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Abstract

In France, vocational educational has a long history. It was institutionalised by the Ministry of Education in the 19th century, separate from private enterprise. Since the 1980s, a new process of convergence between general and vocational education has been engaged in order to propose an initial training and a general education to vocational students and apprentices. To this end, vocational teachers are strongly invited to use professional resources, such as those used in the commercial sector, as references.

Our paper investigates the issue of resource usage by teachers in a specific field: automobile maintenance. This field is particularly interesting because, in recent decades, the knowledge and competencies to be transmitted have widely evolved. After a thorough literature review, we found only a few scientific references about research on these issues, which have mainly been undertaken by ergonomists, sociologists and didacticians in this domain. However, many resources have been developed, in particular on the Internet, and these constitute an interesting field to investigate. So the situation might be changing.

Keywords: automobile maintenance, vocational education and training, resources, teachers, history

1. Introduction

In the last few decades, a remarkable trend in education has been the wide diffusion of, often informal, digital resources, which have the potential to supersede textbooks and a direct impact on teacher action: teachers now have the possibility to create and modify resources, and to prescribe their use. Students, on the other hand, have huge opportunities for accessing more or less informal resources. This trend is in fact not new.

Ten years ago, an IARTEM conference held in Caen discussed emerging trends in this situation and, in particular, the rise of new online environments that are not only media but, more accurately, resources and instruments (Bruillard, Aamotsbakken, Knudsen, & Horsley, 2005). Burning questions at that time included the possible industrialisation of education and training, and the consequences for teacher action. Among the perspectives delineated at that time was the ongoing trend toward “hybridisation of traditional teaching and online activities and distance learning” and the “setting up of integrated systems of management combining functions and activities which were previously separate” (Moeglin, 2005).

The focus of the conference was more on general education, with much interest paid to topics like language learning and cultural issues, but vocational education was also present. It is this last topic that interests us here, particularly in the field of automobile maintenance.

Vocational education has always had a positive approach toward technical artefacts. The history of computers in education teaches us that, on the one hand, teaching has always had to keep up pace with the technological progress and, on the other hand, that educational technology was developed early in this field. Multimedia resources, images, schema and the like, which allow one to link text with concrete situations have always been much used, as in the case for databases.

We shall concentrate here on the case of automobile maintenance in France, a specific domain we are currently studying in a research project funded by the French Agency for research: REVEA[1].

2. Contextual data about vocational education in France

France is known to have a particular school system where, traditionally, the national state occupies a central position, teachers being in their majority civil servants of the state. However, compared to general education, vocational

[1] Ressources vivantes pour l'Education et l'apprentissage, http://anr-revea.fr/.

education has specific features, which we shall analyse. For this purpose, we will have to consider the historical context.

2.1 Historical landmarks of vocational education and training in France

2.1.1 References to technical/vocational education

From an historical perspective, it is generally considered that the educational vocational system has officially existed since the passing of the law creating it, the *Loi Astier*, announced on July 25, 1919. But, elements of vocational education did actually exist earlier.

In France, before Ferry's laws (1881-1882), primary education was organised by both lay and religious institutions. Some of the latter, such as the Lasallians, from 1680, proposed vocational education in order to ensure the education of underprivileged young people. In the case of this organisation, at age 10 children could attend schools in order to receive both teaching in general matters (reading, geometry, drawing) and religious training. At the same time, they were engaged into a job-learning activity (Terral, 2009).

Starting from the Third Republic, at the end of XIXth century, things began to evolve. Vocational education was also perceived as a means of ensuring the promotion of children from the lower bourgeoisie (Terral, 2009). To this end, the law of December, 11 1880 created a mixed-educational system divided into two kinds of pathways (Hamon, 2012):

- Manual schools of apprenticeship characterised by technical teaching, organised by municipalities and financed by the Ministry of Agriculture and Business;

- Public schools for further primary teaching, created and financed by the Ministry of Public Education, in which general and professional teaching were taught.

The *Loi Astier* of 1919 went in the same direction as the previous ones. Indeed, it issued a regulation for technical teaching, but did not appear to fully recognise vocational education. To this end, it created a system in which teaching was assured by the Ministry of Public Education and where success was sanctioned by a test period in order to obtain a certificate of professional ability (CAP).

Periods of vocational learning were allocated to technical students and for those who were apprentices. In reality, it represented a small part of the teaching load.

Indeed, Article 44 stipulates an obligation to teach students between 100 and 200 hours per year[2].

In the same way, the law of July 13, 1925[3] established a special tax for apprenticeship, paid by industrial and commercial firms in order to bring them into the training process, which concerned technical teaching and apprenticeship. But for Christian Hamon (Hamon, 2012), this law aimed at higher technical teaching and not at elementary training.

These different measures had many consequences for the organisation of technical and vocational education. Indeed, during the 1920s, we can observe a growing number of students within technical schools and a diminution of the number of apprentices. According to Stéphane Lembré (Lembré, 2013), this can be explained by the establishment of a technical school system regulated by the government and by growing difficulties for company managers to hire apprentices. As a result, the boundary between vocational and technical educations became rather confused, and apprenticeship was isolated.

With the Decree of September, 20th 1939, in a context of preparation for the war to come, the first elementary vocational school was created (Hamon, 2012). This change continued after the Second World War with the support of the General Workers' Confederation, who managed apprenticeship centres until 1947 in order to prepare students for a certificate of professional ability in the domain of industry. Even if apprenticeship centres were considered to be a path of technical training for the working class, their status remained low (Pelpel & Troger, 2001).

In 1959, the Berthoin reform[4] brought a major change to the organisation of public education in France. Indeed, besides an extension of the age to stay in compulsory education from 14 to 16 years, the secondary education system were totally modified.

After primary education, students could be enrolled in a second-degree school pathway. This second-degree system was divided into two steps. The first one was an "observation cycle", during two years. At the end of these two years, students were allocated to one of three pathways:

- general schools;

[2] Astier Law, July 25, 1919.

[3] The New financial law July 13, 1925.

[4] Decree of January 6, 1959.

- “long” technical pathways, in which students pass a professional diploma in three years, and then a technician’s certification in a technical high school;

- short technical pathways, consisting in the preparation of a professional diploma in three years.

From that point things remained rather stable until the seventies: apprenticeships took place in centres for training apprentices, at the margin of the school system, mainly through the initiatives of professional organisations. For these organisations, vocational education was considered unfit to preparing students for professional practice (Tanguy, 2013).

2.1.2 The 1970s: the separation of technical and vocational schools

A sharp change of direction occurred with the Orientation law of July 16, 1971: a clear distinction was created between technical education (henceforth named technological education) and vocational education (Hamon, 2012). In 1975, the *Loi Haby* (July 11) created a unique middle school until the end of compulsory education. Professional pathways were from this point to be followed in a new kind of school (*lycée d'enseignement professionnel* – vocational education school).

This tendency was later more firmly established. The 1980s saw a very important move in French policies: decentralisation. Starting in 1983, regions received supplementary responsibilities regarding apprenticeship and vocational education. Generally speaking, regional political authorities were in charge of distributing money to schools for every expense, save teachers' salaries, which remain to this day the responsibility of the national state. Concerning technical and vocational education, special subventions were also available for buying specific equipment.

A report elaborated in 1983 for the Ministry of Education by the French historian Antoine Prost pointed out problems of equity between schools with this new system.

Statistics quoted by Prost’s report showed, in effect, an inequity between grants distributed by local authorities and those by tax for apprenticeships. Indeed, according to the results, tax for apprenticeships represented between 55 percent and 60 percent of grants distributed to schools but, because it was financed by firms, this caused strong disparities between attractive areas where there were a lot of firms and those with less. In the same way, the report showed that entirely private establishments were able to use part of the tax however they liked within the vocational domain.

Most importantly, the government created in 1985 a new kind of *baccalauréat*, the final exam and main linchpin of secondary education. This is highly correlated with the desire to take 80% of students through to the baccalaureate level. Teachers of vocational lycées received an increase in their wages, equal to what other teachers received in general lycées.

Finally, in 1993, a five-years law[5] created a new apprenticeship section in order to support professional insertion for students with difficulties. To this end, these sections were integrated in professional lycées, training centres for apprentices or secondary schools and proposed a vocational cooperative education for students from the age of 14.

Thus, these laws endeavoured to create links between general education, regulated by the Ministry, and vocational education in relationship with firms. But, according to (Culpepper, 2006), the reform failed:

> *French employers continue to invest relatively little in general skills of their young workers. When they use training measures, they use them almost entirely to invest in specific-skills training.*

The issue of links between firms and the vocational educational system has a long record. Recently, a reform of the vocational baccalaureate in 2009[6] reinforced the tension between these two stakeholders. For example, this reform led to the reduction of three years of training to two, resulting in the elimination of some intermediate diplomas and professional certificates previously obtained in two years *before* enrolment in a professional baccalaureate (but not for all professional pathways). For example, in the case of the vocational pathway for automobile maintenance, passing a baccalaureate required four years (two years in BEP and two others in baccalaureate). Now, it is only three years and this has been contested by professionals.

We shall now focus on the resource situation in vocational training and, more specifically in the field of automobile maintenance. This case, in effect, is a kind of paradigmatic example of current evolutions where, within a few decades, the work situation has evolved from mechanics towards the use of computer-assisted diagnostics.

3. Methodology

We are conscious that vocational education and training for automobile maintenance is a rather narrow field. But it has, for us, some crucial

[5] Five-years law of December 20, 1993 about work, employment and vocational training.

[6] Special official report n° 2 of February 19, 2009.

characteristics: it furnishes a very interesting example of a situation where the necessary knowledge has profoundly changed in a short time and continues to change.

Indeed, since the seventies, progressively, electronic systems have replaced previous mechanical or hydraulic systems in order to increase security and comfort for drivers and passengers. Thus, current cars are now equipped with electronic systems, guided by software that is in charge of controlling all equipment such as doors, dashboards and lights. Furthermore, cars are more and more equipped with technological devices such as radios, navigation systems, and CD and DVD players (Navet, Song, Simonot-Lion, & Wilwert, 2005).

Thus, in a few decades, the situation has changed from a focus on transmitting knowledge and competencies linked to mechanics towards a new focus taking also into account electronic controls and multiplex communication between different on-board subsystems. This has had important implications in terms of what to teach to students and apprentices, in particular for using remote diagnostic devices.

Studying what is happening obliges us to concretely take into consideration the links between education and the industry. We have therefore specifically considered this field, first broadening our investigation to the case of industrial vocational education, where new technologies have brought much change in previous decades.

We have proceeded in a standard way, searching the Internet and also relying on historical documents.

3.1 Collecting data

The goal of this article being to categorise existing research in the domain of resources for vocational education and particularly in the maintenance field, we consulted eighteen databases and nine reviews using different keywords (in French and in English, here only indicated in English):

- Handbook + Maintenance
- ICT + Maintenance
- Environment + Simulator
- Resources + Industry
- Resources + Vocational education

All the databases and reviews we used are listed on Table 1 in annex. They concern various domains of research such as social sciences, didactics, ergonomics, psychology, and nine of them involve more than one domain of research in the sciences and social sciences.

In addition, we consulted IARTEM's archive, from which we selected two other references. One was published in 2002, about the uses of CD-Roms (Askerøy, 2002). A second discussed the occupational status of educational texts (Høye, 2002) in technical and vocational training.

We also searched the Arthèque[7] resource at the *Ecole Normale Supérieure de Cachan*, which keeps a record of teaching in the technical fields. All research was conducted from November 2014 to March 2015.

3.2 Brief presentation of the selected references

Overall, few results have been published in this field of research. Indeed, we could only select eleven references from all of the results. The criteria for selecting contributions was: publication either in a scientific journal, in a wider spectrum journal devoted to pedagogical innovation but in collaboration with researchers, or in the proceedings of a conference linked to pedagogical research.

In fact, a minority of these references directly concerns vocational maintenance training at school. Four of them concern the maintenance field, with one focussing on lifelong training. One study is about engineer training and technological education, three are about industrial vocational schools in general, and one is about lifelong training in the aeronautical maintenance field.

So, the use of ICT resources has so far not been really investigated in this domain compared with other educational fields.

As we can see in Table 2, our references are both old and recent. Indeed, 4/11 are articles published during the eighties and the nineties, respectively in 1988, 1989 and 1992. However, 7/11 were published after 2000, respectively in 2002, 2004, 2006, 2007, 2012 and 2013.

[7] http://artheque.ens-cachan.fr/

4. Results

4.1 Resources for technical and vocational training in the field of industrial technology: a general panorama

Different kinds of resources have always been used, both in the industry and for training technicians and professionals.

Beyond books, real machines have been much used in vocational schools. For example, the following figure show a steam engine used for didactic purposes at the *Ecole nationale d'arts et métiers* of Aix-en Provence at the same period.

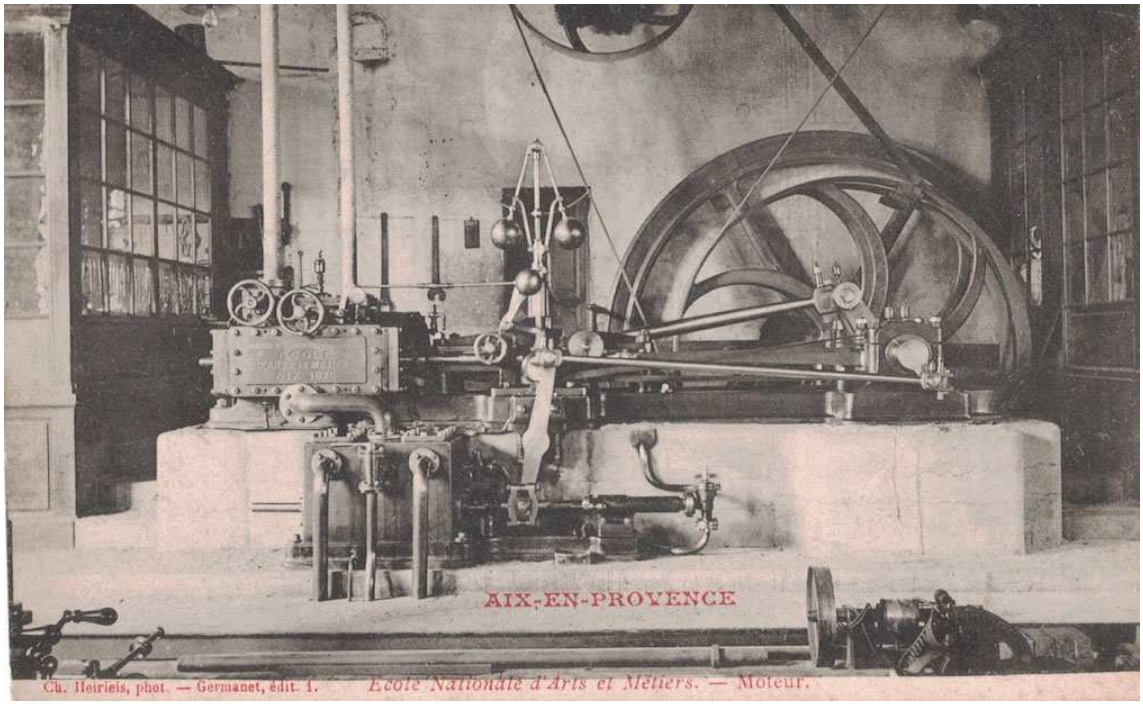

Figure 1. Engine at the Aix-en-Provence National School for Arts and Crafts, 1901. Personal collection.

What was new in the last decades of the twentieth century was the growing diffusion of simulators and devices exploiting digital databases. In France, as early as the end of the sixties, some classes had received computers, in order to implement computer-assisted production. For example, as early as 1973, a bulletin of the National Institute for Pedagogical Research and Documentation (INRDP) presented a panorama of experiments thus far carried out on industrial subjects with informatics at the lycée level[8]. Logically, those experiments considered activities using algorithms and programs, functional analysis,

[8] Institut national de recherche et de documentation pédagogique, Service des études et recherches pédagogiques, section informatique et enseignement, *Bulletin de liaison l'informatique dans l'enseignement secondaire*. N° 7, mai 1973.

computer-assisted drawing, and different computations for optimising the fabrication of pieces.

At the beginning of the 1980s, authorities led ambitious national policies regarding computers and technologies in education. Technical and vocational education were then, and until the end of the decade, considered as a priority. In the industrial sector, the focus was on topics related to the diffusion of automated machines, and robotics. Large-scale computer-assisted drawing and computer-assisted production were popular topics, with a focus on programmed machines and algorithms for driving machines. Innovators tried to implement solutions for their students, a common problem being to use affordable hardware, the opportunity of having a real machine being beyond the means of the school (Bris & Régnier, 1988).

Of course, in a bottom-heavy system like the French institution, things did not move quickly. Bernard Dauga, writing in 1989 in an innovators' journal (*Bulletin de l'EPI*) remarked that, at that time, in vocational high schools, teacher computer-assisted drawing was not explicitly taken into account in the syllabus (Dauga, 1989).

In a contribution to a 1989 conference about the integration of informatics in education, Jean Prevost, an inspector general of industrial studies remarked that teachers in this field were confronted with a problem: they had to use complex and upgradeable software in their teaching activity while being obliged to maintain continuity relative to existing tools, that are often like « black boxes ». Hence, the necessity for them to have a knowledge of concepts far beyond mere operation in concrete situations (Prevost, 1989).

One of the main problems concerning the use of new software, is related to teacher education, a domain where the institution is doomed to lag behind the evolution of a technology that keeps going on the fast track. Thus the importance of online resources, either formal, informal or semi-formal. One of the most important trends of the last decades has probably been the spread of the Internet and the availability of online resources that teachers exchange, modify and use in their work, under the supervision of inspectors, but with a wide margin of autonomy.

This situation is not confined to France: in 2002, at the 2002 IARTEM conference in Stockholm, two papers dealt with vocational training. One was about the use of a CD-ROM for learning car electronics (Askerøy, 2002). This author remarked that at that time, at least in Norway,

Teaching aids which combine updating on the Internet, textbook and

> *chat groups are mostly developed for general subjects. Databases in technical and vocational branches that renders access to in depth information on historic aspects of a trade, old or traditional techniques, theory, research and value questions, or subjects which borders other branches are still to be developed. (Høye, 2002, p. 62)*

The other paper estimated that “web-based curriculum will probably fit in nicely in many technical and vocational teachers' pedagogical practice”, and that “The continuing challenge for these teachers is to be aware of and able to analyse pupils’ different learning strategies, to assist their learning of subject matter, their development of vocational skills and their metacognitive strategies” (p. 74).

Over the years, the situation has evolved considerably. Online databases and information now play a crucial role in every sector of activity and much of what was previously in the field of mechanics has incorporated so much electronics that the work procedures have changed and, henceforth the great lineaments of what vocational education should transmit.

Technological high schools, as well as general high schools, have also been concerned with educational technology and particularly media and resources for learning. A recent trend is linked to computer-assisted design and serious games. A study conducted by Michel Galaup (2013) analysed the use of a serious game, *Mecagenius*, during technological courses. Even if, in each class observed, a session is given to the discovery of the game by students, it was used primarily by teachers in others to illustrate pedagogical contents.

4.2 Resources in the field of vocational education and training for automobile maintenance

4.2.1 Resources for lifelong training

The maintenance field is, like other vocational pathways, marked by a desire to teach or to train with resources that are present at the workplace. This is common in the case of industrial training because of the “necessity” to train workers in new technologies and new techniques which are actually used in the workplace.

Indeed, in the case of the car manufacturer, Renault, Margarita Anastassova (2006) identified three kinds of resources used by trainers during in-service training with employees: 1) resources that exist in the workplace, such as tools, 2) some more informal resources such as information about new technologies or new equipment, obtained during a conversation with colleagues, probationers or training designers, and 3) specific pedagogical resources designed by training designers.

This model of training causes problems, in particular of an economic nature. Companies have already reduced costs associated with training, more precisely by developing simulators and augmented reality (Anastassova, 2006).

This is not unique to France. It is possible to note similar initiatives in other countries such as Portugal as, for example, in the case of maintenance training for F-16 aircraft engines. They developed an augmented reality system to train further technicians to repair these military aircrafts (Pinheiro, Fernandez, Maia, & Cruz, 2012). But, according to trainers, these systems are problematic when it comes to reproducing actions in real situations, because situations illustrated in augmented reality contexts are not really the same as workplaces.

4.2.2 Resources for vocational education in automobile maintenance

This phenomenon is also present in the context of vocational training. Schools are faced with an economical problem because materials are expensive, substantial and in a perpetual process of change. So, in order to propose an alternative way of training in this field, some workshops propose simplified pedagogical models of automotive systems.

Landry Ndoumatseyi-Botongoye (Ndoumatseyi Botongoye, 2007) has conducted a study in Gabon with students enrolled in a maintenance course who used this kind of resource. According to him, the simulation models look like real systems but because of their scaletall, it is possible to show that all components may not be at the same place as in real systems.

Figure 2. Example of a braking simulation system, presented p. 4 (Ndoumatseyi Botongoye, 2007)

Furthermore, because these models are pedagogical, some adaptations are needed. As a consequence, during a manipulation, students may observe a situation of a functioning system which is not the same in reality.

As an example, the author cited the case of a tire-pressure system. In the case of over-pressurisation, a warning light appears on the model. But in real systems, this light does not exist. According to the author, these adaptations cause problems when translating practices from pedagogical situations to real situations and for students' comprehension of such systems.

This is a particular case of a more general problem, well documented in the domain of simulation. To what extent should simulators have a high fidelity with reality? In a seminal paper, Samurçay and Rogalski (1998) remark that situations of simulation are didactic situations, where the key issue is transposing situations of reference toward didactic situations. They warn that the realism of simulators should not be confounded with their efficiency for developing competencies. The tutor's competencies are crucial, and they warn that basic help systems should be developed in order to allow instructors to have an accurate view of learners' activities, so that they can monitor them. Finally, they point out a problem that will prove to be persistent insistent: building deep knowledge takes time, more time than the duration of empirical studies about the effects of such simulation systems.

This issue has been raised in many vocational and professional disciplines. One with perhaps the most experience in simulation is medicine. There, many forms of simulations are performed, with various degrees of realism, from standard patients to unsophisticated or very sophisticated high fidelity patient simulators. In a review published in 2006, Paul Bradley remarks that the dichotomy between low and high fidelity is illusory and that simulation should better be considered "as a continuum with roles to fulfill at all levels of seniority within and between professional groups" (Bradley, 2006). He also remarks that current literature on the effects of simulation have a low-level evaluative nature.

4.2.3 The question of knowledge about the use of computer tools

An important issue is the *knowledge* of students and trainees about the use of computer tools, since specialised computer applications have now become pervasive. It is widely acknowledged that these applications require a degree of understanding of the functions that are applied and, generally speaking, a technical culture in the field of informatics. The question is to devise ways of transmitting this culture.

Regarding students, the French government has manifested since the eighties a determination to develop students' competencies in the field of informatics and the Internet. All sectors have been implicated, including vocational education. The institutional response has been to launch specific certificates at the various levels for all students and to introduce specific new contents in technical fields. But so far no specific new discipline in informatics has been created in secondary education (Baron & Bruillard, 2011).

Of course, these initiatives have raised the issue of teacher and trainer training. This is illustrated by Bernard Blandin (2004), in the case of apprentices' trainers in the maintenance field. He analysed the case of a specific scheme spanning several years, launched in 2000 by the institution in charge of collecting professional tasks for automobiles, ANFA[9]. This scheme, designed on a systemic basis, involved not only trainers in apprentice training centres, but also administrators and used an alternation of presence training and distance activities (this would now be called "hybrid learning"). A key element was familiarising trainers with digital tools they were not familiar with, so that they could afterwards use them with students. Results showed that training had effects on trainers' uses insofar as they developed pedagogical sequences using new technologies such as slides in order to project courses. These results also showed that trainers' uses are focused on a transmissive pedagogy.

Since 2005, some certificates for all teachers were developed in order to render pre-service teachers able to later use ICT tools in their teaching, not so much from a technical point of view but from a didactic perspective. For example, a scheme called C2i[10] was developed for all secondary schools, for apprentices and vocational students. We have not found research data on their efficiency. But it may be remarked that C2i does not pay much attention to issues linked with the core of informatics: programming processes.

5. Discussion

Finally, research on the use of resources in the field of vocational education and training in automobile maintenance remains scarce. The references we found are far less numerous than, for example, what has been published about word processing for vocational education in the field of administration and services.

[9] ANFA (*Association nationale pour la formation automobile*): an association created in 1952, which works in partnership with the Ministry of Education, since 1995, in other to propose trainings to teachers in the industrial field and in particular in the automobile maintenance field. This association is in charge of collecting the Tax for apprenticeship and participates to professional regulation meetings in other to actualize certifications and diplomas in the industrial field.

[10] Information and Internet Certificate.

This does not mean, of course, that there has not been much consideration on the topic. Much reflection may be found in various resources that are currently published for teachers. For example, in the REVEA project, a general panorama of resources was established at the end of 2014. It shows that these resources may be classified in several categories, according to the kind of official approval they receive.

1) In the case of vocational and technological education in the industrial field, a set of institutional sites publishes resources acknowledged as pertinent by the Ministry of Education and its regional branches. This is in particular the case for *Eduscol* that offers a space where teachers can leave their own courses or consult those of others. Here, the supervision is given by inspectors. In the domain of automobile maintenance, ANFA, in partnership with the Ministry of Education, manages a website, named *Educauto*[11] proposing official documents (skill bases, annals of exams) and also pedagogical resources such as written courses edited by teachers.

2) It also possible to find less formal websites, where teachers can exchange and consult pedagogical documents. Some of these sites are hosted by local education authorities and directly created by teachers with a certain degree of supervision from inspectors.

3) Furthermore, other more informal websites and content are created by teachers and not supported by any organisation. The same documents are available and they propose some 3D animations and photos. Videos of activities are also published on YouTube in order to explain maintenance steps for particular systems.

An interesting effect of the drive to link education and business practices has been the creation of in-service training schemes aimed at informing teachers about new technological or technical practices. These trainings have different forms and are assured by two important institutions. First, the ANFA proposes thematic sessions whereas firms such as PSA Peugeot-Citroen propose online training. In the first case, all teachers can use the resources obtained during the sessions in order to adapt them to their teaching, since the ANFA recently obtained ownership of all documents designed for training.

In conclusion, in the vocational educational maintenance field, many resources for teaching and learning are available on the Internet but, currently, few studies have studied the issue of resource usage and transformation. It would be

[11] Educauto.org : http://www.educauto.org/

interesting to understand how teachers, as “designers” of pedagogical objects (Bruillard & La Passardière, 2003), search for information in order to prepare their courses, how they select resources and how they use them in class. This is one of the aims of project REVEA. In particular, in a context of changing directives from the national pedagogical authorities, where so many resources are online, it seems interesting to us to study the kind of communities that grow and to analyse the way they operate, depending on the kind of support they receive, from the different stakeholders.

6. References

Anastassova, M. (2006). *L’analyse ergonomique des besoins en amont de la conception de technologies émergente : le cas de la Réalité Augmentée pour la formation à la maintenance automobile* (phdthesis). Université René Descartes - Paris V. Consulté à l’adresse https://tel.archives-ouvertes.fr/tel-00340103/document

Askerøy, E. (2002). CD-ROM as educational text in technical and vocational training. In S. Selander & M. Tholey (Éd.), *New educational media and textbooks The 2nd IARTEM Volume* (Vol. 9, p. 6268). Stockholm: Stockholm Institute of Education Press. Consulté à l’adresse http://www.diva-portal.org/smash/get/diva2:179683/FULLTEXT01.pdf

Baron, G.-L., & Bruillard, E. (2011). L’informatique et son enseignement dans l’enseignement secondaire général français. Enjeux de pouvoir et de savoirs. In J. Lebeaume, A. Hasni, & I. Harlé (Éd.), *Recherches et expertises pour l’enseignement scientifique* (De Boeck, p. 7990). Bruxelles. Consulté à l’adresse http://www.stef.ens-cachan.fr/annur/bruillard/2010_B&B_DeBoeck.pdf

Blandin, B. (2004). Développement de l’usage des TICE et de leur « utilisabilité » dans les CFA du secteur automobile. In *Technologies de l’information et de la Connaissance dans l’Enseignement Supérieur et l’Industrie* (p. 427433). Compiègne, France: Université de Technologie de Compiègne. Consulté à l’adresse https://edutice.archives-ouvertes.fr/edutice-00000680

Bradley, P. (2006). The history of simulation in medical education and possible future directions. *Medical Education*, *40 (*3), 254 262.

Bris, M., & Régnier, A. (1988). L’ordinateur à l’atelier : une application dans l’enseignement de la technologie. *EPI : Ensseignement public et informatique*, 5064.

Bruillard, É., Aamotsbakken, B., Knudsen, S., & Horsley, M. (Éd.). (2005). *Caught in the Web or Lost in the Textbook?*. CRDP de Caen.

Bruillard, É., & La Passardière, B. de. (2003). *Ressources numériques, XML et éducation [Texte imprimé]*. Cachan : Hermes science publ.. Lavoisier. 2003.

Culpepper, P. (2006). Capitalism, coordination, and economic change: the French political economy since 1985. *Changing France: The Politics that Markets Make, Basingstoke: MacMillan Palgrave*, 29–49.

Dauga, B. (1989). Dessin assisté par ordinateur en lycée professionnel. *Bulletin de l'EPI (Enseignement Public et Informatique)*, (56), 119131. Consulté à l'adresse https://edutice.archives-ouvertes.fr/edutice-00000946/document

Galaup, M. (2013, mai 27). *De la conception à l'usage d'un jeu sérieux de génie mécanique : phénomènes de transposition didactique dans l'enseignement secondaire et universitaire : le cas de Mecagenius®* (phdthesis). Université Toulouse le Mirail - Toulouse II. Consulté à l'adresse https://tel.archives-ouvertes.fr/tel-00877257/document

Hamon, C. (2012). *Des enseignements techniques aux sciences de l'ingénieur : Analyse didactique et historique du processus de disciplinarisation depuis la libération*. Paris Descartes. Consulté à l'adresse Université Paris Descartes.

Høye, M. (2002). The status of educational texts in a vocational learning process. In S. Selander & M. Tholey (Éd.), *New educational media and textbooks The 2nd IARTEM Volume* (p. 6975). Stockholm: Stockholm Institute of Education Press. Consulté à l'adresse http://www.diva-portal.org/smash/get/diva2:179683/FULLTEXT01.pdf

Lembré, S. (2013). *L'école des producteurs : aux origines de l'enseignement technique, 1800-1940* (Presses universitaires de Rennes, Vol. 1–1). Rennes.

Moeglin, P. (2005). The Textbook and after... In É. Bruillard, B. Aamotsbakken, S. Knudsen, & M. Horsley (Éd.), *Lost in te Web or caught in the textbook* (p. é863). Caen: CRDP de Basse Normandie.

Navet, N., Song, Y., Simonot-Lion, F., & Wilwert, C. (2005). Trends in Automotive Communication Systems. *Proceedings of the IEEE*, *93 (*6), 12041223. http://doi.org/10.1109/JPROC.2005.849725

Ndoumatseyi Botongoye, L. (2007). Simulateurs et apprentissage : quelles difficultés pour les élèves de maintenance de véhicules automobiles ? Présenté à JIES XXVIII, A. Giordan, J.-L. Martinand & É. Triquet. Consulté à l'adresse http://artheque.ens-cachan.fr/items/show/3049

Pelpel, P., & Troger, V. (2001). *Histoire de l'enseignement technique* (Vol, 1). L'Harmattan Paris : Budapest : Torino.

Pinheiro, A., Fernandez, P., Maia, A., & Cruz, G. (2012). Development of a mechanical maintenance training simulator in opensimulator for F-16 Aircraft engines. *Procedia Computer Science*, *15*, 248255.

Prevost, J. (1989). La rétroaction de l'informatique sur les métiers. Quelles conséquences pour les formations ? In G.-L. Baron & J. Baudé (Éd.), *L'intégration de l'informatique dans l'enseignement et la formation des enseignants* (EPI-INRP). Paris. Consulté à l'adresse http://epi.asso.fr/revue/dossiers/d12p062.htm

Prost, A. (1983). Les lycées et leurs études au seuil du XXIe siècle. Rapport du groupe de travail national sur les seconds cycles. *Centre national de documentation pédagogique*, 288.

Samurçay, R., & Rogalski, J. (1998). Exploitation didactique des situations de simulation. *Le travail humain*, *61 (*4), 333359.

Tanguy, L. (2013). Apprentissage en entreprise et formation professionnelle en école : une mise en perspective des années 1950 aux années 1990. *Revue française de pédagogie*, (183), 2737. http://doi.org/10.4000/rfp.4153

Terral, H. (2009). *Éduquer les pauvres, former le peuple : généalogie de l'enseignement professionnel français*. Paris: L'Harmattan.

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Annex:

a) Sources for the Internet research

Academic search premier	Base	Multidisciplinary
Arthèque	Base	Multidisciplinary
Cairn	Base	SHS
Computers and education	Review	SHS
Computers and Industrial engineering	Review	
Computers in Industry	Review	
Curriculum journal	Review	Didactics

Educational Technology research and development	Review	SHS
Ergonomic abstract	Base	Ergonomy
Eric	Base	SHS
Empirical research in vocational education and training	Review	SHS
Francis	Base	SHS
HAL : Hyper articles en ligne	Base	Multidisciplinary
Journal of curriculum studies	Review	Didactics
Journal of educational technology and society	Review	SHS
Journal of vocational education and training	Review	SHS
JSTOR	Base	Multidisciplinary
OpenEdition Freemium	Base	SHS
Persée	Base	Multidisciplinary
ProQuest Sociology	Base	SHS
PsycArticle	Base	Psychology
PsychInfo	Base	Psychology
Psychology and behavioral sciences collection	Base	Psychology
PubPsych	Base	Psychology
Sciences direct	Base	Multidisciplinary
Springerlink	Base	Multidisciplinary
TEL : Thèse en ligne	Base	Multidisciplinary
Thèses de l'Université Paris Descartes	Base	Multidisciplinary
Thèse.fr	Base	Multidisciplinary
TIC et SOCIETE : technologies de l'information, de la communication et société	Review	SHS
Web of science	Base	Multidisciplinary

b) Specific references selected about resources in industrial education

Name	Type	Domain
Academic search premier	Base	Multidisciplinary
Arthèque	Base	Multidisciplinary
Cairn	Base	SHS
Computers and education	Review	SHS
Computers and Industrial engineering	Review	
Computers in Industry	Review	

Curriculum journal	Review	Didactics
Educational Technology research and development	Review	SHS
Ergonomic abstract	Base	Ergonomy
Eric	Base	SHS
Empirical research in vocational education and training	Review	SHS
Francis	Base	SHS
HAL : Hyper articles en ligne	Base	Multidisciplinary
Journal of curriculum studies	Review	Didactics
Journal of educational technology and society	Review	SHS
Journal of vocational education and training	Review	SHS
JSTOR	Base	Multidisciplinary
OpenEdition Freemium	Base	SHS
Persée	Base	Multidisciplinary
ProQuest Sociology	Base	SHS
PsycArticle	Base	Psychology
PsychInfo	Base	Psychology
Psychology and behavioral sciences collection	Base	Psychology
PubPsych	Base	Psychology
Sciences direct	Base	Multidisciplinary
Springerlink	Base	Multidisciplinary
TEL : Thèse en ligne	Base	Multidisciplinary
Thèses de l'Université Paris Descartes	Base	Multidisciplinary
Thèse.fr	Base	Multidisciplinary
TIC et SOCIETE : technologies de l'information, de la communication et société	Review	SHS
Web of science	Base	Multidisciplinary