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Emerging Technologies landscape Report v1

SEVENTH FRAMEWORK PROGRAMME

HoTEL Holistic Approach to Technology Enhanced Learning

Innovators – Opinions – Perspectives

WP1 | D 1.1.2

Emerging technologies landscape: Report on Field Research results

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Executive summary

The HoTEL Support Action aims to contribute to more effective, holistic and faster innovation cycles in European Technology Enhanced Learning (TEL), by increasing quality at the level of the cycle itself and of the different phases foreseen, that can be replicated in the future. Taking inspiration from the "Deming Cycle" model (Plan/Do/Check/Act) the HoTEL project focuses on the design, testing and validation of a new innovation working method for TEL (the HoTEL Innovation Cycle).

In particular the WP1 activities are aimed at getting an overview of the technologies (already in use, successfully piloted/emerging) that are believed to have an impact (or to have a potential impact) on learning in the coming decade.
This deliverable presents the first Emerging technology landscape report as outcome of the critical analysis of the emerging technologies identified by desk and field research. And it represents the stepping stone for the development of activities of Wp3, Wp4 that will eventually contribute to the definition of the HoTEL Innovation Cycle. It is also expected that results from WP4 will be used to further update the contents of the Emerging technology landscape.

This report firstly includes the identification and clustering of the most researched technologies within the European Union, the analysis of the areas of learning where these technologies can be applied, and also the evolution of the research over the last years. Secondly it spots generic ICT that can be –among other uses- also utilised for supporting learning and specific technologies and applications specially designed to support/enhance learning in one of the three contexts targeted by the project. And thirdly, it presents the results of the assessment of the relevance of those technologies and their possible impact on the learning practices in each of the educational sectors addressed by the project. Such analysis also took into consideration the visions exposed in the interviews with 24 experts in different technological areas and in Technology Enhanced Learning.

The current report is a living document that will be further updated in M18 taking into consideration the feedback to be provided by the results of the Learning Lab Exploratoria.

Acknowledgements

The researchers involved in the creation of this report, specially thank all experts who dedicated part of their time to participate in the interviews and contribute to this research with their meaningful insights about the technologies under assessment. The list of interviewees is presented in the Annex 5.

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Introduction

Innovation happens in three distinct phases: 1) emergence, 2) incubation, and 3) industrialisation of ideas in form of applicable technologies and their mainstream adoption. In addition to the number of ideas created in the first phase, a critical success metric is the reduction of the time to move ideas from phase one to the two later phases. In the case of innovation in TEL that critical success metric is seen as the effectiveness and mainstreaming of new ways of using ICT to support learning within reasonable time considering the different speeds of evolution between technologies and learning practices. And this is one of the final endeavours of the HoTEL project through the design of an innovation cycle to speed up the mainstreaming of new relevant and meaningful ways to use technologies for learning purposes[1].

Inspired by the "Deming Cycle" model (Plan/Do/Check/Act), the HoTEL project focuses on the design, testing and validation of a new innovation working method for TEL (the HoTEL Innovation Cycle). The project selected three educational sectors, Higher Education (HE), Workplace Learning (WPL) and Informal Learning within Professional Networks (ILPN), to validate the innovation cycle to be defined in real life environments and to provide the TEL community with concrete examples of how the cycle works to facilitate its broader adoption.

To be in a position of designing the HoTEL innovation cycle, WP1 "Emerging Technologies landscape" aims at getting an overview of the technologies (already in use, successfully piloted or emerging) that are believed to have an impact (or to have a potential impact) on learning processes in the three previously presented educational sectors. Accordingly, the work carried out in WP1, presented in this document, was divided in two main tasks: desk research and field analysis.

The desk research focused on technologies that support already existing forms of learning, and also on technologies that enhance new learning paradigms. Already adopted and successfully piloted technologies have been considered in the study, with the main goal of identifying the emerging technologies that will be part of the educational landscape in the near future. The desk research analysed the work produced in the frame of FP6 and FP7 programmes, in the area of Information and Communication Technologies (ICT)[2], other EU funded programmes and by specialised institutions and agencies such as the Institute for Prospective Technological Studies (IPTS) and The New Media Consortium (NMC).

[1] Project objectives description in the HoTEL DoW Part B, page 3

[2] The equivalent in FP6 is IST (Information Society Technologies). This document uses ICT to refer both FP6-IST and FP7-ICT.

Meanwhile, the field analysis focused firstly on spotting emerging generic ICT that can be –among other uses- also utilised for supporting learning and specific technologies and applications specially designed to support/enhance learning in one of the three contexts targeted by the project. Secondly, the analysis focused on the assessment of the relevance of those technologies and their possible impact on the learning practices in the different educational sectors targeted by the project. This study was carried out through a consultation based on Interviews to 24 experts in different technological areas and in Technology Enhanced Learning.

This deliverable presents the first Emerging Technology landscape report as outcome of the critical analysis of the emerging technologies identified by desk and field research. The document is structured as follows:

Chapter 1 *Methodology* describes the methodological approach used to perform both research activities. In the case of desk research, it includes the data sources, the filtering criteria, the tools and details about the analysis performed. For the field analysis, it includes a description of the sources of information and criteria used to select a set of technologies to be analysed in the experts' consultation and the details about the process of preparation and execution of the interviews.

Chapters 2, 3, 4 and 5 describe the Emerging Technologies landscape resulting from the different perspective analysis considered in the investigation carried out by the desk and field research.

Chapter 2 *Trends in Technology enhanced learning* presents an analysis of the evolution of the research over the past years according to the sources consulted in the desk research.

Chapter 3 *Technology clusters* identifies and clusters the most researched technologies within the European Union based on the desk research analysis.
Chapter 4 *Areas of learning* includes the analysis of the areas of learning where the technologies identified in Chapter 3 can be applied.

Chapter 5 *Emerging technologies analysis* presents the study of the 30 selected technologies according to technology clusters identified in Chapter 3 and the information gathered in the different interviews. Such analysis examines each technology in terms of its relevance for each of the targeted educational sectors (HE, WPL and ILPN), its potential for supporting new learning practices in those sectors and the factors which represent barriers and facilitators for their broadly adoption.

Chapter 6 *Conclusions* summarises the findings of the desk research and field analysis. It also describes the contributions to the designing process of the HoTEL innovation cycle.

1. Methodology

This chapter describes the methodology followed to carry out desk and field research activities that aimed at providing an overview of the emerging technologies landscape.

Teams involved in the desk and field research deployed activities in parallel. Such approach allowed us to cross-check whether similar results were obtained when running those research processes independently. In this case we obtained convergent outcomes which are presented in the next chapters.

Next sections in this chapter present an overview of the methodology followed to conduct both research activities. Firstly the desk research methodology is presented: It includes data sources, the filtering criteria, the tools and details about the analysis performed. Secondly the methodology for field analysis is defined: It includes a description of the sources of information and criteria used to select a set of technologies to be analysed in the experts' consultation and the details about the process of preparation and execution of the interviews.

1.1 Desk research

The desk research focused on technologies that support already existing forms of learning, and also on technologies that enhance new learning paradigms. Already adopted successfully piloted technologies were considered in the study, having the main goal of identifying the emerging technologies that will join the educational landscape in the near future.

Being one of the goals of desk research the identification of already adopted technologies for learning, we have reviewed the existing literature in order to identify those aspects of TEL that are considered as effectively adopted or planned to be adopted in the near future. In particular, we have focused on studies from IPTS, who gathered their information from expert workshops, field consultations and desk research. Thus, they provide a complete view of the current state of TEL in European countries.

Another goal of desk research was to identify those technologies that will impact education in the near future. For this purpose, we have used two different information sources. First, the analysis of the EIT research areas which provides a brief overview of the research priorities in the European Union. Second, the analysis of the different editions of the Horizon Report (i.e. Higher education, K-12 and museums) shows what the New Media Consortium selected as the most relevant technologies for the future of learning.

1.1.1 Data sources

The desk research aimed at identifying technologies enhancing new forms of learning, specially focusing on the research carried out in the frame of EU funded programmes. However, for the elaboration of this document we have also considered other information sources.

In particular, we have analysed the EU research projects funded by the FP6 and FP7 programmes, and also studies and reports from the Institute for Prospective Technological Studies, the Gartner Group and the New Media Consortium.

FP6 and FP7 projects

As stated in [13], the CORDIS repository stores information about research projects funded by the European Union. The projects involve the participation of several European research institutions such as commercial organisations, research institutes and universities. The CORDIS repository stores the project information once the agreement has been signed, and, if there is a change in the contract, updates the stored information upon specific request. The records remain in the repository after the project has ended. Not all projects contain the same set of information fields. However, there is an overall homogeneity that allows bulk retrieval and classification of projects information. The information stored at CORDIS is populated by the EC Directorates-General and Agencies responsible for the projects. That is, contains information of projects from FP4, FP5, FP6 and FP7. CORDIS contains information of very different research fields, where educational technologies appear as a subtopic of ICT.

FP6 and FP7 Networks of Excellence

Information about Networks of Excellence (NoE) is stored and structured at CORDIS in the same way as in the case of the projects. However, a NoE project should not strictly be considered as a research project. NoEs are designed to strengthen scientific and technological excellence on a particular research topic through the durable integration of the research capacities of the participants. They aim to overcome the fragmentation of European research by gathering the critical mass of resources and gathering the expertise needed to provide European leadership. NoEs also have to spread excellence beyond the boundaries of its partnership and must include a training component in the frame of their spreading of excellence activities.

Institute for Prospective Technological Studies

The Institute for Prospective Technological Studies (IPTS)[3] is one of the seven scientific institutes of the European Commission's Joint Research Centre (JRC). The

[3] HoTEL got access to the in-progress results of the MATEL study, which is formally ending at the time of this writing but an official report has not been published yet.

mission of IPTS is to provide customer-driven support to the EU policy-making process by developing science based responses to policy challenges that have both socio-economic as well as a scientific or technological dimension. The Institute's work programme, based on "Actions" (or macro-projects), cover the fields of research policy and techno-economic foresight, sustainable development, industrial and clean technologies, energy, transport, agriculture and rural development, and the information society. For the sake of this desk research we have focused on actions in the field of information society, within the subtopic "ICT applications for society". The studies carried out by the IPTS lead to the publication of reports, which are focused on specific scientific and technical issues. These reports are publicly available for consultation (about 700 available reports), being some of them quite aligned with the goal of this desk research. Therefore, they have been considered as one of the sources for our analysis.

The New Media Consortium

The NMC (New Media Consortium)[4] is a renowned international community of interest in educational technology. It constituents are experts, practitioners, researchers and visionaries concerned about the future of learning. The NMC helps driving innovation in the use of TEL for universities, colleges, museums and organisations. Part of the work in NMC is founded on the idea that regular communication enables and catalyses discussion among the different stakeholders, at the time that engages them in research. Currently, NMC hosts three different initiatives aimed at answering the following questions:

- Dynamic Knowledge Initiative: How can technology drive the formation of new knowledge, expand dialog, and fuel the exchange of ideas?
- Emerging Technology Initiative: How can the NMC and its members keep abreast of emerging technologies that may be important to our collective work?
- New Collaborations Initiative: How can we leverage the work of learning organisations outside our usual spheres to inform and enhance our own work and reach new audiences?

For the sake of the HoTEL research, we have considered the information offered by the *Emerging Technology Initiative*, which produces the most popular report offered by NMC: the Horizon Report. Annually published, the Horizon Report is "*a decade-long research project designed to identify and describe emerging technologies likely to have an impact on learning, teaching, and creative inquiry in higher education*". A full list of the reports consulted is available in the Reference section of this deliverable.

[4] http://www.nmc.org.

1.1.2 *Selection criteria for desk research*

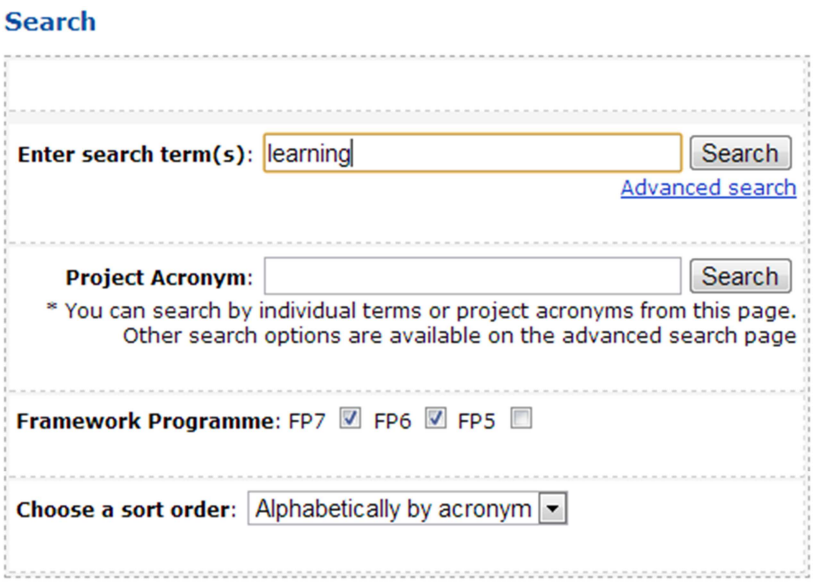
FP6 and FP7 projects and NoEs

The research is based on the public information of accepted research projects, which is offered by the Community Research and Development Information Service (CORDIS). All the information used in this analysis has been retrieved from: http://cordis.europa.eu/fp7/ict/projects/home_en.html.
The CORDIS search engine provides access to 1174 and 1786 different projects from FP6 and FP7. From them, we have selected those particularly interesting in the field of Technology Enhanced Learning.

As the search criteria, we used the simple search interface (see Figure 1) as follows:

- Search terms: education, TEL, learn, learning, teaching, train, training, school
- Project Acronym: (left empty)
- Framework programme: FP6 and FP7 checked.
- Sort order: by acronym.

Figure 1. *Simple search interface for ICT projects*



The following table shows the number of projects found with the different search terms.

Table 1. *Projects found with the different search terms*

Search term	FP6 results	FP7 results
Education	391	259
Learn	34	46
Learning	140	222
Teach	2	2
Teaching	19	21
Train	11	26
Training	185	184
School	51	66

We reviewed the description of the found projects and discarded those that did not fit with the desk research goals. For example, the *3D VIVANT* project was in the results set, but it was discarded because it is not directly related to education. After this manual review, 102 projects were selected. The collection of 102 projects used for this desk research contained 7 Networks of Excellence. They were also considered for the purpose of this study, and are discussed in Section 3.12.
In a second review round, we reviewed the project descriptions with more detail and assigned several keywords to each project. More details about the keywords assignment are given in section 1.1.3. As we read the project descriptions more carefully than in the previous round, some more projects were discarded in this second round. The 86 projects considered in this study are listed in Annex 2.
After the creation of the thesaurus (see Section 1.1.3 for details), a final review of its contents was done and we manually assigned metadata. In this final round, the spontaneous keywords initially assigned to the projects were translated into the formal terms stated in the thesaurus. Also, the keywords were formally divided into two groups: researched technologies and area of learning for the application of such technologies.

Institute for Prospective Technological Studies

The reports elaborated by the IPTS are publicly available for consultation (about 700 available reports), being some of them quite aligned with the goal of the HoTEL desk research. From all the available reports, we have focused on those regarding ICT and Educational Technologies. Therefore, we have filtered the number of documents by applying the criteria described as follows:

- Using the search engine provided at the web page [22], we have restricted the reports to those matching the keyword "ICT".

- Then, we have manually reviewed the project descriptions, and we have selected those that explicitly mention education.
- Finally, we have reviewed the reports given the summary of e-Learning related projects [23] and added them to our selection.

A complete list of the reviewed documents is given at the References section.

The New Media Consortium

The New Media Consortium elaborates yearly reports, focused on different learning areas. In particular, they produce reports for higher education institutions, for K-12 education and, since 2010, for museums. These reports analyse and predict the ICT use at institutions at the United States. However, such predictions are quite aligned with the research that is being performed in European countries. For this reason, we included the NMC reports as another source of information of this study. In this desk research, we have used the NMC Horizon Reports to analyse trends and predictions on ICT and education. Having that, it would have been useless to consider old reports whose predictions refer to past years, and therefore are already deprecated. Accordingly, we considered the reports at the three mentioned categories (higher education, K-12 and museums) since 2009. A complete list of the reviewed documents is given at the References section.

1.1.3 Analysis

Taking into consideration the sources of information consulted in the desk research the analysis was conducted in two strands: the existing projects and the reports predicting the use of ICT in Education. Next both analysis approaches are explained.

FP6 and FP7 projects

For each of the 86 selected projects, the following information fields were considered:

- Acronym
- Title
- Status
- Start-End date
- Programme acronym
- Subprogramme area
- Contract type

- URL at CORDIS
- Subjects
- Description
- Manual keywords (see below)

It was the authors' opinion that the *Subjects* field, available at the CORDIS site, does not offer sufficient information of the project's research topics. For example, the ELEKTRA project aims at the development of an educational game, which is hardly outlined by its subjects (education, training - information processing, information systems - telecommunications). Thus, the first task was to obtain a more descriptive set of keywords to summarise each project topics. The task was manually done by the authors: first, reviewing the project description; second, writing keywords that match with the description. A combination of the identified terms with the terms extracted from the IPTS and NMC reports resulted in the elaboration of a thesaurus that guided the classification of the research areas.

The selected terms included technologies (e.g. virtual environments) and application fields (e.g. workplace learning). Note that the manual nature of the keywords selection could have introduced an involuntary bias on the study. During the analysis of the different sources of information, a number of technologies have been identified. In some cases, the same technology was mentioned using different terms. In some other cases, different technologies are related among themselves so that they can be clustered in research areas. With all the identified terms and technologies, we have elaborated a thesaurus that classifies them by research areas, find synonyms and allows for a more systematic analysis.

The thesaurus has been created as follows:

- First, the descriptions of the all the selected FP6 and FP7 projects were manually reviewed. The reviewer assigned keywords to those projects. The directives to keyword assignment were:
    - The assigned keyword must identify those technologies used in the project.
    - Identify both main and secondary technologies used in the project.
    - Identify the area of learning where the technologies are applied.
    - Do not use a pre-defined set of keywords, be spontaneous.
- Second, the IPTS and NMC reports were reviewed, writing down the technologies mentioned in the reports. The names of these technologies were collected as they appeared in the documents.

- Synonyms were identified from all the keywords collected at the previous steps. This step reduced the number of available terms and translated the spontaneous keywords, assigned in the first step, into a collection of more formal terms.
- Related technologies and areas of learning were grouped into clusters. The creation of the clusters was guided by the research areas identified in all the reviewed documents and the expertise of the authors of the desk research.

The thesaurus, shown in Chapter 8 has been used for the classification of FP6 and FP7 research projects, as presented in Section 2.3. It is divided in two main categories (technologies and areas of learning), which are divided into subcategories (above referred as clusters). Each cluster contains a collection of keywords related to the subject.

NMC and IPTS reports

All NMC Horizon Reports follow the same structure: they choose six different technologies and classify them by the expected time for adoption. Three classifications are available: "one year or less", "two to three years" and "four to five years". For each identified technology, the report includes an executive description, a discussion of its relationship with education, and a collection of examples that uses technology in the educational field. For the purpose of this desk research, we have compiled all the identified technologies in the reviewed reports, also considering its field of application (given by the report in which they appear) and the time period on which the prediction was made.

The IPTS reports do not follow such a fixed structure and the way the information is there presented depends on the specific objective of the report and the project that frames the document. Thus, it is not possible to extract the information from these documents with the methodological approach adopted in the case of NMC. Due to such difficulty, and considering the nature of IPTS reports, they have been used to collect which technologies they mention. In other words, to determine which technologies were considered relevant for their studies.

Information collected from both NMC and IPTS reports were used in Chapter 0, to analyse research trends in the TEL field, and to perform a time based analysis of the TEL predictions.

All compiled information was analysed from different perspectives, as follows:

- **Trends in technology enhanced learning** - The IPTS and NMC reports were reviewed to determine which technologies are being researched in TEL. The analysis is presented in Chapter 0.

- **Clusters on researched technologies** - Different clusters were identified depending on the used technologies. We analysed the total number of funded projects, funded projects by year, application fields and pursued goals. Also the time- based analysis was conducted taking into consideration how the number of funded projects, involved technologies, application fields and pursued goals evolved on time. The detailed analysis is presented in Chapter 0.
- **Areas of learning** - For each area of application in the Education, we analysed the total number of funded projects, funded projects by year, involved technologies and pursued goals. The detailed analysis is presented in Chapter 3.12.
- **Networks of Excellence** - The 7 NoEs selected from the CORDIS site are described in terms of involved technologies in Section 3.12.

1.2 Field research

Field research in the initial phases of the HoTEL project (WP1) was foreseen to include a wide consultation addressing 200 stakeholders in the field of TEL on the emerging technologies for learning as well as interviews with experts to assess the potential of the identified technologies for learning. However in the project kick off meeting it was agreed by the Consortium that priority would be given to interviews as a first step of field analysis and that the online survey would be launched in a later phase. This was justified by the need to avoid the risk to get a limited number of replies, given that between the time the project was written and the time it was approved many similar online consultations in the field had been launched.

It goes without saying that field research needed inputs by desk research in order to structure and identify respondents to interviews properly and in a meaningful way. In particular, given that interviews had to be launched while the analysis of FP6 and FP7 projects was still on going, an initial agreement was made in relation to the importance of analysing the reports produced by IPTS, Gartner and the NMC Consortium to identify emerging technologies. After such agreement the analysis was carried out independently under with different and complementary perspectives by the responsible partners for desk and field research.

1.2.1 Data sources

Field research aimed at spotting and analysing the relevance and potential impact of emerging technologies (general IT technologies and specific related to educational support) on the learning practices in the 3 sectors targeted by the project.
Consequently, the first part of the research was aimed at localising available sources that could provide us with information about emerging technologies, their maturity and practical applicability to select the set of technologies to be further explored

through the experts' consultation. We found feasible access to the Gartner Annual reports, the MNC Horizon reports and IPTS MATEL study as data sources: the two latter sources supplied information about specific technologies to support educational processes meanwhile the first one was used to gather information about general IT technologies.

Next we present the information retrieved from each of those sources and the criteria used to choose the set of technologies to be analysed.

Gartner Reports

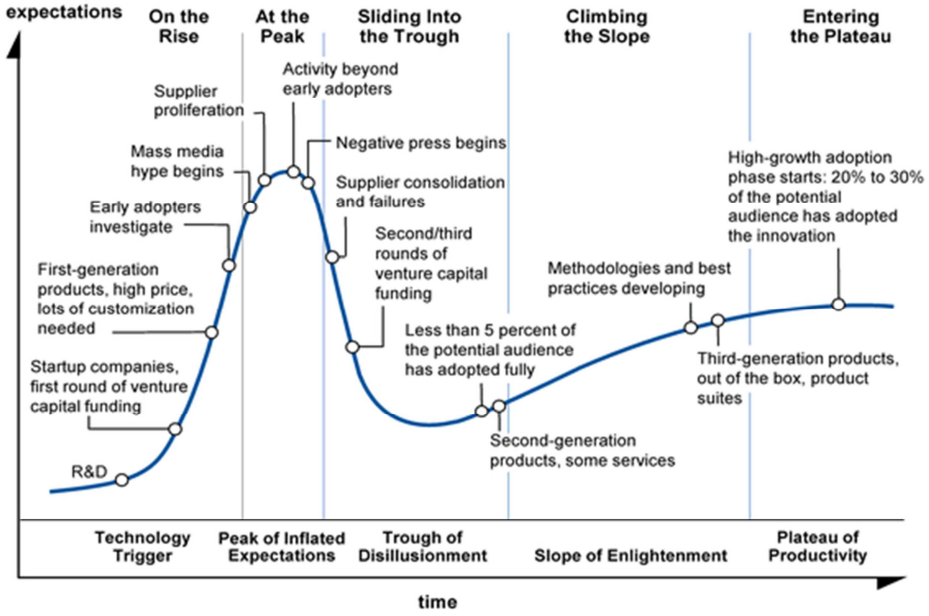
Gartner[5] is one of the world's leading information technology research and advisory companies, which offers technology-related insight services to more than 12,400 clients from distinct organisations: corporations, government agencies, high-tech and telecom enterprises professional services firms and technology investors. One of the most world-wide referenced sources is its Annual Hype Cycle Research Report. The Gartner's Hype Cycle Research Report is an annual maturity assessment study which includes business benefit and future direction of technologies and IT trends. It is published since 2004, although it's Hype Cycle has been used by the company since 1995. The Hype Cycle is used to track technological innovations and visually represent its cycle of overenthusiasm, dashed expectations and eventual maturity that can serve as reference to select which technologies are more appropriated for a specific sector of application and their level of maturity in order to assess the risks and benefits of their adoption.

Innovation adoption does not happen as strait line but follows a predictable S-shaped curve, according to Rogers in [52]. It transits through the different stages of expectations about the real utility and potential impact of the technology as shown in Figure 2:

- High enthusiasm about technology's potential shown within "Technology trigger" and the "Peak of Inflated Expectations" stages.
- Disillusionment with the proliferation of reports on the technology failed implementations and drawbacks of its application in diverse areas in the period represented as the "Through disillusionment" stage.
- Overtime deep understanding of what technology can really achieve in the period between the "Through of disillusionment" and "Slope of Enlightenment" stages.
- Eventual maturity of the technology and beginning of its mainstream adoption represented in the "Climbing the slope" and "Entering in the Plateau of Productivity" stages.

[5] http://www.gartner.com/

Figure 2. *The Hype Cycle Explained [18]*



The Hype Cycle represents the expectation stages in relation to the time as is detailed in the previous Figure: each technology, presented in the Annual report, is positioned in the diagram at certain stage accompanied with data about the prediction of time to reach the "Plateau of Productivity". Its particular contribution is in highlighting the challenge of adopting an innovation during the earlier stages of innovation's life cycle and helps to assess how valuable the innovation (technology) is for an organisation, how mature the innovation is and how good the organisation is tolerating and managing the associated risks. The Hype cycle has been used as working management decision tool tracking thousands of innovations over more than a decade [18].

The Hype Cycle for Emerging Technologies annual editions from 2010 [17], 2011[40], 2012[39] were used in this research as source of information for the selection of a set of emerging and general ICT to be used in the consultation. Also the Hype Cycle for Education 2012 [24] was used to select another set of emerging technologies with some impact in the competitiveness of the educational institutions. All those technologies were further analysed in terms of their possible impact on supporting learning processes in the three sectors targeted by the HoTEL project; and prediction of their adoption in those contexts considering the level of maturity of the technology and the characteristics of each of those contexts.

The New Media Consortium Horizon Reports

The NMC Horizon Project, as it was previously commented in Section 1.1.1 , is the cornerstone of the NMC Emerging Technologies Initiative and its main outcomes are presented through the NMC Horizon reports which chart the landscape of emerging technologies for teaching, learning, research, creative inquiry, and information.

For the field research reported in this document the following NMC reports were used:

- The Horizon report on Higher Education edition 2012[36], Short List 2013[37] and 2013 preview edition [38] provided us with information about a set of emerging technologies, their applications in the higher education environments and data related to piloted experiences for each of the 6 technologies selected by each report edition.
- The Technology Outlook for STEM+ Education 2012-2017 [35]: Some European institutions like *The Centro Superior para la Enseñanza Virtual (CSEV), Departamento de Ingeniería Eléctrica, Electrónica y de Control at The Universidad Nacional de Educación a Distancia* (UNED), and *The Institute of Electrical and Electronics Engineers Education Society* (IEEE) collaborated with MNC in the preparation of this report. It presents relevant developments in the technologies that can provide support for the educational process related to Science, Technology, Engineering, Mathematics and Communication and Digital media technologies (STEM+) over the next five years after the publication of the report. The report explores 12 technologies their possible application to support learning processes in those knowledge areas and the time forecasted for their adoption. The rationale behind the selection of this report as source of information for our study was the similarity of learning experimental needs for the referred knowledge areas in the report and two of the learning sectors targeted in HoTEL: HE and WPL.

Institute for Prospective Technological Studies

The study entitled "Mapping and Analysing Prospective Technologies for Learning"[6] (MATEL)[1] from the Institute for Prospective Technological Studies, was also used as data source for the Field research. The results of this study charted the cluster of top technologies that are expected to support changes in all educational areas in Europe during the next 5 to 10 years. The educational areas covered in the study were Primary Education, Secondary Education, Vocational Education and Training, Higher Education (Formal Education and training), Workplace learning and Reskilling approaches, and Informal learning as part of Long life learning.
The results of the MATEL study were found as suitable data source for the field analysis firstly because the time period of 5-to 10 years from now can be considered as a predictable time for the mainstream adoption of the technology clusters and we consider that was worthy to analyse some technologies included in those clusters considering facilitating and hindering factors for their adoption. And secondly, the use of those clusters of technologies was highly recommended for our study considering that the three educational sectors under research in HoTEL project are specific areas of those covered in the MATEL study: the two first HE and

[6] HoTEL got access to the in-progress results of the MATEL study, which is formally ending at the time of this writing but an official report has not been published yet.

WPL are explicitly considered and the third one ILPN is an special case of the Informal learning as part of Long life learning.

1.2.2 *Selection criteria for field research*

The set of 30 technologies used for the experts' consultation was selected according to the following criteria: the predicted time for their mainstream adoption and the clusters of technologies which are being spotted as trends in the different studies consulted.

Time to adoption
The time forecasted for the adoption of a certain technology can be considered as an indicator of its maturity level. This criterion was used in the field research to differentiate emerging technologies which are in the earlier stages of their innovation cycle and can be consider "less mature" from those technologies having a higher potential to be mainstream adopted since there are plenty of facts showing their utility in different (or at least one) application areas.

In the case of Gartner reports this criterion was applied for the selection of technologies which were presented in the Hype Cycle in the following stages:

- Emerging technologies in the earlier phases of innovation (less mature): Those technologies localised in the following stages "On the rise" when there is the initial proliferation of technology suppliers and "At the peak" when there are some signs of the technology usage beyond the earlier adopters.
- Emerging technologies in the later phases of innovation (more mature): Those technologies localised in the following stages "Sliding into the Through" and "Climbing the slope". In the first one is when there are plenty of technology suppliers and an important number of organisation adopting the technology. Meanwhile in the second one is when there are available second generation of products based on the technology and the number of adopters steadily grows.

The position on the different stages can be somehow fuzzy information, therefore it is important to stress that information about the stage is accompanied by the forecasted time to reach the Plateau of productive (or be mainstream adopted) that gives a more exact idea of the maturity of the technology.

In the case of NMC Horizon reports, the time to adoption criterion was explicitly included and it was classified in three categories that also show the readiness of technology for it mainstream adoption and to some extent its maturity. Those categories are: a) "one year or less" for those technologies more mature and ready to be adopted and b) "two to three years" and "four to five years" for those technologies less mature.

In the case of the MATEL study there was not a distinction of the time of adoption prediction and all clusters were considered to have some relevance in the learning sectors in the next 5 to 10 years.

The reason of selecting emerging technologies with different degrees of maturity for the field research and in particular to choose those 'less mature' is to provide extra information to the WPs in charge of designing the HoTEL innovation cycle. Such type of information will allow to foreseen the possible impact of those technologies on the different learning sectors in advance. That will help to detect which could be the most appropriated conditions for taking advantage of the facilities offered by the technology to support new learning practices in order to check the feasibility of putting in place mechanisms to ensure the reduction of time for adopting the technology in the targeted educational contexts.

Clusters of technologies

The analysis of the impact of a technology on certain application area should not consider the technology as isolated island. Many specific technologies may be associated with a particular strategic technology trend. Some technologies complement others in order to facilitate the successful implementation of technology trend. Some of them can be considered as highly disruptive or an acceleration, shift or tipping point occurring now or during the next few years that will make the set of those technologies newly strategic or wide applicable.

Table 2. *Clusters of technologies in the sources consulted for the field research*

Gartner Trends	MATEL study clusters
Contextual and social user experience (Pervasive Computing)	N/A
Natural interactions	Devices, Interfaces and Connectivity
Personalization	Learner Management Services
Any channel, Any device, Anywhere (BYOD[7])	Devices, Interfaces and Connectivity
Collaboration	Networked Collaboration
Visualizations	Tools for visualization and Simulation
Gamification/Gaming	Games
Next Generation Analytics	N/A
N/A	Contents
N/A	Learning Environments

[7] BYOD: **B**ring **Y**our **O**wn **D**evice

The studies used as source of information for selecting the emerging technologies in some cases like Gartner studies [39,40,17] grouped the technologies in trends meanwhile MATEL [1] listed them in clusters. In the latter case clusters represented aggrupation of technologies with common features that also facilitated the implementation of certain support for teaching/learning processes. In the next table a correspondence between clusters and trends is presented.

1.2.3 Expert consultation

The expert consultation, designed in form of personal interviews, was aimed at gathering expert's feedback in relation to the relevance and potential impact of the selected set of emerging technologies on learning practices in the three sectors targeted by the project.

The consultation was organised in three main stages: selection of technologies to be analysed, identification and selection of experts to participate in the consultation and conduction of interviews. Next we explain each of those stages.

Selection of emerging technologies to be analysed: This process considered the sources of information and the selection criteria presented in the previous section. A preliminary set of emerging technologies were selected from each of those sources. We found some overlapping in the spotted technologies from all sources, especially those considered as "more mature" although there were some variations in their time to adoption. For the selection of "less mature" technologies besides the predicted time to adoption, it was considered their belonging to the technological trends spotted in the Gartner reports. The outcome of this process was the selection of 30 technologies. The list of chosen technologies is presented in the Chapter 9. For each technology a mapping to the clusters identified in desk research with the clusters presented in Table 2 (above) is shown. The set of technologies appears sorted according to the level of maturity and for each technology it's time to adoption forecasted by the different sources is also presented.

Selection of candidates to participate in the consultation: All partners of the project provided us with contact and profile information about the experts they considered as more suitable candidates to be interviewed. A total of 42 candidates were invited to take part on the consultation, from those 24 individuals accepted to participate in the consultation. The list of interviewees is presented in the Annex 5 included in Chapter 12.

Interviews: This process was articulated in two phases: preparation and execution. During the preparation, first we designed a questionnaire to gather experts' insights about the relevance of selected technologies, possible impact and adoption in the different educational sectors targeted by HoTEL. This questionnaire was used as basis of the script used to conduct the interviews. Next, we carried out a matching between the expertise of interviewees and the technologies to be

analysed aiming to maximise the benefits of their participation. The result of this sorting activity is also presented within the table of interviewees included in Chapter 12. The last part of the preparation phase was the design of the recording and transcription procedures. For the execution of the interviews we offer two options to the experts: to participate in a recording session or to provide us with their answers to the questionnaire. The majority of experts chose the first option.

Next chapters present the different aspects of the Emerging technology landscape resulted from the different perspectives analysis carried out by the desk and field research. In particular, Chapter 5 presents the analysis of the 30 selected technologies carried out as part of the field research. Technologies were analysed according to clusters presented in Chapter 3 and the information gathered in the different interviews. Such study examines each technology in terms of its relevance for each of the targeted educational sectors (HE, WPL and ILPN), its potential for supporting new learning practices in those sectors and the factors which represent barriers and facilitators for their broadly adoption.

2. Trends in Technology enhanced learning

2.1 Introduction

This section presents the review of the NMC, and IPTS reports, listed in the Reference section, and the conclusions extracted from them in order to identify the set of trends in technology enhanced learning. The reviewed documents can be classified in three types: reviews of existing technologies (IPTS research reviews), identification of new trends (IPTS reports on trends); and forecasting reports (NMC Horizon reports).

The above mentioned documents were the source of information of the Thesaurus, which was constructed as follows: we reviewed the documents in order to determine if any of the technological keywords of the thesaurus (see Annex 1 in Chapter 7 for details) is mentioned in the documents. If the same keyword appeared more than once, or if a synonym of the keyword was mentioned, the keyword was annotated only once. That is, we annotated whether or not a keyword appears in the document. The result was a list of documents and the technological keywords that appear in them.
Then, we classified the keywords according to their corresponding clusters (subcategories, in the thesaurus). In the following table, each row represents one different cluster, and the different columns represent the document types discussed above. Thus, cells contain the documents that mention the keywords from a certain cluster, belonging to a certain document type.

Table 3. *Mentions to the identified clusters in IPTS and NMC reports*

Clusters	IPTS research reviews	IPTS reports identifying trends	NMC reports identifying trends
Web 2.0 based tools and systems (WEB)	[47] [21] [21] [21] [2]	[46] [46] [46] [46] [33] [33] [33]	[26] [26] [27] [29] [29] [30] [31] [31] [31] [32] [31]
Ubiquitous computing (UC)	[47] [47] [21]	[46] [48] [48] [48] [33] [33]	[25] [26] [27] [27] [28] [28] [28] [29] [29] [29] [30] [30] [31] [31] [32] [32] [36] [36] [36] [33] [37] [31]
Augmented reality (AR)		[46] [48] [33]	[25] [27] [28] [30] [32] [33] [31]
Access-to-content related technologies (CRT)		[46] [48] [33]	[25] [26] [27] [28] [28]
Human computer interaction (HCI)		[48] [33]	[25] [27] [30] [32] [36] [33]
Learning Analytics (LA)		[33] [33]	[25] [26] [36] [33] [37]
Games and Virtual Worlds (GVW)	[47] [21]	[47] [47] [48] [48] [48] [33] [33]	[26] [30] [36] [33] [37] [31]

Environments and technologies for collaboration (CSCL)	[47]	[29] [50]	[26] [31] [31] [31]
Semantic-aware systems (SAS)	[47] [47]	[50]	[29] [32]
Personalized, adaptive technologies (PA)	[47]	[47] [48] [48] [50]	
Other technologies (OT)	[11] [9]	[50] [50] [50]	[25] [33] [37] [37] [31]

Note that cells in the table may contain two or more references to the same document. This is because we placed one reference to the document for each different mentioned keyword. For example, document [28] makes mention to 'digital preservation' and 'electronic publishing', both classified into the CRT cluster. Therefore, two occurrences of the reference to this document appear in the corresponding cell.

If we consider a technology to be more relevant the more occurrences it has in the reports, three different behaviours are expected to appear on the table: first, technologies relevant in past research, but not so relevant in the predictions; second, technologies that are as relevant in the past research as they are in the predictions and third, technologies more relevant in the predictions as in past research.

Technologies relevant in past research, but not so relevant in the predictions. It could indicate that such technologies were relevant in the past, but will not be relevant in the future. The only cluster that might fall in this category is PA, which is mentioned in IPTS predictions but not in the Horizon Reports.

Technologies which are as relevant in the past research as they are in the predictions. In this group we see WEB and SAS clusters. The relevance of web based systems in past TEL research cannot be denied, and the semantic web has counted with the support of the W3C.

Technologies more relevant in the predictions as in past research. Most of the clusters fall in this category. It is worth to mention the cases of LA, AR and HCI. Such technologies have recently appeared in the TEL world, so they receive no mention in past TEL research. Surprisingly, CRT cluster received no mention at all in past research reviews. However, MOOCs and OpenCourseWare will definitively impact TEL research in the future years.

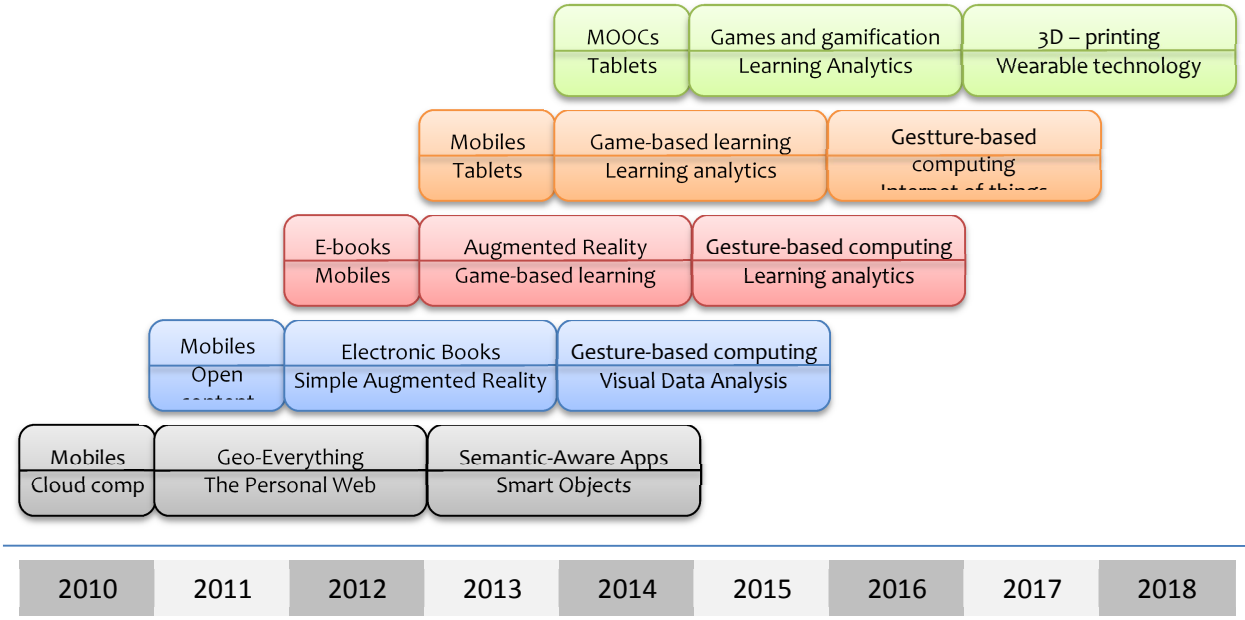
2.2 Time analysis of NMC predictions

In this subsection we have visually represented the predictions made by NMC reports in a time line, in order to show how they evolved over the years. We provide three different figures: one for higher education, another one for K-12 education (the US equivalent to the 'schools' area of learning), and the last one for museums.

Figure 3 shows the predictions for higher education. The following observations can be made:

- Since 2009, mobiles adoption is expected to occur in "one year or less". The prediction is repeated year by year but the goal does not seem to be achieved. In the last two editions of the report, 'mobiles' are being replaced by 'tablets'.
- Learning analytics appeared in the 2011 report and, since then, they are expected to have an impact on higher education sooner or later. The same can be said with games.
- Massive Open Online Courses suddenly appeared in the 2013 report, and are expected to have a clear and immediate impact in higher education.
- The 2013 report introduces new and interesting concepts, such as 3D-printing and wearable technology.

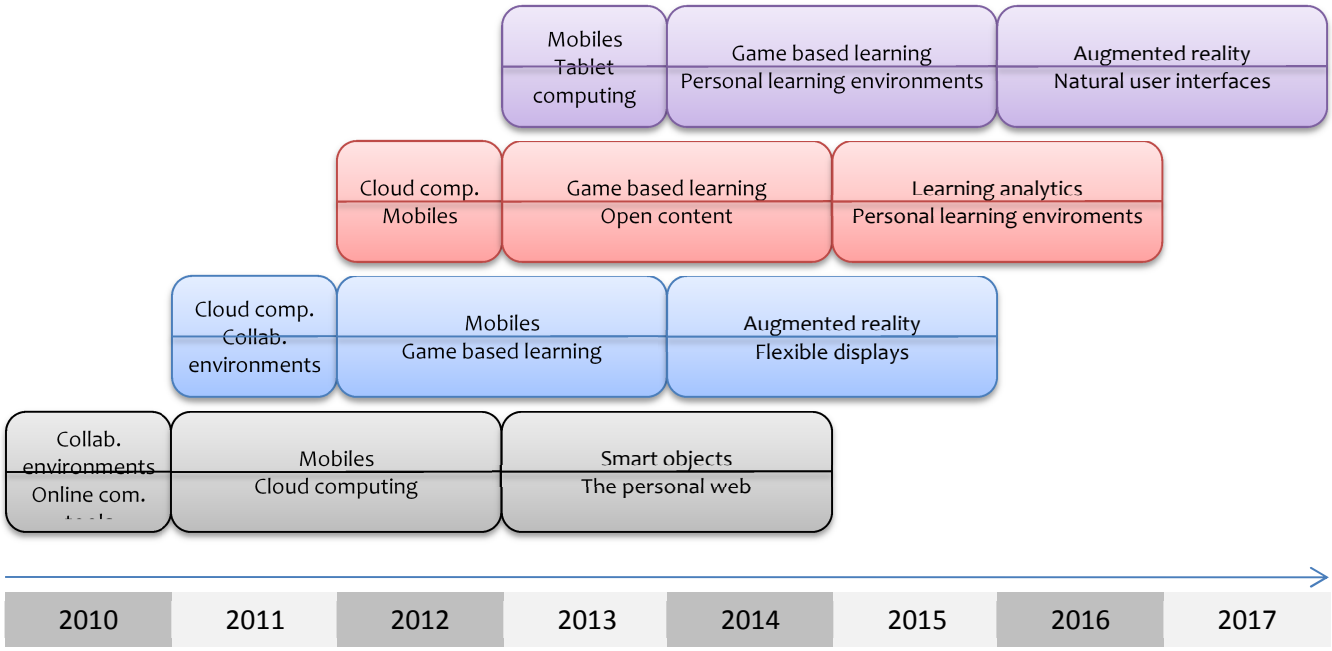
Figure 3. *NMC predictions for higher education*



From Figure 4, which shows the predictions for K-12, the following observations can be made:

- Mobiles are expected to be adopted, but the prediction is less "aggressive" than in higher education. However, it seems to be an always live promise.
- Game based learning is expected to play a relevant role in K-12 education. This is coherent with Section 4.1.

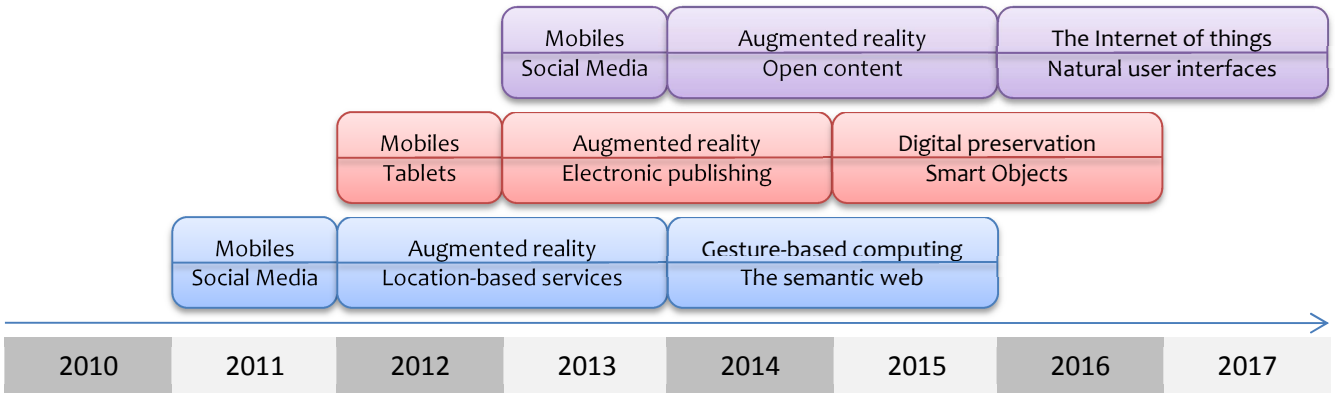
Figure 4. *NMC predictions for K-12*



From Figure 5, which shows the predictions for museums, the following observations can be made:

- Innovative methods to interact with the information are subject of research. Thus, augmented reality, gesture-based computing and natural user interfaces are expected to be adopted in museums. This is consistent with Section 4.4.
- As also happened in higher education and K-12, mobiles are expected to be adopted in the next year (since 2010), but the goal does not seem to get accomplished.

Figure 5. *NMC predictions for museums*



2.3 ICT research at FP6 and FP7

As an introduction of this section, we first provide a quick overview of the topics researched in the projects funded by the European Commission within the FP6 and FP7 programs. After that, we run a detailed cluster-by-cluster analysis, based on the thesaurus presented in Chapter 8: in order to illustrate the quick overview of the involved technologies in the selected projects, two different tag clouds are provided. A tag cloud presents all the words in a given text (excluding common words) and emphasizes the most frequent ones with a bigger size. Such type of representation is useful for quickly perceiving the most prominent terms in a text.

In this desk research, we have created two different clouds. To create the first one, we have created a single text, composed by the text of all the project descriptions, as they appear on the CORDIS web page. The result is presented in Figure 6. It can be seen that the most relevant terms are hardly related with technology, ant it is difficult to identify, at a glance, which are the most relevant technologies or project goals.

To create the second tag cloud we used the manually assigned keywords. Such keywords were selected from the thesaurus and assigned as explained in Section 7. The resulting tag cloud, presented in Figure 7 contains much more technology related terms, and it is therefore more feasible to obtain a quick overview of the most relevant technologies. It can be seen that technologies related to learning games, content management, interfaces, collaborative environments or semantic analysis (just to mention few) are frequent topics in FP6 and FP7 research projects, and therefore play a relevant role in recent research on Technology Enhanced Learning.

Figure 6. *Tag cloud from all the project descriptions*

Figure 7. *Tag cloud from manually assigned keywords*

Table 4. *Most frequent keywords assigned to projects*

Keywords	Occurrences
semantic-aware technologies	11
Games	10
learning management systems	9
collaborative environments	7
social networks	5
human computer interaction	5
context-aware systems	5
personalized content presentation	5
web 2.0	4
personal learning environments	4
learning standards	4
grid computing	4
content repositories	4
augmented reality	4
mobile devices	4

After this quick overview based on tag clouds, a cluster-by-cluster analysis is presented. The following subsections are focused on the specific clusters identified for the purpose of this desk research.

3. Technology clusters

After the identification of the relevant technological terms describing the considered FP6 and FP7 projects, and also the collection of the terms that appear in the IPTS and NMC reports, the related technological terms were grouped into clusters.
The creation of the clusters was guided by the research areas identified in all the reviewed documents and the expertise of the authors of the desk research. That is, after reviewing all the documentation, the authors proposed a set of clusters to group all the identified keywords. Then, each keyword was assigned to one of the groups. In a second iteration, the authors reviewed if the keywords had been properly assigned to the groups, reallocating keywords and splitting groups when appropriate. The process was repeated until the authors agreed in the keywords distribution and the appropriateness of the clusters.

3.1 Web 2.0 based tools and systems (WEB)

The traditional web, based on static HTML pages and no chances for interaction, experienced a big change with the widespread use of technologies that allowed dynamic generation of web content. With such approach, the users became able to interact with the web, easily writing and publishing their own content. Then, the traditional web shifted to the web 2.0. Such change also impacted educational systems, so that learners were able to interact with the content and with peers. The "web 2.0 based tools and systems" cluster refers to those learning technologies whose most typical interface is web based, designed or not for educational purposes.

Table 5. *Keywords for WEB cluster*

Web based tools and systems	
web 2.0	service-oriented
online communication tools	learning management systems
blogs	learning standards
podcasting	interoperability
accessible web content	cloud computing
e-portfolio	grid computing
multimedia content	social networks
web interfaces	social media
widgets	foaf
integration	online communities
distributed open infrastructure	social network analysis
linked data	social software
online applications for teaching	

The collection of all keywords considered to be part of this cluster is presented in Table 5. Table 6 presents the most repeated keywords within WEB projects. A

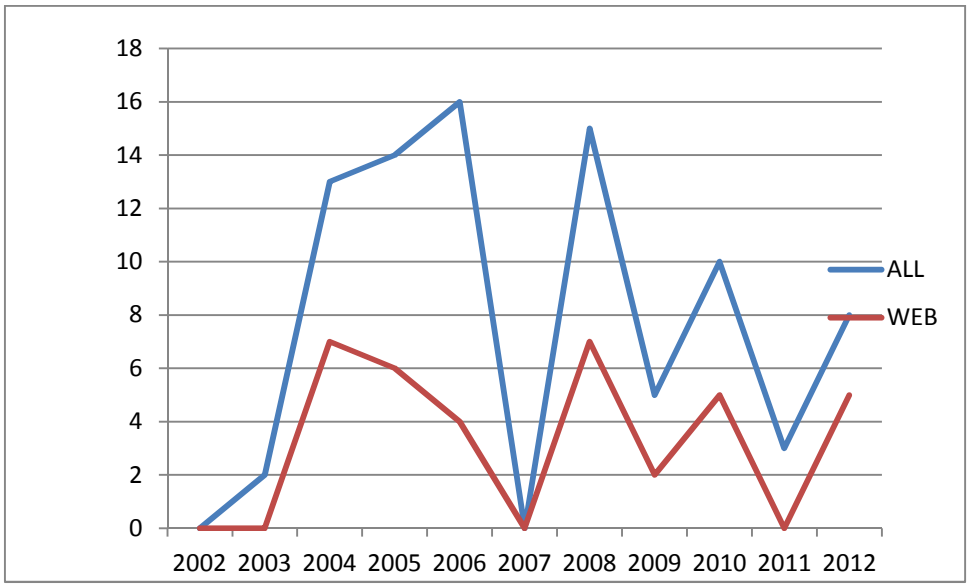
project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The WEB cluster is therefore quite related to SAS (7 occurrences of 'semantic-aware technologies'), UC (4 occurrences of 'mobile devices', 3 of 'context-aware systems'). LA and PA are also related to the WEB cluster. For presentation purposes, the presented list has been truncated.

Table 6. *Most repeated keywords in WEB cluster*

Keywords	Occurrences
learning management systems	8
semantic-aware technologies	7
social networks	5
mobile devices	4
learning standards	4
web 2.0	4
grid computing	4
context-aware systems	3
learning analytics	3
personal learning environments	3
Interoperability	3
collaborative environments	3
content repositories	2
information visualization	2
online communication tools	2
personalized content presentation	2
smart spaces	2
accessible web content	2
online applications for teaching	2
pervasive technologies	2
multimedia content	2
open source content	2

Figure 8 shows the evolution of WEB projects on time. It can be seen that WEB is the most funded technological cluster regarding TEL research.

Figure 8. *Projects of WEB cluster over time*



3.2 Ubiquitous computing (UC)

Ubiquitous (or pervasive) computing refers to a type of human-computer interaction where the information processing is integrated into everyday objects and activities. The term ubiquitous computing was coined by Mark Weiser in 1988, and the topic has received much attention since then. Ubiquitous computing is related to distributed computing, mobile computing, sensor networks, human-computer interaction, and artificial intelligence. There are many ways in which information can interact with people. For example, from a non intrusive perspective, ambient displays may react to events by changing their decoration; another example could be the TV volume automatically turned down when a visit enters the living room.

Ubiquitous learning refers to the support of anytime-anywhere learning. That is, when the specific goal of the ubiquitous technology is to support of the learning process, then we call it ubiquitous learning. Intuitively, this technology fits with informal learning approaches, but also applies to formal learning strategies such as flipping the classroom, or activities involving different spatial locations.

Table 7. *Keywords for UC cluster*

Ubiquitous computing	
ambient intelligence	smart spaces
internet of things	mobiles
smart objects	tablet computing
location based services	mobile apps
ubiquitous computing	mobile devices

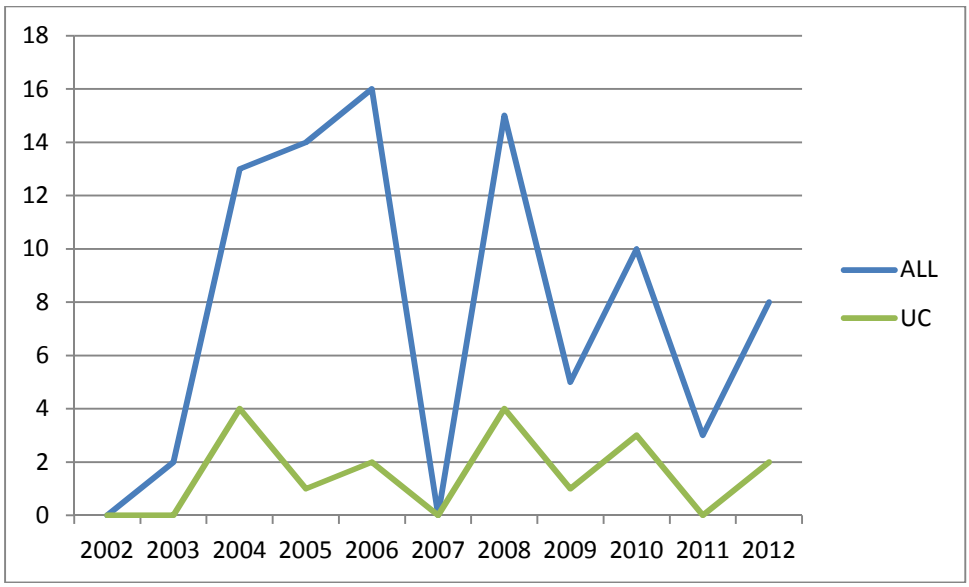
intelligent contexts	mobile learning
pervasive technologies	geo-everything
context-aware systems	creative classrooms
pervasive computing	future classroom

The collection of all keywords considered to be part of this cluster is presented in Table 7. Table 8 presents the most repeated keywords within UC projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The UC cluster is therefore quite related to PA (2 occurrences of 'personalized content presentation') and WEB (2 occurrences of 'social networks'). For presentation purposes, the presented list has been truncated.

Table 8. *Most repeated keywords in UC cluster*

Keywords	Occurrences
context-aware systems	5
mobile devices	4
ubiquitous computing	3
personalized content presentation	2
smart spaces	2
social networks	2
mobiles	2
pervasive computing	2
pervasive technologies	2

Figure 9. *Projects of UC cluster over time*



3.3 Augmented reality (AR)

Our lives are increasingly surrounded by technology, and it is difficult to think of a daily task that is not supported by any device or gadget. We use computers for work and leisure, and we communicate with others with smartphones with a lot of integrated functionalities. In this scenario we can use the displays of our devices to view the real world, but another interesting usage is to augment our view of the real word by mixing such view with elements drawn by the computer. Such mixture of the real world with virtual elements, only visible through the corresponding display, is what we call augmented reality.
Such technology has been exploited in games, e-commerce and also learning. The information that we capture with our senses can be enhanced with augmented reality techniques, with the corresponding impact in the learning process.

Table 9. *Keywords for AR cluster*

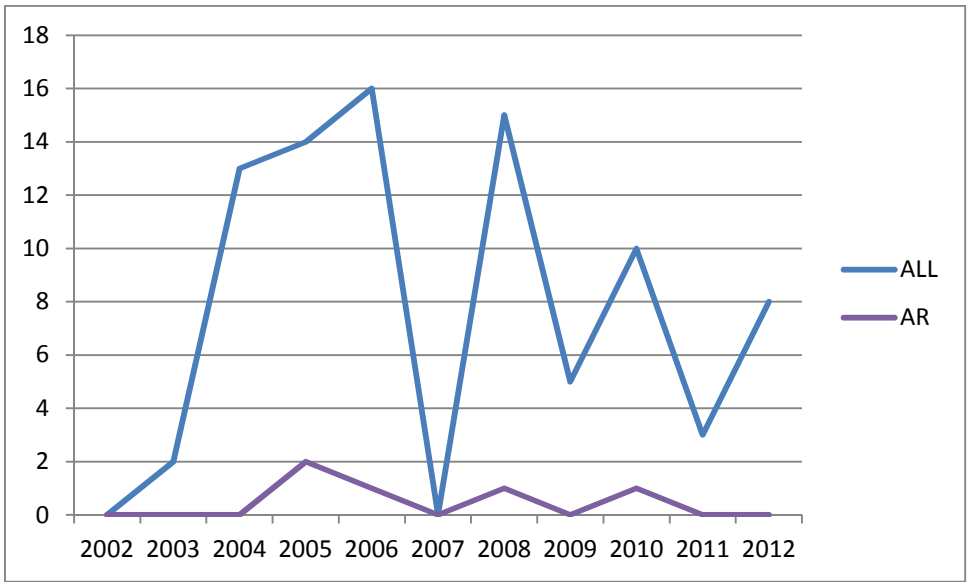
Augmented reality
augmented reality
simple augmented reality
merge virtual and physical worlds

The collection of all keywords considered to be part of this cluster is presented in Table 9. Table 10 presents the most repeated keywords within AR projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The AR cluster is therefore quite related to HCI and GVW.

Table 10. *Most repeated keywords in AR cluster*

Keywords	Ocurrences
augmented reality	4
human computer interaction	2
immersive virtual worlds	1
haptic interfaces	1
gesture based computing	1
simulations	1
merge virtual and physical worlds	1
enriched interfaces	1

Figure 10. *Projects of AR cluster over time*



3.4 Access-to-content related technologies (CRT)

Before the digital revolution that came with the Internet, the production of educational content was hardly affordable by teachers, who used textbooks created and sold by third parties. However, digital content can be easily created and, more important, easily reused. Reusability of learning content increases the efficiency of the authoring process, so the definition of methods for an efficient creation, distribution and use of learning content has been on hot topic in educational research.

Content repositories store large amounts of learning objects, which can be used to compose new, richer, learning objects. Interoperability among repositories enables a more agile distribution of such learning objects. Such agile distribution of content required new copyright strategies, compatible with the surrounding technology. Thus, in 2002 the OpenCouseWare initiative (course lessons created at universities and freely published via the Internet) was launched at the MIT and was soon reinforced by the launch of similar projects at different universities. Also, the Creative Commons license defined the copyleft (as opposed to copyright), that provided legal mechanisms to authors to allow free access to their content. The last step towards such open culture is the MOOC movement (Massive Open Online Courses), which are online courses (not only content) freely offered via the web. MOOC is one of the current buzzwords in educational research.

Table 11. *Keywords for CRTcluster*

Access to Content related technologies	
open source content	digital preservation
massively open online courses	creative commons

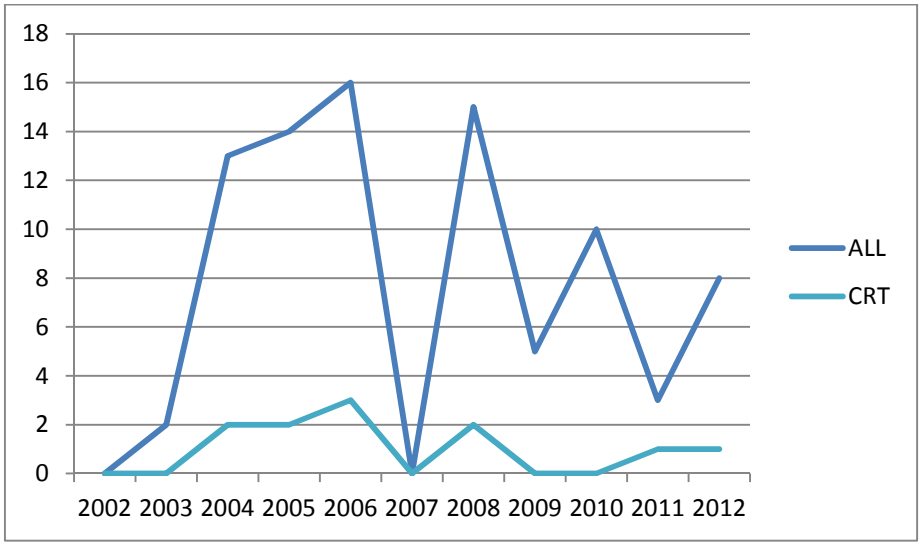
alternative licensing	open courseware
super rich online repositories	content repositories
electronic publishing	content creation

The collection of all keywords considered to be part of this cluster is presented in Table 11. Table 12 presents the most repeated keywords within CRT projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The CRT cluster is therefore related to SAS (2 occurrences of 'semantic-aware technologies') and PA (2 occurrences of 'personalized content presentation').

Table 12. *Most repeated keywords in CRT cluster*

Keywords	Occurrences
content repositories	4
open source content	3
digital preservation	3
semantic-aware technologies	2
personalized content presentation	2
grid computing	2
web interfaces	1
super rich online repositories	1
serious games	1
semantic interoperability	1
learning standards	1
content creation	1

Figure 11. *Projects of CRT cluster over time*



3.5 Human computer interaction (HCI)

Human–computer Interaction (HCI) involves the study, planning, and design of the interaction between people (users) and computers. It is often regarded as the intersection of computer science, behavioural sciences, design and several other fields of study. Strictly speaking, HCI research brings on innovative computer interfaces, including new way of presenting the information and new ways to introduce human's input.

Table 13. *Keywords for HCI cluster*

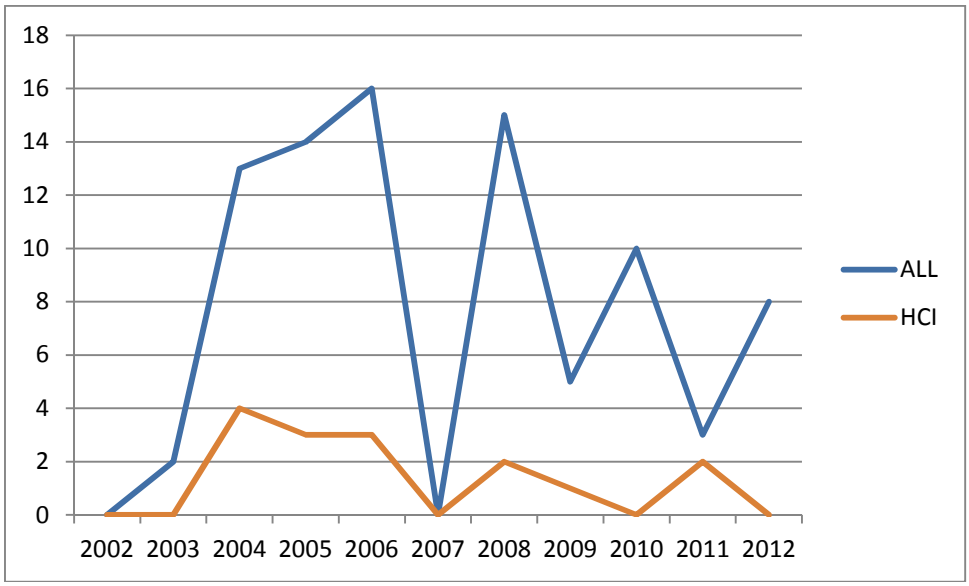
Human Computer Interaction	
human computer interaction	haptic interfaces
gesture based computing	enriched interfaces
natural user interfaces	interfaces
brain-machine interfaces	tactile interfaces
3-d holographic displays	voice interfaces
adaptable interfaces	

The collection of all keywords considered to be part of this cluster is presented in Table 13. Table 14 presents the most repeated keywords within HCI projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The HCI cluster is therefore quite related to AR, with 2 occurrences of 'augmented reality'. For presentation purposes, the presented list has been truncated.

Table 14. *Most repeated keywords in HCI cluster*

Keywords	Occurrences
human computer interaction	5
gesture based computing	3
haptic interfaces	2
augmented reality	2
interfaces	2

Figure 12. *Projects of HCI cluster over time*



3.6 Learning Analytics (LA)

While we interact with computers, we produce large amounts of information that can be stored and processed. The analysis of such information has been used in fields such as e-commerce to determine the customers' personal habits, and vendors use this technique to offer them personal recommendations, usually aimed at increasing the benefits.

As computers enter in the educational world, learners' activities can be traced and stored and this fact enables the use of the abovementioned analysis techniques. Thus, learning analytics is defined as the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimizing learning and the environments in which it occurs.

Table 15. *Keywords for LA cluster*

Learning Analytics	
data mining	information visualization
big data and learning analytics	student monitoring
learning analytics	visual data analysis

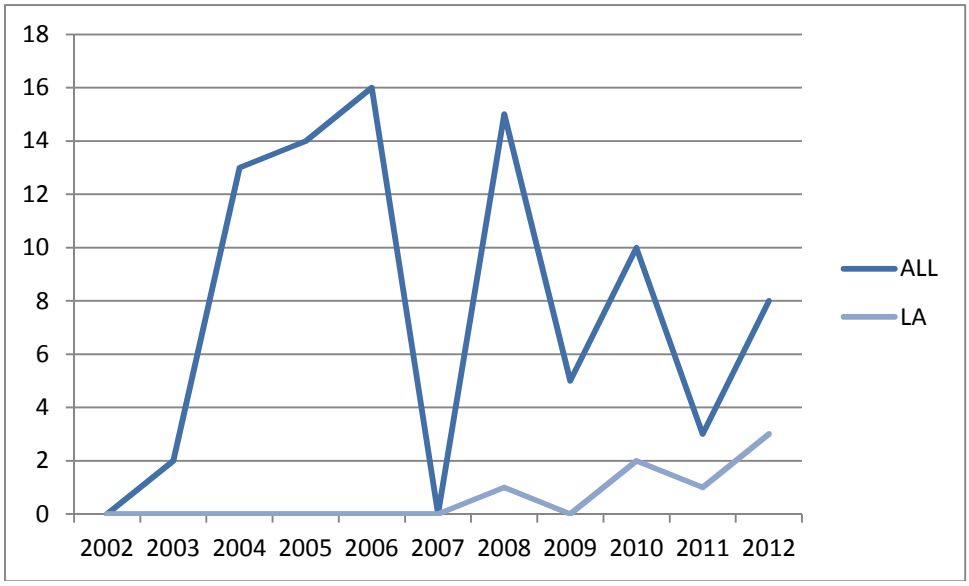
The collection of all keywords considered to be part of this cluster is presented in Table 15. Table 16 presents the most repeated keywords within LA projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The LA cluster is therefore quite related to GVW and WEB. However, LA is so recent in the TEL field that not so many projects have been funded in the field. As a result, there is no meaningful overlap with other clusters.

Table 16. *Most repeated keywords in LA cluster*

Keywords	Ocurrences
information visualization	3
learning analytics	3
social networks	1
social media	1
online applications for teaching	1
learning management systems	1
games	1
data mining	1
virtual environments	1
student monitoring	1
semantic-aware technologies	1
multimedia content	1
mobile devices	1
interfaces	1
e-portfolio	1
computer supported collaborative learning	1

Figure 13, which represents the LA projects funded over time, shows how LA is a new topic that is gaining momentum in the last few years.

Figure 13. *Projects of LA cluster over time*



3.7 Games and Virtual Worlds (GVW)

The term virtual world is largely used as a synonym of 3-D virtual environment. In such environments, the user plays the role of an avatar and "lives" inside this world. Virtual worlds have evolved from simple text-based interfaces to rich 3-D environments that allow for an immersive user experience. In virtual worlds, a real person interacts with objects in computer simulated environments.

Virtual worlds provide means to augment or enhance the way we receive information and has received the interest of educational researchers. In virtual worlds, interaction with peers is an important part of the environment, so they enable the collaborative and cooperative learning strategies. User engagement in the virtual world can be achieved by gamification techniques, thus enabling serious games to be developed for educational purposes.

Table 17. *Keywords for GVW cluster*

Games and Virtual worlds	
immersive virtual worlds	Simulations
computer generated simulations	games
simulation of physical, chemical models	game-based learning
simulations for training	serious games
virtual environments	3d virtual worlds

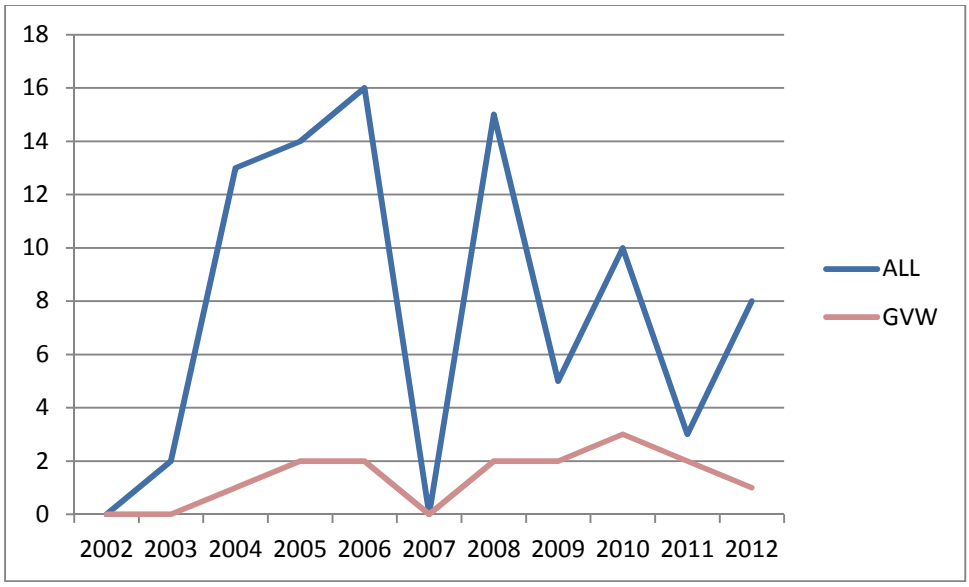
The collection of all keywords considered to be part of this cluster is presented in Table 17. Table 18 presents the most repeated keywords within GVW projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The GVW cluster is therefore related to UC, LA, HCI, among others.

Table 18. *Most repeated keywords in GVW cluster*

Keywords	Occurrences
Games	9
immersive virtual worlds	3
simulations	2
Mobiles	1
information visualization	1
content repositories	1
adaptive learning system	1
virtual environments	1
tactile interfaces	1

student monitoring	1
social networks	1
interfaces	1
gesture based computing	1
emotion-aware systems	1
collaborative environments	1
augmented reality	1

Figure 14. *Projects of GVW cluster over time*



3.8 Environments and technologies for collaboration (CSCL)

The ability to carry out an effective collaboration is a transversal skill that, thanks to constructivist learning approaches, receives lots of attention in the educational research world. Collaboration involves interaction between humans which is, by nature, quite unstructured. Such interaction can be supported by computers. When collaborative techniques are used to foster learning with the support of computers, we call it CSCL (Computer Supported Collaborative Learning).

Table 19. *Keywords for CSCL cluster*

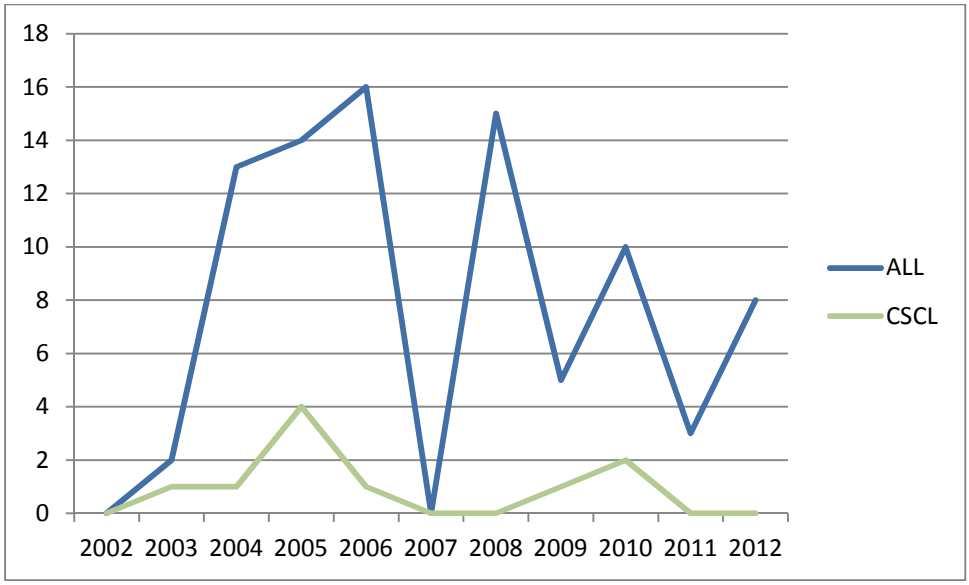
Environments and technologies for collaboration	
collaborative environments	online communication tools
computer supported collaborative learning	synchronous learning
tele-presence	

The collection of all keywords considered to be part of this cluster is presented in Table 19. Table 20 presents the most repeated keywords within CSCL projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The CSCL cluster is therefore quite related to HCI, SAS and LA.

Table 20. *Most repeated keywords in CSCL cluster*

Keywords	Occurrences
collaborative environments	7
computer supported collaborative learning	2
online communication tools	2
tactile interfaces	1
semantic-aware technologies	1
information visualization	1
electronic tutors	1
attention management	1
artificial intelligence	1
ubiquitous computing	1
Tele-presence	1
social networks	1
personal learning environments	1
immersive virtual worlds	1

Figure 15. *Projects of CSCL cluster over time*



3.9 Semantic-aware systems (SAS)

In computer science, a semantic reasoner is a piece of software able to infer logical consequences from a set of asserted facts. These facts (called semantic metadata) are usually represented by a formal language such as RDF and refer to textual or multimedia objects stored in a repository, and to users' information.
In the educational field, semantic analysis research is oriented towards the understanding of natural human language (as opposite to computer languages) in order to provide better search mechanisms on learning content, and also to provide better interaction with computers.

Table 21. *Keywords for SAS cluster*

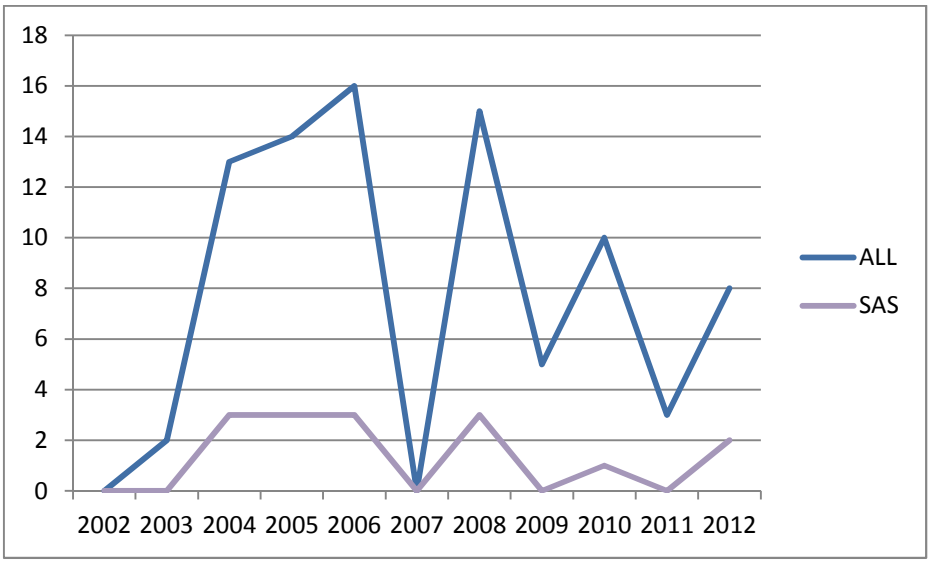
Semantic-aware systems	
semantic web	semantic-aware technologies
metadata generation	semantic interoperability
natural language processing	translation technologies

The collection of all keywords considered to be part of this cluster is presented in Table 21. Table 22 presents the most repeated keywords within SAS projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The SAS cluster is therefore related to WEB (4 occurrences of 'learning management systems'), PA and CRT. For presentation purposes, the presented list has been truncated.

Table 22. *Most repeated keywords in SAS cluster*

Keywords	Occurrences
semantic-aware technologies	11
learning management systems	4
translation technologies	2
personal learning environments	2
content repositories	2

Figure 16. *Projects of SAS cluster over time*



3.10 Personalized, adaptive technologies (PA)

According with the learning styles theories, different students achieve learning with different methods, and prefer different content types. However, computer systems usually make no difference among users and present the same content to every student, structured in the same sequence, and offer the same interface.
The personalization and/or adaptation of the learning process may cover the different needs of the different students, so they can achieve their learning goals in a more efficient manner.

Table 23. *Keywords for PA cluster*

Personalized, adaptive techchologies	
virtual mentors	adaptive learning system
electronic tutors	personalized content presentation
realtime assessment monitors	recommender systems
artificial intelligence	the personal web
attention management	personal learning environments
adaptive content	role-switching
smart learning content	emotion-aware systems

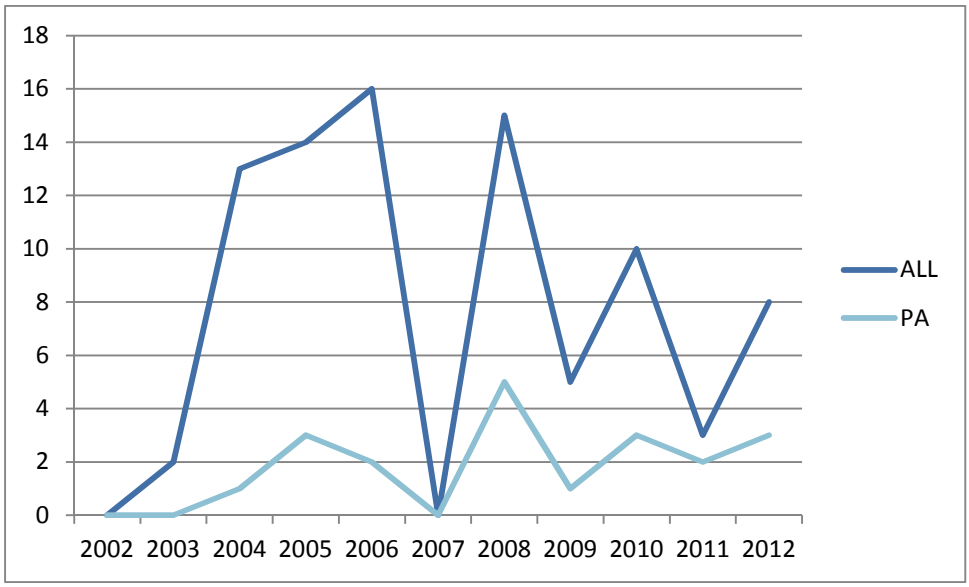
The collection of all keywords considered to be part of this cluster is presented in Table 23. Table 24 presents the most repeated keywords within PA projects. A project may contain keywords associated to different clusters, and the table shows how the different clusters overlap among themselves. The PA cluster is therefore quite related to WEB (5 occurrences of 'learning management systems'), SAS (4

occurrences of 'semantic-aware technologies') and CSCL. For presentation purposes, the presented list has been truncated.

Table 24. *Most repeated keywords in PA cluster*

Keywords	Occurrences
learning management systems	5
personalized content presentation	5
semantic-aware technologies	4
personal learning environments	4
collaborative environments	3
electronic tutors	3
web 2.0	2
Games	2
adaptive content	2
emotion-aware systems	2
context-aware systems	2

Figure 17. *Projects of PA cluster over time*



3.11 Other technologies (OT)

This cluster includes all those technologies that are somehow related to the analysed projects and documents, but have not been included in the defined clusters. Table 25 shows the list of technologies in the cluster.

Table 25. *Keywords in OT cluster*

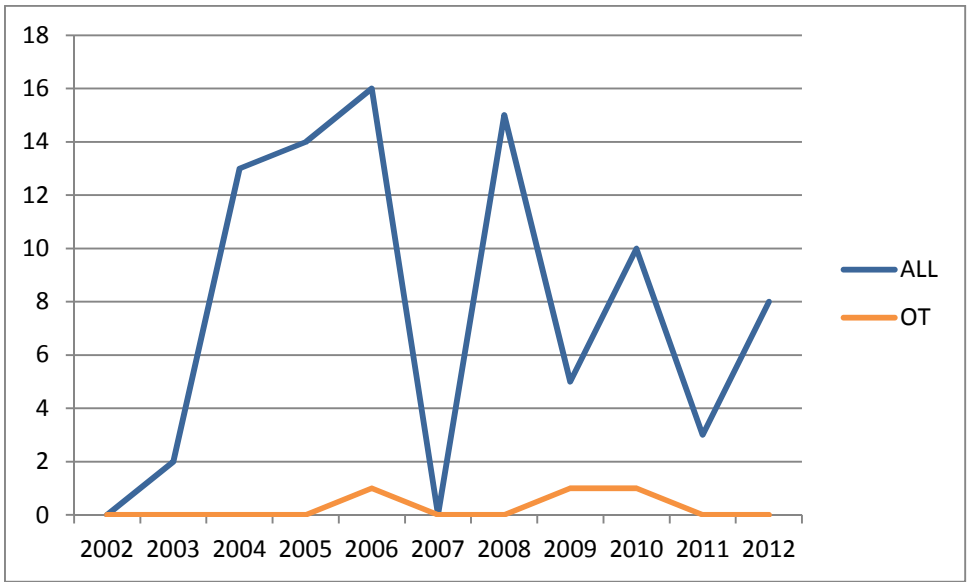
	Other
flexible displays	3d printing
smart-tv	interactive whiteboards
e-books	wearable technology

Not so many projects in this cluster have been funded by the FP6 and FP7 programs. However, this cluster is interesting because presents not so frequent technologies (may be emerging) that can be promising for TEL research. For example, no project related to 3D printing has been found, while the last NMC report mentions such technology in its predictions.
Other interesting technologies are wearable interfaces (also related with UC cluster), or e-books as an innovative way to deliver learning material.

Table 26. *Most repeated keywords in OT cluster*

Keywords	Occurrences
smart-tv	1
semantic web	1
context-aware systems	1
wearable technology	1
interfaces	1
interactive whiteboards	1
future classroom	1
ambient intelligence	1

Figure 18. *Projects of OT cluster over time*



3.12 Networks of Excellence

An analysis of the trends in technology enhanced learning, in relation with the ICT FP6 and FP7 Networks of Excellence (NoE) was also run. Despite NoEs were not classified as belonging to any specific cluster, in order to complete the information presented above, we will now presented an overview of the 7 identified NoEs in terms of involved technologies.

- AIM@SHAPE: by recognising the relevance of multimedia objects (called shapes) in different application fields such as scientific simulations or edutainment, this NoE promoted semantic-based shape representations and semantic-oriented tools to acquire, build, transmit, and process shapes with their associated knowledge
- PROLEARN: this NoE worked in personalized adaptive learning and interactive media, with learning resources connected to real-world settings and reusable in different contexts. It investigated issues especially relevant for professional training in SME's and larger companies.
- MUSCLE: aims at harnessing the potential of machine learning for the automatic semantic annotation of multimedia content, creation of interfaces for the exploration of complex content, improvement of interoperability and exchangeability. This NoE also aims at the distribution of such technology to the stakeholders, such educational institutions.
- KNOWLEDGE WEB: Supporting the transition process of Ontology technology from Academia to Industry is the main and major goal of this NoE. This is

achieved by providing support to incorporate this technology, developing high-class education in the area of semantic web, and researching new uses of semantic web and web services.

- GaLA: This NoE that acknowledges the potential of serious games in the support of the learning process. It aims at the integration and harmonization of research activities across European institutions, as well as at the organisation of joint research activities and the dissemination of serious games to support learning.
- IRIS: Interactive Storytelling is a major endeavour to develop new media which could offer a radically new user experience, with a potential to revolutionise digital entertainment. European research in Interactive Storytelling has played a leading role in the development of the field, and this creates a unique opportunity to strengthen its position even further by structuring some of its best actors within a Network of Excellence. IRIS (Integrating Research in Interactive Storytelling) aims at creating a virtual centre of excellence that will be able to achieve breakthroughs in the understanding of Interactive Storytelling and the development of corresponding technologies.
- STELLAR: represents the effort of the leading institutions and projects in European TEL to unify our diverse TEL community. This Network of Excellence is motivated by the need for European research on Technology-Enhanced Learning (TEL) to build upon, synergize and extend the valuable work we have started by significantly building capacity in TEL research within Europe, which is required to allow the European Union to achieve its goals via the Bologna Agreement and the execution of the Lisbon Agenda. The European TEL agenda has been set for the last 4 years by the Kaleidoscope network - with a huge strength in pedagogy and scientific excellence, and the Prolearn network with a complimentary strength in technical and professional excellence. We see integrating this excellence and moving on to the higher strategic formation of policy based in leading research is the challenge for the next three. STELLAR will move beyond the earlier networks by setting a new and critical foresight agenda for TEL via an annually reviewed Grand Challenge programme.

4. Areas of learning

This section analyses to which areas of learning the previously-identified technologies are applied. In some projects the proposed system is aimed to a very specific field. For instance, the ELEKTRA project was focused on the development of a game to help teaching grade 8-level optics. On the contrary, the technology researched by other projects, such as E-LEGI, claims to be pedagogically neutral. That is, it could be used in any learning situation.

According to the thesaurus presented in Annex 1 (Chapter 8), six different areas of learning were identified:

- Formal education
- Non-formal learning
- Workplace learning
- Museums
- Unspecified field
- Others

The following sections analyse these six different areas.

4.1 Formal education

Formal education corresponds to a systematic, organised education model, structured and administered according to a given set of laws and norms, presenting a rather rigid curriculum as regards objectives, content and methodology [15].
For the convenience of this study, we have divided the formal education learning area in three main parts: schools (primary education), secondary education, and higher education.

Primary education

Table 27. *Projects in the "Primary education" area of Learning*

Project	Technological clusters
CONNECT	GVW
MICOLE	HCI
CALIBRATE	SAS, CRT
EMAPPS.COM	GVW
ATGENTIVE	CSCL,PA
ARISE	AR

ECIRCUS	GVW
GRID4ALL	WEB, CRT
AGENT-DYSL	HCI, PA
COSPATIAL	HCI, GVW, CSCL
HEATTRONICS	SAS, UC, OT
NEXT-TELL	WEB, LA
TERENCE	PA, GVW
Total: 13 projects	

Table 27 shows the list of projects that research technologies for primary education. The most repeated cluster is GVW, related to games and virtual worlds. It sounds logical, since games are used to increase learners' motivation and children are especially prone to like games. Therefore, games seem to be a promising technique to improve learning at schools. Another relevant technology for schools is HCI. That is, new interfaces offer more intuitive interactions with computers, and allow children (not yet used to other interfaces) to more intuitively learn.

Secondary education

The following projects have direct application in secondary education:

Table 28. *Projects in the "Secondary education" area of Learning*

Project	Technological clusters
LEACTIVEMATH	SAS, CRT
ECIRCUS	GVW
ELEKTRA	GVW
80DAYS	GVW, LA
METAFORA	WEB, LA, CSCL
HEATTRONICS	SAS, UC, OT
NEXT-TELL	WEB, LA
JUXTALEARN	WEB
WESPOT	WEB, UC, LA
Total: 9 projects	

The most relevant technologies for secondary education are the Web and learning analytics. On the other hand, promising techniques such as augmented reality and human computer interfaces are not even mentioned, and there are only two occurrences of ubiquitous computing techniques. It could be argued that innovation in secondary education is limited by the classroom scenario, where mobile phones are in most cases not even allowed.

Higher education
The following projects have direct application in higher education:

Table 29. *Projects in the "Higher education" area of Learning*

Project	Technological clusters
LEACTIVEMATH	SAS, CRT
ICAMP	WEB
ARGUNAUT	CSCL, SAS, PA
COOPER	CSCL
LT4EL	SAS, WEB
EU4ALL	WEB
GRAPPLE	WEB, PA
ALICE	WEB, UC, PA
ETOILECASCADESIDEAS	CRT, PA
JUXTALEARN	WEB, LA
Total: 10 projects	

In the case of higher education, the web is the most researched technology, with personalization techniques playing a relevant role. Access-to-content technologies are also relevant in this area. This is logical since initiatives such as OpenCourseWare and MOOCs initially started at universities.

4.2 Non-formal learning

Educative processes endowed with flexible curricula and methodology, capable of adapting to the needs and interests of students, for which time is not a pre-established factor but is contingent upon the student's work pace, certainly do not correspond to those comprised by formal education, but fit into the so-called non-formal education [15].
Non-formal and informal education terms are frequently used indistinctly. Without entering in a debate of the appropriateness of each term, in this study we have identified that projects that focuses on informal learning are in fact related to what we have defined as non-formal learning. Thus, these two terms have been used indistinctly.

The following projects have direct application in non-formal learning:

Table 30. *Projects in the "Non-formal" area of Learning*

Project	Technological clusters
GRID4ALL	WEB, CRT
LOGOS	UC
LEACTIVEMATH	SAS, CRT
PALETTE	CSCL
LOGOS	UC
IDSPACE	WEB
TENCOMPETENCE	WEB, CRT
EU4ALL	WEB
GRAPPLE	WEB, PA
INTELLEO	WEB
IMREAL	GVW, AR
Total: 11 projects	

In the field of non-formal learning, the WEB is the most researched technological cluster, and research on access to content technologies also plays a relevant role. It sounds logical since non-formal learners are usually intrinsically motivated to learn, so what they need is a good collection of learning materials (provided by the CRT cluster) and a method to interact with such material at their own pace (provided by the WEB).

4.3 Workplace learning

By 'workplace learning' we refer to those strategies applied by companies in order to let their employees to acquire new competences related to their position. The following projects have direct application in workplace learning:

Table 31. *Projects in the "Workplace " area of Learning*

Project	Technological clusters
GRAPPLE	WEB, PA
ARGUNAUT	CSCL, SAS, PA
COOPER	CSCL
MATURE	WEB, SAS, PA
TARGET	GVW
ALICE	WEB, UC, PA

MIRROR	-
APOSDLE	CSCL
TARGET	GVW
ARISTOTELE	PA, CSCL
Total: 10 projects	

Environments for collaborative learning are the most researched technologies in this area of learning. Furthermore, this is the area of learning that gives more priority to CSCL technologies. In other words, collaborative and cooperative skills are highly demanded at the workplace. On the other hand, personalization techniques are also relevant in this area.

4.4 Museums

Museums could be considered as a vehicle for non-formal or informal learning. However, the development of new methods to engage visitors by mixing leisure and information delivery has unique characteristics in museums, and several projects are aimed to this specific field. Thus, we have considered museums as an area of learning different to non-formal learning.

The following projects have direct application in museums:

Table 32. *Projects in the "Museums" area of Learning*

Project	Technological clusters
CALIMERA	-
AGAMENON	UC, HCI
CONNECT	GVW
ARISE	AR
DECIPHER	LA, HCI, GVW
Total: 5 projects	

Few projects are explicitly devoted to research technology for museums. Among them, HCI techniques and Virtual Worlds are the most relevant technological clusters. In museums, it is important to engage visitors, which requires innovative methods to interact with the exhibits. Therefore, research is oriented toward this goal.

4.5 Unspecific field

The area of learning to which a project applies was determined by extracting such information from the project description, as published at CORDIS. However, there are some project descriptions in which such information is not explicitly stated, so we were unable to classify to which area of learning they belong. Into this group of 'unspecific field' projects, there are two subgroups.
First, projects whose goal is explicitly oriented towards educational purposes, but do not state to which area of learning they belong. We have classified these projects as 'not explicit area of learning'. Second, projects that matched with the selection criteria stated in Section 0, but are not explicitly aimed at educational purposes. We have classified these projects as 'not explicitly for learning.'

Not explicit area of learning.
The following projects regard to educational research, but do not explicitly specify to which area of learning they apply:

Table 33. *Projects in the "Not-explicit" area of Learning*

Project	Technological clusters
UNFOLD	WEB
COHERENT	HCI
TELCERT	WEB
E-LEGI	WEB, UC, CSCL
PAPERWORKS	AR, HCI
MGBL	UC, GVW
LEAD	CSCL
RE.MATH	-
ELU	-
LUISA	HCI, OT
REFLECT	UC, PA
LTFLL	WEB, SAS, PA
ROLE	WEB, PA
ILEARNRW	CRT, GVW, PA
INTUITEL	WEB, LA, SAS, PA
Total: 15 projects	

The WEB is the most relevant researched technology in this type of projects. As also happens in the higher education cluster, personalization techniques are researched as a way to improve the educational face of the web. It can be argued that those projects that do not explicitly state their area of application are generically

designed, and can be adapted to different educational settings. It is therefore important to achieve a high degree of personalization and adaptation.

Not explicitly for learning

The following projects are related to technologies to might be applied to educational settings, but it is not explicitly stated on the project description:

Table 34. *Projects in the "Not-explicitly for learning" area*

Project	Technological clusters
AMI	CSCL
ACEMEDIA	WEB, SAS, UC
CALIBRE	CRT
AKOGRIMO	WEB
ENABLED	WEB, HCI, UC
AETHER	UC
ACCESS-EGOV	SAS
CASPAR	CRT
A-WARE	WEB, CRT
QALL-ME	SAS
ATRACO	HCI, UC
IMPACT	CRT
LIWA	CRT, SAS
SOCIALNETS	WEB, UC
PERSIST	UC, WEB, LA
NIW	HCI, AR
OPPORTUNITY	UC, OT
SOCIETIES	WEB, UC
Total: 18 projects	

Ubiquitous computing is the hot research topic in this type of projects. Surprisingly, this topic has no major relevance in the rest of the areas of learning. It could be argued that ubiquitous computing is a promising research field, but it is not still clear how to apply it in educational settings.

4.6 Other

Finally, there are some cases where the project description states an educational purpose, but the application area does not fit to any of the previous criteria. Topics

covered in this 'others' area of learning are digital libraries, social inclusion, conflict resolution, learners with specific needs, music institutions and educational curriculum. The following projects were classified as 'other' area of learning:

Table 35. *Projects in the "other" area of Learning*

Project	Technological clusters	Application area
BRICKS	WEB, SAS	Digital libraries
DL.ORG	-	Digital libraries
LITERACY	WEB, PA	Learners with special needs
REPLAY	GVW	Social inclusion
INCLUSO	WEB	Social inclusion
TARDIS	GVW, HCI, PA	Social inclusion
MASELTOV	UC, SAS	Social inclusion
I-MAESTRO	HCI, AR	Music institutions
VEMUS	HCI, PA	Music institutions
SIREN	WEB, GVW	Conflict resolution
EUCLID	WEB	Educational curriculum

It can be seen that music education puts emphasis on HCI technologies to improve learning. Another observation is that games are used as the vehicle that drives motivation in projects toward social inclusion.

4.7 Summary

Table 36 summarises the above subsections by representing the cluster occurrences grouped by areas of learning, where an asterisk means that there is a project that research technological cluster X (column), and applies to area of learning Y (row).

Table 36. *Clusters occurrences in the different areas of learning*

	WEB	UC	AR	CRT	HCI	LA	GVW	CSCL	SAS	PA	OT
Schools	**	*	*	**	***	*	*****	**	**	***	*
Sec. Ed.	****	**		*		****	***	*	**		*
High. Ed.	******	*		***		*		**	***	****	
Non-formal	******	**	*	***			*	*	*	*	
Workplace	***	*					**	****	**	*****	
Museums		*	*		**	*	**				
Not specified	******	***	*	*	***	*	**	**	**	*****	*
Not exp. for learning	*******	********	*	*****	***	*		*	****		*
Other	*****	*	*		***		***		**	***	

5. Emerging technologies analysis

In this chapter we provide an analysis of 30 technologies selected according to the technology trends spotted by the consulted sources (Gartner studies, MNC and IPTS reports), their predicted time-to-adoption; the clusters of technologies identified in the desk research and the information gathered from the 24 conducted interviews.

For each technology, a short definition is presented and it is complemented with the analysis of its relevance for each of the targeted educational sectors (HE, WPL and ILPN), its potential for supporting new learning practices in those sectors and the factors which represent barriers and facilitators for their broadly adoption. The analysed technologies appear sorted according to the maturity level defined by the predicted time to adoption from NMC Horizon reports and Gartner studies. In the next section the term "not mature" is used as synonym "less mature" to refer the maturity level of the analysed technology.

5.1 Mobile Apps

A mobile application (or mobile app) is a software application specially designed to run on mobile devices like smartphones and tablet computers. Usually, they are downloaded from the application distribution platform to a target device, such as an iPhone, BlackBerry, Android phone or Windows Phone, but sometimes they can be downloaded to laptops or desktops. They were originally offered for general productivity and information retrieval, including email, calendar, contacts, stock market and weather information. However, public demand and the availability of developer tools drove rapid expansion into other categories like gamming and GPS and location-based services[8].

Relevance for Education: Mobile apps are particular useful as means to learn, share and experience new concepts independently of the physical situation of the learner and often across multiple devices. In cases of experimental learning like in the case of Sciences they can be provide new forms of interaction with the contents that can lead to better understanding of the presented contents. The BrainPoP mobile app[9], the Spanish IEEC/UNED iPhone app[10] and the iStanford apps[11] are working examples of educational mobile apps. There are other general apps for content management that can be used for supporting the learning process like Dropbox or Google Drive.

[8] Mobile apps definition in Wikipedia http://en.wikipedia.org/wiki/Mobile_apps
[9] http://www.brainpop.com/about/mobile/
[10] Spanish IEEC/UNED iPhone app https://itunes.apple.com/us/app/ieec-uned/id540049168?ls=1&mt=8
[11] iStanford Apps features presented in http://celstec.org/content/istanford-and-daily-lifelong-learning

This type of application has also potential for supporting personalization allowing the presentation adaptation to the needs and preferences of the user (learners) and especially as a form of assistive technology for those learners with special needs in conjunction with educational apps like Google Apps for Education[12]. We recommend to check the section dedicated to Tablet Computing for more details about the potential to support personalization.
The use of this technology in formal learning settings like in HE allows extending the limits where the learning can take place not only in location but also in terms of time. It will facilitate more smooth implementations of blended learning: The prescribed learning activities will not be restricted to the classroom or laboratories but they can be started/ continued in other places like home or on the road.
The same applies for WPL and the use of Mobile Apps will also have impact on lowering the costs of training processes since it will be possible for the organisations to choose whether offer alternative delivery options for the same training course, reducing travelling costs and minimising disruption as staff may not need to be out of the office for training purposes. On the other side, workers have greater choice about when they learn, and eventually the training can become a continuous process, rather than an isolated learning activity.
On other hand, Mobile Apps usage in both sectors can have impact on the implementation of new learning practices like "Flipping the classroom" since it facilitate the learners' access to the videos/material of the lecture and to process such information on their own pace before going to the classroom to develop a set of key learning activities with the professor/trainer.
In the case of ILPN, the Mobile Apps usage has the same relevance for personalization and to access anywhere anytime the shared spaces of the professional network but according to the experts consulted it does not have impact on new learning practices.

Mainstream adoption: According to the MNC Horizon reports [35,36] the mainstream adoption of Mobile apps will be in 1 year or less time. The distribution price of this type of applications is generally low, sometimes even they are free of charge but other factors are hindering their broad adoption in the different educational sectors. Some of those barriers are: budgeting issues mainly related to the acquisition of mobile devices at large scale to allow the deployment of Mobile apps in the learning settings of HE. Other factors of influence can be the challenges posed by the institutional policies and restrictions for the use of supporting devices and the need of smooth integration of pedagogical aspects in the design of activities that will be supported by learning Mobile Apps.

[12] Google Apps for Education available at http://www.google.com/enterprise/apps/education/

5.2 Tablet computing

A tablet personal computer (tablet PC) is a mobile/portable personal computer equipped with a touchscreen as a primary input device, and running a modified desktop OS designed to be operated and owned by an individual.[13]. These devices typically offer a touchscreen, with finger (or stylus) gestures acting as the primary means of control, though often supplemented by the use of one or more physical context sensitive buttons or the input from one or more accelerometers; an on-screen virtual keyboard is generally offered as the principal means of data input. It is one of the most prominent and promising pervasive technology and as one of the experts interviewed expressed: "Tablet computing is going to be the main form of computing everywhere; touchscreen will be interaction means by default in all type of application areas not only in Education since it is easy to use and the interaction with it goes in the most natural form".

Relevance for Education: The use of tablet computing is relevant for educational practices in the similar way as Mobile apps, since tablets are one of their possible hardware supports. The tablet's built-in facilities offered for controlling features of the touchscreen like colour contrast, light contrast, size of typography used to present textual information are crucial to provide the personalization specially for users with special needs or disabilities like visual impairments. Also the availability of camera to make shots of the professor or peers' notes and the facilities to enlarge those shots for better visibility or for incorporating them into new personal learning resources that allow overcoming the interaction barriers those users face in their learning.
In relation to the impact on new practices learning appearances or fostering the adoption of such practices in the educational sectors targeted by HoTEL, the analysis presented for Mobile Apps also applies for the use Tablet Computing. As example of working project related to this technology, the experts highlighted the efforts of the iTEC project[14] to transform learning and teaching practices in Europe through the definition, test and validation of future learning scenarios based on the strategic application of technologies that will be taken into account the educational reform process at national and European level.

Mainstream adoption: Gartner studies [39] consider Tablet computing in the stage of "Climbing the slope of enlightenment" in the next 2 years, which means that exist evidences of the maturity and utility of this technology that will facilitate its broad adoption. According to the MNC Horizon reports [35, 36] the mainstream adoption in Education of Tablet computing is foreseen in 1 year or less time, the same as Mobile Apps. Although the fact of budget restrictions previously

[13] Tablet computer definition available at http://www.pcmag.com/encyclopedia_term/0,2542,t=tablet+computer&i=52520,00.asp

[14] iTEC project: http://itec.eun.org/web/guest/home

highlighted as barrier for the Mobile Apps' broad adoption in educational settings, it is also worthy to mention the existence of initiatives like the Aakash Tablet produced by DataWind, which it is a low cost tablet distributed all across India for all educational sectors including HE[15].

5.3 Collaborative environments

Collaborative environments are online spaces — often cloud-based — where the focus is on making it easy to collaborate and work in groups towards the achievement of common goals, no matter where the participants may be[16]. Such environments generally include sets of communication and conferencing tools to facilitate the exchange of information amongst the participants and sets of collaborative coordination and management tools that allow the organisation of activities and participants' interactions. Such environments are not new but the reason to include them amongst the list of emerging technologies is the fact that currently they are based on cloud infrastructures.

Relevance for Education: The use of collaborative environments in educational settings favours the implementation of collaborative learning approaches where learners work together to solve a problem, complete a task or create a product. According to Gerlach in [20] "Collaborative learning is based on the idea that learning is a naturally social act in which the participants talk among themselves and it is through the talk that learning occurs".
The use of such environments in the case of formal settings like HE and WPL facilitate the implementation of collaborative learning in face-2-face, online or blended fashions. For face-2-face settings they facilitate the tools needed to redefine the traditional student-teacher relationship in the classroom, since they facilitate more active participation of students and support the teacher in the role of facilitator of the learning process. For online and blended learning the same applies, also those environments usage makes possible the deployment of joint projects with learners of other institutions and countries. Those projects expose learners to a variety of challenges and help in the development of soft skills besides the required competences on the subject of learning. Example of working project based on the analysed technology in HE is the Forensic Chemistry Virtual Crime Scene Application[17]

The availability of collaborative environments is one of the cornerstone supports for the ILPN since the learning in such settings is cooperative and social per nature and those environments provide the tools needed for resources sharing, brainstorming and creating solutions that lead to the knowledge acquisition. The essential

[15] Aakash Tablet produced by DataWind http://www.datawind.com/aakash/index.html
[16] Collaborative environments analysed in Horizon Report for STEM+ [35], page 6
[17] https://app-ps.secure.griffith.edu.au/forensic_ar/

attribute of the technologies in this set is that they make it easy for people to share interests and ideas, to easily monitor their collective progress, and to see how ideas have evolved throughout the whole interaction process. Facebook, Wikis, blogging tools, directories, discussion groups are examples of collaborative environment frequently used for ILPN.

Mainstream adoption: The MNC Horizon report [35] foresees the mainstream adoption of the collaborative environments in educational settings in 1 year or less time. Such forecast considers the technology's current degree of maturity: Those environments are being incrementally and broadly adopted because their cost of acquisition is low or free, they are easy to use and generally they are interoperable through different access application and devices.

5.4 Cloud computing

The term Cloud computing refers to the use of shared computing resources (hardware and software) that are delivered as a service over a network, typically through the Internet. This technology is the result of Grid computing research and transforms once-expensive resources like disk storage and processing cycles into cheap commodity. The adoption of cloud-based applications is changing the ways we configure and use software and storage our data: it does not matter anymore where the data is stored but that is always easy to locate and retrieve, independently of the devices we are using or which is our location. Consequently, Cloud computing is one of the tipping technologies that allows the broad use of Mobile Apps and Collaborative environments.

Relevance for Education: This type of technology is relevant for all the sectors considered in HoTEL project but the impact of its usage varies in the different settings of those sectors. The use of cloud computing is more and more frequent since they offer an ideal infrastructure support for collaboration between learning peers and with their tutors/professors/trainers, offers more flexibility to learners to access and carry out their assignments, retrieve the results of their evaluations or the certification of achieved competences in the frame of formal learning settings like HE and WPL. Other important reasons are the financial advantages associated to cloud-application business models and its scalability potential: The use of cloud represents costs savings for initial infrastructures, streamlining of services and the agility and flexibility it provides for organisations to respond to the needs of today's learners and ever changing labour market. In terms of scalability it facilitates agile responses to the changes based on demand in peak periods like exams or during the starting period of learning experience in corporate environments. This type of technology stack allows rapid modifications without the need of acquiring additional hardware that could take some time and maybe will be under used in the future.

Examples of working projects using cloud-computing infrastructures are again the use of Google Apps for Education in universities like the ESSEC Business School[18] , the University of Ferrara in Italy[19]. Another example is Cloud-Based Learning Management Systems - ETEC 522[2021]. Meanwhile, Lectora Review link[22] is another example of the use of cloud infrastructure for team collaboration in WPL.
In the case of ILPN, cloud computing is relevant in the sense that it provides a transparent infrastructure for the applications that supports the pervasive exchange and collaboration amongst the participants of the professional network.

Mainstream adoption: According to the MNC Horizon reports consulted Cloud computing will be broadly adopted in educational settings in 1 year or less time [35,36]. Meanwhile the Gartner Report of Emerging Technologies for 2012[39] puts this technology in the "Sliding through" in 2 years that shows its maturity, since there plenty of examples of real applications and suppliers of this technology. The challenges for the adoption of Cloud computing are not so much of technical nature but they are more related to the requirement of mechanisms to control the learning process flow, means to verify the achievement of skills and competences and to guide the learners to ensure that their learning goals can be achieved. Other important challenge is to deal with privacy issues related to the organisation and management of the learning outcomes evidences and the availability of students' performance data.

5.5 Social networking

Social networking it is mostly about creating connections and relations that bring individuals together. The exchanges carried out within social networks environments are designed to be brief, easy to start and shareable. Nowadays social networking communications are extensively used and they are replacing email and other forms of traditional communication. Relationships are the currency of these systems, and already we are seeing systems evolve in ways that are changing the way we search for, work with, and understand information by placing people at the center of the network. Social operating system tools, such as the analytics built into Facebook, help users understand who members of their communities know, how they know them, and how deep those relationships actually are. They can lead us to build new social connections we would otherwise have missed [35].

[18] ESSEC Business School has gone Google http://www.youtube.com/watch?v=v7E_cJ6NJHk
[19] University of Ferrara uses Google apps http://services.google.com/fh/files/misc/ferrara.pdf
[20] Cloud-Based Learning Management Systems - ETEC 522 http://cloud-basedlms-etec522.weebly.com/best-practices.html

[22] Lectora Review Link http://lectora.com/online-collaboration-course-review-reviewlink/

Relevance for Education: Social networking tools enable participants to forge relations and collaborate with their peers from anywhere, at any time. Social networking gives opportunity for rapid and efficient contact and information exchange. Its adoption is relevant for the three sectors addressed in HoTEL as it is one of the possible implementations of the collaborative environments previously analysed and it provides support to the learning processes based on two-level interaction: between participants and, among participants with the contents. In some HE organisations Facebook features like Groups are being used to share teaching and learning activities, giving feedback using comments and at some extent are used to complement the functionalities of LMS. A Facebook group or page, made available as a workplace learning environment allows gathering people with the same concerns, easily accessing to information and permitting to take actions accordingly. The same applies for WPL settings where the use of Enterprise Social Network tools is becoming a central support for corporate training processes. In the case of ILPN, social networking can be considered as one of the main technological support for informal learning. The sharing and re-sharing features, allowing commenting and following discussions can enable professional development within professional groups, sharing resources, job opportunities training events and so on. In all targeted sectors, the use of Social network tools also provides means to enforce each participant of the learning process presence and sense of belonging: social networks are also used as means for recruiting students and to arise awareness about the effectiveness of the learning approaches followed.

Some examples of social networking experiences in educational sectors are: The Social media map[23] created by the Duke University in collaboration with the Murdock University. This is a citizen science experiment: which students use to share observations about the ecosystems of North-western Australia and will help to save and protect endangered species. The Teachers' Lifelong Learning Networks,[24] a project supported under the Lifelong Learning Program,[25] which addresses and fosters teachers' professional development in Europe by means of social networking technologies and especially through the network eTwinning[26]. An informal learning approach is used in the eTwinning communities supported by Facebook facilities to facilitate the peer communication and professional development. Also the Facebook e-learning Gurus[27] is a Group for e-learning professionals where the exchange amongst its members lead to the individual professional development.

[23] Social Media Map http://research.duke.edu/stories/social-media-mapping-may-protect-last-great-marine-wildernessl
[24] Tellnet project www.tellnet.eun.org
[25] Lifelong Learning Program http://ec.europa.eu/lifelong-learning-programme/doc78_en.html
[26] eTwinning network www.etwinning.net
[27] Facebook group e-learning Gurus https://www.facebook.com/groups/elearninggruspt

Mainstream adoption: Gartner studies consider Social media and networking as technologies "Entering in the plateau" in the next 2 years [39] meanwhile Horizon reports [35] and foresees their adoption time in "1 year or less". Both predictions consider the maturity of these technologies and it readiness to be mainstream adopted. However some factors like data protection and privacy issues have been highlighted as key challenges to be addressed for a wider adoption of social networking in education and training settings, mainly when personal data are at stake. In certain contexts the mutual trust of other people identify is not enough, therefore mechanisms to support the verification of members identify are required.

5.6 Augmented reality

Augmented reality (AR) refers to the real-time use of information in the form of text, graphics, audio and other virtual enhancements integrated with real-world objects. It is this "real world" element that differentiates AR from virtual reality. AR aims to enhance users' interaction with the environment.[28]

Relevance for Education: Augmented reality can be considered as a technology to support of user interaction with an interesting potential for learning and assessment since it allows learners to get new and better understanding of the objects and processes which are enhanced thanks to the presentation of new layers of information in real time.
The use of this type of technology has different degrees of importance for the learning sectors addressed in the project: It is might have higher impact on the support of learning processes in HE especially those related to sciences and field studies. And in WPL, to those process related to training in expensive or dangerous conditions. AR allows participants to interact with objects in a real environment but also includes some information that is not visible at first glance within the location, which gives them a deeper insight of the process under study and help to simulate extreme conditions. The fact that extra information is presented in real-time considering the interaction context without the need of having a tutor/trainer guiding and supervising learners on site, can help them in the development of some competences like self-management and self-regulated learning.
In the case of ILPN, this type of technology is relevant for those settings where the focus is on the concurrent interaction between participants and the same resources or contents. For instance in tele-presence scenarios, where what is real on one collaborator's table can be represented as virtual (or 3D projected) in the other collaborator's environment and vice-versa. [29]

[28] Augmented reality definition http://www.gartner.com/it-glossary/augmented-reality-ar/
[29] Microsoft Mirage Block http://research.microsoft.com/en-us/projects/mirageblocks/

There some interesting projects making use of AR to support learning processes like the Virtual Anatomy tool[30] which provides real-time 3D modeling of the human anatomy to replace the Cadaver Lab at Boise State University. Another example related to the WPL is the ARMAR[31] project from Columbia University on which AR is used to support training for heavy equipment maintenance and repair.
Unlocking the hiding curriculum[32] is a project from University of Exeter that provides an AR mobile app that transform the University campus into an accessible learning resource to support the formal and informal curriculum related to Biodiversity studies and conservation activities.

Mainstream adoption: Augmented reality is not mature, it is a technology in progress and it needs a lot of efforts to improve some of its most promised capabilities like activity recognition. According to the MNC studies it will be broadly adopted in 2-3 years [35] and Gartner studies [39] put them at the "Peak of expectations" (5 to 10 years) meanwhile in the MATEL Study the time of adoption is 10 years from now [1]. There are promising examples of the possible broad application of AR like the Google glass project[33] which presents the first prototype for consumer glasses specifically designed for augmented reality applications and is at the time of this writing under user evaluation. The results of such evaluations will determine whether the time to AR applications mainstream adoption can be reduced. By other hand, the broad adoption of mobile technologies has strong influence to make more feasible AR applications but there are still some other factors that hinder its mainstream adoption like the cost of developing AR software support. In the Educational area, the cost of acquisition of supporting hardware/software can the most important factor hindering the adoption of AR applications to support learning practices. In that case, the return of investment argument will be needed to explain that practices supported with AR applications will be more effective in terms of learning outcomes. Another element that can have a negative influence on adopting such type of applications is cultural and is concerned with the resistance to novelties or changes.

5.7 Massive Open Online Courses

The essence of the original MOOC concept was a web course that people could take from anywhere across the world, with potentially thousands of participants. The basis of this concept is an expansive and diverse set of content, contributed by a

[30] Virtual Anatomy tool http://campustechnology.com/articles/2012/03/21/boise-state-u-replaces-cadaver-lab-with-virtual-anatomy-tool.aspx
[31] ARMAR Augmented Reality for Maintenance and Repair http://graphics.cs.columbia.edu/projects/armar/pubs/henderson_feiner_AFRL_RH-WP-TR-2007-0112.pdf
[32] Unlocking the Hidden Curriculum http://blogs.exeter.ac.uk/augmentedreality/about/
[33] Google Glass project http://www.google.com/glass/start/what-it-does/

variety of experts, educators, and instructors in a specific field, aggregated into a central repository [37, 38]. One of the key features of MOOC is the possibility of reusing and mixing materials that were not initially conceived to be presented together. It is important to remark that the two main features of MOOCs: massive and open can be interpreted differently by different providers: some MOOCs are open but not massive and others are massive but not open. The latest trend goes along with the Open Education movement that promotes contents as open source, accessed on free of charge basis and allowing learners to get the corresponding competence certification from the University of their choice.

Relevance for Education: In contrast to other technologies analysed in this study, the concept of MOOC emerges from the educational area. The development of MOOCs is rooted within the ideals of openness in education, that knowledge should be shared freely, and the desire to learn should be met without demographic, economic, and geographical constraints [41].
Different ideologies have driven MOOCs in two distinct pedagogical directions: the connectivist MOOCs (cMOOC) which are based on a connectivism theory of learning with networks developed informally; and content-based MOOCs (xMOOCs), which follow a more behaviourist approach [41]. The first one, cMOOCs emphasise connected, collaborative learning and the courses are built around a group of like-minded 'individuals'. Such approach can represent a disruptive innovation in HE settings but seems to be a natural approach for ILPN. The second one, the xMOOCS model (xMOOCs) is essentially an extension of the traditional pedagogical models practised within the HE and WPL settings but also facilitates the implementation of new practices like "Flipping the classroom" or "Microlearning".
Nowadays edX, Coursera, Udacity and Khan Academy are the most prominent examples of MOOCs. edX[34] is a non-profit MOOCs platform founded by Massachusetts Institute of Technology and Harvard University with $60 million of resources contributed by the two institutions to support the project. Recently University of California, Berkeley has joined edX. MITx and Harvardx courses will not be offered for credit at either university but to online learners who demonstrate mastery of subjects that can pay a modest fee for a certificate of completion. Coursera[35] is a for-profit company, which started with $22 million total investment from venture capitalists, including New Enterprise Associates and Kleiner, Perkins, Caufield & Byers Education. It has four university partners, namely Stanford University, Princeton University and the Universities of Michigan and Pennsylvania. Some partner universities offer credit for their Coursera classes to those who willing to pay a fee to have some extra assignments and work with an instructor and be assessed. UDACITY[36] is another for-profit start-up which currently offers 18 online courses in computer science, mathematics, general sciences, programming and entrepreneurship. When students complete a course, they receive a certificate of

[34] edX: https://www.edX.org/
[35] Coursera: https://www.coursera.org/
[36] Udacity https://www.udacity.com/

completion indicating their level of achievement, signed by the instructors, at no cost. Khan Academy[37] is another well-known free online learning platform and a not-for-profit educational organisation with significant backing from the Bill & Melinda Gates Foundation and Google. It offers over 3,600 video lectures in academic subjects with automated exercises and continuous assessment.

Mainstream adoption: The MNC 2013 reports on HE preview [37, 38] predict the MOOC's adoption in 1 year or less time. Meanwhile Gartner studies [39] put them "On the rise of expectations" stage and to reach the mainstream adoption in 2 years. Those predictions are well back up with plenty of examples of the use of MOOCs in HE besides the previously presented like FutureLearn[38] from OUUK, MiriadaX and Khan-UC3M[39] from Universidad Carlos III de Madrid and OpenCourseWorld[40] in Germany. The use of MOOCs will help HE organisations to showcase their excellence and help attracting the best and brightest minds from around the globe. The same applies for companies that will be in a position to recruit best students based on their assessment results. Nevertheless, institutions willing to adopt MOOC should assess some other factors besides the above mentioned benefits. For instance, the existence of some language constrains since the majority of contents available are in English. Another important factor to take into account is the possible change in HE Business models: as it was previously explained there are different modalities for credits and certification ranging from no costs at all for certification to pay a modest fee or to pay a fee for having a tutor and special assessment.

5.8 Personal Learning Environments

Personal learning environments (PLEs) are a loosely defined term used to describe tools that support self-directed and group-based learning, focus on individual learning goals and needs, with great capacity for flexibility and customization [35]. It is understood as the personal collections of tools and resources a person assembles to support their own learning — both formal and informal. PLE helps them to set their own learning goals, manage their learning contents and process, and communicate with others during the process of learning. PLE is not simply a technology or set of technologies but an approach to support learning that is individualized by design.

Relevance for Education: PLE encompasses not only personal web 2.0 tools used by learners to support their lifelong learning but also personal learning networks (learner's contacts through social networks). A key factor in this type of

[37] Khan Academy https://www.khanacademy.org/
[38] FutureLearn http://futurelearn.com
[39] MiriadaX and Khan-UC3m http://www.uc3m.es/portal/page/portal/biblioteca/UTEID
[40] OpenCourse Worldhttp://www.opencourseworld.de/

environment is not only have learning content per se but to know where (or who) to contact to find it, therefore the support for localizing, collecting reference materials and communication tools is essential. Personal learning environments are equally relevant to all educational sectors targeted in the project especially when a learner centred and self-regulated formal/informal learning process is deployed on the context of those sectors.
The iGoogle[41] environment and the ROLE project[42], are two examples of PLE working projects. The iGoogle environment allows learner to create her own personal environment and populate it with those widgets (tools or web based apps) that provide access to contents/functionalities she needs. Meanwhile, the ROLE project is anFP7 project, which main objective is to support teachers in developing the open personal learning environments for their students where they will be able to plan their learning process, search for the resources independently, learn and then reflect on their learning process and progress. It offers the ROLE Widget store[43], a catalogue of learning widgets and widget bundles to be searched and added in users' personal learning environments.

Mainstream adoption: The MNC Horizon report on STEM [35] predicts that PLE are can be broadly adopted in the next 2-3 years. Such prediction is based on the fact that although there are available a great number of apps, tools that support the informal personalized learning, in formal educational settings still is needed to put in place pedagogical approaches that encourage learners to take over ownership of their learning, develop and manage their own learning strategies. Moreover, from the technical perspective and to ensure the effectiveness of PLE still is required to count with mature and intelligent support that will allow the implementation of recommendation mechanisms to help learners in the selection of the most appropriated resources and tools for specific situations. Such type of support could be obtained through the integration of Learning Analytics into PLE.

5.9 Game based learning

Game-based learning (GBL) refers to the integration of games or gaming mechanics into educational experiences [37]. That is not a new concept in education, what is new is the use of technological support for visualization and interactions in the game experience. This topic has gained considerable traction over the past decade as games have proven to be effective learning tools, and beneficial in cognitive development and the fostering of soft skills among learners, such as collaboration, communication, problem-solving, and critical thinking.

[41] iGoogle http://www.google.com/ig
[42] ROLE project: Responsive Open Learning Environments http://www.role-project.eu/
[43] ROLE Widget store http://role-widgetstore.eu/about

Relevance for Education: Since the majority of games are based on the principle of experiential learning, the use of GBL can be relevant for the learning processes in the three sectors addressed in this project. It is important to consider that games designed for formal education let be at HE or corporate training (WPL) usually are intended to address small range of skills for specific target audience. In those sectors, the use of Open-ended, challenge-based, truly collaborative games can help in the achievement of skills for research, writing, collaboration, problem solving, public speaking and leadership.
Next some working projects related to GBL are presented: The 3D GameLab[44] is quest-based learning platform that can turn any classroom into a living game. 3D GameLab helps teachers tie innovative learning activities to standards, providing learners choices while they game their way through a competency-based curriculum. MicroExplorer3D[45] is a game developed by North Carolina State University, allows students who do not have access to a Microscope lab to interact with a 3D model of a compound microscope by clicking (web) or touching (mobile), zoom into detailed views of the parts, and open menu items and descriptions with photograph and video examples.

Mainstream adoption: According to MNC Horizon reports on HE [36,37,38] the time-to adoption of GBL is in the next 2-3 years. Although the technologies that facilitate the implementation of game mechanics have certain level of maturity. There are certain elements that still need further consideration to allow a broader GBL adoption like the preparation and capacity of professors/trainers/instructional designers to effectively integrate games within learning paths to address the learners' specific needs and facilitate the achievement of learning goals. Other important aspect is the need of approaches to integrate pedagogical aspects in the evaluation of learning outcomes within the gaming experience. Also it is required to count with means embedded in the game or connected to analytical tools that inform about the progress of the learning experience within the game, as well as provision of indicators supporting a formative feedback and grading work. Another factor is the availability of proper technological infrastructure in the institutions willing to adopt GBL to facilitate the deployment of such experiences. And last but not least is important is to carry out a deep analysis of return of investment for applying GBL taking into consideration the effectiveness of the implementation of GBL not only in terms of learning outcomes but also in relation to the cost of its implementation.

5.10 Gamification

[44] 3D GameLab http://3dgamelab.org.shivtr.com/
[45] MicroExplorer3D http://go.distance.ncsu.edu/microexplorer/

Gamification is the use of game mechanics to drive engagement in a non-game activity aiming to change some behaviours of the target audience. Many types of games include game mechanics such as points, levels, challenges, leader boards, rules and incentives that make game play enjoyable. Gamification applies those features to non-game scenarios to motivate the audience to higher and more meaningful levels of engagement[46]. As it was explained for GBL in the previous chapter, what is novel about gamification is the use of technology to facilitate the interaction and visualization of the learning experience.

Relevance for Education: Since humans are "hard-wired" to enjoy games and have a natural tendency to interact more deeply in activities that are framed in a game construct**.** The use of gamification can provide some important advantages in learning practices in HE and WPL specially related to raise motivation and achieve engagement.
The use of gamification in learning can help learners to stay highly motivated and the drop-out can be prevented. This can be really useful to support practices aiming to achieve the so called 21 century skills (like collaboration, critical thinking, creative thinking, problem solving, reasoning abilities, learning to learn, decision making). A sound approach to gamification for enhanced learning will assure that students persist and progress at a reasonable rate, and the quality and enjoyment of their learning will increase as they progress, despite persistent and increasing challenges they will face.
Some examples of working projects using gamification techniques are: The PlayForce[47], a project created by the Institute of Play[48], which provides access to a try-out database of games and permit to share learning experiences in games.
Other interesting approach is the application Attent[49] from Seriosity, which help enterprises to develop gamification strategies to face the challenges of their workforce learning that result in an immediate impact on employee productivity, engagement and retention.

Mainstream adoption: Gartner studies [39] put Gamification in the stage "Reaching the Peak" of expectations and predicts it will be mainstreamed in the next 5 to 10 years. Nowadays it is an approach with many early adopters in Advertise and Museums; and in different educational settings, but still there are some concerns about the no- so positive aspects of gamification in particular for learning [42, 56]. These include the possibility of addiction/compulsion, frustration and development of a utilitarian mentality. Other concerns are related to the risk of reducing a complex activity, such as instruction, to a set of mechanics, badges and score opportunities. Finally, extrinsic motivation (rewards, games, trophies, cash, etc.)

[46] Gamification definition from Gartner Glossary http://www.gartner.com/it-glossary/gamification/
[47] PlayForce project from the Institute of Play http://beta.playforce.org/
[48] Institute of Play http://www.instituteofplay.org/about/
[49] Attent http://www.seriosity.com/attent.html

can be helpful to attract the learners' interest but what it is really essential to also achieve learners' engagement through the appreciation of the relevance of the studied topics and the achievement of the related competences (intrinsic motivation). Therefore there are still required effective mechanisms to guarantee that learners will reach the desired competences and they actually persist and keep their selves active in the process despite the challenges they can face in the gamified learning experience.

5.11 Learning analytics/Social Analytics

Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs[50]. Social analytics is about monitoring, analysing, measuring and interpreting digital interactions and relationships of people, topics, ideas and content. Those interactions may occur in workplace or in external-communities. Social analytics include sentiment analysis, natural-language processing and social networking analysis (influencer identification, profiling and scoring), and advanced techniques such as text analysis, predictive modeling and recommendations, and automated identification and classification of subject/topic, people or content[51].

Relevance for Education: The application of Learning and social analytics has been recognized as important support for the deployment of learning processes in formal educational settings like HE and WPL. It has been pointed out that analytics has a wide application across educational institutions for various stakeholders, but that the way 'learning analytics' is defined and implemented may vary. That is as predicting tool to detect those learners requiring extra support and attention; to help teachers/ trainers and support staff plan supporting interventions with individuals and groups; for functional groups such as course team seeking to improve current courses or develop new curriculum offerings; for institutional administrators taking decisions on matters such as marketing and recruitment or efficiency and effectiveness measures [43]. Learning analytics also facilitate the implementation of personalization mechanism through the use of recommendations to select or adapt a learning path based on the learner's profile, previous activities and the desired learning outcomes. This also applies to ILPN sector where Learning/Social Analytics is also important for individual learners to reflect on their achievements and patterns of behaviour in relation to others.

[50]Learning analytics in the CFP of the 1st International Conference on Learning Analytics & Knowledge (LAK 2011) https://tekri.athabascau.ca/analytics

[51] Social Analytics definition from Gartner Glossary http://www.gartner.com/it-glossary/social-analytics/

Among the working projects related to this technology are worthy to mention the following: Learning Catalytics[52] a system developed by the Mazur Group at Harvard University, which has been recently acquired by Pearson. Learning Catalytics supports peer-to-peer learning and provides real-time feedback of the interactions taking place during the learning session. Another interesting project supported by the Society for Learning Analytics and Research (SOLAR) is the SoLAR's Open Online Learning Analytics Course[53] which is includes an overview of the current existing learning analytics platforms.

Mainstream adoption: The MNC Horizon reports on HE [36, 37, 38] predict that Learning Analytics applications will be wide adopted within 2-3 years. Meanwhile the Gartner 2012 edition put Social Analysis as emerging technology at the "Peak of expectations" stage predicting that in 2 years will be broadly adopted. Accordingly this set of technologies can be considered "emerging" and "less mature" technologies and that is also confirmed with the facts analysed in the Chapter 3. But as it was previously explained has a great potential to provide effective support for the learning processes and new learning practices like "Microlearning", "Flipping the classroom" or "Gamified learning[54]"in the three sectors targeted by HoTEL. Nevertheless it is important to stress that factors like privacy issues related to the use of personal data in the analysis of learners activities and social interactions should be carefully considered for the deployment of Learning and social analytics applications.

5.12 Collective Intelligence

Collective Intelligence (CI) is derived from collective interactions and knowledge exchange (crowd computing) and it is the tacit intelligence that results from the data generated by the activities of many people over time. Technologies for discovering and harnessing the intelligence in such data — revealed through analyses of patterns, correlations, and flows — is enabling ever more accurate predictions about people's preferences and behaviours, and helping researchers and everyday users understand and map relationships, and gauge the relative significance of ideas and events [35].

Relevance for Education: Implementations of collective intelligence as the meaningful assembly of relatively small and incremental community contributions into a larger and coherent accumulation of knowledge are relevant for all educational sectors addressed by HoTEL and can help to support new learning practices based on Connectivism or on the use of Open educational free resources. In particular CI applications are important to knowledge building processes, i.e.

[52] Learning Catalytics https://learningcatalytics.com/
[53] SOLAR resources http://www.solaresearch.org/resources/
[54] In this report "Gamified learning" is used as synonym of Gamification in Learning.

where new territory is to be mapped; new ground is to be covered. And the relevance degree is minor, where learning focuses on knowledge already available. Examples of working projects related to this technology are: The ChemSpider[55]system developed by the Royal Society of Chemistry, which is a free database for chemical structures that gathers research from across the web into a single repository and allows information retrieval on free of charge basis. Another example is the Wikipedians-in-Residence program[56], a joint initiative among Wikimedia and a group of cultural institutions like museums and archives where volunteer experts publicly document the history of those cultural institutions.

Mainstream adoption: According to the MNC Horizon STEM+ report [35] the CI's time-to adoption is within the next 4-5 years, defining it as emerging (less mature) technology. Experts consulted in this study confirmed such predictions based in current lack of effective approaches to design and use technologies which involves intelligent infrastructure, capture of demanding learning needs and accommodation of highly sophisticated technologies to provide coverage of collective intelligence activities and foster learning through them. Similar technologies were designed and utilized in the recent past by organisations and they contributed in great extent to organisational learning and knowledge creation and management. Therefore, an accumulative approach considering previous experiences in other areas of application is recommended: check these systems contributions, any advantages, disadvantages, limitations, benefits and based on them carry on the design of new CI-focused learning systems.

5.13 Idea Management

Idea management is a structured process of generating, capturing, discussing and improving, organising, evaluating and prioritizing valuable insight or alternative thinking.

Relevance for Education: Idea Management (IM) is concept that can be supported by different technologies depending on its application area. In the Education and particularly in WPL or ILPN related to Education, the implementation of IM has a paramount relevance for innovation and to improve the quality of the teacher/trainer actions in the learning process. Such implementation or solutions help educators to get new ideas, get to get involved in new peers' networks and define new teaching strategies and prepare their selves for facing new challenges in the different educational levels. Also this type of systems can be used in HE to support learning practices based on "Connectivism" or like "Flipping the classroom". Although there is not a unique set of specific technologies to

[55] ChemSpider http://www.chemspider.com/
[56] Wikipedians-in-Residence programmes
http://outreach.wikimedia.org/wiki/Wikipedian_in_Residence

implement IM in the Education, the combination of creative tools, recommendation systems, social networks, knowledge management systems and Ontologies has been used frequently.
Next we mention some working projects or products related to IM: The CrowdLogic Engage[57] is a Learning Reinforcement Software based on the concepts of Idea Management and Gamification. This system according to its creators improves engagement and learning transfer after learning programs finish. Idea Accelerator[58], allows teams to brain storm and collaborate on one or more projects at the same time. The Idea Management[59] website maintains a list of IM software products available on the market. At the time of this writing the list is composed of 44 different IM software applications.

Mainstream adoption: Idea Management is a mature technology according to Gartner study [39], which defines it in the stage "Climbing the slope of Enlightenment" and predicts its mainstream adoption in less than 2 years. Although there are plenty of examples of IM software in other areas, it was quite difficult to find examples of such systems in the different educational sectors addressed by HoTEL. Therefore this is a case of technologies which experiences in other application areas should be considered for its adoption in Education.

5.14 Natural User Interfaces (NUI)

It is a type of user interface that is effectively invisible- or becomes invisible with successive learned interactions- to its users, and is based on nature or natural elements[60]. This kind of user interface is used by a growing array of alternative input devices that allow computers to recognize and interpret natural physical gestures as a means of control. Natural user interfaces allow users to engage in virtual activities with movements similar to what they would use in the real world, manipulating content intuitively.

Relevance for Education: The use of NUI in Education can help to support more types of learning styles and modes, to encourage educators to adopt innovative mixture of pedagogical theories; to enhance the capabilities of technology enhanced learning through socio-cognitive and socio-constructivist approaches; to develop and improve hand-skills and other related competencies through new interaction mechanism [54]. Accordingly, this technology can be equally beneficial for learners and instructors in HE settings and in particular for Open and Distance learning modes. In addition, the integration of NUI with other group of technologies

[57] CrowdLogic Engage http://www.crowdlogicsystems.com/
[58] Idea Accelerator http://www.idea-act.com/products/
[59] Idea Management http://www.ideamanagementsystems.com/
[60] Natural user interface definition available at http://en.wikipedia.org/wiki/Natural_user_interface

can help to foster the development of problem solving, decision making skills and organisational learning in WPL environments. It is clear that NUI use can have a clear impact on the company's credibility, and can contribute to considerable cost savings and increase in productivity and job satisfaction. ILPN is an area with huge potential for NUI utilization because it can directly be combined with the acquisition of new skills and expertise at a fast or slow mode; the latter is dependent on the user/learner, who is/will be given opportunities to adjust her/his cognitive and practical needs in a more flexible, creative and reflective mode of learning than in HE and WPL.
Some examples of working projects are: Handy-Potter[61], a natural user interface that can modify and create shapes in 3D based on hand gestures, which has been developed by a mechanical engineering team at Purdue University. And TeleHuman[62], a 3D visualization of a person based on Microsoft Kinect sensor technology, which has been created by students working in The Human Media Lab at Queen's University.

Mainstream adoption: According to the MNC Horizon STEM+ report [35] the NUI's time-to adoption is within the next 4-5 years, defining it as emerging (not mature) technology. Therefore, financial and technological constraints might be an obstacle to wide participation and access to this type of technology. Also suitable guidelines for social inclusion and equal opportunities for different learning needs and different learning/thinking styles (Sternberg, etc.) must be founded and formed together with policies that guarantee confidentiality, security, and preferences in identity and interaction styles.

5.15 Gesture based computing

Gesture-based computing allows users to engage in virtual activities with motions and movements similar to what they would use in the real world, manipulating content intuitively. The idea that simple gestures and natural, comfortable motions can be used to control computers is opening the way to a host of input devices that look and feel very different from the keyboard and mouse — and that are increasingly enabling the supporting devices to infer meaning from the movements and gestures we make [35].

Relevance for Education: While gesture-based computing has found a natural home in gaming, as well as in browsing files, its potential uses are far broader [35]. The ability to move through three-dimensional visualizations could prove compelling and productive. Thus, Gesture-based computing provides an ideal support for simulation and training in any of the three educational sectors targeted by HoTEL.

[61] Handy Potter http://www.futurity.org/science-technology/3d-design-with-no-mouse-just-hand-gestures/ .
[62] TeleHuman http://www.youtube.com/watch?v=yqmiOsoaIhE

Gesture-based computing has strong potential both for learning and teaching. In general, it can be a good technological support for learning practices like "Microlearning" or Game-based learning. This technology gives learners the possibility to interact with ideas and information in new and more natural ways than using computer operating systems through the traditional input methods. In the case of trainers and teachers, it gives opportunities to explore new ways to communicate ideas.
Examples of working projects: EyeMusic[63] is a project from the University of Oregon Cognitive Modeling and Eye Tracking Lab in which an eye tracker is connected to a multimedia performance environment to create computer music and interactive art based on eye movements. Virtual Autopsy Table[64] is a visualization tool with a gesture based user interface that allows the exploration inside the human body. Various users can interact collaboratively and simultaneously with large and complex data to gain better insights into the human organs, functions and processes. The Virtual Autopsy Table is developed by the Interactive Institute in collaboration with Norrköping Visualization Center and Center for Medical Image Science and Visualization (CMIV) in Linköping, Sweden. Currently it is commercially available for museums, science centers and other type of public institutions under the name Inside Explorer.

Mainstream adoption: According to the MNC Horizon STEM+ report [35] the Gesture-based computing time-to adoption is within the next 4-5 years, defining it as emerging (not mature) technology. As this type of technology can be considered as one of the NUI implementation, the previous analysis of NUI time- to adoption is also valid for Gesture-based computing.

5.16 Gesture Control

Gesture control is the ability to recognize and interpret movements of the human body in order to interact with and control a computer system without direct physical contact. The term "natural user interface" is becoming commonly used to describe these interface systems, reflecting the general lack of any intermediate devices between the user and the system.[65]

Relevance for Education: Gesture controlled user interfaces are most needed where there advantages in natural mapping come into play: first experiments on using gestures and body interaction to better learn scientific representations are available and are convincing. Extending this work and putting it on a solid basis surely will help enrich learning with these new technologies – in formal education institutions.

[63] EyeMusic http://www.cs.uoregon.edu/research/cm-hci/EyeMusic/
[64] Virtual Autopsy Table https://www.tii.se/projects/autopsy
[65] Gesture control definition retrieved from Gartner Glossary http://www.gartner.com/it-glossary/gesture-control/

Beyond that, gesture control and body posture interaction has several niches in which it is used already today with success: for example, in situations where interaction with classic devices such as mouse or keyboard is not available or not relevant (through a shop window, in manufacturing environment, for a professional dancer). In that respect, it also has impact on WPL and ILPN. The use of this type of user interface can be relevant for supporting learning practices like "Microlearning" or "Game-based learning/ Gamification".
An example of working project is TELL-ME[66] an integrated project (tellme-ip.eu) which uses such technology with the intention to support learning in manufacturing. MIT has also demonstrated SixthSense[67], a gesture-controlled necklace device that projects digital information onto real-world objects and locations. It brings intangible, digital information out into the tangible world, and allowing users to interact with this information via natural hand gestures. 'SixthSense' frees information from its confines by seamlessly integrating it with reality, and thus making the entire world our computer.

Mainstream adoption:
The Gartner report on Emerging Technologies 2012[39] defines Gesture Control as mature technology putting it in the "Sliding into the Through" stage and predicts its mainstream adoption in the next 2- 5 years. In this case, the technology is becoming easily available but special attention should be paid to the design of learning processes supported by this technology considering sound and suitable pedagogical and social inclusion guidelines.

5.17 Gesture Recognition

Gesture recognition technologies implemented through camera-based applications are capable of identifying and interpreting user motions. This kind of application allows the recognition and interpretation of human body movements in order to provide computers with user interface without direct physical contact.[68]

Relevance for Education: Facilities to observe and record gestures and allow for sharing of experiences bears potential for changing how learning is supported with technology in particular niches. For example, it is possible to record and visualize the movement of professional dancers to help learners in optimizing their performance or for example, it is possible to assess how well a learner of a sign language is actually matching the prototypical signs. This type of technology represent an ideal support for optimizing training activities and support effective

[66] TELL-ME http://tellme-ip.eu
[67] MIT SixthSense http://www.pranavmistry.com/projects/sixthsense/#PICTURES
[68] Gesture recognition definition from Gartner Glossary http://www.gartner.com/it-glossary/gesture-recognition/

evaluation of physical skills and new learning practices such as "Microlearning" or "Game-based learning" in formal settings like HE and WPL.
Some examples of working projects are: Kinectspace[69] a tool that allows everybody to record and automatically recognize customized gestures using depth images as provided by the Kinect sensors. The software observes and comprehends the user interaction by processing the skeleton of the user. Mogees[70] Gesture-Based Recognition with Contact-Microphone: is an application that uses a contact microphone to turn any surface into a touchscreen recognizing all kind of hand gestures.

Mainstream adoption: The edition 2011 of Gartner Emerging Technologies report [40] defines Gesture recognition in the stage "Sliding into the Through" and predicts it will be mainstreamed in the next 2-5 years. Although a set of Gesture recognition technologies for body, upper limb and hands movements are mature and there is available a wide range of application and devices with user interfaces supporting such gestures' recognition and control. Still there is set of technologies for face gesture recognition which are not so mature, and they require of further refinement to avoid fault positives or negatives interpretation. For the adoption of this type of technology in educational sectors is needed to take into account the same factors were described in the section dedicated to Natural User Interfaces and Gesture control.

5.18 Wearable Technology

Wearable computers and their interfaces, like a wrist-mounted screen or head-mounted display, are designed to be worn on the body and they enable mobility and hands-free/eyes-free activities[71]. Wearable technology will enrich the capabilities of interaction provided by augmented reality.

Relevance for Education: The "traditional" uses of Wearable technologies are for mobile inspection and maintenance in industry and military environments. Consumer uses include display peripherals, computer-ready clothing and smart fabrics. The benefit of wearable technology is that it can conveniently integrate tools, devices, power needs, and connectivity within a user's everyday life and movements. The relevance of this technology to support learning in the different sectors targeted by the project is very similar to the use of augmented reality. In particular in WPL to provide support to those training processes in dangerous conditions, where the use of wearable technologies can help to detect conditions

[69] Kinectspace http://code.google.com/p/kineticspace/
[70] Mogees http://www.sequencer.de/blog/mogees-gesture-recognition-with-contact-microphones/11722
[71] Wearable computer definition from Gartner Glossary http://www.gartner.com/it-glossary/wearable-computer/

where the trainer needs to perform specific tasks or could be affected due to the changes in the environment. In general aspects this type of technology can also provide an effective support for the implementation of informal learning practices like "Microlearning" or "Seamless learning".
Some examples of working projects using this technology are presented. The HC1 Headset computer[72] is a piece of wearable technology developed by Motorola, that consist of a headset that allow the instant access to documentation or start collaboration with other team members with simple users' voice commands or head movements. The Google glass project[73] presents the first prototype for consumer glasses a wearable technology specifically designed for augmented reality applications which is at the time of this writing under user evaluation. Keyglove[74] is a wireless, open-source input device that user wears over the hand to control devices, enter data, play games, and manipulate 3D objects.

Mainstream adoption: The MNC Reports [35, 36, 37, 38] foresee the Wearable technologies' time of mainstream adoption in the next 4-5 years due to the fact they currently are on piloting stages. They are very new (not mature) technologies although the possible range of applications is wide. And the use of this type of technology has potential to provide a good support for learning practices in the three educational sectors targeted in the HoTEL project. Nevertheless, the limiting factors for its adoption in those sectors can be in first place of financial nature since its cost of acquisition is still high for some learning institutions or SMEs; and second there are some cultural barriers in particular related to the use of big head accessories like cameras or helmets.

5.19 Internet of Things

The Internet of Things (IoT) is the network of physical objects that contain embedded technology to communicate and sense or interact with their internal states or the external environment[75].

Relevance for Education: The use of IoT in educational environments can be in first place cost-effective since will allow utilising existing connections and infrastructure in more efficient ways and will require less usability efforts. In particular it will permit to use the existing infrastructure as supportive learning mechanism and the creation of automated learning process according to enquiry-based learning. Moreover, it will have influence in the content management support systems since

[72] HC1 Headset computer http://www.motorola.com/Business/US-EN/Business+Product+and+Services/Mobile+Computers/Wearable+Computers/HC1
[73] Google Glass project http://www.google.com/glass/start/what-it-does/
[74] Keyglove http://www.keyglove.net/
[75] Internet of Things definition from Gartner Glossary http://www.gartner.com/it-glossary/internet-of-things/

all types of physical objects could act as learning objects. Furthermore it will demand of pedagogical expertise to design sound pedagogical process for synchronous and asynchronous modes of learning that can be contextualized, localized or globalized according to the learning needs, time and environment conditions. Therefore, the use of IoT will be relevant for all sectors addressed by HoTEL. In the case of WPL and HE, according to the experience of some of our interviewees, the support that IoT can provide will help to set transparent and communicative learning that would eventually increase responsibility and leadership (e.g. management skills), decrease future training needs and increase problem-solving and other cognitive skills. In general the availability of this technology will facilitate smoother implementation of learning practices like "Seamless learning", "Flipping the classroom" or "Microlearning".
One interesting example of working project related to IoT is Scratchable Devices[76]. It is a research project at Rutgers University that is enabling end-users to use the graphical programming language Scratch to program household devices, such as coffee makers, lamps, and alarm clocks. It enables the average person to program complicated scheduling and repetition, rich interaction between devices, and logical decision making. The Scratch programing language[77] has been designed with learning and education in mind and it allows learners to develop important design and problem-solving skills, learning how to think creatively, reason systematically, and work collaboratively. Another project is Amarino[78], developed by MIT, is a toolkit that allows users to control the lights in a room, and detect exposure levels to radiation or other potentially harmful environmental factors through their smartphones

Mainstream adoption: The MNC Reports [37,38] predict the time of mainstream adoption of IoT in the next 4-5 years as it is a really new (not mature) technology.
While there are examples, such as the Libelium[79], of what the Internet of Things might look like as it unfolds, it is still today more concept than reality. Although the underlying technologies that will make it possible — smart sensors that can easily be attached to everyday objects to monitor their environment or status; new forms of low-energy radio transmission that can enable the sensor to send its information wirelessly or via electric lines to a network hub; and an expanded address space for the Internet — are all well understood, easily mass-produced, and inexpensive. Their integration in ready-to-use applications is yet not available. Therefore the inclusion of this technology in this study aims to keep informed the possible educational adopters of the advantages it can offer and the need of sound pedagogical approaches to get benefit of such advantages.

[76] Scratchable Devices http://scratchabledevices.com/
[77] Scratch programming language http://info.scratch.mit.edu/About_Scratch
[78] Amarino http://www.amarino-toolkit.net/
[79] Libelium http://www.libelium.com/top_50_iot_sensor_applications_ranking/

5.20 Context aware computing

Context-aware computing (CAC) centers around the concept of leveraging information about the end user to improve the quality of the interaction with the end user.[80]

Relevance for Education: Geographical positioning systems and environmental sensors belong to the set of technologies needed for the deployment of Context-aware applications. This type of applications can be used to provide personalized/adaptive support to participants on the learning process, adjusting learning contents or activities according to the environmental conditions of their localization. For instance, if a learner is performing a learning activity that needs the visualization of a video and he is in a very noisy setting, the recommendation mechanisms based on the information gathered by context aware applications will provide an alternative content that will substitute the video by a text to read or will activate the video subtitles. The support provided by context aware computing considering the computing environment (PC, tablet, peripherals, network connections), user context (profile, location, time, emotional state, developed activities) and the physical context (light, noise levels, temperature, traffic conditions) is therefore relevant for all the sectors targeted by HoTEL: In the case of HE; WPL it will facilitate the appropriated implementation of learning practices like "Microlearning", "Gamification", "Flipped classroom".

Mainstream adoption: The 2012 Gartner Report [39] defines Context aware computing on the "On the rise of expectations" stage and foresees that it will be broadly adopted in the 5 to 10 years. Therefore it can be considered as emerging and "not-mature" technology, it is important to stress that underlying technologies like geographical positioning systems and environmental sensors are already mature and wide available but others like facial gesture recognition, voice recognition (speech analysis) or detection of other individuals' presence are still under development. Again a sound pedagogical design should be follow to benefit from the advantages previously explained.

5.21 Context enriched services

The term "context-enriched services" describes software that uses information about an end user's environment, community, process and identity to enrich the functionalities provided to the user[81]

[80] Context aware computing definition from Gartner Glossary http://www.gartner.com/it-glossary/cac-context-aware-computing/

[81] Context enriched services definition from Gartner Glossary (http://www.gartner.com/it-glossary/cac-context-aware-computing/).

Relevance for Education: Context enriched services are the component of Context aware computing that allows to enhance the functionalities provided to the user according to the information gathered from his computational environment, personal context and ambience conditions, let it be personalization or adaptation of the offered functionalities. Thus, the relevance analysis presented for Context aware computing is here valid. Furthermore this type of technology can be considered as an ideal support for "Microlearning" or "Seamless learning" since it use information from the environment to provide services that will represent sources of learning in the first case and to eliminate the barriers between the formal and informal learning in the second case.
Example of working project is Google Latitude[82], which uses Global positioning systems, IP addresses, if WIFI is connected and tower signal info to locate the exact position on Earth but also use your location and time. It allows the user to share his location in the map but also to localize those friends who are using the same application and sharing their location.

Mainstream adoption:
The 2012 Gartner Report [39] sees Context aware computing on the "On the rise of expectations" stage and foresees that it will be broadly adopted in the 5 to 10 years. The analysis presented for Context aware computing is valid here.

5.22 Immersive technologies

Immersive technology refers to technology that blurs the line between the physical world and digital or simulated world, thereby creating a sense of immersion[83]. A fully immersive perceptually-real environment will consist of multiple hardware/software/applications components to provide perception and interaction with the environment. In the case of visual perception required technologies can be 3D display, Holography, head-mounted display. For Auditory perception are needed 3d audio effects, Surround audio. For Tactile perception haptic technologies can be used. Meanwhile Machine olfaction and artificial flavour are used for olfaction and gustation respectively. In addition the interaction is offered through the following technologies Gesture recognition, Speech recognition, Brain-computer interface. Usually the software is provided by AI and virtual worlds applications.

Relevance for Education: Immersive technologies can be considered as ideal support of user interaction with an interesting potential for learning because it allows learners to get better understanding of the objects and processes represented in the virtual environment situations they are immerse in. The use of

[82] Google Latitude https://latitude.google.com/latitude
[83] Google Latitude https://latitude.google.com/latitude

this type of technology has different degrees of importance for the learning sectors addressed in the project: It is might have higher impact on supporting learning processes in HE especially when Game based Learning or Gamification approaches are implemented and they help to encourage the imagination, support exploration and develop soft skills. In the case of WPL, the use of these technologies can be very useful to support learning processes related to training in expensive or dangerous conditions that help to reduce costs and risks.
Examples of working projects are: The Open Orchestra simulation game[84] from McGill University. It is a platform that uses high definition panoramic video and surround sound to provide musicians with the immersive experience of playing in an orchestra or singing in an opera. A touchscreen in the music stand displays an electronic version of the score and the system controls, as well as a visualization that compares the student's performance to that of a professional musician, ensuring the motivation and self-evaluation.

Mainstream adoption: This set of technologies according to the MATEL study [1] will have impact on Education in the next 10 years. They are "not-mature" emerging technologies although some of the technologies belonging to this trend that facilitate auditory and tactile perception are already available, others like 3D displays are slowly getting mainstreamed and others to support olfaction and gustation perceptions are more concepts than real products. Bearing in mind that these technologies are very new, their application to education represent some challenges for instance from HCI how to design immersive experiences that allow to effectively manage the facilities and opportunities the technology offer. Also means to check to which extent the stated learning goals are achieved through the immersive experience. And last but not least important, institutions willing to adopt these technologies should wisely assess their cost of acquisition and the return of that investment.

5.23 Virtual worlds

A virtual world is an online community that takes the form of a computer-based simulated environment through which users can interact with one another and use and create objects [8]. The term has become largely synonymous with interactive 3D virtual environments, where the users take the form of avatars visible to others [14]. These avatars usually appear as textual, two-dimensional, or three-dimensional representations, although other forms are possible like auditory and touch sensations for example.

Relevance for Education: Being virtual worlds one of the applications composing the Immersive technologies, the relevance analysis presented in the preceding

[84] The Open Orchestra simulation game http://canarie.mcgill.ca/project_nep2_index.html

section also applies here. In addition, it is also important to stress the potential of virtual worlds to support collaborative learning activities of project based approaches that can be implemented by means of a simulated (virtual) environment.
One example of the use of this technology for education worthy to mention is SciEthics Interactive[85] a project, funded by HP and the National Science Foundation, that is designed to create virtual simulations with a science and ethics focus. Learners can experience real world situations in the safety of a virtual environment and they can act as scientists collecting and analysing data in ethically challenging situations. The VERITAS[86] project also uses Virtual world technologies to provide training for designers and developers to ensure their products have accessibility embedded from the very initial stages of conception. Another example is Dreamland Metaverse[87] a project which provides OpenSim hosting services that can be deployed for learning activities in all educational sectors.

Mainstream adoption: The edition 2011 of Gartner Emerging Technologies report [6] defines virtual worlds in the stage "Sliding into the Through" as "almost mature" technology that will be mainstreamed in the next 5 to 10 years. There are plenty of examples of the use of this technology to support learning but it is important to stress that challenges for adopting it are mainly from interaction design perspective (HCI) where effective solutions are still needed to effectively manage all possible peer interactions. Also, as in the case of Immersive technologies, it demands of means to check to which extent the stated learning goals are achieved through the virtual interactive experience.

5.24 Hybrid-Cloud computing

Hybrid cloud computing refers to policy-based and coordinated service provisioning, use and management across a mixture of internal and external cloud services[88].

Relevance for Education: The advantages for educational settings explained in the section dedicated to Cloud Computing apply also here. In addition the use of Hybrid cloud computing seems to be the best solution to properly benefit from public and private cloud infrastructures and to overcome possible privacy issues associated to the storage of private or privileged information on public cloud services. Moreover, the availability of infrastructures that allows localizing and retrieving resources

[85] SciEthics Interactive http://www.sciethicsinteractive.com/
[86] VERITAS project
[87] Dreamland Metaverse http://www.dreamlandmetaverse.com/en/e-learning
[88] Hybrid cloud computing definition http://www.gartner.com/it-glossary/hybrid-cloud-computing/

stored in the cloud gives good opportunities to support new learning practices like "Microlearning", "Seamless Learning" and Connectivism".

Mainstream adoption: The Gartner 2012 Report [39] defines Hybrid cloud computing at the "On the rise of expectations" stage and foresees it will be mainstreamed in more than 10 years. Such statement declares this type of technology as "emerging and not-mature". Although cloud computing technologies are already broadly adopted, its hybrid variant requires of effective design approaches for coordinated service provision management across public and private cloud services and of implementation of policies accordingly, which are still in progress and they are not commonly adopted. Therefore, it is recommended to institutions willing to adopt this type of technology to carefully assess the implementation/ adaptation cost of the design of coordinated services management and policies for hybrid computing.

5.25 Private cloud computing

Private cloud computing is a term that refers to a proprietary computing architecture that provides hosted services to a limited number of people behind a firewall. Advances in virtualization and distributed computing have allowed corporate network and data centre administrators to effectively become service providers that meet the needs of their "customers" within the organisation.

Relevance for Education: The advantages for Education explained in the section dedicated to Cloud Computing apply here. In the case of WPL and HE, the use of public cloud computing infrastructures and general cloud-based application can represent a problem mainly because of security and privacy polices implemented in those institutions. Therefore the use of private cloud computing infrastructure becomes the good solution to solve these issues.

Mainstream adoption: Private cloud computing is at the "Peak of expectations" stage and it is predicted that will be mainstreamed in the next 2 years according to the Gartner 2012 Report [39]. Such prediction shows the maturity of this technology but it is essential to consider the effective implementation of organisational and management mechanism that will properly deal with learning outcomes evidences and the availability of learners' performance data.

5.26 Hosted virtual desktops

A **hosted virtual desktop** (HVD) is a full, thick-client user environment, which is run as a virtual machine (VM) on a server and is accessed remotely. HVD implementations comprise server virtualization software to host desktop software

(as a server workload), brokering/session management software to connect users to their desktop environment, and tools for managing the provisioning and maintenance (e.g., updates and patches) of the virtual desktop software stack[89]. Hosted virtual desktops are key elements in the technological trend "Any channel, any device, anywhere".

Relevance for Education: Hosted virtual desktops can be used to setup working/learning environments that will allow learners/trainees to focus on the learning/interaction process and in the development of activities that can lead them to the achievement of the stated learning goals. But also can be a good instrument to support the implementation of learning analytics approaches to understand, optimise and guide the learning process. Hence HVD are relevant for formal learning processes held in HE and WPL. In addition, their use provide appropriated support to implement new learning practices like "Gamification", "Game-based learning" or Flipping the classroom in its face to face phase. The following examples of working projects that provide hosted virtual desktop are not specifically designed for educational settings but they can be adapted according to the requirements of such contexts: CloudMyoffice[90] Rackspace Hosted Virtual Desktop platform[91] and Citrix XenDesktop[92].

Mainstream adoption: This type of technology is already mature according to the consulted Gartner 2012 Report [39], which puts it in "Sliding into the Through" stage and predicts its broad adoption in the next 2 years. Such statement makes sense because HVD products are based on the use of cloud computing infrastructures which are also a mature technology and there are available ready-to use- services that provide HVD. Again the its adoption to support educational process needs to consider effective and holistic design approaches to ensure that pedagogical and interaction aspects are properly implemented in order to facilitate the achievement of learning competences.

5.27 HTML 5

HTML 5 core aims have been to improve the language with support for the latest multimedia developments while keeping it easily readable by humans and consistently understood by computers and devices (web browsers, parsers, etc.). It is also an attempt to define a single mark-up language that can be written in either HTML or XHTML syntax. It includes detailed processing models to encourage more interoperable implementations; it extends, improves and rationalises the mark-up

[89] Hosted virtual desktop definition from Gartner Glossary http://www.gartner.com/it-glossary/hosted-virtual-desktops-hvd/
[90] CloudMyoffice http://www.cloudmyoffice.com/
[91] Rackspace Hosted Virtual Desktop platform http://www.rackspace.com
[92] Citrix XenDesktop http://flexcast.citrix.com/technology/hostedshared.html

available for documents, and introduces mark-up and application programming interfaces (APIs) for complex web applications. Thanks to those features, HTML5 is also a potential candidate for cross-platform mobile applications[93].

Relevance for Education: HTML5 is a technology belonging to the Application stack of BYOD trend as programming language that allows the implementation of cross-platform (interoperable) web applications and Mobile Apps. Therefore the analysis of the relevance of those applications and the use of Tablet computing in Education is also transferable to HTML5. Some examples of working applications based on HTML5 are: Google body[94] that is web app powered with WebGL and HTML5, which allows user to examine and learn details about the human body. Verify[95] is an app lets developers/designers test screenshots of their design work to gain valuable insights on the users' expectations and reactions to designed apps and websites before writing a single line of code. Also HTML5 arena site[96] shows a monthly updated list of examples of HTML5 applications.

Mainstream adoption: This is not mature emerging technology according to the consulted Gartner 2012 Report [39] that puts HTML5 at "the Peak of expectations" stage with a time-to adoption from 5 to 10 years. But in this case, the availability of practical applications contradicts the predictions of Gartner studies: everyday can be found more and more applications that will led to the broad adoption of this technology earlier than the time predicted by Gartner.

5.28 Activity streams

An activity stream is a publish-and-subscribe notification mechanism and conversation space commonly found in social networking settings. It lists activities or events relevant to a person, group, topic or everything in the environment. A participant subscribes to, or "follows" entities (e.g., other participants or application objects) to track their related activities[97]. So it is a kind of list of activities or events relevant to a person or a group or a topic and the participants who subscribe, follow these specific objects and receive all the information about which are the relevant events or activities that took place within an interaction environment.

[93] HTML 5 definition from Wikipedia http://en.wikipedia.org/wiki/HTML5
[94] Google body http://www.zygotebody.com/#nav=1.57,-198.5,172
[95] Verify http://verifyapp.com/
[96] HTML5 arena http://www.html5arena.com/blog/html5/16-awesome-examples-of-html5-applications/.
[97] Activity stream definition from Gartner Glossary http://www.gartner.com/it-glossary/activity-stream/

Relevance for Education: The implementation of activity streams has a potential to help improving the learning processes deployed in HE, WPL and ILPN settings. As it can be used as part of learning analytics solutions to gather information about learners and the actions they perform during a learning process that eventually help to improve their performance and how the process goes. The use of activity streams will allow learners a) to look back and reflect (in a sense, reflection is nothing else than creative sense-making of the past and this is made easier by allowing for rich history keeping through the use of an activity stream). Secondly and b), it allows for sharing experiences and thus allows teachers and facilitators to better orchestrate the learning experience, it allows others to learn from the experiences made, it also allows automated assessment tools to provide formative feedback.

Mainstream adoption: This is a mature emerging technology according to the consulted Gartner 2012 Report [39], which defines it in the "Sliding through" stage and predicts its mainstream adoption in the next 2 to 5 years. There are available successful implementations of activity streams like the one used in Facebook. But in the case of its adoption to support educational process, the design and implementation and use of activity streams mechanism needs to take into consideration, first, privacy issues and, second, the context of interaction. In the first case, special attention must be paid to the learners consent to be subject of tracking his information and actions within the settings of the learning environment.

5.29 Audio Mining/Speech analysis

Audio mining/speech analytics embrace keyword, phonetic or transcription technologies to extract insights from pre-recorded voice streams[98].

Relevance for Education: Audio mining and speech analysis provides an insight that can be used to classify audio streams, trigger alerts/workflows, and help to drive operational and trainer/learner performance through the learning process. This type of technological mechanism can be used for voice recognition and for instance, will help to improve learners' performance in foreign languages learning process since it will provide the means to allow learners to compare their speech and phonetic skill levels to the expected or desired levels. By other side, the use of this type of technology can have an impact on enriching the facilities of interaction offered by Context aware computing/enriching services and Personal Learning Environments. Therefore, the relevance for education analysis presented for those technologies also applies for Audio mining and speech analysis. A working product based on

[98] Audio –mining –speech analysis definition from Gartner Glossary http://www.gartner.com/it-glossary/audio-mining-speech-analytics/

speech analysis is hound-it[99] from Aurix. It includes desktop speech search that utilises high accuracy, high performance speech technology and is capable of complex searches to significantly reduce the resources required to analyse audio recordings.

Mainstream adoption: The consulted 2012 Gartner Report [39] assesses Context aware computing as an emerging "not mature" technology on the "On the rise of expectations" stage and foresees that it will be broadly adopted in the 5 to 10 years. In this regard, it is important to stress that some of the underlying technologies for audio mining and speech analysis are already mature but those related to the semantic analysis of the human voice are yet to be further developed. As it was explained for Activity streams adoption, the use of Audio mining and speech analysis to support educational process should be founded by a sound design and implementation considering privacy issues and the relevance of the interaction context.

5.30 Open-Source Learning Repositories

Learning resources are defined as diverse group of digital materials (often composed of several types of learning assets) which are accessible online. Those learning resources can be simple or complex; interoperable (with capabilities of being playable on a variety of platforms) and can be available based on open source (since their contents are offered for free and they can be modified as far as the terms of their open source licenses will be respected). Open Source Learning Repositories (OSLR) are a kind of digital libraries which allows to share, manage (search, localize, retrieve, upload and modify) open source learning resources. They store learning resources as well as their related metadata. Such repositories can be implemented as web applications, web services or software as services using cloud computing technologies.

Relevance for Education: In contrast to other technologies analysed in this study, OSLR comes from educational area. It is a supporting technology that allows the implementation of approaches based on the openness in Education that advocates for freely sharing of knowledge and states that learning needs should be met without demographic, economic, and geographical constraints [41]. This type of technology has relevance for all educational sectors addressed by HoTEL and provides the resources needed for the implementation of new learning practices like "Microlearning", "Seamless learning", Game based learning, "Flipping the classroom" but also is a cornerstone of the implementation of MOOCs. At individual level, the availability of OSLR facilitates an active learners' participation since they are not only passive content recipients but they can become contributors to the content authoring and thus, helping to foster their creativity. In the case of

[99] hound-it http://www.aurix.com/pages/4835/hound-it_1.3.htm

teachers/trainers/ facilitators, OSLR open new possibilities for contextualization and to enhance their supporting material using the resources retrieved from OSLR. In both cases, the use of OSLR can also promote the collaboration between peers.
Examples of OSLR are the OpenCourseWare initiative[100] launched by MIT in 2001. It is a web-based publication of virtually all MIT course content. OCW is open and available to the world and is a permanent MIT activity. Thus, its availability has a clear impact on the educational market allowing the implementation of MOOCs. The OpenCourseWare Consortium[101] is a worldwide community of hundreds of higher education institutions and associated organisations committed to advancing OpenCourseWare and its impact on global education: As it serves both the individuals who use OCW and the institutions that make OCW a tangible asset for education. Other example is OpenScout[102] a project that provides education services in the internet that enable users to easily find, access, use and exchange open content for management education and training.

Mainstream adoption: Open Source Learning Repositories were spotted by Garner Hype cycle for Education report in 2012[39] in the Sliding into the through" stage as a mature technology trend that can be mainstreamed in the time period from 2 to 5 years. Although there are plenty of examples of OSLR implementations that show the maturity of this technology, important technical aspect like interoperability for search and retrieval facilities still need further development. Also the integration of LMS, repositories and educational legacy systems into a common workflow needs to be addressed as well as the integration with social networking facilities. Last and not least important, the use of OSLR implementation needs of holistic approaches to create and benefit from open educational opportunities. Therefore the list of best practices cases[103] provided by the Open Educational Quality Initiative can be a good reference for institutions willing to adopt OSLR implementations.

5.31 Summary

The previously presented analysis of the experts' views regarding to the relevance and potential use of the selected set of technologies can be summarized as in the following table. Each row of the table includes the information about the studied technology with a mapping of the clusters used for its selection (cluster from desk research/category from Field Research) and the potential of its use for each of the educational sectors targeted in the project. The information gathered in this table in conjunction with the data presented in Annex 3 can be used as input for the selection of innovations to validate the HoTEL innovation model in the Learning Exploratoria.

[100] MIT OpenCourseWare (OCW) http://ocw.mit.edu/
[101] OpenCourseWare consortium(OCW) http://www.ocwconsortium.org/
[102] OpenScout http://www.openscout.net/project
[103] Open Educational Quality Initiative Best practice clearing house http://www.oer-quality.org/clearinghouse/browse/

Table 37. *Selected technologies' potential impact on the educational sectors targeted by HoTEL project*

Technology			Potential impact on educational sectors			
Cluster/Desk research	**Category**	**Name**	**Higher education**	**STEM+**	**Workplace learning**	**Informal learning in professional networks**
Ubiquitous computing (UC)	Networked Collaboration	**Mobile Apps**	X	X	X	X
Ubiquitous computing (UC)	Devices and connectivity	**Tablet computing**	X	X	X	X
Environments and technologies for collaboration	Networked Collaboration	**Collaborative environments**	X	X	X	X
Ubiquitous computing (UC)	Devices and connectivity	**Cloud computing**	X	X	X	X
Environments and technologies for collaboration	Networked Collaboration	**Social networking**	X	X	X	X
Augmented reality	Visualization/Simulations:	**Augmented reality**	X	X	X	
Access-to-content related technologies (CRT)	Electronic Contents	**Massive Open Online Courses**	X	X		X
Personalized, adaptive technologies (PA	Personalization/ Open Repositories	**Personal Learning Environments**	X	X	X	X
Games and Virtual Worlds	Games	**Game based learning**	X	X	X	
Games and Virtual Worlds	Games	**Gamification**	X	X	X	

Technology			Potential impact on educational sectors			
Cluster/Desk research	**Category**	**Name**	**Higher education**	**STEM+**	**Workplace learning**	**Informal learning in professional networks**
Data Mining	Data mining and social analytics	**Learning analytics/Social Analytics**	X	X	X	
Environments and technologies for collaboration	Collaborative environments/Data mining/knowledge management	**Collective Intelligence**	X	X	X	X
Environments and technologies for collaboration	Collaborative environments/Data mining/knowledge management	**Idea Management**		X	X	X
Human computer interaction (HCI)	Interactions	**Natural User Interfaces (NUI)**	X	X	X	X
Human computer interaction (HCI)	Interfaces/ Interaction	**Gesture based computing**	X		X	
Human computer interaction (HCI)	Interfaces/ Interaction	**Gesture Control**	X	X	X	
Human computer interaction (HCI)	Interfaces/ Interaction	**Gesture Recognition**	X	X	X	
Ubiquitous computing (UC)	Pervasive computing	**Wearable Technology**	X	X		X
Ubiquitous computing (UC)	Devices and connectivity/Pervasive computing	**Internet of Things**	X	X	X	X
Ubiquitous computing (UC)	Pervasive computing	**Context aware computing**	X		X	X

Technology			Potential impact on educational sectors			
Cluster/Desk research	**Category**	**Name**	**Higher education**	**STEM+**	**Workplace learning**	**Informal learning in professional networks**
Ubiquitous computing (UC)	Pervasive computing	**Context enriched services**	X		X	X
Games and Virtual Worlds	Visualization/Simulations/Interactions	**Immersive technologies**	X		X	
Games and Virtual Worlds	Visualization/Simulations/Interactions	**Virtual worlds**		X	X	X
Ubiquitous computing (UC)	Any channel, any device, anywhere	**Hybrid-Cloud computing**	X	X	X	X
Ubiquitous computing (UC)	Any channel, any device, anywhere	**Private cloud computing**	X	X	X	X
Ubiquitous computing (UC)	Any channel, any device, anywhere	**Hosted virtual desktops**	X		X	X
Ubiquitous computing (UC)	Any channel, any device, anywhere	**HTML 5**	X	X	X	X
Environments and technologies for collaboration	Smart things	**Activity streams**	X	X	X	X
Data Mining	Data mining and social analytics	**Audio Mining/Speech analysis**	X		X	X
Access-to-content related technologies (CRT)	**Open Repositories**	**Open-Source Learning Repositories**	X	X	X	X

6. Conclusions

This document presents the first version of the "Emerging Technologies Landscape" report, which gathers the results of desk and field research activities carried out in WP1. This report includes an overview of the technologies (already in use, successfully piloted and emerging) that are believed to have an impact (or to have a potential impact) on learning processes in the three educational sectors (HE, WPL and ILPN) addressed by the HoTEL project.

This report presents the results of the desk research based on the analysis of a total of 86 research projects and 7 Networks of Excellence funded by the European Union as part of the FP6 and FP7 programmes. Additionally, we have considered the information from reports on the educational field provided by IPTS and the predictive Horizon Reports produced by the New Media Consortium.

A detailed analysis of the compiled information has allowed to identify the most relevant technologies, and to produce clusters that group them by similarity. The following 11 different clusters were identified: Web 2.0 based tools and systems, Ubiquitous computing, Augmented reality, Access-to-content related technologies, Human computer interaction, Learning Analytics, Games and Virtual Worlds, Environments and technologies for collaboration, Semantic-aware systems, Personalized, adaptive technologies and, finally, a cluster with the technologies that could not be grouped in any of the other clusters.

The analysis showed that *web based technologies* is the most funded topic within EU programmes. Furthermore, those technologies are usually researched in combination with other technologies such as semantic technologies or personalised learning content. In fact, in some cases making a clear distinction among the different clusters is not obvious. The analysis also shows the upcoming interest in ubiquitous computing in learning, especially via mobile and tablet computing. Another interesting conclusion is the irruption of learning analytics, an approach that has recently appeared and is gaining momentum rapidly. The analysis also revealed which technology combinations are more frequent. For example, the new interfaces suggested in the field of Human Computer Information are usually researched in combination with augmented reality techniques.

Another focus of the analysis was the identification of learning areas in which the researched technologies can be applied. The following 4 areas were identified: Formal education (including primary, secondary and higher education), non-formal learning, workplace learning and museums. We also considered technologies that do not apply to any explicit area of learning, and also technologies that do not even explicitly apply to learning.

The analysis shows the relationships among areas of learning and technology clusters. For example, games are mainly researched for their application in schools, while computer supported collaboration is the preferred topic for workplace learning. Furthermore, a number of projects not explicitly for learning research are based on ubiquitous computing technologies, so it is expected that such technologies will impact on the near future of TEL research.

The IPTS and NMC reports (a total of 34 reviewed documents) reveal predictions on which technologies will be used in the near future of education. The most recent predictions introduce new and interesting concepts, such as 3D-printing, the Internet of Things, learning analytics, massive online open courses, augmented reality and wearable technology.

The second part of the report includes the results of the field research and presents an analysis of the 30 technologies selected according to the technology trends spotted by the consulted sources (Gartner studies, MNC and IPTS reports - 20 reviewed documents), their predicted time-to-adoption; the clusters of technologies identified in the desk research and the information gathered from the 24 conducted interviews. The list of analysed technologies is presented in Annex 3.

The field research analysed emerging technologies with different degrees of maturity. In particular, the examination of those technologies considered as "less mature" or "not mature" aimed at providing information to the project WPs in charge of designing the HoTEL innovation cycle. Such type of information will allow foreseeing the possible impact of those technologies on the different learning sectors in advance. First, this will help first to detect which could be the most appropriated conditions for taking advantage of the facilities offered by the technology to support new learning practices. And second, it will allow assessing the feasibility of putting in place mechanisms to ensure the reduction of time for adopting the technology in the targeted educational contexts.

The added value of this study in comparison to the results of the studies used as source of information is a deeper examination of the relevance of each of the selected technologies for each of the targeted educational sectors (HE, WPL and ILPN), its potential for supporting new learning practices in those sectors and the presented overview of the cost, organisational, design factors which represent barriers and facilitators for their broadly adoption such contexts. Those are elements of interest to consider in the HoTEL innovation cycle design, along with the recommendations for matching technologies with learning practices in the different target sectors in order to reduce the innovations' time of adoption.

In addition, this report recommends designers of the innovation cycle to consider the following elements that can characterise the type of innovation each

organisation is seeking to achieve: nature of the innovation (expected level of change: incremental, radical, disruptive); implementation phases (stage of development: pilot, scale, mainstreaming); access level (geographical coverage: local, regional, cross-border); target (actors addressed: single user, multiple actors, wide-range of actors)[9].

The presented "Emerging Technologies Landscape" wants to contribute to the design of the HoTEL Innovation cycle with an overview of the emerging technologies (infrastructure, organisation and applications or tools) with relevance for the learning practices identified in WP2 and the factors of influence for the adoption of such innovative approaches in the three educational sectors addressed by the project. This work will also serve WP3 work, as reference to select grass-root innovators. And finally, it is expected that validation results from WP4 will be also used to further update the contents of this deliverable to produce the second version of the "Emerging Technologies Landscape" report in M18.

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8. Annex 1: Thesaurus created for the desktop research analysis

Categories	Subcategories	Keywords			
Technologies	Web 2.0 based tolos and systems (WEB)	web 2.0 online communication tools blogs podcasting eportfolio accessible web content e-portfolio	multimedia content web interfaces widgets integration distributed open infrastructure linked data service-oriented	online applications for teaching learning management systems learning standards interoperability cloud computing grid computing	social networks social media foaf online communities social network analysis social software
	Ubiquitous computing (UC)	ambient intelligence internet of things smart objects location based services ubiquitous computing	intelligent contexts pervasive technologies context-aware systems pervasive computing smart spaces	mobiles tablet computing mobile apps mobile devices	mobile learning geo-everything creative classrooms future classroom
	Augmented reality (AR)	augmented reality	simple augmented reality	merge virtual and physical worlds	
	Access-to-content related technologies (CRT)	open source content massively open online courses alternative licensing	super rich online repositories electronic publishing digital preservation	creative commons opencourseware	content repositories content creation
	Human computer interaction (HCI)	human computer interaction gesture based computing natural user interfaces	brain-machine interfaces 3-d holographic displays adaptable interfaces	haptic interfaces enriched interfaces interfaces	tactile interfaces voice interfaces
	Learning Analytics (LA)	data mining big data and learning analytics	learning analytics information visualization	student monitoring	visual data analysis
	Games and Virtual Worlds (GVW)	immersive virtual worlds computer generated simulations simulation of physical,	simulations for training virtual environments simulations	games game-based learning	serious games 3d virtual worlds

		chemical models			
	Environments and technologies for collaboration (CSCL)	collaborative environments computer supported collaborative learning	telepresence	online communication tools	sincronous learning
	Semantic-aware systems (SAS)	semantic web metadata generation	natural language processing semantic-aware technologies	semantic interoperability	translation technologies
	Personalized, adaptive technologies (PA)	virtual mentors electronic tutors realtime assessment monitors artificial intelligence	attention management adaptive content smart learning content adaptive learning system	personalized content presentation recommender systems the personal web	personal learning environments roleswitching emotion-aware systems
	Other technologies (OT)	flexible displays smart-tv	e-books 3d printing	interactive whiteboards	wearable technology
Areas of learning	Formal education	higher education	secondary education	Schools	
	Non-formal learning	domestic learners	broad public	informal learning	lifelong learning
	Workplace learning	SME	industry	workplace	training
	Museums	museum			
	Unspecific field	not explicitly for learning	not specified		
	Other	music institutions digital library	learner with special needs educational curriculum	conflict resolution	social inclusion

9. Annex 2: List of reviewed FP6 and FP7 projects

Project reference	Acronym	Title
507740	CALIMERA	Cultural applications: Local institutions mediating electronic resources access
506811	AMI	Augmented Multi-party Interaction
507835	UNFOLD	Understanding Networks of Learning Design
1765	ACEMEDIA	Integrating knowledge, semantic and content for user-centred intelligent media services
507457	BRICKS	Building resources for Integrated Cultural Knowledge Services
508013	AGAMENON	Pictures from the past: A wireless network of magic digital cameras and palmtops for archaeological travels through the time
510166	COHERENT	Collaborative holographic environments for networked tasks
507826	LEACTIVEMATH	Language-enhanced, user adaptive, interactive eLearning for mathematics
507128	TELCERT	Technology enhanced learning certification - European requirements and testing
507844	CONNECT	Designing the classroom of Tomorrow by using advanced technologies to connect formal and informal environments
2205	E-LEGI	European learning GRID infrastructure
4337	CALIBRE	Co-ordination action for libre software engineering for open development platforms for software and services
4293	AKOGRIMO	Access to knowledge through the grid in a mobile world
511592	MICOLE	Multimodal collaboration environment for inclusion of visually impaired children
4778	ENABLED	Enhanced network accessibility for the blind and visually impaired
516895	PAPERWORKS	PaperWorks : Interweaving Paper and Digital Documents
28025	CALIBRATE	Calibrating eLearning in schools
28051	EMAPPS.COM	Motivating active participation of primary schoolchildren in digital online technologies for creative opportunities through multimedia
27168	ICAMP	intercultural learning campus
26883	I-MAESTRO	Interactive Multimedia Environment for Technology Enhanced Music Education and Creative Collaborative Composition and Performance

27607	MGBL	Mobile games based learning
27952	VEMUS	Virtual European Music schools
27087	TENCOMPETENCE	Tencompetence: Building the European network for lifelong competence development
27728	ARGUNAUT	An intelligent guide to support productive online dialogue
27529	ATGENTIVE	Attentive agents for collaborative learners
27073	COOPER	Collaborative open environment for project-centred learning
28027	LEAD	Technology-enhanced learning and problem-solving discussions: Networked learning environments in the classroom
27391	LT4EL	Language technology for eLearning
26751	RE.MATH	Representing mathematics with digital media
27611	AETHER	Self-adaptive embedded technologies for pervasive computing architectures
27020	ACCESS-EGOV	Access to e-Government services employing semantic technologies
27039	ARISE	Augmented reality in schools environments
27866	ELU	Enhanced Learning Unlimited
28038	PALETTE	Pedagogically sustained adaptive Learning through the exploitation of tacit and explicit knowledge
27451	LOGOS	Knowledge-on-demand for ubiquitous learning
27023	APOSDLE	Advanced process-oriented self-directed learning environment
27656	ECIRCUS	Education through characters with emotional-intelligence and role-playing capabilities that understand social interaction
27986	ELEKTRA	Enhanced learning experience and knowledge transfer
27149	LUISA	Learning content management system using innovative semantic web services architecture
33572	CASPAR	Cultural, artistic and scientific knowledge preservation, for access and retrieval
34545	A-WARE	An easy way to access GRID resources
34567	GRID4ALL	Self-* Grid: Dynamic Virtual Organisations for schools, families, and all
34549	AGENT-DYSL	Accommodative intelligent educational environments for Dyslexic learners
34778	EU4ALL	European unified approach for accessible lifelong learning

33860	QALL-ME	Question Answering Learning technologies in a multilingual and multimodal Environment
216837	ATRACO	Adaptive and trusted ambient ecologies
215064	IMPACT	Improving access to text
215893	REFLECT	Responsive flexible collaborating ambient
215434	GRAPPLE	Generic responsive adaptive personalized learning environment
216267	LIWA	Living web archives
217141	SOCIALNETS	Social networking for pervasive adaptation
212578	LTFLL	Language technology for lifelong learning
215918	80DAYS	Around an inspiring virtual learning world in eighty days
216199	IDSPACE	Tooling of and training for collaborative, distributed product innovation
216356	MATURE	Continuous social learning in knowledge networks
215098	PERSIST	Personal self-improving smart spaces
224047	REPLAY	Gaming technology platform for social reintegration of marginalised youth
224044	INCLUSO	Social software for inclusion of (marginalized) young people
222107	NIW	Natural interactive walking
231551	DL.ORG	DL.org: coordination action on digital library interoperability, best practices, and modelling foundations
231717	TARGET	Transformative, adaptive, responsive and engaging Environment
231266	COSPATIAL	Communication and social participation: collaborative technologies for interaction and learning
231590	INTELLEO	Intelligent learning extended organisation
225938	OPPORTUNITY	Activity and context recognition with opportunistic sensor configurations
231396	ROLE	Responsive open learning environments
257639	ALICE	Adaptive Learning via Intuitive/Interactive, Collaborative and Emotional systems
257886	ARISTOTELE	Personalised Learning & Collaborative Working Environments Fostering Social Creativity and Innovations Inside the Organisations
257872	METAFORA	Learning to learn together: A visual language for social orchestration of educational activities

257617	MIRROR	MIRROR - reflectionive Learning at Work
257566	HEATTRONICS	Innovative Technologies for an Engaging Classroom
258114	NEXT-TELL	Next Generation Teaching, Education and Learning for Life
258453	SIREN	Social games for conflIct REsolution based on natural iNteraction
257831	IMREAL	inmersive reflectionive Experience-based Adaptive Learning
257493	SOCIETIES	Self Orchestrating CommunIty ambiEnT IntelligEnce Spaces
257410	TERENCE	An Adaptive Learning System for Reasoning about Stories with Poor Comprehenders and their Educators
270001	DECIPHER	Digital Environment for Cultural Interfaces; Promoting Heritage, Education and Research
271578	ETOILECASCADESIDEAS	Enhanced Technology for Open Intelligent Learning Environments
288578	TARDIS	Training young Adult's Regulation of emotions and Development of social Interaction Skills
288587	MASELTOV	Mobile Assistance for Social Inclusion and Empowerment of Immigrants with Persuasive Learning Technologies and Social Network Services
288596	LITERACY	ONLINE PORTAL FOR E-LEARNING AND SUPPORTING SOCIAL INCLUSION OF PEOPLE WITH DYSLEXIA
296229	EUCLID	Educational curriculum for the usage of Linked Data
318803	ILEARNRW	Integrated Intelligent Learning Environment for Reading and Writing
318496	INTUITEL	Intelligent Tutoring Interface for Technology Enhanced Learning
317964	JUXTALEARN	Juxtapositioned reflectionive performance enabling science and technology learning
318499	WESPOT	Working Environment with Social and Personal Open Tools for inquiry based learning.
318299	WE.LEARN.IT	European schools enhancing creativity, exploration and science

10. Annex 3: Grid of technologies used in the Field research

Table 38. *The foreseen time for mainstream adoption of selected technologies.*

Selected Technologies			**Time for mainstream adoption**				
Cluster/Desk research	Cluster MATEL/Gartner	**Name**	**Time of adoption from Horizon reports 2012, 2013[35][36][37][38])**	**Emerging Technologies Gartner 2012[39]**	**Emerging Technologies Gartner 2011[40]**	**Emerging Technologies Gartner 2010[17]**	**MATEL study. Support educational changes in the next 5-10 years**
Ubiquitous computing (UC)	Networked Collaboration	**Mobile Apps**	1-less years	N/A	Climbing the slope (2 years)	N/A	X
Ubiquitous computing (UC)	Devices and connectivity	**Tablet computing**	1-less years	Climbing the slope (2 years)	Sliding into the Through (5-10 years)	N/A	X
Environments and technologies for collaboration	Networked Collaboration	**Collaborative environments**	1-less years	N/A	N/A	N/A	X
Ubiquitous computing (UC)	Devices and connectivity	**Cloud computing**	1-less years	Sliding into the Through (2 years)	at the Peak (2 to 5 years)	at the Peak (2 to 5 years)	N/A

Selected Technologies			Time for mainstream adoption				
Cluster/Desk research	Cluster MATEL/Gartner	**Name**	**Time of adoption from Horizon reports 2012, 2013[35][36][37][38])**	**Emerging Technologies Gartner 2012[39]**	**Emerging Technologies Gartner 2011[40]**	**Emerging Technologies Gartner 2010[17]**	**MATEL study. Support educational changes in the next 5-10 years**
Environments and technologies for collaboration	Networked Collaboration	**Social networking**	1-less years	Entering in the plateau (2years)	N/A	N/A	X
Augmented reality	Visualization/Simulations:	**Augmented reality**	2-3 years	at the Peak (5 to 10 years)	at the Peak (5 to 10 years)	Reaching the peak (5 to 10 years)	X
Access-to-content related technologies (CRT)	Access to Digital Contents	**Massive Open Online Courses**	2-3 years 1-less year (2013)	On the rise (2 years)*	N/A	N/A	N/A
Personalized, adaptive technologies (PA)	Personalization/ Open Repositories	**Personal Learning Environments**	2-3 years	N/A	N/A	N/A	N/A
Games and Virtual Worlds	Games	**Game based learning**	2-3 years	N/A	N/A	N/A	X
Games and Virtual Worlds	Games	**Gamification**	N/A	Reaching the Peak (5 to 10 years)	Reaching the Peak (5 to 10 years)	N/A	N/A

Selected Technologies			Time for mainstream adoption				
Cluster/Desk research	Cluster MATEL/Gartner	**Name**	**Time of adoption from Horizon reports 2012, 2013[35][36][37][38])**	**Emerging Technologies Gartner 2012[39]**	**Emerging Technologies Gartner 2011[40]**	**Emerging Technologies Gartner 2010[17]**	**MATEL study. Support educational changes in the next 5-10 years**
Data Mining	Data mining and social analytics	**Learning analytics/Social Analytics**	2-3 years	at the Peak (2 years)	Reaching the Peak (2 years)	Reaching the Peak (2 - 5years)	N/A
Environments and technologies for collaboration	Collaborative environments/ Data mining/knowledge management	**Collective Intelligence**	4-5 years	N/A	N/A	N/A	N/A
Environments and technologies for collaboration	Collaborative environments/ Data mining/Knowledge management	**Idea Management**	N/A	Climbing the slope (less 2 years)	Climbing the slope (5 to 10 years)	Climbing the slope (2 to 5 years)	N/A
Human computer interaction (HCI)	Interfaces/ Interaction	**Natural User Interfaces (NUI)**	4-5 years	N/A	N/A	N/A	N/A
Human computer interaction (HCI)	Interfaces/ Interaction	**Gesture based computing**	4-5 years	N/A	N/A	N/A	N/A

Selected Technologies			Time for mainstream adoption				
Cluster/Desk research	Cluster MATEL/Gartner	**Name**	**Time of adoption from Horizon reports 2012, 2013[35][36][37][38])**	**Emerging Technologies Gartner 2012[39]**	**Emerging Technologies Gartner 2011[40]**	**Emerging Technologies Gartner 2010[17]**	**MATEL study. Support educational changes in the next 5-10 years**
Human computer interaction (HCI)	Interfaces/ Interaction	**Gesture Control**	N/A	Sliding into the Through (2- 5 years)	N/A	N/A	N/A
Human computer interaction (HCI)	Interfaces/ Interaction	**Gesture Recognition**	N/A	N/A	Sliding into the Through (2-5 years)	N/A	N/A
Ubiquitous computing (UC)	Pervasive computing	**Wearable Technology**	4-5 years	N/A	N/A	N/A	N/A
Ubiquitous computing (UC)	Devices and connectivity/ Pervasive computing	**Internet of Things**	4-5 years	On the rise (more than 10years)	N/A	N/A	N/A
Ubiquitous computing (UC)	Pervasive computing	**Context aware computing**	N/A	On the rise (5 to 10years)	On the rise (more than 10 years)	N/A	N/A
Ubiquitous computing (UC)	Pervasive computing	**Context enriched services**	N/A	On the rise (5 to 10years)	On the rise (more than 10 years)	N/A	N/A

Selected Technologies			Time for mainstream adoption				
Cluster/Desk research	Cluster MATEL/Gartner	**Name**	**Time of adoption from Horizon reports 2012, 2013[35][36][37][38])**	**Emerging Technologies Gartner 2012[39]**	**Emerging Technologies Gartner 2011[40]**	**Emerging Technologies Gartner 2010[17]**	**MATEL study. Support educational changes in the next 5-10 years**
Games and Virtual Worlds	Visualization/Simulations/Interactions	**Immersive technologies**	N/A	N/A	N/A	N/A	X
Games and Virtual Worlds	Visualization/Simulations/Interactions	**Virtual worlds**	N/A	Sliding into the Through (5 to 10 years)	Sliding into the Through (5 to 10 years)	N/A	N/A
Ubiquitous computing (UC)	Any channel, any device, anywhere	**Hybrid-Cloud computing**	N/A	On the rise (more than 10years)	N/A	N/A	N/A
Ubiquitous computing (UC)	Any channel, any device, anywhere	**Private cloud computing (See Hybrid computing)**	N/A	at the Peak (2 years)	at the Peak (2 years)	N/A	N/A
Ubiquitous computing (UC)	Any channel, any device, anywhere	**Hosted virtual desktops**	N/A	Sliding into the Through (2 years)	Sliding into the Through (2 years)	N/A	N/A
Ubiquitous computing (UC)	Any channel, any device, anywhere	**HTML 5**	N/A	at the Peak (5 to 10 years)	N/A	N/A	N/A

Selected Technologies			Time for mainstream adoption				
Cluster/Desk research	Cluster MATEL/Gartner	**Name**	**Time of adoption from Horizon reports 2012, 2013[35][36][37][38])**	**Emerging Technologies Gartner 2012[39]**	**Emerging Technologies Gartner 2011[40]**	**Emerging Technologies Gartner 2010[17]**	**MATEL study. Support educational changes in the next 5-10 years**
Environments and technologies for collaboration	Smart things	**Activity streams**	N/A	Sliding through (2-5 years)	N/A	At the peak (2 to 5 yearsl	N/A
Data Mining	Data mining and social analytics	**Audio Mining/Speech analysis**	N/A	Sliding through (5 -10 years)	N/A	N/A	N/A
Access-to-content related technologies (CRT)	Open Repositories	**Open-Source Learning Repositories**	N/A	Sliding Into the Trough (2 to 5 years)	N/A	N/A	N/A

11. Annex 4: Interview questionnaire

Name of interviewer:
Date of interview:
Name of participant and affiliation
Area of expertise:

Technology selected as main topic: XXX Technology related to the interviewee's area of expertise

[Definition of the technology: to set a common understanding about the technology features for both participants in the interview (host and interviewee)].

1. Considering the previous definition and our project goals, please answer the following questions:
   a) How might this technology be relevant to each of the targeted educational sector (namely Higher Education, Workplace learning, Informal learning within Professional networks)? Why? Please explain your reasoning for each one of the three sectors. [This question was divided in 3 identical questions to facilitate interviewees to recall which of the sectors was analysed.]

   b) What do you see as potential impact of this technology for learning practices in those sectors? Do you think it can support new learning practices? Why?

   c) Do you know any working project related to this technology in any of those sectors? In case of affirmative answer, please can you list them and provide us with their contact information (email or website)?

2. "Geographical positioning systems and environmental sensors belong to the set of technologies needed for the deployment of Location-aware applications that has been considered in the 2011 Gartner Report as "Entering in the Plateau" in 2 years since there were evidences of high growth in its adoption. Location-aware applications can be used to provide personalized support to learners, adjusting learning contents or activities according to the conditions of their localization".

Considering the previous example of the use of emerging technologies with the purpose of supporting learning processes, please give us your opinion on the following:
"Which of the following technologies: **Technology2 and Technology3 (assigned to the interviewee according to his/her expertise)** that are not currently broadly used for learning purposes do you find with higher potential to be used in the sectors targeted by this project? Why? How? Please explain the rationale behind your selection in both cases.

[Presentation of both technologies definitions to set a common understanding about the technology features for both participants in the interview.]

3.- Do you want to make any comment about the topics covered in the interview or related to our project? In case of affirmative answer, please let us know.

12. Annex 5: List of interviewees

Table 39. *Participants in the Experts' consultation*

Name	Affiliation	Country	Domain of expertise	Technology themes
David Wortley	Serious Games Institute (SGI) at Coventry University.	UK	Immersive Technology Strategies	1)Immersive technologies /Cloud computing 2)Wearable computing 3)Activity streams
Eleni Berki	University of Tampere	FIN	Serious games	1) Natural User Interfaces (NUI) 2) Internet of things 3)Collective Intelligence
Hajo Koglin	SHARP	DE	interfaces/TELECOM	1)Mobile Apps 2)Game based learning 3)Gesture based computing
Donald Brinkman	Microsoft Research	USA	Serious games	1) Wearable Technology 2) Audio Mining/Speech analysis 3) Gamification
Nikolaos Avouris	University of Patras	GR	HCI	1)Internet of Things 2)Activity streams 3)Natural User Interfaces (NUI)
Thanos Tsakiris	CERTH/ITI	GR	3D Simulation and metaverses	1)Virtual Worlds 2)Augmented reality 3) Gesture Recognition
Vladan Devedzic	FOS	RS	Knowledge Management -Ontologies	1) Idea Management/Massive Open Online Courses 2) Immersive technologies 3)Private cloud computing
Mirja Pulkkinen	University of Jyvaskyla	FI	Cloud computing/ Organisational	1) Cloud computing 2)Private cloud computing 3) Context aware computing/Context enriched services
Abelardo Pardo	University of Sidney	AU	Learning Analytics	1)Social Analytics/ Learning Analytics 2) Gesture Recognition 3)Audio Mining/Speech analysis

Name	Affiliation	Country	Domain of expertise	Technology themes
Lluís Vicent	Open University of La Salle	AD	Educational Technology	1)Massive Open Online Courses 2) Open source learning Resources 3)Hybrid-Cloud computing
Zhedong Liu	Beijing Institute of Technology	China	ICT	1) Hybrid Cloud Computing 2)Gamification 3)Activity streams
Johann Riedel	Nottingham University	UK	GALA NoE (SG)	1) Gamification 2) Inmersive technologies 3) Virtual Worlds
Paul Lefrere	UK Open University	UK	TEL-Map	1) Audio Mining/Speech analysis 2) Immersive technologies 3) Hosted virtual desktop
Scot Osterweil	MIT	USA	Educational games	1) Gesture based computing 2)Context aware computing/Context enriched services 3) Wearable computing
Tony Bates	Research Associate with Contact North | Contact Nord, Ontario's Distance Education & Training Network.	CA	Learning Design	1)Gesture Recoginition 2)Idea Management 3)Virtual Worlds
Graham Attwell	Pontydysgu	UK/DE	Learning design	1)Game based learning 2)HTML 5 3)Hosted virtual desktop
Mathy Vanbuel	ATiT	BE	Learning design	1) Tablet computing/Mobile apps 2) Collective Intelligence 3) Internet of things
Prof. Dr. Jan M. Pawlowski	University of Jyvaskyla	FI	Digital Media - Global Information Systems	1) Augmented reality 2)Hosted Virtual desktop 3) Private cloud computing/Idea Management

Name	Affiliation	Country	Domain of expertise	Technology themes
Grainne C. Conole,	University of Leicester, UK	UK	Open Source Learning Repositories	1) Open Source Learning Repositories 2)Personal Learning Environments 3)Gesture Control
Teresa Pombo	ERTE	PT	Social networking	1) Social networking 2) Gesture Control 3) Wearable technology
Carlos Santos	University of Aveiro	PT	Personal Learning Environments	1) Personal Learning Environments 2) Wearable Technology 3)Context Aware Computing
Prof.Rodrigo Filev Maia	University Center of FEI	BR	Social Networking	1) Social networking 2) Collaborative environments 3) Context aware computing/Context enriched services
Fridolin Wild	KMi, Open University UK	UK	Gesture Control	1) Gesture Control 2) Collective Intelligence 3) Activity Streams