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D2.2.2

Mapping theories, technology and learning practices

SEVENTH FRAMEWORK PROGRAMME

HoTEL Holistic Approach to Technology Enhanced Learning

Innovators – Opinions – Perspectives

WP1.-2 | D 2.2.2

Mapping theories, technology and learning practices

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Executive Summary

The aim of this deliverable is to further validate and integrate the findings of HoTEL[1] WP1 and WP2 and produce a combined report, whose main contribution is the use of current educational challenges as a starting point to map learning theories, emerging technologies and learning practices. This report is aimed to also support the experts in the HoTEL Exploratorium labs[2] by shedding some light on the recent developments in technology areas and learning practices, which could affect the way we are organizing, delivering and managing learning and education in the future.

To achieve these goals, a one-day workshop with 12 TEL experts was organised by BRUNEL University and ATOS on the 14th of March 2014, in ATOS Innovation Centre in London. As per our HoTEL reviewers' suggestion, we have kept the number of experts small, in order to make it more manageable and to fully engage them in meaningful discussions, while making sure that everyone is actively participating in this process. A list of technological categories was prepared in order to make sure that we invite experts, who in-between them have knowledge in diverse areas in TEL and in emerging technologies around TEL, as well as in TEL pedagogies. This list was based on the two previous WP1 & WP2 deliverables (WP1: D1.1.2 "Emerging Technologies Landscape report" and WP2: D2.1.1. "Report on good practice of innovative Applications of learning theories in TEL") and on some further desk analysis on emerging technologies and learning practices conducted by WP1 and WP2. The selected set of technologies was composed of the following: Augmented reality; Immersive technologies; Internet of things; Wearable technology; Context aware computing/context enrich services; Gesture based computing; Audio Mining/Speech Analysis/natural language processing; Natural user interfaces; Big Data & neural networks; Computer brain interfaces/Neuro-gaming; Agent and Multi-Agent Systems/machine learning/AI; user models Although we contacted some experts in Computer brain interfaces and Neuro gaming, they were not able to attend the event due to prior commitments undertaken on the date of the workshop. The format of the event was based on working groups and strategic conversations.

A further goal of this workshop was to brainstorm on emerging/disruptive technologies and then map them to business/learning practices and learning theories in order to come up with a set of ideas to make the HoTEL ISM more useful

[1] HoTEL is a European Commission (EC) funded project which aims to develop an Innovation Support

[2] The Learning Exploratorium Labs represents a key concept of the HoTEL project: they are three innovation-friendly learning environments (one in higher education, one in a corporate setting, one within an international professional network focused on eLearning quality) which will test selected TEL innovations in real-settings.

and fitting for practice. This corresponds to a top-down expert approach and complements the bottom-up HoTEL Learning Exploratorium Labs' approach, which is based on discussing and testing a selected number of actual TEL innovations.

Three key themes or challenges emerged during the workshop and are presented in this document:
1. Organizational learning: Facing new and unexpected situations
2. Enhancing individuals: Technology enhanced learner
3. Assessment: Rethinking Learning Assessment

Acknowledgements

The researchers involved in the creation of this report would like to pay special thanks to all the experts who actively participated in the workshop and contributed to this research with their meaningful insights about how to map technologies and learning practices in order to face some of the existing challenges in the educational sectors addressed by the HoTEL project. This work will provide important input to the definition of the HoTEL Innovation Support Model and to the Labs. The list of the workshop participants is presented in Annex 5.

1. Introduction

WP1 and WP2 responsible partners took into consideration the reviewers' recommendations[3] by teaming up and collaborating closely during this year, adopting a different methodological approach to our research tasks. The first part of our work was a desk research aimed at analysing and selecting the 10 most relevant emerging technologies from the list of 30 emerging technologies, as summarised in D1.1.2, and 16 of the learning practices presented in the D2.2.1. The second part of our activities focused on organizing an Expert Validation of our desk research in the form of a face-to-face workshop. The present document reports on the outcomes of the sessions of this strategic one-day Experts Group workshop held in ATOS Innovation Centre in London on March 14th, 2014. This workshop aimed at providing a framework for brainstorming in order to improve, through a collaborative activity, the HoTEL Innovation Support Model, centred on how the recent developments in technology areas can affect the way we are organizing, delivering and managing learning and education in the future. The final endeavour of the workshop was to brainstorm on emerging/disruptive technologies and then map them to learning theories and new learning practices in order to come up with a set of ideas to make the HoTEL Innovation Support Model (ISM) more useful and fitting for practice.

A set of two reference documents was previously circulated between the experts who attended the event. This set was composed of:

- **Emerging technologies reference material**, which includes information about 10 emerging technologies, as selected in previous HoTEL's research activities in early 2014. For each technology, a short definition is presented and complemented with explanation of the rationale behind their relevance at the time of this analysis: Which are the latest developments related to such technologies and what examples of working prototypes or commercial products are currently available? Also some initial reasoning is included on how these technologies can be used to support the implementation of some of the learning practices described in the second reference material for this workshop. In particular, we selected these 10 technologies for further studies and validation, and in the desk research we analysed when those technologies can be used as main element to support the implementation of some of the learning practices presented in the second reference material; and when they can be used as additional technologies that help to enhance the implementation of such practices. For instance, if we are analyzing Wearable technologies, there is some evidence that shows that they can be used to enhance the implementation of Microlearning, but it is known that Microlearning can also be implemented without Wearable technologies, as it essentially requires Social networking and mobile

[3] See Recommendations 1,2,3 in the HOTEL Y1 Review report

technologies. The idea here is to differentiate when it is necessary to use some technology for the implementation of a learning practices and when that technology use is optional, in order to determine what is the potential impact of technology on the implementation of learning practices. Detailed information about this material can be found in Annex 2.

- **Overview of Learning practices reference material:** It presents a literature review of 16 learning practices resulting from the research conducted in WP2 during Y1, which was in turn inspired by the Observatory on Emerging Futures of the TEL-Map project. For each of the selected learning practices, a short description and related Learning theories were presented (please see Annex 3).

These reference materials aimed at providing information to the experts as a starting point for the brainstorming sessions, whose purpose was to define how these technologies, described in the Emerging Technologies reference material, can be used in the implementation of the different learning practices introduced in the second reference material. In addition, a google document was created in order to be used as a collaboration space for working together with the experts prior to the workshop. (See more details in Annex 5).

1.1 Workshop Methodology

The workshop was designed to consist of 4 different sessions as described below.

The **Introductory session** aimed at setting up and explaining the workshop working method. The HoTEL partners leading the event presented the HoTEL project and its Innovation Support model; briefly explained the goals of the workshop and the working method as part of introduction to the two main brainstorming sessions related to Emerging Technologies and Learning practices. This session included two presentations which summarised the results the desk research conducted previously by the project in early 2014, based on the outcomes of D1.1.2 and D2.2.1.Then two brainstorming sessions and a final parallel-group session followed.

The first of those brainstorming sessions was dedicated to **mapping emerging technologies** and to map the key themes and transitions associated to the analysed set of 10 emerging technologies.

The method that was followed during the session consisted of this set of steps:

Step 1: With the engagement of the experts, and starting from the technology evolution map presented in the Google document (which was mounted on a

whiteboard before the start of the meeting) try to bring it up to date with the experts during the session:
a) Use the set of 10 emerging technologies provided in the Emerging Technologies reference material and also available in the Google document as a starting point. Brainstorm with the experts on additional technologies not listed in the initial set of emerging technologies, expecting no more than 5 additional technologies.
b) Use the whiteboard and pink post-it notes to model the evolution. Prepare one post-it per technology and include the following information: title, short description, date of its first reference publications. Move and connect the pink post-its to model the evolution of technologies.

Step 2: Looking at the map, start thinking about:
Why things/technologies are now changing?
What is new and can be done differently?
What is connected? Which mix of technologies could facilitate the implementation of X learning practice?

a) Model the output in the map using pink and blue colour-coded post -its to represent: key themes of technology areas, and emergence of new applications, software and devices that can be used.

The second brainstorming session was dedicated to **Map emerging learning practices:** Main features of those practices, related theories and how they can be supported by technologies – and how to define a Value proposition.

The method followed during the session consisted of the next steps:

Step 1: Start thinking about how some of it can affect learning - and record output. Where are the opportunities for the learning practices? What should we do? How should we do it? Write new learning practices or changes/improvements in existing learning practice and add them next to the related technologies. Model the output as key themes of business/learning practice areas. Always use one post-it per technology, per practice.

Step 2: Use a new whiteboard next to the previous one and start making new maps for each learning practice (learning practice, features or characteristics). Start with the learning practices listed in the previous step and include those provided in the Google document, as well as any other learning practices that may be missing, and try to associate related technologies and key themes (using the previous board as input).

Step 3: Group technologies that support specific features in the learning practice. In each learning practice, we need to highlight which are the main features of those practices and how they can be supported by technologies. Note in pink post-its also other technologies that must be developed in parallel. Use colour-coded post-its to

add features, and tools. Any suggestions from the experts on technological categorizations are welcome. Use yellow post-it for each learning practice, pink post-it for each technology; and green post-its for features and blue post-it for the tools.

The **final session** was a combination of group work and a plenary discussion.
Step 1: The participants during this session were asked to choose 3 key themes which emerged during the 2 previous sessions in order to explore them further in smaller groups.

Step 2: Each parallel group reported back on each key theme in a plenary final session.

This methodological approach allowed us to set out the event's Agenda which is presented in Annex 1. The results of the Workshop are presented below.

1.2 Workshop results

The results from this workshop provide Inputs to the design of the HoTEL Innovation Support Model (ISM) in the form of recommendations for matching technologies with learning practices in the different sectors addressed by the project, in order to reduce the time of innovation adoption.

As part of the first brainstorming session, it was agreed with the experts on not pursing the idea of creating a Technology evolution map as part of the inputs for the design of the HOTEL ISM. Although such map is an interesting endeavour, it was analysed that we lacked of resources to conduct such ambitious task, it will become obsolete in a short period of time considering the technology' development fast pace and it won´t be of good utility for assessing the emerging technologies' potential to support innovation and changes in education as part of activities of the Learning Exploratoria (WP4) in the definition of the ISM

Therefore, the experts proposed focus on validating the work conducted by the project (WP1- WP2) through the definition of a set of challenges faced by all the educational sectors targeted by HoTEL (Higher Education, Workplace Learning; Informal learning in professional networks) and to establish a mapping between elements of the set of the selected technologies and learning practices for solving those challenges, following the methodology proposed by the workshop organizers.

The analysis of the technological support for learning, aimed at creating the desired mappings, considered two different levels, namely organizational and individual, and the defined challenges were:

1. Organizational Learning: Facing new and unexpected situations
2. Enhancing Individuals: Technology enhanced learner
3. Assessment: Rethinking learning assessment

The third one is a "transversal" challenge that needs to be addressed at both levels: organizational and individual.

The rest of this report is structured as follows:

- Chapter 2 presents Challenge 1 - Organisational learning: Facing new and unexpected and situations. It relates to some key challenges companies are facing today due to a rapidly changing world and how learning practices and technologies can bring additional value and help to address some of these problems. This challenge was analysed in three levels within an organisation: organisation, group, individual.
- Chapter 3 presents Challenge 2 – Enhancing Individuals: Technology enhanced learner and provides an overview of the main elements needed to take into consideration when addressing such challenge in terms of learning features and supporting technologies.
- Chapter 4 presents Challenge 3 – Assessment: Rethinking learning assessment and discusses some key areas for improvement.
- Chapter 5 Conclusions summarises the main findings of the workshop.
- Annex 1 presents the Workshop agenda.
- Annex 2 includes the links to the Emerging technologies reference material used in the workshop.
- Annex 3 includes the links to the Learning practices reference material used in the workshop.
- Annex 4 includes the links to the workshop's shared working space in the Google cloud.
- Annex 5 presents the list of participants in the workshop.

2. Challenge 1: Organizational Learning. Facing new and unexpected situations

Sector: Workplace learning
Group members: Bill Olivier, Paul Lefrere, Mirjana Ivanovic, Vana Kamtsiou

This group explored the area of Business learning practice and, in particular, the educational benefits related to workplace learning, as well as their associated problems that could be solved by a combination of technologies and learning

practices. The expert group looked at some key challenges that companies are facing today and how learning practices and technologies can bring/add value and help to address some of these problems.

Key issue: how organizations and employees deal with unfamiliar situations that they have never come across before.

As depicted in Figure 1, this issue is iterating over 3 levels: organizational, group, and individual. This analysis is unpacked more in Figure 2 and a summary is provided in the text below.

Organisational learning level

At the organisational level, the group primarily focused on how an organization adapts to a rapidly changing and complex world, when it is faced with new situations and unexpected complexity, and how this adaptation can be supported by TEL. This challenge directly relates to futures, strategic planning, and innovation management and implementation. The discussion was focused towards an adaptive learning and innovation support toolkit for the organization, a package for a company in transition.

In terms of business practices, Foresight, Roadmaps and Technology Forecasts are methodologies widely used today by companies in order to deal with future uncertainties. For companies to be successful, they need to constantly adapt their roadmaps, innovations and strategies to changes in their environments. Action Dynamic Roadmapping is a methodology and a tool that can be used by companies in order to manage their innovations and technological developments.

The first term, "Action" in Action Dynamic Roadmapping implies an active involvement from the organization's managers, employees and other external stakeholders and/or collaborators in both the strategic planning and implementation of the innovations planned in the roadmaps. In that respect, Roadmapping becomes a learning process for the organization. Action Research and Activity theory are learning theories which are closely related to this concept. Action research supports the different roadmapping groups, through active participation and critical reflection in order to improve their innovation strategies and implementation practices, and provide an understanding of their operating environments. To this respect, while learning for one individual is a matter of participation and contribution to the practices of a community, for example in this case the roadmapping group, learning for the entire company is a matter of improving its practices, progressively solve problems via innovations, and attracting new members. In addition, Action Research or action learning also enables the learner to deal with something new, which is a generic new skill that can be transferred later in any future situation or strategic planning activity. Activity theory also implies a learning practice that benefits from a cooperative environment. In

this framework, the roadmapping groups are formed as activity groups connected via shared aims, challenges and activities. In terms of learning practices, Rhizomatic learning is a practice which relates to this type of organizational learning. According to Deleuze and Guattari, Rhizomatic learning arises from the metaphor of a plant which multiplies through horizontal root systems (Deleuze and Guattari 1987, 21). In this analysis, the rhizome pertains to the roadmap that must be produced/constructed, "a map that is always detachable, connectible, reversible, modifiable, and has multiple entryways and exits and its own lines of flight" (Deleuze and Guattari 1987, 21).

On the other hand, the term "Dynamic" in Action Dynamic Roadmapping as a business practice, implies an iteration of the company's roadmaps, as new information, opportunities and threats are emerging. An observatory which continuously captures and analyses trends, signals of change and tensions is needed in order to monitor the roadmaps and keep them alive. The related learning theories to these business challenges are Connectivism and Social Constructionism: Knowledge is distributed across a network of connections, and therefore learning consists of the ability to construct and traverse those networks (Downes 2006). A certain set of technologies and tools are also required in order to enable both collaborative strategic planning, and foresight-based futures analysis. For example, technologies as such horizon scanning, Delphi, weak signal analysis, bibliometrics, Social Networks analysis (SNA) could be used in order to capture, manipulate and analyse information on new developments as they are emerging. Collaborative tools and groupware, such as modelling, visualisation, diagramming, which are related to strategic collaborate planning, are needed in order to put together coordination of people, their ideas, their roadmaps, as well as to coordinate their activities in the organizational learning contexts. It seems that quite a lot of these tools exist already, such as google docs, C-Maps, and videoconferencing tools such as Skype and Adobe Connect, but an integration of these tools that people currently use is missing. Therefore, integration of existing technologies and better software is needed in order to enhance collaboration process (groupware for people working together) or to explore changes taking place in the organisation's external contextual and operational environment in the form of futures observatories. The challenge is to find ways to integrate existing technologies at hardware and software levels, as well as use team analytics to analyse and assess teamwork. Similar tools have been successfully used in military contexts. Additional tools identified in this session include context-aware computing, social media, and trust reputation.

Then, the group explored another issue, which relates to facing unexpected situations or problems in organizations, in terms of how to find experts or co-innovators either internally or externally, who are going to help the roadmapping groups to create innovations. Several technologies and tools are proposed, i.e. intelligent agents, data analytics, Bayesian statistics and neural networks.

Social intelligence agent tools, which can be trusted and have the ability of case-based reasoning are needed, in order to a) enable description of the problems and b) to search across the internet or internally inside the company's knowledge bases (or/and those of its collaborators) for people who have the expertise to help or they had faced similar problems before. For example, consider the following scenario. A person or a group who is faced with an unexpected situation activates their personal agent via appropriate wearable or mobile devices. Instructions to the agent are given in the form of short sentences (in natural language) explaining key aspects of the unexpected situation. Such mobile (intelligent) agent via wireless sensor networks starts searching available internal and external knowledge bases in order to find similar situations and/or appropriate experts (each description of situation is connected to a person/expert that experienced this situation), who might be able to help in resolving it. Knowledge bases contain huge number of situations (i.e. they are big data sets suitable for mining and machine learning techniques) and they are represented/described mostly in a structured or semi-structured way. Each situation is described using numerous pairs of (attribute, value) or short textual descriptions, accurately representing the situation. Personal agent activates numerous searching agents equipped with case-based reasoning capabilities and sends them to search the knowledge bases. Using effective similarity measures and machine learning techniques such as naïve Bayes; support vector machines; feed-forward neural networks; neural networks and variations of decision-tree classifiers to infer meaningful information in case-based reasoning processes, these agents select the most fitting situations i.e. situations most similar to the current situation. Searching agents usually propose several candidate situations and the personal agent selects the final choice of situation. To select the final situation, the personal agent appreciates a number of solutions offered by trustable agents, i.e. agents that proposed good solutions in the past cases. This same process is repeated and iterated until the most satisfactory solutions are found. An extremely important part of this mechanism is to incorporate the lessons learned from this new unpredictable situation in existing knowledge bases. In this way, the situations and their solutions stored in knowledge bases are getting better, more reliable and trustable for future explorations.

Another approach to deal with the issue of finding experts/collaborators in similar situations would be to use Bayesian statistics, in order to identify similar clusters of people, ideas and concepts related to the same or complementary problems. Big data analytics and bibliometrics could also be used in order to identify related cutting edge research as well as the respective research groups. Also in this case, we should be sceptical about the quality of the results, since the bulk content of the data analysed via these methods is noise and in most cases, noise is increasing a lot faster than the valuable information. For example, in 2005, medical researcher John P. Ioannidis published a controversial paper titled "Why Most Published Research Findings are false". According to this paper, most positive findings that have been documented in peer-reviewed medical journals were likely to be rejected when they

were applied in the real world. Bayer Laboratories recently confirmed Ioannidis's claims. When Bayer attempted to replicate themselves the experiments described in medical journals, they found out that two-thirds of the positive results could not be replicated (Silver 2012). This problem of replication or scaling-up positive results is a very difficult one and hard to show: it can happen that a treatment-based improvement (arising from an intervention in medicine, in teaching, or in another area) works in a pilot project, but not in subsequent projects. One reason may be that the improvement is real, but is drowned out by much larger negative effects which are due to "organisational noise", as argued in the 2014 book "Scaling Up Excellence", see Robert I. Sutton, Huggy Rao (2014) or as argued in school cases by Donald J. Peurach, Joshua L. Glazer (2011).

A systematic observation and analysis of the past innovations and their associated trends can support a better understanding of the results stemming from big data analysis. Adopting a **futures observatory approac**h can support mapping of the different innovations, their applications and related technologies, as well as key groups in the industry, and can help identify and explore different innovation and technology patterns over time. This implies that an understanding of our own past bias and assumptions and the nature of the past innovations can help us distinguish the noise from the signals. Following the same argument, since innovations are rarely entirely radical, there are in most cases derived from older innovations. Past roadmaps can therefore be understood as maps of opportunities and limitations, with links and interdependencies that influence the evolution of the future innovations. This idea of understanding the "Old with the new" has emerged strongly within this group. The group considered for example, the following questions: How to store, search and bring back old roadmaps, and practices and reconcile new and old stuff? What has worked and what has not worked in the past? This probes for a more effective knowledge management for the organisation/business. How to track the way new stuff replaces old stuff and substitutes the related learning content? For instance, bring back old roadmaps on demand, ideas and plans that can be developed more easily today, due to new technological possibilities or elimination of other socio-economic barriers. How to track the pre-conceptions and prerequisites associated with the specific roadmaps? How to keep track and renew the knowledge base and the related learning processes. The old knowledge contributes with new information of what we should be paying attention to.

During the roadmapping process and its implementation, we need knowledge management tools in order to collaboratively develop, store and update the maps, data and related information. In terms of learning practices, this stored knowledge is explicit knowledge that should be able to be tracked and analysed at any time. While, on the other hand, the actual roadmapping process is related to tacit knowledge with emphasis on sharing of intuitions, perspectives, mental models, experiences and opinions and involves interaction between people that transforms

individual understandings to new collective understandings of the issues involved as well as increased insights, creativity and learning. The roadmap development is therefore related to organizational learning models like the SECI model for knowledge creation via an iterative process, where knowledge is converted repeatedly between explicit and tacit knowledge.

Group learning level

Moving down to the group level, People, who are working together to deal with this kind of innovation management and its implementation need various kinds of support - support for forming and dissolving groups and initiatives in order to implement the Roadmapping plans, but also to address the related emergent issues and projects. These groups are not usually part of the permanent organisational structure. Instead, they address particular issues as they are emerging and they might draw people from various parts of the organization and possibly from other networked organisations (i.e. suppliers, intermediaries, distributors, customers, etc.). The groups then dissolve back once their tasks have been completed and new groups are formed to face new tasks. Moreover, the groups should be aware when a new situation manifests itself in terms of awareness of change of information and being able to recognize what is different, to reason about it and come up with a solution. Inquiry-based learning, and problem solving are related learning practices to these business challenges. For example, when a new situation manifests itself, it is important to find resources to support the learning, find people to ask for expertise, annotated content, metadata, and semantics. This links back to this perception of peers who might be looking for people to work on common challenges, and then to form a group that agrees to move forward. Integration of existing tools that people currently use is needed - for example, collaboration tools, such collaborative writing, such as Google Docs, diagramming, visualisation, group discussions.

Individual learning level

At this level, this group first looked at the kind of issues that are related to past training and performance support, for instance, when people face a problem at the workplace, and although they might have had some training in the past, they might not be sure about how to implement it, if it is the first time that they attempt to use it, or if they need to use it in a different context. Various learning approaches can be followed, such as capturing learning moments as they are happening on the fly, as in how-to videos. For instance, people may develop YouTube videos on "how-to" topics, with tags and texts, to make it searchable when a situation arises. In addition, annotation tools are required in order to describe the usage of such videos

and their usability. Augmented reality tools, immersive tools, and wearable tools could also be used in order to support learners applying their learning in a variety of real and simulated situations and contexts. The previous tools can be combined with microblogging in order to provide support and help while it is needed. Context aware technologies for applying learning are also important, so that the situation that you're in can be identified by these tools and then advice you with appropriate learning resources, activities, assessments etc., similar to task support-oriented systems.

Just in time Microlearning is the related learning practice associated with a community of people who share their knowledge experiences. Microlearning, supports personalisation using harvesting mechanisms and mobile technologies, but in a trustable environment. The example of finding experts on various topics to guide you via YouTube videos also relates to the learning theories of Constructivism and the Zone of Proximal development.

Finally, user modelling software is important in terms of identifying and providing evidence of the individual's competencies, knowledge gaps and learning contexts in order to support the individual with personalised learning content and learning environments fitting to their needs. These models will be connected to the individual's learning goals, business tasks, plans etc., as well as to their personal portfolios, capturing evidence of their skills, competencies and knowledge by tracking and monitoring their performance. User modelling methods could be based on paradigms of Artificial Intelligence and Machine Learning, which could be adapted to specific environments. These techniques include: ABML (Argument Based Machine Learning), QR (Qualitative Reasoning and modelling) , Q2 learning (Qualitatively faithful Quantitative learning), EBG and EBL (Explanation Based Generalisation and Explanation Based Learning), ILP (Inductive Logic Programming), and specific techniques of behavioural cloning (capturing human skill from observed human behaviour). Individual user portfolio has been established and determined by the user's initial learning style and business preferences. During user's interaction and while facing different complex situations, the user model can be constantly evaluated, updated and improved. Such an improved model is then a good basis for more personalized suggestions. Personal agents which collected several possible situations (from search agents) as possible solutions for unexpected current situations can better select good solutions using user's portfolio and specific user's learning and business needs. For that purpose, reinforcement learning (RL) algorithms, suitable for different decision making semantic networks as well as predictive models using big data analytics, could be used. Moreover, it is necessary to include in learning systems a new paradigm, namely "autonomic computing", which possesses great potential to address shortcomings in today's systems. Autonomic computing refers to a broad set of strategies to reduce the amount of complexity and to intelligently make complex decisions based on large amounts of uncertain, heterogeneous data (Peter Stone

2007). The area of machine learning has made significant progress in developing methods that automate the construction of such complex decision-making systems by inducing robust models directly from relevant empirical data. These will be combined with neural networks, natural language techniques and 'internet of things' technologies in order to track an individual's behaviour and enhance the individual's situational awareness. A collaboratively built knowledge base of user models will improve the organisation's knowledge and competence management and enable fast creation of taskforce teams based on required competencies.

Figure 1. *Schematic diagram of Challenge 1 (Organizational Learning)*

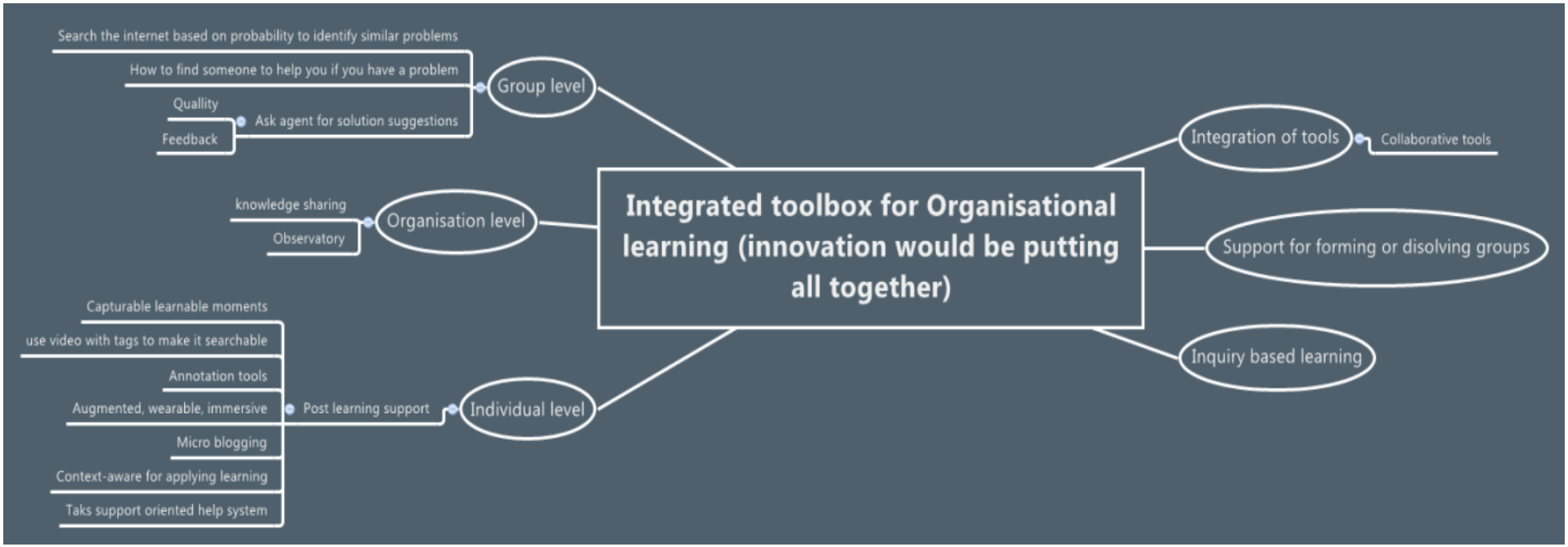
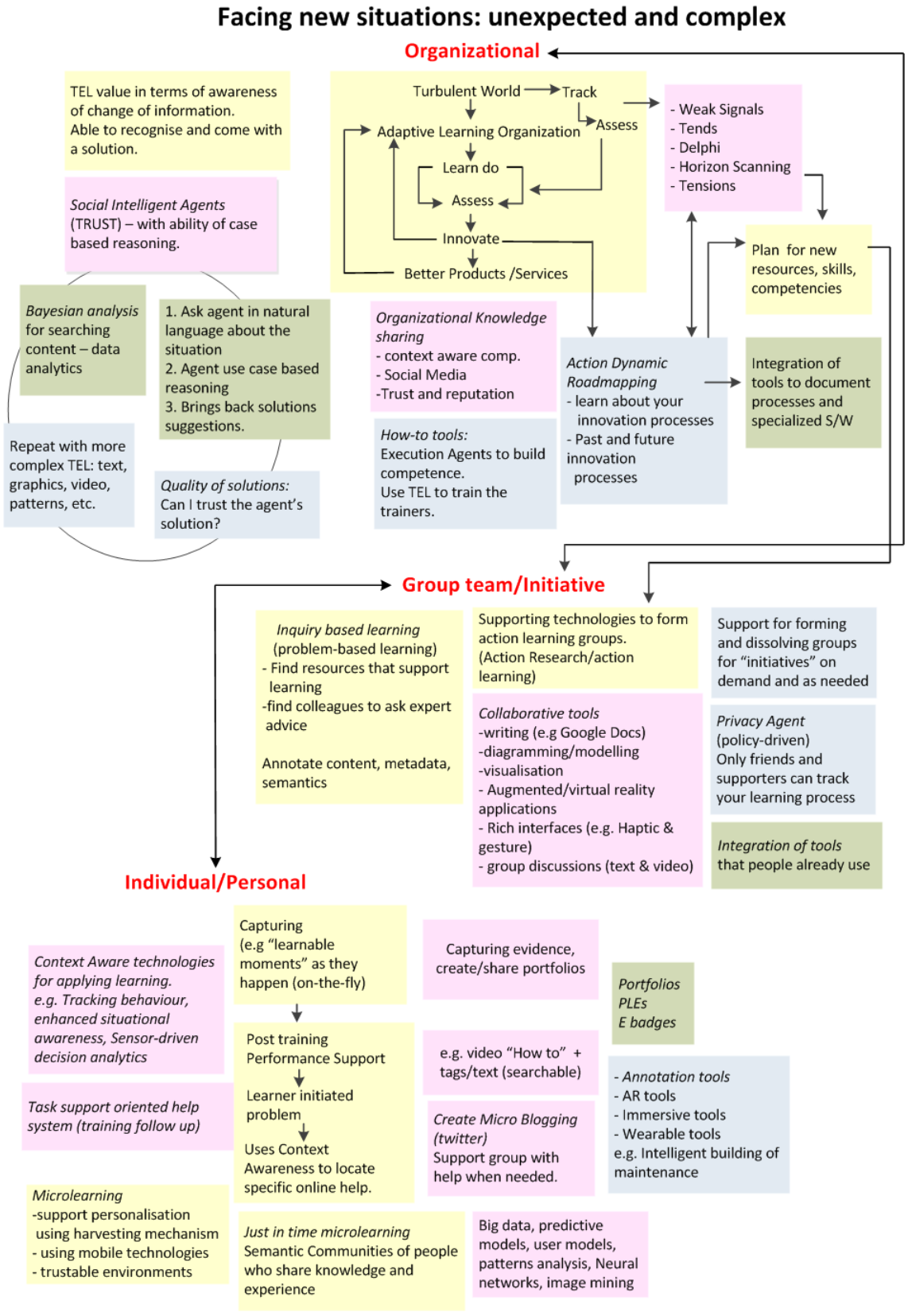


Figure 2. *Challenge 1 : Organizational Learning*



Business situations & learning challenges	technologies	Tools	features

3. Challenge 2: Technology enhanced learner

The second challenge defined by the experts - in order to provide a proper context that facilitates the mapping of emerging technologies and learning practices - was related to the use of technologies to enhance individuals in their learning. Important issues were addressed, such as how to smartly filter the rapidly growing information that is becoming available through the use of latest technological developments and how to restrict their interference on the process of individual learning. These issues are some of the main components of a broader issue about diminishing or fighting the potential of technology that prevent individuals from learning, which is presented in Figure 3 and need to be addressed in the challenge named "Technology enhanced learner".

Carl Smith, Grainne Conole, Scott Wilson and Lydia Montandon teamed up to work on the definition of this challenge and its related technology and learning practices mapping.

Following the methodology presented in Chapter 1, the first part of the group analysis was aimed to identify which of the 10 proposed emerging technologies were more suitable to provide solutions to enhance individuals in their learning, help them to focus on the their main goals, facilitate a continuous flow of information respecting the proper balance between learning and reflexion; providing means to make more effective the process of learning. The main goal was to choose those technologies that contribute to a better design of less noisy, intrusive and interrupting technology applications that will make the technological support more invisible to facilitate individuals to focus on learning and not on dealing with the technology.

The following emerging technologies were selected as result of the participants' brainstorming:

- Wearable technology
- Internet of things (IoT)
- Context aware computing/context enriched services
- Audio Mining/Speech Analysis
- Learning Analytics

The combination of Wearable technology, IoT, Context aware computing and context-enriched services can provide situational awareness and proper adaptation. The use of this combination of technologies can adapt to individual needs by being aware of metrics about learner's state through monitoring the environment and his/her stress levels among other biometrical inputs, in such a way that they can

identify the proper environmental and personal conditions that positively lead any individual to better learn.

In addition, the use of Audio Mining and speech analysis has great potential to support the learning flow avoiding critical interruptions, such as the context of providing automatic content translations or transcriptions. Moreover, Learning analytics, which is included in the above set of technologies, can help: to gather relevant data about performance from organizations; in the decision making for the best learning support; to provide ways for benchmarking individuals in terms of their learning; to get in touch with peers with similar interests, learning styles; to access models of better behaviour and to reinforce good learning practices.
This set of technologies, combined with Social networking technologies, can offer enhanced distributed cognition by amplifying individuals' capabilities through their networks.

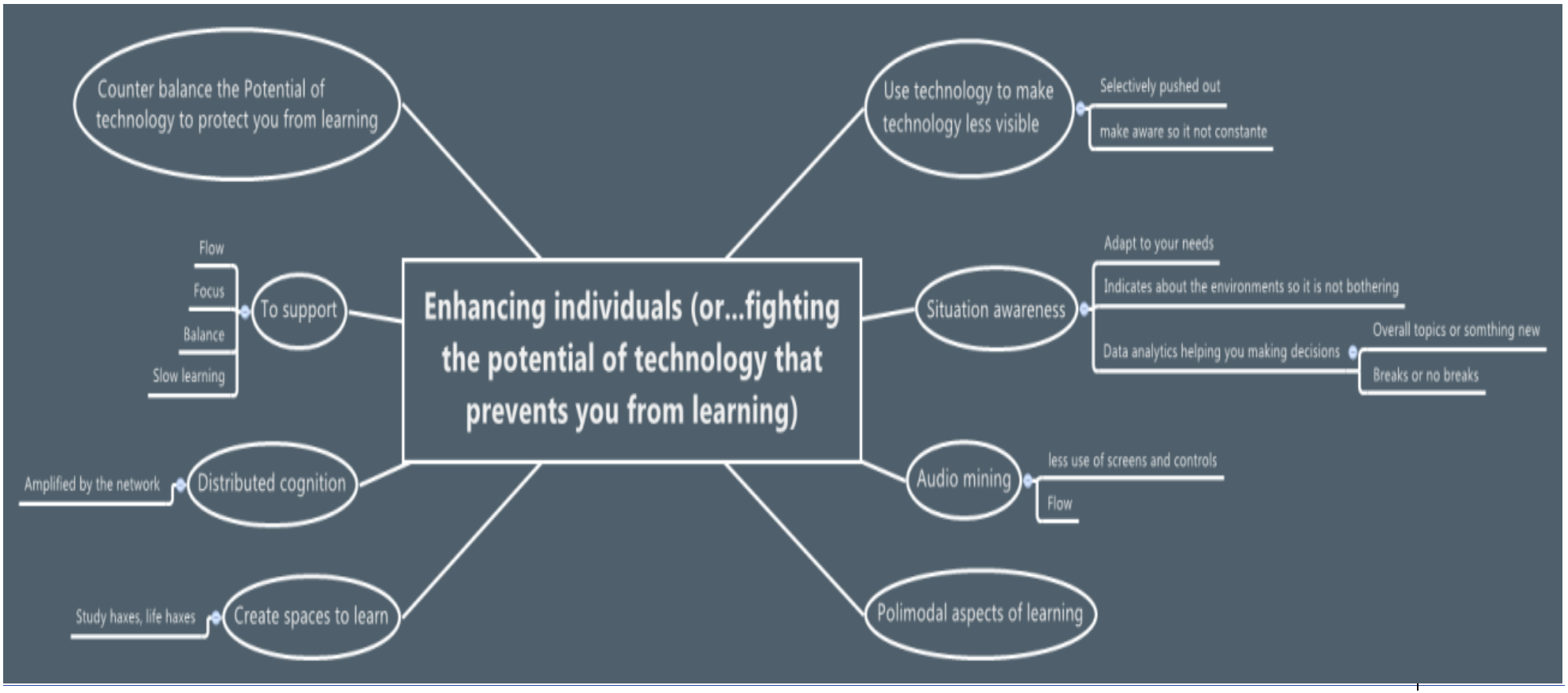
Once the emerging technologies were identified, the second part of the work focused on analysing the main features of learning and which learning practices can be supported by such technologies aiming at enhancing the individuals in their learning, stressing the importance of having proper conditions and the needed time for information acquisition, processing and reflection to facilitate and deliver effective learning to individuals.

For this case of enhancing individuals, the following features of learning were considered as very relevant and worthy of being supported by the selected technologies: reflection, dialogue, collaboration, interaction, application, focus, motivation, simulation, and proper levels of stress. The technology support needs to be multimodal and multimedia-oriented, with a combination of text, video and audio as a way to reach some balanced support for learning.

The idea of providing invisible technological support for the features of learning previously described is closely related to learning practices like Constructionism and social Constructionism, but also to more recent learning approaches, such as Slow Learning.

Slow Learning is a response to the risk of acquiring information just in time, which leads to superficial or strategic learning with little time for reflection and processing of experiences. The Slow Learning approach promotes deep learning, is grounded in the interests of the learner, crosses genres and disciplines, promotes inquiry and dialog, lasts a lifetime, seeks unmediated experiences and supports, and is supported by learning in a community (What is Slow Learning?, 2014).

Figure 3. *Schematic diagram of Challenge 2 (Enhancing individuals)*



4. Challenge 3: Rethinking Learning Assessment

The group was composed by: Adam Cooper, Kairit Tammets, Claudio Dondi, Lampros Stergioulas.

This Challenge was chosen due to the importance attributed - in the plenary session discussion and in the relevant literature - to current/traditional learning assessment and assessment methods as inhibitors of innovation in the education and training systems at large, and to the recognition that the potential of ICT to innovate learning assessment is still very far from being fully exploited or even fully understood.

The Group discussion started by identifying the desiderata about assessment across the various different educational contexts (higher education, workplace, etc.), keeping in mind the scenarios of emerging technologies previously presented and discussed in the plenary session, and then focused on associating technologies to the different "desiderata". "Desiderata" is a latin word currently used in political science (and elsewhere) to define the desired results of an intentional change process, e.g. an innovation, a proposed reform, or a new law. In this case, the concept of "desiderata" was applied to the desired changes, as expressed by the group, in the learning assessment practices. The desiderata are much broader that the specifications but constitute the basis for the macro-design of an innovation.

The main improvement areas (key challenges) identified in the discussion on assessment are the following:

1. WIDENING THE EVIDENCE BASE

Most assessments today are based on a small sample of knowledge and skills exhibited by learners during formal testing sessions, with substantial risks stemming from the inability of these tests to use more information available on learning behaviour and achievements of each learner in different times and different contexts. A big challenge for the future of assessment is to use technology effectively in order to collect and incorporate assessment evidence drawn from different situations – evidence that is more realistic, and relevant to life and career of the individual – collected from an accumulative perspective, following a longitudinal approach to assessment over a period of time. This can lead to more holistic assessment, which assess new areas that were not possible to assess previously.

2. EFFECTIVE COVERAGE OF ALL POSSIBLE LEARNING OUTCOMES

Another challenge is to expand the assessment base of learning outcomes and effectively cover the whole range of possible learning outcomes, including those that are only observable in an organisational context.

3. IMPROVING FEEDBACK TO LEARNERS
The challenge here is to ensure the delivery of as much as possible and as quick as possible feedback to learners, both automated and human-generated (human actors delivering feedback can be teachers, tutors, peers, etc.) in order to strengthen the learning process through assessment. Feedback here was considered in the genuine sense of formative feedback, where feedback is intended to have an effect on learning, and can help to actively improve an individual's learning and to positively influence the learning path down the line.

4. LINKING ASSESSMENT TO QUALIFICATION STANDARDS
Another challenge area is the linkage between assessment and qualification standards and APL. Assessment should not only link to the specific study programme followed in a given educational context. Also links to prior education and learning in standardised ways, empowered by technology, would be of significant benefit.

5. GUARANTEED VALIDITY
Technology can help to further improve and strengthen the validity of assessment, particularly in combination with a "widening evidence" capability (see Area 1).

6. EFFECTIVE AND RELIABLE AUTHENTICATION
Another area for improvement where technology can help is to do with enabling effective and reliable authentication of the person remotely assessed. This also related to Area 1 (Widening evidence), as a wider base of evidence via the use of technology will lead to more robust authentication processes.

7. INCREASED COST-EFFECTIVENESS AND EFFICIENCY
Technology can help to increase the cost-effectiveness of assessment processes on a large scale.

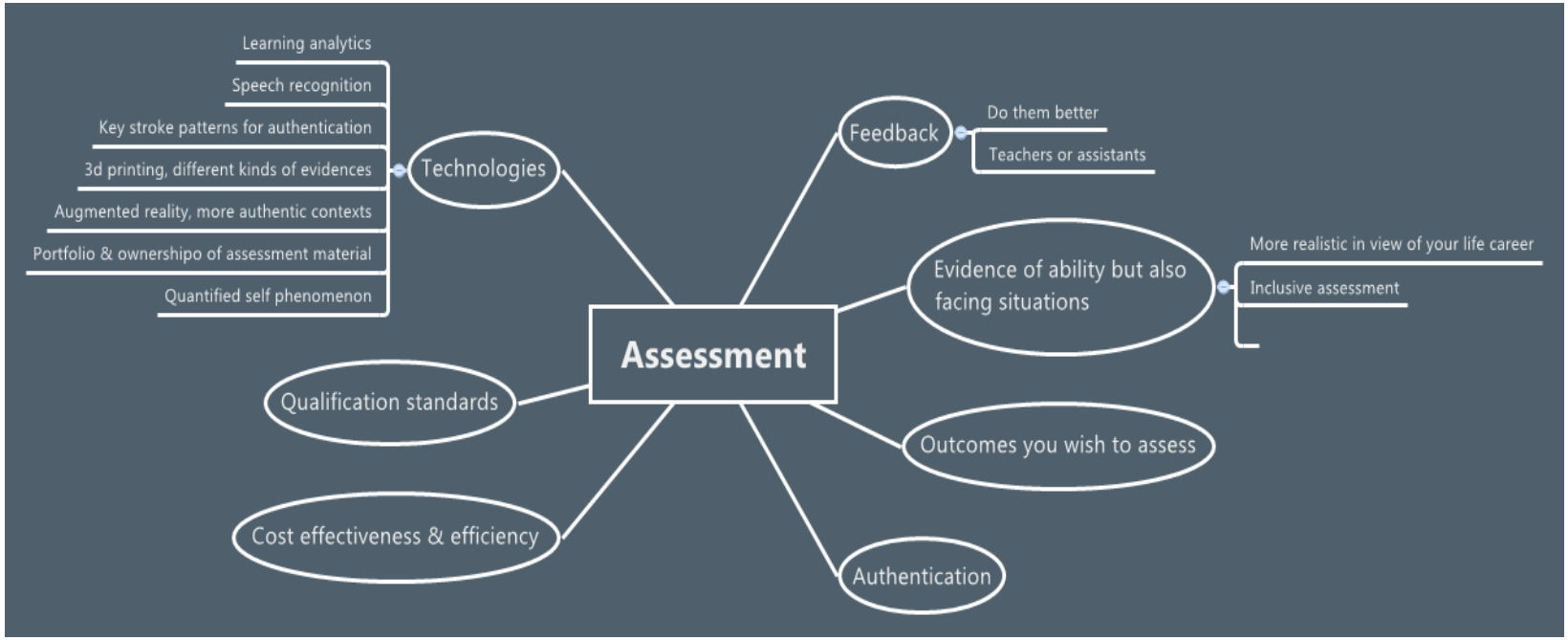
The above identified key challenges were briefly discussed one by one, represented on a graph, and then associations were drawn to the relevant technology families on the same graph see Figure 4.

The identified emerging technologies that are deemed necessary for addressing the above assessment areas of improvement (key challenges) are:

- Learning analytics: There is a huge unexplored potential of Learning Analytics for assessment, particularly in the areas of widening evidence, person authentication, and inclusive assessment.
- Speech analysis and recognition: This technology can provide the means for alternative forms of assessment and can be key for inclusive assessment.
- Keystroke pattern recognition: As technologies used for identification:

- 3D printing: This technology has a lot of potential to provide alternative forms of assessment evidence, in particular more realistic and human-centred forms of evidence.
- Augmented reality and immersive technologies: Such technologies can be widely used to provide more authentic (new or different) assessment environments and contexts (more realistic, more repeatable, with variable degree of hazard, focused on a particular learning purpose, with specific control parameters etc.)
- Other proposed technologies included gesture-based systems and hybrid environments for assessment (used to assess practical skills in physical environments) as well as assessment portfolios (in relation to concept of portfolio, the issue of ownership of assessment material and the phenomenon of the quantified self was discussed in relation to the above).

Figure 4. *Schematic diagram of Challenge 3*



5. Conclusions

The use of challenges as a way of contextualising the educational problems and facilitating the definitions of mappings between technologies and learning practices can be an interesting input to the definition of the HoTEL Innovation Support Model (ISM), since it allows us to assess the real learning-added value of an innovation, as well as other factors such as the costs of implementation and maintenance of the innovation; and to what extent the problem, solved through a particular innovative technological solution, could be present in other different learning contexts, thus indicating that the innovation has potential to be scaled up.

The first challenge is related to how companies nowadays are facing an increasingly **rapidly changing world**. Adaptation to a changing world requires a lot of learning as well as unlearning, not only at individual levels, but at organizational and group levels. The whole organization needs to be working together and learning together. It is a collective as well as individual learning activity and experience. In addition, foresight and signals monitoring methods are needed in order to support the organisation's projects by identifying possible threats and opportunities for their success. It is worth mentioning that Research findings in 1989 by Mitchell of Wharton School, Russo of Cornell and Pennington of University of Colorado "found that prospective hindsight – imagining that an event has already occurred – increases the ability to correctly identify reasons for future outcomes by 30%" (Gary Klein 2007). The recent advances in Big Data, AI and intelligent Agents, as well as in context aware technologies and user modelling software, will further support the development of observatories and roadmaps, but also the formation of project groups on demand and the development of complex and predictive user models. It is also suggested that integration of existing tools which people already use is needed - for example, collaboration tools, such collaborative writing, diagramming, visualisation, and group discussions - in order to facilitate both the development of the technology roadmaps and their updating.

The challenge **Technology enhanced individuals** focused on the urgent need to use invisible and less intrusive technology to support the development of individuals' learning capabilities. A cluster of technologies composed of Wearable technology, Internet of Things technologies, Context aware computing and context-enriched services, in combination with Audio Mining and speech analysis, Social network technologies and Learning Analytics, is proposed as essential technological capability for the implementation of such type of invisible support to learning practices like Social constructivism and Slow learning.

The Assessment challenge spawned a number of main improvement areas, which ranged from widening the assessment evidence base and more effective coverage of learning objectives to better feedback to learners and linkage to universal qualification schemes (thus to provide more useful and more widely applicable and

recognisable assessment). A number of further key challenges were identified in the role of technology in improving the mechanisms of assessment, such as improving the validity of assessment, securing more reliable authentication, and improving the cost-effectiveness of the assessment process across the board. A set of emerging technologies were identified to support the above challenge areas, including amongst others: big data analytics, speech recognition, pattern recognition and identification sensing technologies, 3D printing, augmented reality, etc.

Finally, although there are considerable TEL opportunities from emerging technologies, the experts thought that TEL still remains a controversial issue today. There is still not enough evidence of the added value that TEL brings in education and learning, which can scale up beyond the remits of small pilots or research projects. Cost-benefit analysis and further research, which will look in the exploitation of past and current TEL research results and in technology areas outside TEL, should be done in order to encourage more investments in TEL approaches and technologies. The same is true for the TEL-associated learning theories and/or practices, which need to be further investigated and backed up with real large-scale cases. A more bottom-up approach, which will examine successful innovations and the respective learning practices or theories, would build an important knowledge base for demonstrating TEL effectiveness.

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Annex 1 Workshop agenda

Experts Group Workshop
How theory and technology evolution can support learning practices?

ATOS Innovation Centre (4 Triton Square, Regent's Place, London, NW1 3HG)
March 14th, 2014

Agenda

Table 1.

	8:30-8:50	**Registration**	
Session 1:	**8:50 - 09:30**	**Setting up the scene and explaining the working method**	
	8:50-9:00	Welcome, HoTEL supporting innovation	Claudio Dondi
	9:00-9:15	Setting the scene presentation: Introduction to learning technologies	Carmen L. Padrón/ Lydia Montandon
	9:15 - 9:25	Setting the scene presentation: Introduction to learning practices	Vana Kamtsiou
	9:25-9:35	Instructions and preparation for working together	Vana, Lydia, Claudio
Session 2:	**09:45- 11:00**	**Mapping emerging technologies: Brainstorming on emerging technologies**	Group session
Break	11:00 - 11:30		
Session 3:	**11:30 - 13:00**	**Mapping emerging learning practices: Main features of those practices, related theories and how they can be supported by technologies**	Group session
Lunch	13:00- 14:00		
Session 4:	**14:15 - 17:00**	**Describe examples and find evidence, ways to move forward. Wrap up**	Group session

Annex 2 Emerging technologies reference material

Please check the Emerging technologies reference material here https://drive.google.com/file/d/0B7QazvTsNoQXRDBfWVM2NGpLZFU/edit?usp=sharing

Annex 3 Learning practices reference material

Please check Learning practices reference material here https://drive.google.com/file/d/0B7QazvTsNoQXUzlwZWtGem1zWUk/edit?usp=sharing

Annex 4 Group Google document: How theory and technology evolution can support learning practice workshop

Please check all details of the workshop shared working space at: https://docs.google.com/spreadsheet/ccc?key=0Am8WoUVfI-4YdEhPNmpfZzhGanAtMjNwb01rbEpDNkE&usp=drive_web#gid=0

Annex 5 List of workshop participants

Name	Surname	Affiliation
Adam	Cooper	University of Bolton, CETIS. UK
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Claudio	Dondi	MENON, BE (HOTEL)
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