renew their ideas and their methods when they come into contact with digital technology, particularly in the areas of geography, linguistics, sociology, history, literature, etc. (see section 5). It is high time that students interested in social sciences were able to take advantage of the progress made in this area.

A call for educational freedom

While we felt it important to refer to areas where the need for digital teaching, although essential, is not the most important, we feel that in the long term the spirit of this new baccalaureate should be passed on to the other general baccalaureates and the entire national education system. We suggest (in sections 1 and 2) that every single pupil should be taught about digital technology. The introduction of the Humanities baccalaureate should be used as a sounding board and a catalyst for all kinds of IT courses. It would enable teachers from various subject areas to share their experience and ideas that could be used to change and renew their teaching methods.

The Humanities baccalaureate would be positioned in the education system as follows:

1. Upstream: by grasping a better understanding of the knowledge and skills required to study this degree, teaching methods could be changed in primary, middle and high.
2. Other general baccalaureates: it is hard to imagine introducing this kind of teaching in Humanities without science students and possibly economics and social science students asking to receive the same sort of teaching almost immediately.
3. Downstream: the Digital Humanities baccalaureate could encourage "digital humanities" departments in universities and engineering colleges to carry out more research[21] in both areas, breathing new life into entire sectors of the economy (publishing, press, luxury goods, tourism, etc.). Students with this type of baccalaureate may reasonably decide to move into other areas. Their IT knowledge would be a major plus. Lastly, the Digital Humanities baccalaureate would help further bridge the gap between schools and universities by creating a connection between them.

Conclusion

[21] See, for example, http://pireh.univ-paris1.fr/DHfrancophone/index.php

Today's companies are looking for graduates that the current system does not know how to produce. Post-baccalaureate courses are being created in an attempt to meet these expectations:

- Growing number of business & engineering courses.
- Growing number of multidisciplinary courses in public (*Paris-Est D* School at *Ecole des Ponts*) and private (Web School Factory) schools.
- An increasing number of international courses to promote greater mental agility.
- More schools are creating their own incubators.
- Growing popularity of more versatile courses (e.g. Sciences Po).
- Emergence of recruitment methods based on soft skills (see France Business School) and no longer on academic ability alone.
- Increase in students enrolling for more than one course to obtain a more varied profile.

Today, we must address the issue of how to make digital technology teaching part of the school curriculum to meet the business world's expectations and prepare students to be creative after school and beyond.

The Digital Humanities baccalaureate would also help to renew ties between the education system and students by giving them hope, helping them prepare their future and gathering their support for a highly symbolic baccalaureate that meets the demands of the business world and digital society.

Its introduction would provide evidence of the French school system's ability to make important changes to adapt to the country's economic, cultural and societal needs, and that the changes would be in line with the values promoted by the digital society, i.e. working together, taking part, being open to the outside world, and having a flexible attitude.

Given its symbolic value for children and parents alike, we must make this baccalaureate something that everyone wants to study, a course for creative individuals in the digital age, a centre of excellence focused on innovation, and a different baccalaureate that appeals to pupils that are not necessarily suited to the other baccalaureates.

Introducing a baccalaureate of this type is perhaps not quite as essential as other reforms to the education system. Nevertheless, we feel that as a symbol, catalyst and sounding board, the Digital Humanities baccalaureate would help considerably in bringing our education system into the digital age.

Recommendation 14: Implement a pilot phase for the Digital Humanities baccalaureate as quickly as possible, decide whether or not it should be rolled out based on a transparent public assessment

We feel a quick pilot phase would be better than several years of thought and discussions about how the course should be introduced and what methods should be used. It could be tested in a couple of high schools on a voluntary basis by the teaching staff.

But how could this be done without jeopardising something as important as the baccalaureate exam? Rather than answer this question that the professionals are clearly more capable of answering, we can propose several solutions:

- Quickly introduce the new course in *troisième* via a double baccalaureate (literature or economics and social sciences plus digital humanities, depending on the profile of the pupils in *première* (17-18 years old)), then roll it out to *première*
- To support this double baccalaureate with different teaching methods, greater weighting should be given to project-based work in the marking scheme (by rolling the positive example of supervised individual work to *première*)
- Negotiate agreements in advance with certain preparatory schools, secondary schools and universities to have them consider the digital humanities baccalaureate as a genuine route to entry

The pilot phase must be carried out on a continuous assessment basis, the results of which should be made public as quickly as possible to improve the system and take a transparent decision as to whether it should be rolled out or not. Although this assessment would be carried out by the General Education Inspectorate, we believe that teachers, students and the higher education establishments that will teach these students once they have obtained their digital humanities baccalaureate should also be given a decisive say.

Recommendation 15: remote pilot phase for the Digital Humanities baccalaureate

A remote pilot phase for the Digital Humanities baccalaureate could be carried out with the support of the CNED as well as companies specialised in distance, group-based learning. This would leave the door open to a versatile range of teaching approaches and would make it possible to focus on certain categories of students, some of whom could particularly benefit from this new degree.

In the longer run, it would make sense for all pupils to be able to register to study remotely for the digital humanities course in addition to the other subjects chosen and therefore obtain a double baccalaureate. This would serve as a test of the newly overhauled teaching methods used to deliver a nationally recognised baccalaureate.

Recommendation 16: garner support from clusters and nonprofit organisations

The digital humanities baccalaureate would represent an additional step towards an "open education": middle schools would find it difficult to develop this new course without the help of external partners. One way of going about this would be for several middle schools to form a network and decide quickly what their degree would consist of, using the support of clusters and nonprofit organisations (e.g. IT education, robotics, game design, etc.) to find professional teachers, keep in line with training centres and the job market requirements, gain access to the necessary hardware and software, and teach more about the various IT jobs available and IT companies that exist.

Part 2:

Overhauling the educational fabric

4 – Introduce networked schools

Forming a new educational partnership

Education has always benefitted from outside influences. The terms "instruction" and "education" refer to two different aspects. "Instruction" focuses on passing on knowledge of a particular kind in a formal manner, while education refers to manners, interpersonal skills, etc., which are normally taught at home. The distinction is quite a soft one, as community life, non-formal education, the media, and life experiences are as much about instruction as education. And education only partially covers the manner in which knowledge of society and methods, ways of thinking, and the thirst for learning and content all interconnect. The line between formal (i.e. explicit school-based lessons) and non-formal education (implicit school- and non-school based learning) is increasingly blurred. Students receive information on their smartphones throughout the day, and even during class time, in addition to what they learn in class and what is contained in their textbooks. Teachers and parents have noticed that this has a detrimental affect on concentration levels and behaviour. But these resources can be used by pupils keen to learn things on their own, satiating their intellectual curiosity while adopting a responsible attitude. It is often the case that pupils check their smartphones during a lesson to check, add to or contradict what the teacher has just said, almost as though it were a condition for them paying attention in class.

Given that our schools are wide open to Internet and its unequal distribution of wellbeing, social advantages play an important role in determining how information sources are sorted and how much discretion students use in deciding whether or not they should trust what an Internet page tells them. Although Internet can have a positive influence in that it encourages open-mindedness and brings variety, it also brings with it new risks of inequality. It also means that the death knell has sounded for the position of our schools as the undisputed fount of all knowledge. The robustness of our education system will depend on the ability of teachers to be guiding lights and to help pupils navigate their way through material that is outside of the school curriculum, standard school subjects and the scope of exams.

Learning outside of school is also fundamental for our pupils' future. Non-school learning will help boost their ability to work as part of a group, and encourage them to share and be creative. It will also help prepare them for dealing with their social life in the future in all its complexity, to cope with the demands it will make of them and the insecurity that they may feel on occasion. Pupils learn on their own on Internet via tutorials, by watching programmes in their original language version, via Wikipedia, or by playing educational games such as Code War[22] or major experiments

[22] Code War is a programming challenge (a student hackathon) between students who have only eight hours to analyse a problem, create a solution and test it. Some 35 US universities took part in 2014: www.windward.net/code-war

in sciences that serve society, such as GalaxyZoo[23] or Fold It[24]. Schools must do more to encourage pupils to "learn how to learn" and "learn how to create", both vital for the future. Digital numeracy means that teaching methods focus more on ensuring that pupils work in groups and learn how to share the workload. This is not enough: our schools and our educational establishment must also enter the digital age where network technologies are steering us towards a more group-based, interconnected meeting of minds.

Classroom teaching is open to the outside world and pupils are used to their teachers asking them what they may have learned from everyday experiences and observing the outside world. Schools are in step with what is going on outside their gates. Orientation classes, intergenerational socialising, teachers' social networks, cooperative teaching and changes in teaching sequences are all signs of openness. In their quest to deal with the digital transition and educational crisis, educational teams will have to depend even more on support (digital and in the field) from their local educational associations, businesses, other establishments and educational organisations. One of the main reasons for this is because digital education is organised around students and their everyday uses of digital technology that can substantially change their approach to learning by providing them with multiple information sources. We must adapt our educational approach to keep up with this digital revolution.

Our educational crisis calls for a broad-based system that looks after everyone. Our schools are looking for a new partnership to introduce the regulations, contributions and improvements that will help give them a new lease of life and help society prepare for the future. They face three basic challenges: cooperation, i.e. offering the new type of support required by pupils and teachers; governance, forging stronger ties with local authorities, parents' associations and student groups; and technological, i.e. being able to offer a range of services and functionality that can inspire users and ensure that French culture continues to be spread in the increasingly globalised digital universe.

Cooperation: open classes

A proliferation of educational methods forges a continuous link between school and real life. These methods have proven their effectiveness in dealing with school dropouts and demotivated students, a key area. Working closely with educational associations can revive the fight against educational inequalities, even within school itself. Teaching teams can look at taking a different approach that will no longer be focused on classroom teaching.

[23] GalaxyZoo (www.galaxyzoo.org) is a collection of Citizen Science Projects that invites site users to work with astronomers to classify undiscovered stars and galaxies. A huge database of galaxy images has been made available. Fifty million classifications have been made in one year by 150,000 volunteers. This cooperative approach (crowdsourcing) offers a new way of learning and contributing to research.
[24] Fold It is a biology computer game used to contribute to biology research. Subjects include protein folding, a subject that computers have tackled unsuccessfully. The site currently asks visitors to design an Ebola glycoprotein peptide inhibitor.

Demotivated students

Demotivated students send out a warning signal. They are a sign that a shake-up is needed in the way we approach teaching. We need to look at new ways of getting students involved, of creating networked fablabs that can be a source of energy for our schools, providing a showcase for students to show teachers how much effort they can put into projects when they are allowed to run them themselves. In January 2014, the Education Minister published a report outlining how to tackle absenteeism and school dropouts. The report calls for "innovation and experimentation" to limit the feeling dropouts have of being "hemmed in". School dropouts and demotivated students can be passive and silent, which can be psychologically harmful, can damage self-confidence and pupils' confidence in the future. Most pupils are bored in secondary school. The French education system has reacted badly to a student failure rate of 20%. It has no prevention policy in place. Some educational associations have tried to revive pupils' interest by introducing them to digital technology, teaching them to create their own websites, publish their own texts, develop their own businesses; but also to pass on their IT knowledge to others, learn more about creative jobs, experience success and discover how to do things under their own steam. Using digital technology in the fight to stop students from becoming demotivated has produced some extraordinary success stories. Students can become demotivated if they are on a different wavelength from what is going on at school. But there demotivation can also be used as a catalyst for change. Based on the numerous measures taken (mentioned previously), we are convinced that if we encourage students to set themselves ambitious targets and we give them the freedom and the means to reach them, they will be highly motivated to do so.

Ecole 42: Peer-to-peer teaching

Ecole 42 was launched in 2013 to offer IT training to students with no diploma attached. Fifty thousand students have signed up since its launch. It comprises logic tests conducted via Internet and a one-month session known as "The Deep End", during which some 500 candidates solve programming problems on a daily basis without the help of their teacher. They ask their neighbours questions, look for the solution everywhere and watch web tutorials. This autonomous approach is made possible thanks to a high-performance digital environment. Data is recorded for all of the activities, performances, time spent on jobs, number and quality of strategies and analysed by an algorithm, from whic a profile for each student is created at the end of the month. Seven hundred students graduate after spending three summers in "The Deep End". The most surprising thing about these summer schools is how much the students enjoy working for nights on end, seeing it as an escape from school or university[25].

[25] Ecole 42 , "a peer-to-peer school" , www.42.fr

Simplon.co: Programming and empowerment

Simplon.co holds nine-month courses for members of the public that have little knowledge of digital technology. It also targets women, senior citizens, disabled people and young people from a diverse range of backgrounds. The thinking behind Simplon.co is that those living in problem neighbourhoods are extremely keen to follow a training course that can help them get ahead quickly by working as part of a group, creating their own project based on their neighbourhood's daily needs, learning to develop their own website based on useful functionality or learning how to use connected objects. These training courses to promote creativity and encourage students to adopt a proactive approach have grown in popularity in the last few months and a version of the course is now available online[26].

Transapi: Secondary schoolchildren studying in "school cafes"

To enable secondary school pupils to organise their own school timetables and leisure time, Transapi makes co-working spaces available to them where they can work in groups or socialise outside school hours. They can have a tea or coffee, meet their friends, sign up for a statistics or French workshop, revise together, participate in a maths/music workshop or meet a teacher[27].

Biarne, the networked fablab, bridging the gap between secondary schools and clusters

The Biarne fablab has formed partnerships with two high schools located in Dole (to work on student projects), the Bois-à-Moirans-en-Montagne secondary school (knowledge and equipment sharing), Besançon University, three clusters (working on the vehicle of the future, micro-technology and Plastipolis), two companies located in Dole (preprototypes at the Net-IKi fablab), and nonprofit organisations located in Franche-Comté region (engineers from ENSEMM, UTBM, etc.).

A network of fablabs in the Jura region is currently taking shape: "We must look to the future. We all have skills that we should share and pool. We should work together with digital technology and innovate. In rural areas just like elsewhere, it is us up to us to get things moving, to create, imagine and get everyone on board to genrate wealth, value and jobs. We should create jobs in the biggest fablabs, but we should create and innovate to generate long-term, local jobs"[28].

[26] Learning together via Simplon Distance Learning: http://simplon.co/foad/
[27] Transapi.fr gateways
[28] Minot Lab, Franche-Comté FabLab: http://www.net-village.org/fablab/?page_id=41

Smart Kids and the Pierre et Marie Curie School:
Open street map and *Babytwit* to find out more about your neighbourhood

In a neighbourhod undergoing significant change, Céline Souleille, a school teacher at the Pierre et Marie Curie de Floirac school located in the Gironde *département*, felt that it was time to help pupils play a proactive role in the life of their region. She decided to get pupils working on a mapping project that would enable them to build a map of the place where they live to show the constant changes taking place, and to use digital technology as a new method for sharing knowledge. During the mapping group meetings set up by the Smart Kids organisation, the pupils identified locations on the map that had to be changed (e.g. new streets or shops, buildings that had been knocked down, etc.). Back in the classroom, they entered their findings on the OpenStreetMap database, thus taking part in the global project underway[29]. Pupils learned about the formal requirements of contributors as the project progressed: publishing, responsibility and sharing. They also forged their own idea as to what can be achieved via Internet, how it can contribute to culture, and how knowledge is a common good that can be created together and shared. Several months later, the map was used to create a multimedia map used to support a poetry-based guided tour around the school. A joint writing project between *CM1* (9-10 years old) pupils and first year students at the Nelson Mandela middle school was put online on the *Babytwit* website. The end result is available in the form of an open map created using Umap[30.] When the pupils realised that other contributors were interested in their neighbourhood, the image they had of their own region changed and they suddenly became interested in the towers, squares and shopping centres surrounding them.

These examples are proof of the key role played by new organisations seeking to bridge the gap between schools and local authorities. They encourage pupils to play an active role in their own education by forming a link between personal and school projects and by giving them the power to act. Teachers of relay classes mentioned previously have said the same is true of the classes they run.

Partnerships between universities, national education authorities, local authorities and the Canopé network, such as the "OPPidum" project, which is backed by the *Association des maires de France* (AMF), are being set up in several towns. This entails local authorities signing agreements to carry out pilot studies before deciding whether or not to roll them out to a wider population. Class network projects in conjunction with local nonprofit organisations (e.g. in IT) often provide much-needed resources to these organisations while motivating pupils and making them responsible for how their end product is used by real users.

[29] Description of OpenStreetMap sessions: http://www.calestampar.org/spip.php?article1208
[30] http://umap.openstreetmap.fr/fr/map/les-haikus_6728#16/44.8366/-0.5228

Recommendation 17: encourage teachers and educators to work together to avoid pupils dropping out

- Join forces with nonprofit organisations to encourage demotivated pupils to return to school, help them discover new digital skills and jobs, and raise the profile of skills acquired outside school. Organise combined workshops together.
- Experiment with new timescales and formats, such as fablabs or hackathons, and set creative group challenges with a deadline that will encourage pupils to work together to create something of real value.

Loosen teachers' reins

Teachers are seen as playing a key role in the digital changeover. But their role is in jeopardy due to the difficulties they face in the classroom. Furthermore, classroom teaching cannot change if schools themselves do not undergo fundamental change.

Using tablet computers in the classroom or having courses available online will not change the school environment. They will become part of an already complex scenario; what purpose will they really serve if the underlying environment remains the same? The only question worth asking is how can they make life easier for pupils?

Teaching has become a lonely and difficult profession. It is not as appealing as it used to be, and most people are aware of the difficulties faced. The number of candidates for recruitment has dwindled. The 50 minutes it takes to give a class can be exhausting, with teachers having to constantly reprimand pupils or liven them up. And regardless of the many innovative approaches taken by a great number of teachers to introduce digital technology into the classroom, this will not be enough. Schools are changing due to the influence of digital technology. And as part of a connected social network, they are changing independently of existing techniques. The teaching profession must oversee its own transformation to ensure its survival.
Change management in schools must be driven at ground level.

Teaching in the future

The *Canopé* workshops (100 in the next few years) have introduced the concept of co-design into the teaching profession: teaching events are held outside school, classes are prepared jointly, and digital courses co-produced locally are developed by teams of teachers of different subjects from various schools. The networks joining several local schools together are not designed for training but rather have been created with the aim of encouraging teachers to form a network to create their own classes. Head teachers play a key role in these networks. But any change must be managed in a non-hierarchical manner. These networks can play a key role in passing on the digital revolution message in schools: working as part of a network, teachers can devote more time to encouraging pupils to make their own choices and increase their autonomy as they learn.

Teacher training colleges (ESPE) should play a key role in creating these teacher networks, encouraging teachers to create their own training courses based on a forward-looking approach into what their professional needs will be, at least in the short term. Teacher training colleges should form R&D networks for teachers in conjunction with other R&D bodies and economic players. A logical approach would be to introduce a 100% digital teacher training course created by a mixed group of teachers, head teachers, supervisors and representatives from the private sector, clusters, non-formal education bodies, social entrepreneurs and designers. Following the example of the *27e Région*[31] (27th Region), which presented co-designed equipment projects to regional representatives, a 100% digital teacher training course could make co-design possible for the teaching profession by becoming the teachers' "Think-and-Do Tank". In the short run, it could offer interesting and useful training courses. The aim would be to create a pilot teacher training course based on social networks and contributions. The teaching clips databank (*BSD - Banque de Séquences Didactiques*) produced by the *Canopé*[32] workshops provides a starting point. The BSD website provides access to videos filmed in the classroom focusing on group work. The comments made in these videos by teachers and assistants plant the seeds for a genuine debate to be held. Based on the experience recorded in these videos, it is clear that distance training combined with local clubs can help teachers and support the changes the profession is going through as a result of the growing influence of digital technology.

When introducing digital technology into the classroom, we must put a stop to the supply-based approach which has failed. We must not force digital technology upon our teachers and pupils, and must take steps to involve teachers in designing any future IT training for both themselves and their pupils.

Recommendation 18: involve teaching teams in shaping their profession through the creation of a digital teacher training college, a "do-tank" for the whole profession

- Provide schools with the tools they need to assess their teaching activities, decide how digital technology could help them perform difficult tasks (correcting homework, following up individual pupils) and make improvements.
- Ensure teachers are better trained to organise project work for pupils, and that they are able to publish the results and show how much value has been added. Encourage projects with external third parties (businesses, nonprofit organisations, academics/researchers).
- Give teachers the power to shape their own profession and involve them to a large extent in the design of training programmes through "pathways to the future" initiatives.

Governance: schools forging their own local identity

The role of government and local authorities

France's education system is supported at one end of the spectrum by government in the shape of an almost monarch-like education minister who outlines policy. At the other end, teachers adhere

[31] The *27e Région*, a public policy "Do-Tank": http://blog.la27eregion.fr/-A-propos-
[32] Teaching clips databank: videos of classes reviewed by the teacher themselves with other participants to focus on teaching methods: http://www.reseau-canope.fr/

to this policy with a certain amount of freedom to diverge from it. In between, schools are supposed to be more or less identical regardless of their location, upholding the key French principle of equality. In reality, the situation is slightly less clear-cut. Many schools have forged their own local identity. To attract the best pupils and motivate them, schools have created departments that teach European studies, rare languages, music, drama and arts subjects. Timetables are adapted to suit pupils. This could be taken one step further and schools could be encouraged to open specific departments and offer subjects that teach pupils about their local area or region. This could help to do away with the negative image of many schools.

The government and local authorities (local council, *département*, regional council) jointly oversee our schools. The responsibility for supplying these schools with IT equipment lies with local/regional authorities. They should therefore play a key role in outlining and managing digital education policies.

To make the successful switch to digital technologies, schools must be given a more important role to play overall and when working with local and regional authorities. The government draws up digital policies and then turns to local/regional authorities to fund and implement them. By working at class level, the government underestimates the school's internal workings. The problem goes beyond mere details. For example, a school may be equipped with tablet computers, but have no wifi connection and is therefore unable to use them.
Digital teaching at class level obviously depends on the school's digital policy. IT for administrative purposes cannot be separated from IT for teaching purposes. Having a comprehensive IT system for the entire school based on user experience should therefore be looked at closely.

Recommendation 19: boost local powers to improve school governance

- Recognise schools as individual educational establishments.
- Involve local authorities in digital projects from start to finish.
- Improve upstream cooperation between the government and local and regional authorities.

Recommendation 20: communicate at local level

- Overhaul IT environments to improve school governance and relationships with third parties. The system can also be used to improve internal mobility procedures.
- Use the digital environment and social networks for: (i) teacher's teaching projects; (ii) re-establishing ties between government and teaching teams; and (iii) strengthening ties between schools and local authorities.

The role of parents in the education continuum

Digital society has contributed to the diminishing role of the authorities. School no longer has the same authority it once had. Parents do not always agree with the methods used in school and often voice their concerns. They are keen to discuss the approach taken to teaching and assessment with

their children's teachers on an equal footing. They are interested not only in their own child's schooling but in the global approach taken to education. All parents act as mentors to their children at home. When problems arise, i.e. their children are demotivated or doing badly, they are obviously disappointed. Something must be done to revive children's interest in their schooling.

New communication methods between parents and teachers can be used to forge ties and ensure ongoing education outside normal school hours. However, they may also exclude some parents, or lead to a deterioration in or the disappearance of the parent/teacher/pupil relationship.

Traditionally, parents played a role in school life through the Parent Teacher Association (PTA). Digital technology means that the role they now play is altogether different. Some share their experiences of digital teaching on blogs or websites, such as "Parents 3.0". This is a source of inspiration and encouragement for the entire teaching establishment. There is now a digital (via email or social network) and a physical link to keep parents informed. Thanks to the use of social media, homework can now be done on a group basis. The relationship between teachers and pupils, parents and pupils, and between local authorities, parents and pupils has also changed as a result. There is now more scope for providing individual pupils with support or coaching for groups of pupils experiencing difficulties in class.

But parents also behave as though they were consumers comparing the different offers available, using Internet for resources. With schools ill-equipped to deal with pupils who have dysphasia, dyspraxia or dyslexia, exercises and methods are available on Internet, which again diminishes the credibility of schools in this area. We may well now see digital schools catering to these particular niches springing up. Parents are looking for answers to these questions and seeking to renew ties in this area. Our educational system must decide where it stands.

Parents play an active role in their children's education, digital included. The social network created by parents provides a pathway to the world of work, business, nonprofit organisations and opens many doors for schools supported and held in high esteem by the general public. Parents expect to be more closely involved in school life, the discussions held, and the actual measures implemented.

More than 400 "tweet-classes" enable parents to communicate on a daily basis with their children during school activities. These classes use Twitter, Pinterest, Tumblr or Google Drive to work remotely with experts in a particular field and learn about digital technology. They can publish their work, which boosts their status while working with third parties looking after their welfare. Many teachers use digital projects as a gateway to the outside world, particularly the school's local area.

Teaching at home via Internet

Families work together on Facebook to complete homework assignments. Parents use the Khan Academy website to revise basic mathematics. Wikipedia (accounts for 30-40% of Google consultations) is the main site used by families performing a documentation search. You Tube videos are used at home for tutorial purposes. OpenClassRoom has published over 1,000 tutorials created by its young contributors. Digischool offers the entire baccalaureate revision course and provides pupils with guidelines. MyBlee provides maths exercises. And numerous mentoring websites are being developed.

Recommendation 21: get every parent involved in digital literacy

- Provide IT training courses and non-formal/Internet digital literacy courses in schools for both schoolchildren and adults. Provide everybody in the local council catchment area with support for learning outside normal school hours.
- Make school websites a gateway to school life and a forum for discussion with pupils living on housing estates.

Recommendation 22: get parents involved

- Convert the digital workspace reserved for schoolwork into a digital exchange space that places pupils at the centre.
- Invite parents and pupils to regularly describe their work and what they have learned from working at home (exercises on Internet, personal publications, etc.).

Recommendation 23: provide teachers with connected workspaces in towns

- Teachers do not have their own office in schools: by providing them with an office in town where they can work and meet other teachers, parents and pupils, the key role they play on housing estates is recognised. This would also help promote projects and knowledge sharing between schools. It could be used by the whole community to share experiences, learn more about digital teaching, discuss education and as a meeting place for parents where events could be organised.

Active governance by local authorities, teachers', parents' and pupils' associations

Digital technology offers individuals greater scope to act by, for example, joining forces together as part of a wider group. The same can be said for consumers, patients, or social pioneers who hold some sway over industrial groups or government policy makers. The French national education system is a centralised, hierarchical organisation. It is now open to change that will come from the emergence of proactive and committed groups of stakeholders. By taking part in a flatter organisation more focused on local needs, teachers, parents and elected representatives will be

more actively involved in the decision making process. The emergence of this new type of relationship between schools and their users could result in a relatively sudden change once the new uses of technology gradually filter through.

This will affect primary and secondary school children. They will also expect to play an active role in shaping their own education for which they will have to be prepared. Funds have been earmarked for secondary school pupils to this end, which several regions have allocated to secondary school councils. These councils set up projects selected by the pupils (home design, projects on selected topics, such as health, the climate or the circular economy, improvements in school democracy). The use of digital technology by primary and secondary school pupils clearly has a transformative effect on IT teaching and on school life itself. Rather than fighting against this trend, we must therefore make every effort to ensure that what pupils learn outside school can make a positive contribution to life within it.

Joint design of future secondary schools in the regions

Two regions (*Nord-Pas de Calais* and *Champagne Ardenne*), *27e Région* (digital region)[33] and two designers (Romain Thévenet and Françis Jegou) have piloted the "*Echantillonneur de lycée"* programme, a method for designing future secondary schools.

Regional investment in education is significant and requires a commitment of 10-20 years. How can we avoid reducing the future of our secondary schools to the choice of architecture to be used for the new building? And how should we deal with different stakeholder views of the approach to take? We must try to invent a method that enables our elected representatives, education services and citizens to work together to produce a truly inspiring, strong and attainable vision of the future. Creative workshops involving various stakeholders (pupils, teachers, education experts, elected representatives, directors, etc.) have come up with different scenarios which school pupils have then used as a basis to create their own visions of the future teaching process. The programme comprises a set of illustrated cards split into four categories: Visions (particular political priority allocated to the school), Ideas (inspiring proposal which helps make the vision reality), Processes (a method that contributes to changing the way a school is designed) and Examples (an actual school case that helps to illustrate or achieve a vision). The programme's role is to promote discussion between the stakeholders and help them to agree on a tangible, sustainable and attainable vision of their future school.

The role of schools as a certifying body

[33] The *27e région*, a laboratory working towards changing government regional policy http://www.blog.la27eregion.fr/L-echantillonneur-de-lycee,306

Will schools, like universities and the top *grandes écoles*, seek to bring together all of their users on public social networks? Will they try to join regional networks? Gaining the loyalty of users on public social networks is a must: the social media platform emanating from the public education service that will bring together a huge number of education groups in the widest sense as well as pupils and various other groups of stakeholders, will keep track of uses and host data. It will offer a viable alternative to the appeal of private Internet services that could be persuaded to form positive partnerships without getting left behind (see indexation and ranking strategies in the section entitled "Quelle édition pour la littératie de l'âge numérique ?").

One or more social network public education platforms[34], national and/or regional, and educational case studies will place the education system in a strong position to remain the key player in awarding diplomas and certificates. Providing certificates for informal courses raises a major question. Maintaining the authority of the public education system in educational environments that risk becoming increasingly fragmented depends on the ability of schools to find new ways of certifying the skills obtained. Schools will have to take these informal courses into account as they will be mentioned more and more frequently by pupils who will compare these courses and try to understand how they differ from one another. This would provide a useful gateway to critical thinking. With digital technology increasingly blurring the lines between school and home learning, life outside school and the use of IT technology will both enhance the learning experience. Pupils will willingly follow online maths courses, or learn basic biology with an American or Japanese online teacher. Families will have greater access to new, online educational services, which will make it easier for pupils to show what they have learned. Teachers will have access to new information about what their pupils are studying. Schools must then decide what to do with this information. Should they ignore it? That would be hard to do, as parents would see this as a specific effort that had been made to strengthen ties with the school.

In the future, schools will have to factor in the specific knowledge acquired in this way by pupils as they will no longer leave behind what they have learned outside school once they go through the gates. They will share what they have learned and put it to good use. We will quickly end up with individually-tailored study courses that will be certified on the basis of established frameworks for skills and knowledge they are expected to acquire. To what extent are today's primary and secondary schools in a position to organise informal learning of this kind on a massive scale? Our education system will probably learn how to encourage, organise and certify this type of learning over which it has no control. This obviously applies to first-time learners but also to vocational training and teacher training. Skills certification in open learning environments is also coming to the fore. It could potentially be applied to all types of training and learning scenarios. The systems that would be required to allow this type of learning to flourish do not exist and would have to be created, a significant challenge.

[34] "Public" here refers to visibility: available to the general public, these platforms create educational case scenarios and make them available to the general public; this in no way rules out the possibility of forming private partnerships with digital education industries, which are best-placed to provide these types of services.

Recommendation 24: encourage schools to switch to "open knowledge" and provide physical and digital support at regional level

- Test participative digital teaching methods in schools.
- Update certification and assessment procedures to include digital learning.
- Introduce a regional digital content policy that highlights and places importance on local knowledge to bolster regional skills and identities.

The challenge facing education: open design

The transformation that learning is undergoing in today's digital society opens the door to numerous new educational initiatives in France as long as rewarding partnerships are forged between our educational communities and educational industries.

The future of France's educational system depends heavily on the country's IT industry. A robust industry that suits its users' needs should lend its support to the specific characteristics of our education system both nationally and abroad. But if not used on a massive scale, the lack of domestic foundations will hold back our digital industry that must be tested and developed in France as close as possible to our education system; the consequences for our digital footprint in education and research are clear.

Success will require a change of tack.

Up until now, teachers have been asked to use digital resources selected for them without any prior consultation. They have rarely been asked to outline their expectations, how they would put the resources to practical use or how these resources might make their lives easier. We will not go into how public procurement markets work or their outcome here, but would simply like to state the following:

- We can no longer continue to buy hardware, then worry about content, before deciding that teachers must be trained to use the new equipment. This is a supply-based, top-down approach that is unsuitable on a number of levels and which has failed.

- Teachers are unhappy with the policy. Overall, most of them do not think that the digital solutions on offer have any real use as far as teaching is concerned and that most of them were designed with no real thought as to how they will actually be used by teachers or end users.

- This approach offers only artificial support to the economy in that it does not lead to long-term use by the vast majority. It favours dominant players who have access to the decision-making process and excludes new players who do not have access to decision-making circuits.

A different approach to use is required. As mentioned previously, digital-based teaching, i.e. using online courses, will not be enough to reach the targets set of digital literacy, changing the teaching

profession's culture, overhauling how schools are organised and adopting a more "horizontal" setup vis-à-vis regional authorities.

Steps must also be taken to deal with the arrival of disruptive digital technologies. Online courses open up this new market to schools. Adaptive learning (see the section entitled "Quelle édition pour la littératie à l'âge numérique ?") combines computers with cognitive science and opens the way to targeted uses for certain needs (reading, arithmetic, etc.). The national education department must promote their use (see section 5) to promote success and to motivate pupils in the classroom and at home when supervised by parents. This will require a partnership with researchers and industry, with the focus on the economics of data: personal data acquires value when used as well as a commercial value if used as part of big data processes and stored on platforms. What framework should be put in place to value this data? Such a framework could lead to the possible targeting of individuals to receive personalised teaching courses either as part of their school studies or in addition to them.

The digital transition in education will heavily impact future French-language resources and the spheres of cultural influence in Europe, Africa and Asia. The world currently boasts two hundred and twenty million French speakers. If these resources are not used massively on the domestic front, they will be hard to export to the rest of Europe and Africa, both demanding markets. In 2050, Africa will boast two billion inhabitants including one billion under 20 years of age and 750 million potential French speakers. They will all need teaching materials. It will be difficult to share a French view of the world (through the French approach to logic, references, teaching methods, etc.) with such strong competition from the US. Spreading the French language and culture through education requires a French-speaking market. Every global success story in digital teaching has been backed by a buoyant domestic market.

We must promote widespread use of digital technology through our cultural industries. This use can focus on educational social networks, infrastructures, software and terminals. We should be able to offer national and international audiences learning materials that reflect our culture. We should offer teachers a variety of solutions that comply with international standards and which are easily interchangeable.

How can we achieve this? We must base our approach on open design, combining users (teachers, pupils, parents, head teachers, classroom assistants, partner associations) with industry players and researchers to co-design solutions based on current or expected uses. There are around two hundred startups and innovative companies in the education sector in France. They are growing on international markets due to weak domestic demand. They are essential for maintaining the quality of our teaching and for creating a more profitable innovative education ecosystem in France. Actual experience in schools will bring about an improvement in services and products, will help to measure their performance, and will lead to the withdrawal of what does not work as well as the use of the best ideas and technologies. Local activity across the entire country would enable startups to grow first in France before achieving rapid growth abroad on foreign markets to strengthen their international profile. Such an approach will help to create a national industry in a sector dominated by US learning models (Moocs, Google, etc.).

Recommendation 25: creating living labs (Educalabs) to bring schools, users, industry players, local authorities and researchers together

- Share research experience and results (cognitive sciences, digital education, digital humanities, etc.); share practical case studies, draw up specifications jointly.
- Create prototypes, run tests, create new uses; design services that have a real rather than theoretical connection with actual practice and that users are looking for.

Recommendation 26: guarantee a French-language market open to innovation

- Use the public procurement market to organise the French and French-language market around goals focused on teaching, culture, industry and modernising education.
- Co-design French-language offers that meet local needs and user requirements to support the French language with the support of the relevant organisations (AUF, OIF, etc.) and the involvement of relevant educational groups.
- Guarantee new and innovative niche players access to the education market
- Create a framework for standards and open source interoperability.
- Innovate technically to create new uses: enhance self-training and certification options through platforms offering skill portfolios

Conclusion

By calling for an open education system, an open classroom, open governance and open design, we have attempted to reflect the current reality of open education and open knowledge. Opening up the education system is the best way of preparing for overhauling the teaching profession that will reshape our educational communities.

Independently of the decisions taken by the national education department, and faced with the indifference of the majority of teachers, the education system's makeover has begun, triggered from the outside by the digital economy. Taking the digital society's characteristics as a starting point, the Edtech movement is gradually providing the key pieces required for education in the digital society: communities of learning to which individuals can contribute, individual learning programmes and tutoring, platforms containing learning materials, etc.

Our system was founded on equal opportunity for all. It is currently one of the highest ranking among OECD countries in terms of inequality. The number of pupils experiencing problems has increased in the last ten years. One pupil in five lacks the opportunity to continue in school beyond the statutory age. Equality is far from being a reality. On average, and based on results, girls clearly outperform boys. But this does not carry through to their choice of career, with too few females present in scientific or technical fields despite their success at school. The OECD's PIAAC survey, which measures adults' literacy and numeracy skills (arithmetical and mathematical skills that enable a person to function in society), ranks France among the lowest OECD countries. The more educated the population, the more able it is to become involved in community life, take part in

politics and have confidence in their abilities. This democratic promise raises questions as to our schools' ability to promote social inclusion. As we mentioned in our previous report about e-inclusion, we must now combine social inclusion with digital literacy at local and regional level. The goal being strived for through an open digital education is to guarantee the future of an innovative, efficient and accessible public education system.

5 - Linking research and education

Imagining the changes in teaching in primary and secondary education in connection with digital technology is impossible without also considering the profound shift that this technology will require in the areas of research and higher education as well. This is principally because primary and secondary school teachers are trained in these very universities. Moreover, the world of research is the venue where conditions for knowledge-building are studied – conditions which have been thoroughly upended. We would like to focus our attention and our proposed actions on this point. It is high time to build strong ties between research and basic education, to test new teaching methods, to bring about tangible changes that are justified by scientific studies and to disseminate them within schools.

Knowledge reshaped by and with digital technology

Over and beyond changes in teacher-student relations, digital technology is reshaping the very nature of knowledge taught at every level of the educational system, and will continue to do so in the years to come. This is similar to the way it is changing practices in the laboratory and the way research is conducted in every discipline.

Digital technology is not simply a resource for scholars and students. Rather, it is *the new memory environment for every form of knowledge*, an environment in which both teachers and taught must learn (and relearn) how to think and operate. The digital changes that have taken place since the introduction of the Web are profoundly affecting ways of working and being as much as theoretical and formal knowledge.

Such sweeping changes are the result of how digital technology is reshaping various codes (of language, writing, sign systems and all manner of systems for recording and saving information) and the reflections for which they provide a platform. This is similar to how the emergence of writing provided a new era for languages, and how languages are environments of thought.

Knowledge – whether in the form of life skills or theoretical and academic knowledge – is primarily that which is handed down from generation to generation; it is collective memory. This presupposes vehicles for preserving and transmitting such knowledge. We have known for more than a century that these are not simply means of transmission, media for recording knowledge play a role in changing this knowledge; *they are knowledge itself*. When the *conditions for establishing* knowledge are transformed, which is very much the case with digital technology, *knowledge itself is transformed*. Linguistic technologies profoundly alter relationships to language and associated linguistic knowledge. The same is true for human geography, which has been transformed by “digital landscapes” – and every environment in which the inhabitants possess digital equipment are digital landscapes. And so on.

A fundamentally cross-disciplinary issue

The boundaries of disciplines are being redrawn. Methods for gathering academic data no longer pertain to a specific discipline; research methods are employed on unprecedented scales both quantitatively and qualitatively speaking, and not just by researchers, which involves sweeping changes to our critical capacity.

Regardless of the ways in which these changes affect ways of teaching, research and higher-level education must immediately co-opt these issues and transform themselves in the process. The necessary digital studies require a new epistemology, cross-disciplinarity and a wide-ranging scientific discussion at international level. As part of this, cross-disciplinarity should not be seen as a barrier, but rather as a springboard for researchers' careers.

New grammatical systems for exploring Big Data

The Venice Time Machine is a cross-disciplinary project, in which the digitised archives of the city of Venice, dating back to the fifteenth century, provide a focal point for history, sociology, linguistics, demographics, urban studies and machine learning. It was conceived in 2013 in partnership with the Ecole polytechnique fédérale de Lausanne (EPFL), Ca' Foscari University and Telecom Italia. Venice Time Machine embodies a new type of constructivist research that allows users to go back and forth over time and space. According to Frédéric Kaplan, holder of the Digital Humanities chair at the EPFL, the Venice state archives consist of 80 kilometres of documents stretching back over twelve centuries. Using the Time Machine, users can analyse how the city has changed over several centuries, or examine the market for sheet music in the late fifteenth century.

The programme's first research topic is the interconnection and redefinition of the various disciplines, together with decisions on the best ways to use multi-faceted Big Data. It has already been observed that the concept of "the past" is called into question by present-day access to data that are not from the archives. The idea is to tease out structures – grammatical systems that will lend order to the movement of researchers in these new cross-disciplinary zones.

An epistemic and epistemological revolution

As it transforms knowledge itself, digital technology is bringing about an epistemic shift and a series of epistemological revolutions[35] of varying degrees. They are such that it has become commonplace to refer not only to the digital generation and lasting changes to the human brain (see, for example, Maryanne Wolf or Katherine Hayles), but also to an anthropological break. This is

[35] We use the term epistemic (*épistème*) in the sense of the French philosopher Michel Foucault, i.e. that which defines and unites all of a particular era's knowledge. We use epistemology not to refer to a general theory of knowledge, but as one that theorises about knowledge on a discipline by discipline basis.

why pedagogic and didactic issues presuppose a new epistemological approach that is on a par with what is at stake, and sustained by research and higher education policies that explicitly call for such an approach.

The speed of the changes being wrought, the ground-breaking nature of the questions being asked and the essential nature of the economic, political, social and cultural stakes demand outstanding cooperative efforts between the worlds of research, primary, secondary and tertiary education and the publishing sector.

For this reason, the ongoing acculturation of the primary and secondary teaching environments when faced with constantly-changing technology calls for a restructuring of research and higher education so that:

- Graduate schools can theorise about the epistemological changes underway and spell them out
- IT training for researchers can be made available in every masters-level programme, and involve cooperation with digital industries, which in turn can use educational and research applications as areas for testing and technological development
- Initial training for primary and secondary school teachers can incorporate these new elements and issues concerning knowledge amassed in the new digital memory environment
- Ongoing training for these teachers can also include this work, via a contributory approach, i.e. using a research method that encompasses the principles of action research, and the opportunities that contributory technologies and methodologies can open for such research
- These efforts lead to research and inventions, as well as to scientific, educational and pedagogic publishing innovations arising from the research and teaching communities themselves. This would replace adapting to purely commercial solutions (which does not mean that this work should not lead to new commercial solutions that draw on them – quite the contrary).

Immediate action research methods

Clearly, the epistemic and epistemological issues engendered by the advent of the digital era affect the training of primary and secondary school teachers as well as the priorities of scientific research programmes and how higher education is organised. As a result, questions concerning training with respect to the epistemological and educational issues surrounding the digital world should be raised and dealt with on three levels:

- Scientific training
- Disciplinary – and specifically cross-disciplinary training
- Pedagogic training

Digital cannot *reasonably* (that is to say *rationally*) be integrated into schools unless it has been introduced at all three of these levels.

And yet, such a condition (starting with initial discipline-specific training reshaped by digital technology and including the results into teacher training) is *literally impossible*: it presupposes, taking a reasonable, rational approach, that an entire generation will undergo a full training programme and integrate it based on criteria of rationality that are themselves the result of long-term research efforts and a peer review process.

This is why we must approach the issue of knowledge in the era of digital recording as it stands in 2014 as the dawning of a specific, *transitional* moment in which the public authorities and academic community need to agree on specific measures that are in line with what is at stake. Given that digital technology has been widely appropriated by all without having been theorised *stricto sensu* by anyone (with the exception of partial viewpoints in the fields of applied mathematics, theoretical IT, information theory and sociology), we must *revive action research methods* (research with a twofold objective – transforming reality and generating knowledge about such transformations). This should be done by redefining these methods based on the contributory potential of the digital technologies themselves.

Such an approach will allow us to *simultaneously work in two temporal zones* – the need to amass rational digital knowledge in every discipline by taking the time to conduct research and establish theories does not mean that we cannot act at the primary, secondary and tertiary educational levels. Nevertheless, acting without critical academic input and theoretical comparisons could be disastrous. Many mistakes have been made in this domain – mistakes that, incidentally, have not been systematically analysed and assessed – including the introduction of materials without proper debate about their educational merit, etc.

Recommendation 27: introduce cross-disciplinary action research programmes

- Researchers in the areas of epistemology, philosophy, anthropology, neuroscience, the cognitive sciences, educational science, information theory, etc.
- Instructors and students in teacher training institutions
- Associations devoted to non-formal education, the regions, etc.

Getting teacher training institutions on board is vital, so that a certain number of teachers and graduating classes become involved, and so that the results of their involvement can be ploughed back into theoretical and rational research efforts. It will confirm the link between secondary education and research and add value to the career path of teachers involved in research efforts, particularly in the area of digital teaching.

A contributory research programme based around epistemological breaks

Action research is not intended to stand in for basic research – quite the contrary.

The 2015 Action Plan and General Call for Projects by the National Research Agency (NAR) is a vital resource for implementing a wide-ranging research programme around these epistemological breaks. It specifically lists ITCs in its list of nine major social challenges, with a chapter devoted to "digital technology for training and education", and another to "digital technologies for intellectual and knowledge purposes", and makes reference to both intra- and inter-disciplinary epistemological research.

Several calls for projects (the Invest for the Future Programme, FUI and European funding programmes, among others) are open to financing research in the area of digital education and to partnerships between research teams and schools, startups, businesses and local authorities.

However, we need to go further by setting up a permanent contributory research programme that includes large numbers of PhD students from every discipline, with an eye to practicing and theorising about the digital world in their respective domains. Such a programme can and should result in field work and well thought-out, supervised experiments at every level in the educational system.

In the medium term, we recommend that 500 doctoral theses be financed each year in France across all disciplines with the goal of reshaping every research area within the context of the new digital memory environment[36]. As a thesis takes three years to complete, such a programme would cost in the neighbourhood of fifty million euros annually, a small amount in comparison to the thirteen billion euros that will be invested in the coming years in broadband networks.

These theses would:

- Provide additional material for the action research proposal set out above

[36] Note that some 11,000 theses are defended each year in France.

- Add to online higher education resources
- Enrich a digital academic and scientific publishing policy (see following point)

To encourage the growth of French and European research within university laboratories, major research organisations and in industrial and publishing R&D, the issue of access to research data, articles, archives, investigatory materials and calculations (standards for existing software, interoperability, open access) is critical. The goal of what we propose introducing in systematic fashion, taking a contributory research approach – which also includes setting up open access publishing platforms – is to create conditions such that predatory practices (which are always extremely present at moments of sweeping technological practices) do not produce the reverse of the desired effect. This has been observed particularly in the UK with respect to open data.

Recommendation 28: develop contributory research in digital studies

- Finance 500 doctoral theses per year in every discipline, with support from thesis grants, that focus on digitally-related epistemological breaks
- Support for laboratories' commitments to digital studies from French and European research assessment agencies
- Spotlight degree institutions that create cross-disciplinary doctoral programmes devoted to study of and research into intellectual digital technologies
- Highlight the value of cross-disciplinarity in researchers' career paths

A vitally important digital academic publishing policy

Simultaneously, based on the work produced by the ANR and on doctoral theses, we need to introduce **a new digital academic publishing initiative**. The everyday experience both in and out of school is one of near-universal access to Facebook, Google and Wikipedia, and *digital academic publishing* has yet to see the light. And yet, so-called rational knowledge is accumulated via publication, i.e. open to criticism using public criteria that have been publicly discussed.

The French and European publishing industry has managed to survive only by upstream reliance on this re-imagined knowledge. In the words of Mathias Döpfner, CEO of Axel Springer, "We are afraid of Google". An academic system that is recast in a digital context presupposes a corresponding recasting of its publishing system; its future also lies with the publishing industries, which are themselves the prerequisite for the establishment of scientific criteria of peer recognition and scientific (and more generally academic) certification.

More generally speaking, the digital world is only one part of the blinding pace of transformation and transfer of academic knowledge to the industrial sphere. By appropriating and democratising academic efforts in the context of economic competition through innovation, the industrial sector introduces a *structural delay for teachers and the material they convey* about the reality of technical and scientific knowledge at work in the daily lives of their students. At the same time, issues raised by innovation and scientific research have become a favourite topic of both traditional and new media, which organise their own programmes and publications. As a result, the teaching profession

finds itself discredited by the inordinate haste of the media and by its own *structural anachronism* with respect to this material.

Over and beyond a defensive approach, a multi-channel publishing policy is important so that the above-mentioned research work can feed directly into teacher training efforts. Excellence in publishing is also a prerequisite for high-quality teaching, whether book- or digitally-based. Thesis work and workshops for research and contributory publishing will allow for the inclusion of work by recent, digital-era graduates producing new forms of knowledge, and will become instruments for new heuristic, didactic and pedagogic practices.

Moreover, **a new scientific and pedagogic publishing initiative will also foster national-level discussions concerning digital industries in every sector**. This will come about by putting startups together with established French publishers who have played a major role in primary, secondary and tertiary teaching, and without whom national-level scientific publishing could not survive.

Lastly, with the advent of digital technology, the conditions for establishing public criteria for certifying and therefore legitimising knowledge are undergoing profound shifts. How these criteria are made public, how they are drafted and critiqued by academic argumentation, and their practical implementation by scholars is now being short-circuited by steady advances made via the presence of digital technology in research and teaching. This happens because the research community and the public authorities that dictates the community's public-service missions and provides the means to do so are not yet prepared for this.

Ensuing that one has the resources also means seizing the chance to establish a national digital vision and strategy, re-establishing a national authority able to offer a European strategy, particularly in partnership with Germany.

Recommendation 29: organise high-level scientific publishing conferences in the digital era

- Bring together the publishing industry, publishing-sector startups, researchers working on the issue of epistemological breaks in the digital era, multimedia stakeholders, institutions such as the INREA, etc.
- Create a publications platform where the new criteria for certifying knowledge can be discussed – criteria whose definition will already have been discussed at publishing conferences, among other places

Citizen science: between teaching and research

Scientists from every discipline are very aware of changes to how they work in the Web's new documentary, social and methodological environment, because they have been living with it for over a decade. Even though their administrative bodies do not reflect these changes, scientific communities have established entirely new relations, ones that are more cross-disciplinary, more globalised and more equipped with technology in order to tackle very large and varied datasets.

Open archives, participatory scientific blogs and social networks have upended monitoring and training methods, and are also affecting relations between scientists and publishers.

Moreover, digital technology is transforming research tools. Major datasets have, for some time now, been processed semi-automatically and explorations of Big Data are giving rise to cross-cutting questions and goals via ground-breaking concepts and methods. At the very heart of these disciplines, convergence with computerisation is self-evident. Biology is developing in pace with physics and computer science. The possibilities of mapping for the historical and geographic sciences are endless, and so on.

The same is not true in schools. Teaching is more strictly divided up in secondary education (via programmes and textbooks), and there is a widening gap between the disciplinary cultures in primary versus secondary schools. Even though teachers are aware of these processes during their training, they either have not experienced the transformation directly, or the academic sphere (textbooks, strict division between disciplines, curricula, inspections) discourage them from attempting to pass on this new scientific environment.

Citizen science is bringing about a revolution. In the areas of healthcare and the environment, citizens and large communities of interest (patients and their families, activists) have become part of the research process. This is not merely an issue of sharing data that has been gathered (such as "quantified self" data or environmental measurements of radioactivity, pollution, electromagnetic radiation and energy consumption), but rather contributions to the interpretation of data and methods.

This contributory approach made possible by current computer technologies is an enormous issue for the sciences – citizen participation in research is important given the scientific challenges. It also leads to critically important socially responsible behaviour. Citizen science will be present in every area.

Because of this, it is important to involve educators in this shift through close relationships between research and education. University-level education must change, by becoming (starting at master's level) a research-based training programme, i.e. one of stating and challenging hypotheses, of experimentation and even by the creation of open-source sensors. Such hands-on experience offers special access to scientific inquiry and to understanding mechanical, physical and biological processes. Students at primary school can enter into research-based learning[37]. Digital-era literacy and its cooperative element are not social posturing but rather a genuinely new condition for knowledge creation. This involves close ties between research and secondary education, accompanied by acknowledgement and affirmation of the research facet of teaching that exists at every level.

[37] The Saventuriers are students that work for a half-day per week with a PhD student who helps them design experiments based on their own questions. In this video clip, students learn how to calculate the speed of an insect: www.youtube.com/watch?v=PxMHIpAgmrQ

Recommendation 30: encourage institutions to take part in citizen science

- Establish action research into these topics in teacher training institutions in connection with university research curricula
- Get classes involved (a national challenge in connection with Science Days, a web-based challenge) with the support of scientific associations and local support providers

6 - Support the explosion in new publishing usages

Academic publishing has a central role to play in providing teachers with content that matches their curricula. It is a key stakeholder in interpreting of those curricula, and is at the heart of the link between teachers and students, particularly with respect to homework.

Academic publishers are responsible for translating national curricula that are applied throughout every school from primary level up to high school. Following the July 2013 French Schooling Reform Act, these curricula are now drafted by the Higher Council for Curricula. The publisher's role is to give form to these curricula using attractive and adapted contents, and to create a working tool that is familiar to both teachers and students. Publishers must simultaneously research, create and select contents based on their quality and relevance, organise and structure knowledge and skills based on educational approaches and assessment methods, to shape them to match the needs of users, to define a layout that complies with the educational intent and the age of the students, etc. This is a vital role, because a textbook is a social object. It is a common landmark for teachers, students and parents; through it, traditional publishers not only are given widespread access to society but also acquire a significant reputation and earn the public's trust. Textbooks are vehicles for social norms and values, as recent discussions on textbooks and on gender equality have shown[38]. Since a school's teachers must agree on the choice of textbook, this tends to lead to the choice of the lowest common denominator, leaving little room for original works[39]. Like so many other sectors, publishing has been profoundly affected by the arrival of digital technology in schools. This is all the more destabilising in that textbook publishing has traditionally operated in a

[38] "As sometimes the only books to enter the homes of the most disadvantaged families, textbooks can be drivers of social change (…). The picture is not pretty one. A great deal more progress could be made, educationally speaking, on textbooks with respect to equality".*Lutter contre les stérétoypes sexistes. Faire du manuel scolaire un creuset de l'égalité*. Report by Monsieur Roland Courteau, on behalf of the Delegation for Women's Rights. Fo. 645 19 June 2014 http://www.senat.fr/notice-rapport/2013/r13-645-notice.html

[39] A 2012 report by the *Inspection Générale de l'Éducation* describes a textbook as being in a state of "regulatory weightlessness", and calls on the Ministry to organise a concerted approach between the various stakeholders: "The Ministry's responsibility could also be to ensure that the textbook and the associated resources are consistent with the curricula and the needs of students in various disciplines and educational situations. The diversity and complexity of the means for producing and financing these resources calls for a concerted approach between public- and private-sector publishers, the ministry and local authorities. The current compartmentalisation between those establishing curricula, publishers, financial sources and textbook users is the source of considerable distortion; this makes the current situation very unsatisfactory from the point of view of all stakeholders. The ways in which curricula are established should take account of this". Michel Leroy, *Les manuels scolaires, solutions et perspectives*, Report 2012-036.

very specific market, one that is very different from that of higher education, for example. In the past, this market has been regulated by public procurement, based on the rate at which curricula are revised. In a highly competitive environment, textbook publishing has a guaranteed audience.

Over the past few years, several transformations – in which digital technology is playing a critical role – have led the publishing sector to innovate. One factor is new arrivals in the market. Textbook publishers must deal with competitors offering digital products produced by a number of stakeholders[40]. The second factor has to do with the generation of data in connection with these new vectors for transmission and learning that digital media represents, as well as to the new economic and scientific activities that such data will elicit. This is only the beginning, and textbook publishing will need to fully transform itself in order to be the channel for digital and citizen literacy for future generations.

From the centrality of the textbook to a plethora of pedagogic content

The primary source of destabilisation is the **diversification** of sources available to teachers, students and parents. Both in and out of class, a wide variety of content is available on the Internet, and stimulating new uses. Both teachers and students are already casting their nets into this sea of knowledge.

As a corollary to this abundance of content, a great many teachers are **reconfiguring their classroom materials**. They did not need digital technology to use printed materials in an often non-linear fashion – reorganising content by combining it with their own personal resources and by shifting the rate at which material is taught. However, the profusion of available content has made the search for material and the combination of relevant content a much simpler and richer process, and thereby has breathed new life into the concept of publishing.

Simultaneously, more and more teachers are **producing their own content**. Once again, actions such as production of their own sequences of courses or exercises, co-creation of resources with their peers and sharing of feedback about those resources are not new. Digital technology simply increases the possibilities – in terms of tools, sources, networks and scope, among others – for carrying out such tasks.

This wide range of content is supplemented by **open-access materials** that continue to grow in both quality and diversity. Éduthèque is a portal offering educational, cultural and scientific resources for teachers; these are produced by various government-funded cultural and scientific establishments. Édu'bases offers teaching sequences for secondary-level education, and Éducasources preselects online resources for teachers. Some regional authorities also provide open-access content catalogues; these include Corrélyce, the catalogue for the Provence-Alpes-Côte d'Azur region, aimed at high schools.

[40] Textbook publishing is a sort of oligarchic structure, since five stakeholders share between 80 and 90% of the market.

Canopé (the new version of the CNDP-CRDP teacher training network) provide support for educators in their teaching practice. In 2013, Canopé gave teachers access to a database of animated films on the basics of open content. Services and new areas provide support for teachers who wish to create and structure content, based on the idea of "local micro-publishing" and co-design of uses between various interested parties. These new spaces provide a local, on-the-ground response to the principles of content distribution and use, as requested by teachers and stakeholders such as local communities.

Non-profit and private-sector stakeholders also contribute to the variety of content, via solutions that are sometimes basic and sometimes quite elaborate. These include an entire structure to support teachers as they construct their pedagogy. Some provide specific responses to classes' needs, others focus on after-school activities and student support. For example the Pass Education + nonprofit Association offers 10,000 teaching resources grouped by cycle, level and type of course to be used in class. BiC Education has a "Resources" platform that provides free and for-pay teaching resources that can be used within schools and at teachers' homes as they prepare their classes.

This trend is set to continue, as distance learning structures emerge, leading to new ways of integrating content and encouraging publishers to develop services associated with these resources that meet students' needs. The centrality of the textbook in teaching is thus called into question, which is a source of unease to a publishing sector that is already coping with a falloff in public orders.

Jointly-produced and customisable digital textbooks, created and curated by teachers

The publishing world has already begun to address the digital era. Starting in 2009, all curricula-compliant textbooks are published in both printed and interactive digital version. Since 2010, new editions of digital textbooks are interactive and provide increasingly expanded opportunities to customise the material. By 2014, there were nearly 1,500 digital textbooks for primary and secondary schools, and more than 2,000 digital resources available across the primary and secondary school spectrum.

However, **with respect to the publishing offer and possible uses, the changeover is only partly accomplished**. For the lion's share of teachers, digital use is similar to that of a printed textbook. It is students who are coming up with new uses, and we need to create new supports and services based on their learning patterns.

Today, the goal is to expand the functionalities that facilitate individual learning efforts (pre-structured textbooks, with different ways of working through the material based on a student's learning ability) as well as collective efforts (sharing functions, collective annotations, interaction with outside sources, etc.).

Digital publishing is very much on the side of equality and educational success. It contributes to achieving the goals of the Act of 11 February 2005 concerning schooling for students with disabilities: between eight and ten per cent of school-age children suffer from learning difficulties (dyslexia, dysphagia, dyspraxia).

Students with visual, hearing and motor disabilities can share the same tools as their classmates, provided that these textbooks and educational resources are properly designed and produced. They need to be compatible with technical aids used by those with disabilities. Every student must be able to take advantage of digital resources that comply with accessibility standards, and materials that they can easily access and consult.

The digital textbook could also be **expanded to include content produced by teachers** themselves, or free or for-pay external documents sourced by them.

The relationship between textbooks and exercises also deserves to be examined, with an eye to including **content co-produced by students** as part of teaching them about the publishing process (see the chapter on digital literacy).

Many of these educational supports are of limited use to schools that have signed up for them; in particular they cannot be modified. To get beyond this, the concept of "open-source educational resources" should be expanded (e.g. lelivrescolaire.fr). This approach is largely supported by the Francophone University Agency (AUF), particularly because these materials could be used throughout the world.

Five prerequisites for open-source and co-produced content

Opening up the school textbook is possible only if the following conditions are met:

1. The introduction and use of **open and interoperable standards for supports (tablets, interactive tablets, etc.), software and content**

Currently, classroom aids such as digital workspaces and interactive digital tablets (TNI) and regular tablets are, generally speaking, neither standardised nor interoperable. Two TNIs may not be able to open the same document within the same school. Proprietary tablets limit the tools and content that teachers use. One major inconvenience with respect to tablets is that it is nearly impossible to make them interoperable. They force publishers to make expensive multiple editions, with no long-term guarantee. Once hardware is purchased, the school is captive to a supplier. Resources cannot be interfaced using different ENTs[41], and so on.

[41] Drafting relevant norms and standards presupposes cooperation between the various stakeholders (manufacturers, textbook publishers, pure players, software publishers, the Ministry for Education and devolved parliaments). A government-led strategy must lead to innovative solutions that ensure high-quality offerings and open up international markets. This position is underscored in the 2012 report entitled "La structuration de la filière du numérique éducatif**:** un enjeu pédagogique et industriel" (*Structuring the Digital Educational Sector: An Educational and Industrial Issue*), jointly authored by government and education

Recommendation 31:

- Make France a leader in developing and distributing international standards such as EDUPUB, which came out of the work of the International Digital Publishing Forum (IDPF)
- Expands the Interoperability Guidelines (RGI) to factor in the French educational system and to encourage open standards in terms of both classroom aids and dedicated software
- Promote open-source educational resources by linking subsidies for creating teaching resources to their distribution under a Creative Commons license
- Free or open-source software of equivalent quality should be preferred over proprietary offers

2. Constitution of a **structured offer** that allows teachers to browse and make selections from an ever-expanding base of documentation, but also to ensure that the content they produce can be reused by others

This involves increased use of a system for **indexing** standardised, easy-to-use content. A structure for describing digital educational resources (ScoLOMFR)[42] and its associated thesauruses (Motbis) has existed since 2010. These bring together a **metadata** structure based on LOMFR standards (2010) and several vocabulary typologies, and to the various stakeholders in the teaching sector. Other tools make it possible to publish metadata for teaching documents, such as éducaméta. The creation of a national educational resource indexing service [43] is part of this. All of these tools are underused and little known by teachers and publishers. The role of a public educational indexing service would help structure metadata links to resources and provide access free of charge. Hosted in an open-access/open-data environment, these resources could be referenced by search engines. This would have a twofold goal: making French-language resources visible on both a national and international level, and increasing their use (language, culture, frames of reference), and bringing together, via consultation and publishing, a wide social network of users who would ensure the relevance and the viability of a web-based public educational assets.

Recommendation 32: initial and ongoing teacher training should include a segment devoted to content reuse and production, including:

- Curating, i.e. the selection and assembly of sources, annotation and customise uses of existing textbooks as well as external resources
- The use of open-source licenses allowing teachers to reuse copyright-free content and to choose the most suitable license for their own productions

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inspectors and representatives from the Ministry for the Economy and Finance. (www.igf.finances.gouv.fr/webdav/site/igf/shared/Nos_Rapports/documents/2013/2013-M-023-02%20-%20Rapport%20numerique%20educatif.pdf)

[42] With OTAREN, a new indexing language, users can create actual courses based on principles of the semantic Web.

[43] The creation of this department was one of the recommendations of the report cited in footnote 6: "La structuration de la filière du numérique éducatif**:** un enjeu pédagogique et industriel" (*Structuring the Digital Educational Sector: An Educational and Industrial Issue*).

- Learning about how to publish metadata and the specific vocabulary for the educational community

3. A greater choice of educational content raises the issue of **quality**

One of the essential roles played by traditional publishers was to co-design textbooks with groups of educational experts of their choice, and thereby providing a sort of certification of the quality of the content. Given the ever-increasing amounts of content, there is the risk that quality will be compromised and that teachers will waste time assessing them. Thus, other means for designing and validating textbooks must be introduced, such as sets of rules and best practices for rating textbooks and educational content.

Recommendation 33:

- On that content-production platforms, introduce a peer-based assessment system based on best practices on the web and in epistemic groups
- Encourage publishers to provide a quality certification system for content produced by third parties. Publishers have the requisite skills and legitimacy to accomplish this new task.

4. The search for **new business models for the world of publishing**.

Public procurement has fallen off dramatically (in France it has declined from 90 million in the 1990s to 65 million in 2013[44], with an additional 13% shrinkage in 2014[45]), and there is competition from content from a number of sources. Publishers must be urged to seek a business model that is no longer based on marketing an object (a printed book) or bulk content (a digital schoolbook), but rather on granular content and on associated services – content certification, educational support for teachers, interactivity added to existing resources, learning scenario platforms, etc. Despite initial good intentions, the e-education roadmap as part of the *Nouvelle France Industrielle* plan does not include actions that would allow the sector to rethink its business model[46]. This is a gap that must be filled by several complementary economic models, and in particular by creating a model based on downstream provision of products and services (and not simply on upstream resources).

Recommendation 34:

- Stimulate cooperative innovation between sector stakeholders, in connection with startups and research laboratories
- Clarify the various roles of public and private-sector publishers, develop service and functionality ecosystems that combine free and for-pay resources and encourage use of these resources via optimised search and indexing tools

[44] Source: Sylvie Marcé, CEO of Belin and chair of the Textbook Publishers Association (http://www.la-croix.com/Famille/Actualite/Le-gouvernement-veut-aider-les-editeurs-scolaires-2014-07-09-1176564)
[45] Source: Vincent Montagne, Syndicat national de l'édition (SNE) http://www.lesechos.fr/tech-medias/medias/0203598058330-la-chute-de-ledition-scolaire-pese-sur-le-marche-du-livre-1018380.php?AIOvY2fbjw5lqHzu.99
[46] proxy-pubminefi.diffusion.finances.gouv.fr/pub/document/18/17721.pdf#page=5

- Encourage the extension of teaching innovations to the entire French-speaking world, by ensuring that products can respond to local cultural requirements

5. Greater flexibility and expansion of the concept of the "**educational exception**"

Following the Copyright and Related Rights in the Information Society Act of 2006, the educational exception was introduced via a flat rate negotiation between schools and royalty-collecting organisations[47]. The works in question may not be taken from textbooks; here the issue is the use by teachers of documents (text, images, sound and video clips) produced in another context by authors who are members of these organisations. In keeping with the production of educational resources by teachers, it would be preferable to have a more flexible definition of the contents of an educational exception, in particular specifying the particular role played by public domain and freely-available works. This definition could use the exceptions of framework called for within the context of the European Union Copyright Directive, and defended in current European negotiations about copyright. A reuse right would allow users to incorporate extracts of texts, images, sound files and video clips into new teaching resources to be distributed and shared in a nonprofit manner. This would provide legal certainty for teachers who create such resources.

Recommendation 35:

- Create a tool outlining the general perimeter of the teaching exception to support teachers in their use of materials
- Provide greater flexibility in usage authorisations for documents in not-for-profit teaching resources to provide greater legal certainty for teachers
- Make it easier to cite sources for works used in teaching resources, much like the automatic citation generator used by Wikicommons
- Encourage the mixing of educational material based on extracts from texts and use of images, as well as sound and video clips, for resources used in classes as well as those distributed by teachers on not-for-profit, free educational resource platforms

From content publishing to data publishing – adaptive learning and learning analytics

Today, the class is still the basic learning unit, even if work in sub-groups sometimes takes place alongside. We know how difficult it is for teachers to bring an entire, heterogeneous classroom along at the same pace, whether in terms of the students' relationship to school, self-confidence, social and cognitive capital, pleasure in learning, etc.

Currently, educational research supplemented by digital technology is focusing on an **increasingly individualised education adapted to each child's specific needs**. For example, applications are

[47] https://www.ac-paris.fr/portail/jcms/p1_360882/droits-d-auteur-et-exception-pedagogique

appearing that automatically correct spelling errors in dictation tests, which lighten the fastidious work of test correction and allow teachers to focus on higher aspects of their calling. These tools identify a student's sticking points on which the teacher can focus. Other applications offer exercises based on a child's pace of learning, or provide additional teaching resources based on identification of the difficulties encountered.

The idea is to provide individual solutions en masse that can be used both in class and at home, and in group or individual settings. In doing so, the hope is to make the classroom a more flexible place, alleviating teachers of repetitive tasks and allowing them to focus most of their time on interacting with students.

This area of educational research, entitled "adaptive learning" is not new. Its roots lie in artificial intelligence research from the 1970s, but this area began to be actively explored less than two decades ago. In 2013, there were some 40 businesses working in this sector[48].

If this approach were to develop on a wider scale, it would have a far-reaching impact on textbooks (whether digital or not) and, beyond this, perhaps on national curricula by emphasising extreme granularisation of content.

Moreover, every use of digital supports generates data (number of exercises accomplished, error rates, progress, time spent reading content, etc.). Adopting individual teaching solutions would only boost this production of data with ever more specific data about the learner.

There are a growing number of stakeholders in the learning analytics sector[49]. Currently, the offer is exclusively focused on higher education, but it is more than likely that it will be extended to primary and secondary education in the medium-term. These stakeholders have high hopes for this new sector. In addition to contributingto learning that is customised and adapted to the difficulties of each learner, they promise to be able to predict student performance via statistical analyses combined with external data (home environment, social milieu, economic conditions, etc.).

This approach freely mixes different levels of usage, under the banner of "Big Data for education", practices whose interest and risks are quite different. We have already seen a certain number of players expressing great interest in the potential market for educational data.

As long as the **publishers of today and tomorrow will be the managers of this data**, the question of future usages and rights or limits pertaining thereto must be planned for, starting now.

Differentiating the use of data generated by learning analytics

The typology of the uses of educational data remains to be drawn up, since it varies depending on different criteria. These include the type of data collected, the conditions under which they are

[48] edgrowthadvisors.com/gatesfoundation/
[49] infographic on learning analytics: www.opencolleges.edu.au/informed/learning-analytics-infographic/

made available (only for the learner or the learner's family, only for the Ministry of Education, commercialised, open data, etc.), whether or not they are combined with other data, whether or not they are anonymised, etc. We have already observed a large framework of uses in practice and in theory:

- Uses of teaching "micro data", i.e. data only for the student and the teacher, in order to fuel discussion. This data should allow students to become aware of gaps and difficulties as well as strengths (e.g. the Signals project developed by Purdue University)[50], or help them to structure a homework assignment (e.g. the Open Essayist project[51]). Such data should also allow teachers to provide support based on flags generated by the data. But the educational relevance of these approaches is the subject of intense debate[52].
- Uses of "micro data" for assessing teachers and schools, based on results and student progress. This assessment may be reserved for Ministry of Education authorities, in a New Public Management approach, or it may be shared as open data with parents and with the general public. This approach to institutional assessment via data is very much in use in the US and is actively opposed by a portion of the educational community[53].
- Commercial uses, based on the resale of data to advertising agencies for the purposes of pushing personalised ads to students (e.g. for academic support), teachers and schools (e.g. for equipment).
- Scientific uses, having to do with learning strategies. Connection data (length of consultation, typology of activities, success rates, learning curves) is being used as a research database to analyse the relevance of methods, in combination with cognitive and educational sciences.
- Big Data uses, in which data is aggregated and anonymised, providing the public authorities with a much more detailed and real-time scorecard of needs in terms of teachers, equipment, etc., by combining the overall results with demographic and urban planning data (e.g. construction of new districts), among others.

These issues are not merely theoretical – MOOCs, which are making their appearance in higher education, are rarely transparent with respect to the governance of data gathered as part of usage. This lack of transparency should be immediately eliminated.

Building a framework for data use

It is quite clear that these uses cannot be treated the same way. In particular, the evangelising by certain stakeholders for educational open data might go hand-in-hand with a strategy for privatising teaching and the introduction of "à la carte schools", in which parents put both schools

[50] www.educause.edu/ero/article/signals-applying-academic-analytics
[51] oro.open.ac.uk/37548/
[52] See, for example, “Snooping on students' digital footprints won't improve their experiences” (www.theguardian.com/education/2014/mar/26/students-digital-footprints-experience)
[53] See, for example, “Principals Protest Role of Testing in Evaluations” (www.nytimes.com/2011/11/28/education/principals-protest-increased-use-of-test-scores-to-evaluate-educators.html?pagewanted=all)

and teachers in competition with each other based on open data. Such a use, far from combating educational segregation, will accentuate it. This is at odds with France's goal of equal schooling for all.

Recommendation 36:

- Learning analytics research should be accompanied by social science research on ethical criteria for making this data available or not, on the economic conditions under which they are made available and on the social effects of data use.
- The conditions for public discussion of the use of this data should be set up, with an eye to providing a framework for practices by data managers. Given its status, Etalab could organise the discussion as well as the construction of the framework.

Sharing open data between schools, local authorities and the government

Without anticipating future discussions on the use of the data mentioned above, there are already certain types of statistical data whose use is clear, because they are not produced either by teachers or students, but by the schools themselves.

The Minister for Education has made some of these data sets available[54]. They include the number of students enrolled in primary and secondary schools, success rates for baccalaureates and professional certificates (a value-added indicator for general, technical and professional high schools), elements concerning domestic spending on education and its change vis-à-vis France's GDP, what has become of students 15 years after entering first grade, etc.

Other data sets could be made available immediately, such as more detailed information for individual schools about what they offer (number and type of classes, options and specialties, etc.), as well as school-specific data on the number of students enrolled, including historical data going back several years. Data can also be made available about types of training offered beyond junior high school level (pathways offered, length of study, admission requirements, types of skills acquired, jobs available at the end of the training). Work remains to be done to consolidate or create databases that compare various training pathways and the percentage of graduates who successfully find work, as well as on the connections between professions, the skills required and the training courses that are available. In this way, data becomes a genuine tool to help orient students, particularly those who have not opted for the general and technical branch.

Providing statistics to the central government represents a burden for schools. It is seen as a strictly bureaucratic tool for oversight, whereas this data could foster more participatory governance between central government, devolved departments, the regions and the schools. It could bolster individual schools' initiatives and thus give citizens an understanding of educational performance.

[54] https://www.data.gouv.fr/fr/posts/la-rentree-scolaire-2014/

Sharing and data and creating shared governance between local authorities and central government (ministries and devolved departments) is critical for good educational guidance with respect to concerted procurement policies and an incentive to reduce regional inequalities.

Recommendation 37:

- Call on the Minister of Education to extend and prolong efforts to make data available, working with other institutions such as ONISEP
- Create a framework for two-way transparency and shared governance between local authorities, devolved government departments and the Ministry for Education with respect to data generated by all stakeholders

7 - Accept new training industries

In the past, the French educational system could feel completely in control of how it evolved. Curricula directed teachers' activities, and were updated at the desired pace. Public procurement provided impetus for the production of textbooks, materials and software. By injecting public monies and ensuring a long-term market, the system had an effect on the industrial sector. Exams and competitions put pressure on families and ensured the overarching power of the institution. This is no longer the case, and it will never be so again. There are no more givens; competition and deregulation have entered the scene. The French educational system has made a place for private schools, although maintaining the same requirements and frameworks in place for public-school education. However, it has had little to do with the non-private sector, despite historic ties with non-formal education.

A very different offer is now making an appearance, provided by independent educational businesses; these firms have services to sell and are not seeking any explicit recognition from educational institutions to enter the market. They do not belong to the inner circle, but they do not feel powerless – they sell digital services and do so freely. The creators of these services care little for being accepted by educational communities. They position themselves as players outside the school system who have decided to intervene, directly targeting their offer at families, students and adults.

Their message is plain: is the French educational system too complicated to reform? Let's get away from the paralysis. Here are some simple and useful ways – based on peoples' needs – to tackle training in the 21st century. This is simplistic, and blurs the face-to-face socialisation process that is education's domain, but it invites one to respond, and even to benefit, from this pragmatism by taking it on board.

The educational establishment needs to understand this new environment, which is flourishing through a precise understanding of the system's faults: it can no longer ensure a quality, and therefore the entire teaching relationship needs to be overhauled. This new branch of the digital economy will profit from the heart of the educational profession: understanding students, grasping their behaviour, providing a customised offer, the student-teacher relationship. It will do so, among other means, by analysing private data and via adaptive learning.

New businesses, of various sizes and ambitions, are beginning to blossom at the doorstep of France's primary schools, high schools, universities and *grandes écoles*. They include software publishers and providers of new educational services (online and face-to-face tutoring, teaching kits, etc.). Their growth has not gone unnoticed by the teaching establishment. The educational

system is of interest to a new type of industrial player, who, with no prior experience in the media, is upending educational professionals, academics, teachers and publishers.

Their appearance shows that education has been identified as a profitable growth sector that has been neglected, and an area in which new business models can easily take root. This is what these businesses are doing. Whether they were founded a decade or a couple of months ago, their executives all have experience in the digital economy. To create value, profile relationships, social networking and data analysis are more important than understanding the teaching profession. For these new market entrants, that can come later. These firms appeal to a number of teachers, students and families.

The French schooling system is a huge social network

MOOCs currently concern mostly higher education, targeting independent learners, these online courses have shed light on a French ecosystem of pure digital players, who provide courses in languages and mathematics, and who create thematic materials for history, geography, life sciences, etc. Simultaneously, the Khan Academy has achieved global renown by providing short, easy-to-understand video clips that turn everyone into a potential teacher. Translated into French, they are one of the tools used by Libraries Without Borders, which provides teaching in refugee camps abroad and in Roma encampments in France.

In France, Open Class Room, in the wake of its incredibly popular online HTML training course, is positioning itself as a key platform for online courses. It is also a social network of contributing learners. In this way, Open Class Room is a teaching model in which knowledge is shared and co-generated, and demonstration of how a national online course platform could function socially, pedagogically and technically.

Like the music, tourism and publishing sectors, education has come into contact with the digital economy.

With its population of students and their families, the education market is a potential social network that remains unstructured. Expectations of great profitability will undoubtedly play a role, different from those of traditional private teaching. The firm that manages to attract a large portion of this social network to its platform will become a major educational player, and the traditional players will be that firm's subcontractors. This is how this new industry will play out.

It goes by various names: Edu Tech, Ed Tech, Education and Technology. A global network of startups, social enterprises and nonprofit organisations is entering the domain of education without a prior connection to it.

This network has its events, conventions, researchers, designers, websites, sponsors, business angels and venture capital firms, lobbyists, experts, reference experiences, Twitter and Facebook networks, meetups and boot camps.

Targeting the private market rather than schools

Traditional textbook publishers basically take a B2B approach with respect to recommender teachers, librarians, school directors and regional financial authorities. On the other hand, the new players start from a B2C (Business to Consumer) standpoint. They target teachers on an individual basis (and not necessarily in their role as recommenders), selling them teaching kits at low prices and offering free access to for-pay platforms. Their products are useful since they are granular sequences that can be purchased like songs, without having to buy the entire album and pay for access (premiums, subscriptions). Simultaneously, they also target families via a digital offer that makes learning fun that is addressed to parents, teachers and tutors. The materials are designed so that each user can feel like an instructor. For these new players, waiting for schools to decide is a complex process. They target the private sector, but the fact that they are in the educational market provides both reputation and legitimacy. The barriers to entry are currently too much for new firms. They are not prepared to use traditional means, for example setting up a distribution network, to make useful political and professional contacts in every *département*, region and school. Moreover, they think that digital technology, with its ability to attract a large number of users to their products and services, will make these contacts unnecessary.

In France, this business activity is not yet having a noticeable effect on education.

And yet, various signals indicate that changes may be underway in the education economy.

The digital economy has taken note of the education sector

At the same scale as the global digital economy, the Edu Tech movement is organised into networks. These networks include representatives from every country in which teacher training, educational technology and associated financing are critical for development and the country's presence in the global economy of the future. These include the US, Colombia, Brazil, India, Korea and Nigeria, to name just a few examples.

Their strategies include two key action drivers. The first is the encouragement given by education budgets in each country, and the overall total in every country and every situation. Even earmarking a small part of public funds for these new players is extremely hopeful. Total education budgets around the world represent $4 billion (educational spending as a percentage of GDP). This is an area that the digital economy is out to conquer, as it is attempting to do for areas such as energy, mobility, healthcare and insurance. In 2013, funding rounds for education were highest in the US, about $1.5 billion. There is an assumption that the next digital tsunami will involve a global firm capturing the education market, as others have managed to do in other areas (Amazon.com for books, Netflix for video rental, etc.).

The second driver is that digital technologies, which are ubiquitous by nature, will free students from attendance. They provide an answer to the question that every student asks sooner or later:

why should I be bothered to go to school? The face-to-face encounter between a teacher and 30 students is, in addition to being an educational obligation, obviously a good reason to go to school. But every student knows that he or she can learn in other areas besides the classroom – in bed, on the couch, with friends, in a café, sitting on a bench or riding a bus. We are not able to define what that "learning" is – which for the moment does not have much in common with how a school would define it. However, it could change by the two environments coming into contact, at least partially. The comparison is not easy: school "learning" is poorly understood, and this is no small problem. Students might discover that they could have Chinese or African teachers, since distance does not impede dialogue (although languages do).

It is not news that 50% of educational time is non-formal and takes place outside of school – in the family, through personal reading, television, sports, non-formal educational venues, leisure associations and (for the past 15 years) via the web.

However, over the past five years, a very attractive educational universe has taken shape on the Internet. Far from the rigid and closed online courses from the 2000s, this new setting offers a readily-available response to an ever-increasing and varied number of questions.

All of the time spent on the Internet could lead to an unquenchable thirst for learning. All the conditions are there for a virtual school to reach out to students of all ages and all walks of life, who are always searching for answers to questions on the web. We should point out, however, that there is a risk of inequality in this curiosity – all web users are not spontaneously motivated by the desire to learn.

Education, social innovation and ideals

In addition to these two drivers – a global industrial strategy and the asset of ubiquitousness – there is the recent appearance of a fixation on education within the digital world, in the largest sense of the term, over and beyond strictly economic players. Training courses in coding and programming, fab labs and makerspaces of all types have increased the venues in which the federating question is how can people learn better, faster, together and more serenely. Moreover, one of the hallmarks of the worlds of IT is the constant need to learn: programming languages, design methods, tools.

Currently, the digital world, including startups as well as alternative communities, social entrepreneurs and the non-private sector, are debating the value and importance of education. This is a positive, reassuring and far-reaching discourse addressed to the general public, not simply to families with school-age children.

Education is, obviously, an area of general interest that involves the entire human community. Unfortunately, when it is in the news, it is often to discuss falling levels, violence at school, unmet needs and absenteeism. When education is left to specialists, experts and schools, it appears to either bore or frighten everyone. It is very rare when the ideals of the French school system are

spotlighted. The strength of this discourse by digital innovators of all types with respect to education is that it transcends constraints and creates a link between education and the future of the planet. Because the problems of employment, the environment, energy, healthcare, mobility and inequality are immense, we need future generations who are not only well trained, but creative and forward-looking.

There is no doubt about this. Although proponents of Edu Tech are few and far between in France, they reflect a global momentum, positioned at the crossroads between the economy and social innovation. They are self-organised, and state that they are meeting basic needs that, in their view, neither the public sector nor the classic private sector are able to meet.

This is a discourse that is difficult to contradict, but the consequences vis-à-vis the image of schools are not neutral.

A new relationship to education via digital technology

Their reasoning leads one to think that education goes beyond tightly-defined educational systems. Because of this, these very systems no longer have the monopoly on the educational "resources" that the Internet has made available, and in great quantity.

In response to overloaded classrooms and a system at breaking point, there is a vision of a distance teaching relationship that is liberating and more personal. This relationship is liable to be completely reinvented – network, cooperative, at a distance, peer-to-peer, embodied by experts around the world, the top scientists in various areas. Moreover, the virtual relationship can be set up in the physical world. It can be located in small home-based schools, and play a role in the professional training of new teachers, mentors and tutors.

At any rate, this is the reality that is beginning to take shape alongside a school system that is fundamentally oriented towards transmitting specific contents and preparing students for exams.

These new designers of education are bringing together basic and ongoing education in a shared concept of skill building to enable individuals to act, to undertake and to solve problems that computers are unable to solve, to ask questions that have never been asked, and to take part in answering them.

French firms in an international market

These various companies have several points in common:

- They are targeting a relatively unified global market, since the tools and techniques have been simplified, in order to easily adapt to emerging and developing countries, as well as for countries in which there is an educational structure but it is in crisis (translations, ad hoc reworkings of identical resources), in order to maximise their return on design investment

- They sell tools for developing skills (general knowledge, cooperation and creation), rather than scholastic tools connected to disciplines. This allows them to combine ongoing and initial training, as the market for adult learning offers a profitability which frees them to view initial training as a nonprofit, at least initially.
- They combine open source products and for-pay services
- In France, they are riding the wave of the popularity of MOOCs and the Khan Academy, and they defend a French cultural aversion of increased productivity and new directions for teaching
- They are in the process of opening up French-speaking African markets

The proof of usefulness for teachers is based on three arguments

A great deal of basic knowledge (multiplication tables, how to solve equations, definitions, vocabulary, declensions, conjugations, etc.) are learned through exercises and repetition, and there is no longer any need for a qualified teacher to guide and oversee this. Hence the notion of a "rehearser", which relegates to a machine the task of monitoring repetitive learning in the form of interactive applications, and operating on a system of scores and rewards.

Management tasks that are a burden in the daily life of teachers can also be delegated (attendance monitoring, ways of working in class, when studying, and at home), along with correcting papers (quizzes, but also automated management of transcripts and assessments, and integration of peer-to-peer correction).

Certain areas of some curricula for which current working conditions make it difficult to imagine a digital structure (in the life sciences, for example, and the difficulty of experiments) could result in occasional orders for material for a course or a sequence, and inexpensive teaching kits that teachers could simply purchase themselves.

New and effective means for monitoring school work (collaborative or automated correction).

The basic argument, which deserves to be heard, is that this digital delegation frees up teachers' time and skills to allow them to concentrate on the heart of their profession.

For institutions, these digital services are a source of competition for digital workspaces. New, more intuitive platforms are available to teachers with new services also available for families.

Both the structure of the exercises and functionalities that are more open than those of digital workspaces make it materially possible to imagine an in school/out of school continuum (family life, education outside of the classroom).

These platforms offer various services, including mentoring, orientation, advice and help for parents. Most often these are free of charge, financed by advertising or by exploiting the collected data.

In this new wave of the education industry, tablets play a key and ambiguous role, because they combine three characteristics:

- **Automation** of learning tasks (applications for measuring progress, self-correction and memorisation of learning paths)
- **Customisation** (offers profiled by "data-driven education", driving learning paths through the data processing)
- **Outsourcing** of learning anytime and anywhere (availability of digital support, mobility) with mentors who may not be educational specialists, in a "third time and place" which is no longer the school, and which makes school possible everywhere

This arrangement allows us to grasp where the creation of economic value takes place. Not through the marketing of educational resources, nor through teaching, but rather through the exploitation of educational data according to the desired direction: renewed research by bringing together cognitive sciences and IT; digital assistants for coping with cognitive impairments (such as dyslexia and dyspraxia), thanks to algorithmic diagnoses; tools for guiding individual and school assessment; targeting for financing and strategies, potential source of recruitment and selection for schools and businesses.

These changes are already realities. There is a seamless shift underway from public systems to private systems. By seamless, we mean that end-users will not see the difference, they will only notice that the interface responds better to their requests. This can be seen in the success of Digischool among high school students. They log in looking for a service to help them prepare for the baccalaureate exam, and encounter private schools. They don't care about the algorithm that improves their connection based on their search histories.

In private test-prep schools that help students prepare for business school entrance exams, the *colleurs*, i.e. those who drill the students, are students themselves who have already gotten into their desired schools. Thanks to a mentoring platform, these *grandes écoles* students become freelance workers that are much less expensive for the school in question. The platform was able to recruit a majority of *colleurs* candidates, who understand the effectiveness of belonging to a network in which they are clearly identified, and where they can find potential clients without prospecting for them, without being much less well-paid. For the employer, the savings are obvious.

Another business school example: there is a falloff in the number of students applying to MBA programmes, and an analysis has shown that students are no longer willing to go into debt to pay for these expensive courses. They are finding a new ecosystem that provides the same benefits in professional social networks, Moocs and incubators, to such an extent that MBA programmes are turning to startups with an eye to reinventing themselves.

Today, it is generally thought that these changes only concern higher education, which is a mistake. The entire profession of teaching is involved.

Intellectual and intermediation professions have thought that they were safe from the wave of computerisation that has swept through many other professions. Like every other profession under threat, teaching tends to respond to these changes defensively, focusing on specific factors (quality, experience, values). It would be wrong to underestimate the power of these environmental phenomena. The changes underway in the service sector (trade, tourism etc.) and in the creative realm (music, cinema, etc.) have proved to be radical and fast.

And yet, the French educational system has major assets that will allow it to take control of events:

- Every stakeholder states that they are contributing to educational change, and speak of schools that are more egalitarian, more welcoming with respect to diversity, and more future-oriented. At a local level, they contribute to the success of projects by educational teams, outside of school time. It would be an error to target them. Under the Schooling Reform Act, heads of schools have the means to organise these exchanges and support structures.
- With its teachers, administrative teams and students, the French educational system represents a huge social network that is already linked by shared interests, commitments and questions to be solved together. However, this network is not a living or valued network; it is perceived by the general public as an entrenched camp that has hit a wall. Discussions with some of the stakeholders in Edu Tech could help alleviate this misunderstanding.
- The French educational system is the source of a great deal of published resources of which teachers are the guardians; they are the best qualified to give them value. However, the databases containing these resources are closed.

If the French education system does not want to undergo the upheavals experienced by the cultural industries, it must prevent its own erosion at all costs.

France's industrial environment is creative. It represents an incentive for the school system to benefit from its skills in order to affirm its value in the digital economy – the school system could organise itself at national level as a key platform, bringing together enormous volumes of high-quality, indexed and searchable resources, varied and linked-up social networks around complex processes of exchange and production.

The major platforms that host data capture knowledge, customise relations with users and transform experts into sub-contractors. This must not happen with teaching. France's industrial fabric is schools' best ally, and can provide original, relevant ecosystems of services and functionalities, while providing the best guarantees of independence and neutrality. Working with schools, French industry can also find needed areas for testing in order to achieve differentiated designs.

In every activity of infrastructure, material, applications and publishing that one could list, data is enjoying an ever increasing role (see the chapter on publishing).

In addition to administrative and identity data, new data sets (connection, cooperation, localisation, learning modes, behaviours and areas of interest) are being amassed. For all types of data generated in an educational setting, the government must anticipate that there will be investments in "data-driven education". The value of this data consists in the possibility for certain operators to link them up with data generated by Facebook, Amazon, Google, etc. For this, France needs a national industrial strategy.

This also involves training teachers, students and parents in this new context, which, in addition to aspects of marketing, involves ethical behaviour (see chapter on digital literacy).

Recommendation 38: Highlight educational resources via tools of the digital economy, indexing, social networks, usages (see Chapters 4 and 6)

Recommendation 39: Analyse the core of the teaching profession and computerise repetitive, low-value-added tasks through industrial partnerships

Recommendation 40: Organise and structure France's educational data industry

Conclusion

There are two key parts to our proposal:

- Digital education: IT training in high school, the IT and Digital Sciences (ISN) option for all baccalaureate streams, digital humanities via a general baccalaureate diploma, digital literacy throughout the teaching professions
- Expanding the educational fabric to include nonprofit educational associations, local authorities, digital entrepreneurs, families and the digital realm of open knowledge and collective publishing, the education industry and digital-sector entrepreneurs

The initiative must begin in schools – this general recommendation is the prerequisite for the success of this roadmap. Each school's digital project (or, to be precise, the project of bringing the digital age into each school) is local and people-based. Chance and encounters play significant roles: a colleague whose trailblazing experience inspires others to get involved, a teacher who watches students thrive and enjoy themselves, the arrival of a new head of school or a new school inspector for whom digital technology is a given, etc.

The web itself is a source of encounters. A teacher who happens upon Sugatha Mithra's[55] TED talk and thinks "why not me?", or who reads about how a sixth-grade class in a poor area of Mexico took the top spot in a national mathematics test[56].

Every teacher can be an experimenter, a researcher, a creator, as can every student. Groups of students discuss constantly, solving problems, comparing, becoming interested, affirming. Their teachers guide, adjust and stabilise the students' reasoning. Therein lies the strength of our school system.

We believe that the digital changeover represents social transformation, made possible by networked technologies.

There are two facets to these technologies – the subjugation of individuals who become robots manipulated by an enormous machine, and the emancipation of individuals who find, in the enormous machine, new and accessible information that is vital for intelligence, interrelations and

[55] Sugata Mitra is a professor at Newcastle University and a proponent of the concept of "Minimally Invasive Education" (MIE) (http://en.wikipedia.org/wiki/Sugata_Mitra). His "Hole in the Wall" experiment showed that children can learn about computers all on their own (www.bbc.com/news/technology-21614181)
[56] 12-year-old Paloma Noyola Bueno and her classmates believed that, in the digital age, no knowledge and no dream were beyond their grasp. They worked very hard to answer the question that their teacher, 31-year-old Sergio Juarez Correa, asked: "What do you want to learn?" (see "How a Radical New Teaching Method Could Unleash a Generation of Geniuses", http://www.wired.com/2013/10/free-thinkers/all/

action. The school is there to expand on this second facet, and ensure that the enormous machine is brought under control. Instruction and education now mean instructing and educating in a sea of information that exists in schools, even if there is not a single computer or tablet in the classroom.

This is why we believe that the digital project will not arise from teachers' practices – a complex practice and one, generally, that is impossible to computerise. Being a teacher implies a contextualised discourse, meaningful techniques, multilevel leadership, the ability to manage multiple interactions, a tremendous amount of behind-the-scenes knowledge and a cultural level that can be reformulated in a number of ways. The value of this skills set is expressed in teachers' principle of pedagogic freedom, an attribute that is never called into question and that can be exercised regardless of the setting. This is the heart of the teaching profession. But there are many things that should be computerised in schools, and this would considerably alleviate the burden on teachers, who expect genuine interfaces for managing school work and communication with multiple partners with the class and with a school – project zones *par excellence*. The taboo topic of computer-corrected tests, automated grades and attendance, the delegation of rote learning to computerised tutors, and even the management of pupils' learning curves – teachers need to closely examine what they are prepared to give up or not. What is at stake is protecting the heart of their profession. The truth is that the teaching profession has entered into a quality war with teacher-free, web-based schools.

The idea of such a war should seem bizarre and fantastical to most citizens, who think that the educational institution is eternal, particularly for primary and secondary schools. There are many signs that schools are in danger – a 20% failure rate among students, families' loss of interest, disorientation with regard to the 800,000 young people each year who leave school without training, without social security, without employment and even without signing up with the employment office, and the lack of resources on the part of the government and local authorities, who adapt to dysfunction and rally against the disrepute of the teaching core as portrayed in the media. If we compare this to the goal of a digital economy, which is showing every sign of its ability to take over the educational economy, we must prepare for thoroughgoing changes.

The French school system will emerge stronger and more effective, because it must reaffirm its *savoir-faire*.

This presupposes that the teaching profession agrees to reinvent itself, gradually, based around students who, in a way, have the upper hand, because it is a question of their desire to learn. To do so, teachers and educators must surround themselves with designers and project leaders who may come from the rich world of non-formal education, and who could facilitate these creative efforts and create, working with teachers and students, ecosystems for digital and physical learning based on experiences that the schools themselves put forward. This involves all of the other educational stakeholders: families first of all, local authorities and the cultural and creative industries in the educational sector, as well as nonprofit educators and social entrepreneurs, educational publishers, educational pure players (video games, serious games, digital scenarios, etc.), equipment and infrastructure manufacturers, software publishers, etc.

Diverse practices require a diversity of equipment. In the same way that Bring Your Own Device (BYOD) is becoming a part of the private sector, it will enter the educational field. This is also an area where schools must adapt – allowing each individual to learn in his or her own digital environment, making sure that each has the proper equipment. The question of equipment is, of course, critical. Hardware is predictive of the educational ecosystem that will be introduced by the school and the local authority. And it is precisely for this reason that it must be managed not in a centralised fashion, but via negotiations and arbitration between local stakeholders (students, parents, local authorities, schools) within the context of a specific, collectively-defined project.

The equipment strategy must support the educational strategy, in which re-motivating students and helping them succeed are the primary goals, along with supporting (and un-shackling) teachers' pedagogic freedom. This does not mean we should not measure results and provide scientific support for experiments via a public research policy. Finally, we must provide quality and state-of-the-art management and communication systems – give the schools wings instead of weighing them down!

The educational digital changeover is an enormous technical, creative and imaginative challenge. It could become a flagship effort, because, contrary to what we hear elsewhere, other countries are not doing much better in this area. No country has succeeded in every single area – IT training, high-quality equipment, and educational revolution, student emancipation, increased pedagogic freedom, preparation for educational Big Data, and so on.

Throughout our long immersion in the field of Ed Tech, we are often told, "Hold on! This has nothing to do with teaching. This is about manufacturing!" What is implied is that teachers do not want industry to have the upper hand. We have also been told: "Your approach is totally ideological! You won't be credible unless you start from the industry end of things!" However, our educational digital industry will not really take off without being rooted in usage, without being rooted in a national market. In parallel to the French school system, its ideals and its critical quality will wither away if its digital base, its resources, its social networks of learners and its teaching platforms are not part of the global educational economy.

Reforming the school system is not simply a problem – a very complex one – for the government. It is a problem for all of French society, and it is not only a national problem. Throughout the world, education is being reinvented right now; is being stimulated and reconfigured by industries and digital cultures. The challenge for France lies in an alliance between a certain idea of education and its industry, and the convergence of economic interests and the desire to maintain the French social model. This presupposes close, *in situ* cooperation, and the use of methods in force in the most competitive areas of our digital industries. The digital sector is also about being creative and fostering participatory environments of responsible innovation. When it comes to education, everyone feels responsible, particularly as it is our European cultural sovereignty that is at stake.

The National Digital Council's 40 recommendations for building a fair and creative school system in a digital world

1 - Teaching information technology: a must

Recommendation 1: introduce a targeted IT-teaching approach at every level of primary and secondary school

- Teach the basics of computational thinking using the plugged or unplugged approach at primary school, making good use of extracurricular activities for beginners.
- Teach IT at middle school level. Start by introducing a one-year IT course focusing on basic computer programming skills during the time currently allocated to technical studies.
- Teach IT to every high school pupil through the rapid rollout of the IT and Digital Sciences option.

Recommendation 2: take a two-step approach to training IT teachers

- During the transition phase, IT would have to be taught in secondary schools by existing teachers. In addition, we would have to look for potential teachers elsewhere, i.e. among the population of computer researchers, engineers or non-formal teaching professions.
- Develop the recruitment of qualified IT teachers, i.e. those who have a Masters degree in information technology or computing science.

Recommendation 3: play a key role in changing the face of education

- Place group projects at the heart of IT lessons and give priority to projects that require working jointly with students studying subjects other than IT.
- Set up benchmarks for progress, such as the percentage of students leaving the education system with a "satisfactory" level of IT knowledge.
- Monitor the practices implemented to oversee their improvement or help them feed through to other disciplines.

2 – Introduce digital literacy

Recommendation 4: teach the real benchmarks of digital literacy

- Encourage every teacher to incorporate some aspects of digital literacy into their classes.
- Ensure digital literacy is taught in such a way that every pupil is treated equally. Develop teacher support and group work for pupils.
- Appoint a digital literacy coordinator in each school (teacher/documentation specialist, head teacher, etc.) who will be responsible for teaching of B2i based on the feedback from teachers regarding the skills acquired by pupils based on the cross-disciplinary approach taken.

Recommendation 5: help students make sense of the changing digital landscape

- Train teachers, particularly teachers-documentation specialists, about the societal issues raised by the digital revolution at teacher training college and through vocational training.
- Use group work and online methods for teachers' digital literacy vocational training.
- Insert a module dealing with these questions in almost every subject's curriculum and classes.

Recommendation 6: create a school environment that encourages the production of material inside and outside the classroom

- Schedule at least one group-based project using digital technology per year for each class.
- Encourage teachers to involve third-parties (e.g. a business, nonprofit organisations, teachers/researchers) in their projects.
- School heads should provide support for these projects, identify newprojects and ensure their long-term development.
- Promote teaching which gives students the initiative and encourages them to contact third-parties outside school as part of their group project work.

Recommendation 7: teach pupils how to publish and broadcast their work via Internet

- Encourage schools to publish their work systematically, particularly websites, blogs, sustainable social networks, digital workspaces, etc.
- Train pupils to use open licences (such as Creative Commons) and teach them about the related editorial decisions (re-use, sharing, circulation) and how this applies to the use of documents for which they have exclusive ownership.

Recommendation 8: promote the use of shared educational resources

- Train groups of teachers at teacher training college and through vocational training to use and enhance the pool of common knowledge.
- In each digital workspace's list of "educational resources", include all of the workspace's common knowledge, free educational resources and related tools and applications to ensure that they are more easily accessible to teachers.

Recommendation 9: work with other EU Member States to harmonise France's digital literacy framework with that of other Member States to produce one single, harmonised framework.

Recommendation 10: encourage new approaches to learning

- Add a starter course in new digitally-enhanced teaching practices to teacher training courses, placing the focus on how to involve the most vulnerable pupils.
- For CAPES, CAPET and CAPEPS admission tests, introduce the option for candidates to carry out dissertations based on group learning methodology training programmes.
- Using an online sharing service, provide teaching teams with access to the experience, methodologies and tools documented that they can use to add these metholodogies to their teaching practices.

Recommendation 11: change the way teaching is assessed

- As part of the teacher assessment process (see above), develop the use of digital media by teachers, particularly in the development of open source teaching materials, the implementation of interdisciplinary digital projects and/or when working jointly with third parties.
- Simplify the publication process and encourage discussions on experience-sharing websites (e.g. *Expérithèque*[57])

Recommendation 12: adapt classroom equipment for project-based work

- All new classroom equipment must be adaptable, enabling teachers to adapt the classroom layout to suit his/her teaching programme.

Recommandations 13: open co-working spaces

- Open a co-working space in schools for internal and external use.
- Streamline the associated red tape, ensure that an extra caretaker is always present when necessary outside normal school hours to supervise:
    - Educational associations, non-formal classes in science and technical studies and particularly digital literacy.
    - Those involved in digital mediation providing help to members of the public finding it difficult to master digital technology.
- Budget for the employment of a digital mediator or facilitator.

3 - Introduce a new general baccalaureate in digital humanities

[57] *Expérithèque* is a website documenting experimental teaching practices: http://eduscol.education.fr/experitheque/carte.php

Recommendation 14: implement a pilot phase for the Digital Humanities baccalaureate as quickly as possible, decide whether or not it should be rolled out based on a transparent public assessment

- Quickly introduce the new course in *troisième* via a double baccalaureate (literature or economics and social sciences plus digital humanities, depending on the profile of the pupils in *première* (17-18 years old)), then roll it out to *première*
- To support this double baccalaureate with different teaching methods, greater weighting should be given to project-based work in the marking scheme (by rolling the positive example of supervised individual work to *première*)
- Negotiate agreements in advance with certain preparatory schools, secondary schools and universities to have them consider the digital humanities baccalaureate as a genuine route to entry

Recommendation 15: introduce a remote pilot phase for the Digital Humanities baccalaureate

- With the support of the CNED as well as companies specialised in distance, group-based learning.
- In the longer run, it would make sense for all pupils to be able to register to study remotely for the digital humanities course in addition to the other subjects chosen and therefore obtain a double baccalaureate.
- Deliver a nationally recognised baccalaureate

Recommendation 16: garner support from clusters and nonprofit organisations

- Encourage schools offering the Digital Humanities baccalaureate to form networks
- Develop partnerships using the support of clusters and nonprofit organisations (e.g. IT education, robotics, game design, etc.) to find professional teachers, keep in line with training centres and the job market requirements, gain access to the necessary hardware and software, and teach more about the various IT jobs available and IT companies that exist.

4 – Introduce networked schools

Recommendation 17: encourage teachers and educators to work together to avoid pupils dropping out

- Join forces with nonprofit organisations to encourage demotivated pupils to return to school, help them discover new digital skills and jobs, and raise the profile of skills acquired outside school. Organise combined workshops together.
- Experiment with new timescales and formats, such as fablabs or hackathons, and set creative group challenges with a deadline that will encourage pupils to work together to create something of real value.

Recommendation 18: involve teaching teams in shaping their profession through the creation of a digital teacher training college, a "do-tank" for the whole profession

- Provide schools with the tools they need to assess their teaching activities, decide how digital technology could help them perform difficult tasks (correcting homework, following up individual pupils) and make improvements.
- Ensure teachers are better trained to organise project work for pupils, and that they are able to publish the results and show how much value has been added. Encourage projects with external third parties (businesses, nonprofit organisations, academics/researchers).
- Give teachers the power to shape their own profession and involve them to a large extent in the design of training programmes through "pathways to the future" initiatives.

Recommendation 19: boost local powers to improve school governance

- Recognise schools as individual educational establishments.
- Involve local authorities in digital projects from start to finish.
- Improve upstream cooperation between the government and local and regional authorities.

Recommendation 20: communicate at local level

- Overhaul IT environments to improve school governance and relationships with third parties. The system can also be used to improve internal mobility procedures.
- Use the digital environment and social networks for: (i) teacher's teaching projects; (ii) re-establishing ties between government and teaching teams; and (iii) strengthening ties between schools and local authorities.

Recommendation 21: get every parent involved in digital literacy

- Provide IT training courses and non-formal/Internet digital literacy courses in schools for both schoolchildren and adults. Provide everybody in the local council catchment area with support for learning outside normal school hours.
- Make school websites a gateway to school life and a forum for discussion with pupils living on housing estates.

Recommendation 22: get parents involved

- Convert the digital workspace reserved for schoolwork into a digital exchange space that places pupils at the centre.
- Invite parents and pupils to regularly describe their work and what they have learned from working at home (exercises on Internet, personal publications, etc.).

Recommendation 23: provide teachers with connected workspaces in towns

- Teachers do not have their own office in schools: by providing them with an office in town where they can work and meet other teachers, parents and pupils, the key role they play on housing estates is recognised. This would also help promote projects and knowledge sharing between schools. It could be used by the whole community to share experiences,

learn more about digital teaching, discuss education and as a meeting place for parents where events could be organised.

Recommendation 24: encourage schools to switch to "open knowledge" and provide physical and digital support at regional level

- Test participative digital teaching methods in schools.
- Update certification and assessment procedures to include digital learning.
- Introduce a regional digital content policy that highlights and places importance on local knowledge to bolster regional skills and identities.

Recommendation 25: creating living labs (Educalabs) to bring schools, users, industry players, local authorities and researchers together

- Share research experience and results (cognitive sciences, digital education, digital humanities, etc.); share practical case studies, draw up specifications jointly.
- Create prototypes, run tests, create new uses; design services that have a real rather than theoretical connection with actual practice and that users are looking for.

Recommendation 26: guarantee a French-language market open to innovation

- Use the public procurement market to organise the French and French-language market around goals focused on teaching, culture, industry and modernising education.
- Co-design French-language offers that meet local needs and user requirements to support the French language with the support of the relevant organisations (AUF, OIF, etc.) and the involvement of relevant educational groups.
- Guarantee new and innovative niche players access to the education market
- Create a framework for standards and open source interoperability.
- Innovate technically to create new uses: enhance self-training and certification options through platforms offering skill portfolios

5 – Linking research and education

Recommendation 27: introduce cross-disciplinary action research programmes

- Researchers in the areas of epistemology, philosophy, anthropology, neuroscience, the cognitive sciences, educational science, information theory, etc.
- Instructors and students in teacher training institutions
- Associations devoted to non-formal education, the regions, etc.

Recommendation 28: develop contributory research in digital studies

- Finance 500 doctoral theses per year in every discipline, with support from thesis grants, that focus on digitally-related epistemological breaks
- Support for laboratories' commitments to digital studies from French and European research assessment agencies

- Spotlight degree institutions that create cross-disciplinary doctoral programmes devoted to study of and research into intellectual digital technologies
- Highlight the value of cross-disciplinarity in researchers' career pathsRecommendation 28: Développer la recherche contributive en études numériques

Recommendation 29: organise high-level scientific publishing conferences in the digital era

- Bring together the publishing industry, publishing-sector startups, researchers working on the issue of epistemological breaks in the digital era, multimedia stakeholders, institutions such as the INREA, etc.
- Create a publications platform where the new criteria for certifying knowledge can be discussed – criteria who definition will already have been discussed at publishing conferences, among other places

Recommendation 30: encourage institutions to take part in citizen science

- Establish action research into these topics in teacher training institutions in connection university research curricula
- Get classes involved (a national challenge in connection with Science Days, a web-based challenge) with the support of scientific associations and local support providers

6 - Support the explosion in new publishing usages

Recommendation 31: introduce and develop the use of open and interoperable standards for hardware, software and content

- Make France a leader in developing and distributing international standards such as EDUPUB, which came out of the work of the International Digital Publishing Forum (IDPF)
- Expands the Interoperability Guidelines (RGI) to factor in the French educational system and to encourage open standards in terms of both classroom aids and dedicated software
- Promote open-source educational resources by linking subsidies for creating teaching resources to their distribution under a Creative Commons license
- Free or open-source software of equivalent quality should be preferred over proprietary offers

Recommendation 32: initial and ongoing teacher training should include a segment devoted to content reuse and production, including:

- Curating, i.e. the selection and assembly of sources, annotation and customise uses of existing textbooks as well as external resources
- The use of open-source licenses allowing teachers to reuse copyright-free content and to choose the most suitable license for their own productions
- Learning about how to publish metadata and the specific vocabulary for the educational community

Recommendation 33: develop assessment and certification systems to ensure content quality

- On content-production platforms, introduce a peer-based assessment system based on best practices on the web and in epistemic groups
- Encourage publishers to provide a quality certification system for content produced by third parties. Publishers have the requisite skills and legitimacy to accomplish this new task.

Recommendation 34: invent new business models for the world of publishing

- Stimulate cooperative innovation between sector stakeholders, in connection with startups and research laboratories
- Clarify the various roles of public and private-sector publishers, develop service and functionality ecosystems that combine free and for-pay resources and encourage use of these resources via optimised search and indexing tools
- Encourage the extension of teaching innovations to the entire French-speaking world, by ensuring that products can respond to local cultural requirements

Recommendation 35: expand and ensure greater flexibility for the educational exception

- Create a tool outlining the general perimeter of the teaching exception to support teachers in their use of materials
- Provide greater flexibility in usage authorisations for documents in not-for-profit teaching resources to provide greater legal certainty for teachers
- Make it easier to cite sources for works used in teaching resources, much like the automatic citation generator used by Wikicommons
- Encourage the mixing of educational material based on extracts from texts and use of images, as well as sound and video clips, for resources used in classes as well as those distributed by teachers on not-for-profit, free educational resource platforms

Recommendation 36: construct a framework for the use of educational data

- Learning analytics research should be accompanied by social science research on ethical criteria for making this data available or not, on the economic conditions under which they are made available and on the social effects of data use.
- The conditions for public discussion of the use of this data should be set up, with an eye to providing a framework for practices by data managers. Given its status, Etalab could organise the discussion as well as the construction of the framework.

Recommendation 37: encourage open data between establishments, local authorities and central government

- Call on the Minister of Education to extend and efforts to make data available, working with other institutions such as ONISEP

- Create a framework for two-way transparency and shared governance between local authorities, devolved government departments and the Ministry for Education with respect to data generated by all stakeholders

7- Accept new training industries

Recommendation 38: highlight educational resources via tools of the digital economy, indexing, social networks, usages (see Chapters 4 and 6)

Recommendation 39: analyse the core of the teaching profession and computerise repetitive, low-value-added tasks through industrial partnerships

Recommendation 40: organise and structure France's educational data industry

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