BREAKING EDUCATIONAL BARRIERS WITH CONTEXTUALISED PERVASIVE AND GAMEFUL LEARNING

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Statement of originality

This deliverable contains original unpublished work except where clearly indicated otherwise. Acknowledgement of previously published material and of the work of others has been made through appropriate citation, quotation or both.

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ABBREVIATION LIST

DoA – Description of Action

ICT – Information and Communications Technology

STEM – Science, Technology, Engineering and Mathematics

UX – User Experience

EXECUTIVE SUMMARY

The Beaconing project will provide different learning scenarios supported by different technologies for teaching and learning in an inclusive society. There is an explicit focus on skills, competencies, strategies, learning outcomes and learning disabilities closely related to 21st century.

This document includes the design of a framework for problem-based learning, which will encapsulate the mechanics of different learning models for different learning environments. An extensive literature review on pervasive, gamified and problem-based learning has been included to support the proposed Beaconing Taxonomy on which the different play-lesson scenarios are based on.

The main goal of this document is to describe the mechanics and dynamics of the framework that will support the different learning scenarios and the rationale behind this model with planning support and lesson instructions. The pedagogical approach and the play-lesson scenarios described in this document will inform the UX and gamification design in Task 3.4, the technical specifications in Task 3.5 and the gamified lesson plan integration in Task 4.7. This framework reflects a holistic and modular approach that combines learning, games and technological specifications, which will be further, refined and updated in an iterative and incremental manner.

This is a live document that will be updated throughout the duration of the BEACONING project to include specific elements for the play-learn scenarios (measures, technologies, mini games, etc.) based on the updated analysis from the requirements (T3.1) and inventories (T3.2), UX and gamification specification (T3.4, T4.7), technical requirements (T3.5), the evaluation results of the small scale pilots (WP5), and specifically before the large scale testing (WP6) takes place. The design and development of the different learning scenarios will be fed into the BEACONING interface to support the foundational, meta and humanistic knowledge of the 21st century learning.

1 INTRODUCTION

1.1 ROLE OF THIS DELIVERABLE IN THE PROJECT

The Beaconing project will support the learning design and specification of a platform that will provide various gamified learning scenarios and activities based on STEM subjects and closely related to 21st Century learning objectives. In particular, this deliverable aims at three objectives, and explicit actions have been taken to achieve them:

1. An extensive review and analysis of problem-based learning and how the different learning approaches can be combined with the fast technology development to support teaching and learning in the 21st century;
2. Development of a framework that encapsulates different learning models for different learning environments;
3. A proposed Beaconing Taxonomy to be used by teachers for creating play-lesson scenarios;
4. The outcomes of this deliverable will be used in other technical work packages to ensure a learner centric design and development.

1.2 APPROACH

The aim of this document is to create a framework and propose a taxonomy that can be used by the Beaconing Consortium to create and share play-lesson scenarios and activities based on problem-based learning and STEM subjects. This document has been prepared following specific guidelines described in the Beaconing DoA and has been improved through:

1. Literature review on pervasive, gamified and problem-based learning;
2. Literature review on gamification and mini games used in learning and education;
3. Play-lesson path missions and quests design session during the Beaconing workshop in Barcelona;
4. Play-lesson path and scenarios (the backbone) session during the Beaconing workshop in Porto;
5. Technical and pedagogical requirements meeting at Coventry University;
6. Various brainstorming sessions among Coventry University team, the technical partners and the pilot partners.

1.3 STRUCTURE OF THIS DOCUMENT

The deliverable is structured as follows:

Section 2 gives an extensive analysis and literature review on pervasive, gamified and problem-based learning.

Section 3 presents the methods behind the proposed Beaconing Taxonomy and includes the pedagogy, learning requirements, game mechanics and dynamics.

Section 4 describes in detail the Beaconing Taxonomy with its specific categories such as skills/competencies, learning objectives, time allocation, participants, places of interest, tools/resources, evidence, incentive rewards, location-based technologies and mini games.

Section 5 presents the instructions of how the Beaconing Taxonomy can be used by teachers to create gamified lesson plans based on specific context and learning objectives.

Section 6 presents two play-lesson scenarios provided by Beaconing partners (ORT and HWU) that will be used in small scale pilots. These two scenarios tackle different learning objectives and have been select to show the variety of the play-lesson scenarios the Beaconing platform can support. The

scenario on Basic Algebraic Skills provided by ORT tries to address the algebraic difficulties that high school students face, whereas the stonemasonry scenario by HWU focuses on vocational training. The rest of the play-lesson scenarios (provided by other Beaconing partners) are presented in the Appendix.

2 LITERATURE REVIEW

The Beaconing platform will facilitate, assess and author contextualised, pervasive and gamified learning activities with the digital activities located in the physical world. Its pedagogical foundation is the problem-based learning, and the learners are placed in the centre of the learning process. The Beaconing platform will underpin new commercial opportunities and immersive ways of teaching, learning and assessment and thus, it should follow the new learning methodologies and technological advances.

2.1 PERVASIVE LEARNING

The relationship between learning, its context and the technologies thereof, has been a central issue since the beginning of modern research in education (Vygotskij's, 1978). The rise and diffusion of digital technologies gave new meaning to this debate, through the generation of a new kind of spaces where communities of learners as discussed by Lave and Wenger (1991), could emerge and experiment with constructivist learning approaches. This tendency could only explode with the rise of pervasive computing technologies, as in this ubiquitous media ecology, learning is transformed into an immersive experience, providing innovative opportunities and avenues for education to explore connections between life and learning as discussed by Beetham et al. (2007), which suggests that we move beyond simplistic, delivery oriented e-learning toward learner focused, accessible activities.

Dan Pontefract (2013) defined pervasive learning as "learning at the speed of need through formal, informal and social learning modalities" (See Figure 1).

Figure 1 - Pervasive Learning (Dan Pontefract, 2013)

It is easier today than ever before to find information on any topic online, and learning has become seamless and *"anytime anywhere"*, but also fragmented and contested (Shuib et al., 2015). Given this environment, more and more attention should be given, within formal education institutions, toward acknowledging and giving value to informal and social learning.

This social, informal aspect of learning is emphasized by Ito et al. (2015), who discuss the relevance for educational research, taking into account the various spaces and practices of learning in informal youth communities, their ethos of "doing it together", and the correlated opportunities for pedagogical research to obtain insight in the 21st Century learning processes.

Acknowledging the informal, playful nature of today's learners' activities, and the specific applications of pervasive learning promoted by the Beaconing platform, pervasive learning will necessarily cross over pervasive gaming (Montola et al., 2009). In this book, the authors theorise the opportunities brought on by games' expansion on a special, temporal, and social level to explore the boundaries between life, learning and play.

2.2 GAMIFIED LEARNING

"Gamification" is a term coined in 2002 by programmer Nick Pelling and defined as "applying game-like accelerated user interface design to make electronic transactions both enjoyable and fast". It was not until 2010 that it became widespread, when Bunchball (2010) defined it as "integrating game dynamics into your site, service, community, content or campaign, in order to drive participation". Other definitions include "the process of engaging people and changing behavior with game design, loyalty, and behavioral economics" (Zichermann, 2011), "the use of game design elements in non-game contexts" (Deterding et al., 2011) and "the craft of deriving all the fun and addicting elements found in games and applying them to real-world or productive activities" (Yu-Kai Chou, 2012).

The American game designer Jane McGonigal (2011) argues that advancing a "gameful" mindset in the real world can produce effective and measurable change, leaning on modern research in positive psychology to promote games as an integral factor which contribute to human happiness, motivation, meaning and community development. Despite being "the public face of gamification", McGonical distanced herself from the denomination (favouring the notion of "gameful" design) and its then emerging negative connotations. With more and more scientific research and data complicating the field after the initial (marketing oriented) enthusiasms, gamification is a contested field of studies which raises objections from three main directions; efficacy, ethical acceptability and techno-determinism.

The first objection is addressed by Hamari and Koivisto (2014) in a review of empirical studies, highlighting both the basic fact that gamification can indeed work, and the methodological issues that persist in many studies (most of which underestimate the impact of social and organizational context), and that need to be addressed by future research. The second objection is articulated in much depth by Walz and Deterding (2015), who discuss the accusations of manipulation by inquiring the roots of enjoyment we draw from games and highlighting how "good" gamification (just like good games) emphasizes the intrinsic human motivation toward competence, autonomy and relatedness.

The third objection is addressed by Arnab and Clarke (2016) who propose a holistic model for gamified and pervasive learning design, highlighting the necessity to shift the focus away from current strong overemphasis on technology in the field, and move it toward prioritizing the value of context, pedagogy and basic game design.

Moving beyond the specific field of gamification to expound the diversity of points of view and approaches to the relationship between gaming and learning, Whitton (2014) proposes a wide spectrum review of the perspectives on the role of digital games in education, discussing four main perspectives to categorise research and practices in the field, and their respective constructions of games; games as active learning environments, games as motivational tools, games as playgrounds, games as learning technologies. Throughout her review, Whitton contrasts behaviorist and constructivist learning approaches, underlining how games can be a paradigm of constructivist learning and promote the development of capacity for synthesis, creativity, teamwork, evaluation and critical thinking, which are hard to foster under traditional learning institutions' structures and resistant to standardized formal assessment.

Finally, collating data, reflection and evidence from literature, and widening the possibilities of play and games for a wider societal impact, Stewart et al. (2013) reported a multifaceted picture of how the "meaningful play" can be employed to promote equity and societal progress.

2.3 PROBLEM-BASED LEARNING

Savin-Baden (2000) defined problem-based learning as "an approach to learning that is characterized by flexibility and diversity in the sense that it can be implemented in a variety of ways in and across

different subjects and disciplines in diverse contexts. As such it can therefore look very different to different people at different moments in time depending on the staff and students involved in the programs utilizes it. However, what will be similar will be the focus of learning around problem scenarios rather than discrete subjects".

Barrows and Tamblyn (1980) identified a problem-based learning model that has the following characteristics:

- Complex, real world situations that have no *right* answer are the organizing focus for learning;
- Students work in teams to confront the problem, to identify learning gaps, and to develop viable solutions;
- Students gain new information through self-directed learning;
- Staff act as facilitators;
- Problems lead to the development of problem-solving capabilities.

Conway and Little (2000) suggested that problem-based learning should be used either as an instructional strategy or as a curriculum design. Learners should focus at one problem at a time and this problem will guide the learning process. The main types of problem-based learning are the pure model and the hybrid model. In pure model the whole curriculum is problem-based and there are no lectures or tutorials only small teams of learners, while in hybrid model there are some fixed lectures or tutorials only for supporting learners. The Beaconing project explores a *hybrid* problem-based learning approach using a range of blended learning techniques and classroom-based teaching methods. Extending the learning experience beyond the classroom settings and complementing existing methods of teaching, learners will acquire the needed skills for STEM careers such as cooperative working, integration of information, critical thinking and communication skills (Dolmans et al., 2005). Using the Beaconing platform, learners will work in interdisciplinary groups bringing together their scientific inquiry skills, developing a range of employability skills and investigating open-ended real-world problems.

Problem-based learning is used in various disciplines; medicine, engineering, architecture, economics, educational administration, social work and so on. The problems/scenarios are the starting point and centre of learning which enable learners to become independent inquirers, while knowledge becomes a flexible entity and assessment triggers learners' inquiries.

When problem-based learning is used in online platforms, pedagogy becomes collaborative, which focuses on team-led discourse, team's capabilities, knowledge and understanding. Learners working together online, better identify their own learning needs and skills and thus they work collaboratively and effectively to solve or manage the problems. Learners can work either in real-time or asynchronously but the online platform should support some essential synchronous collaboration tools such as chat, shared whiteboards, video conferencing and group browsing (Savin-Baden, 2007).

The Beaconing's pedagogical foundation is the problem-based learning, in which active learning is the centre and learners have to work with different tools and resources in order to solve problems (quests). In the Beaconing platform, teachers will initiate the problems/quests in the system and learners through self-directed and independent study will set their objectives and goals for solving these problems. The problem-based quests can be either classroom-based activities or after school assignments/homework. This approach encourages learners to share and discuss the acquired knowledge and skills with the Beaconing community, and also promotes learners' engagement with learning in general; gamified lesson plans with quests that learners try to solve in contextualised settings. Appropriate problems will increase learners' knowledge and understanding, and promote their interest in STEM subjects.

3 METHODS

The Beaconing project focuses on problem-based learning for STEM (Science, Technology, Engineering and Mathematics) subjects and should map the learning objectives and activities to purposeful play and game mechanics. Different pedagogical approaches will be integrated to support *anytime anywhere* learning for all learners, while the introduction of the current learning requirements will prepare learners for living and working in the 21st century. Adding game mechanics and dynamics to the Beaconing platform will support the various gamified lesson plans.

3.1 PEDAGOGY

The Beaconing platform will adopt various pedagogical approaches that will test the level of *anytime anywhere* learning during the small and large scale pilots. The Beaconing project focuses on STEM subjects and cross-subject approach. This focus is well embedded into problem-based learning, which is one of the best exemplars of a constructivism learning approach which promotes contextualized learning within real world problem solving and applications. In other words, the Beaconing project adopts a learner-centric approach that situates learners at the core of the learning experience, and amplifies their role in the process of filtering and connecting concepts framed under practical, investigative and exploratory scenarios. Essentially the Beaconing project serves as a source of 'puzzlements' (Wilson, 1996, p. 13) or challenges that are seen as stimulating learning that is taking place beyond the barriers of space and time. This fits well with the purpose of the project as described in the DoA which is to examine novel ICTs in multiple ways that merge learning acquired in formal, non-formal and informal means.

The Beaconing's focal point is an active learner who interacts with a variety of resources and tools, developing his or her own understanding through a mixture of experimentation and guidance. The Beaconing project highlights the importance of the collaboration and communication among learners, and also the development of learning scenarios that will draw on game-based approaches for learning. Thus, the Beaconing platform will be developed as a learning environment where the end-users (e.g. teachers) can design learning activities that are underpinned by playful approaches to learning. In addition to this, the platform combines resources such as mini-games, tools for open-ended, linear or non-linear investigations with tools that enable communication and collaboration among learners, along with tools that will provide analytics and guidance to the learners for their achievements. When analytics are included in the pedagogical activity, teachers can get a better insight regarding their learners' progress and achievements.

Among the main propositions of constructivist approaches to learning is that one's understanding of the world lies in his/her interactions with the environment, and what is learnt cannot be viewed in isolation of how it is learnt. The Beaconing project is in line with this proposition as it will emphasize learning both as a product and a process, hence it will track and provide rewards not only for the outcomes but also for the process under which these outcomes were achieved.

Focusing on constructivist approaches for learning, Savery and Duffy (2001) outline eight principles that can guide the practice of teaching and the design of learning environments. These principles provide a good foundation to describe the Consortium's pedagogic approach that is an essential bound to problem-based learning.

For Finkle and Torp (1995) problem-based learning is "a curriculum development and instructional system that simultaneously develops both problem solving strategies and disciplinary knowledge bases and skills by placing students in the active role of problem-solver confronted with an ill-structured problem that mirrors real-world problems." It is clear that the focus is on organizing the curricular content around problem scenarios. Learners work to solve or manage these situations but

for Savin-Baden (2000) "they are not expected to acquire a predetermined series of *right answers*". Instead learners are expected to engage with the complex situation presented to them and decide what information they need to absorb and what skills they need to gain in order to manage the situation effectively. Drawing on this, the learning activities in the Beaconing platform will be framed within a larger task or a wider problem which will be situated in the real world. The connections between the individual activities/quests in relation to the larger task/problem will be made explicit to the learners to create a purpose for learning that goes beyond the individual tasks and beyond the confined walls of a classroom, and to enable the participants to perform more effectively in our world.

The Beaconing platform will provide clear goals to learners regarding the learning activities they should complete. However, it is acknowledged that, what and how is learned is largely dependent on the individual's motivation and expectations, past knowledge, experiences, interests and beliefs (Falk & Dierking, 2000). To align the goals of the activities with the learners' experiences, the development of the Beaconing platform should be based on a range of methods that focus on participatory approaches to learning. Essentially this strategy will define a domain and then work closely with the stakeholders (e.g. teachers, learners) to co-design and co-develop meaningful problems or tasks within that domain. An alternative way would be to frame a challenge/problem in such a way that learners will engage with and adopt it to their own needs and interests, and eventually take ownership of that.

The design of the activities is important not only for framing the problem but also for 'authenticating' the experiences we are creating for our learners. During this process the role of the teacher is highlighted, as s/he will be essentially the one to design the experiences and challenge the learners, not by telling the learners what to do or how to do it, but to coach and mentor them through their explorations. The ultimate goal should not be the replication of assessment or activities that are classroom-bound (e.g. memorise a text) but rather to engage learners in various scientific discourses and problem solving (Savery & Duffy, p.4). Teachers should promote reflective thinking throughout the learning process, because through this active and reflective thinking process, learners become responsible for their own learning. Embedded learning analytics in the Beaconing platform provide the teachers with the tools to support reflection on both the content learned and the learning process.

The Beaconing project puts the emphasis on problem-based learning approaches as this implementation and combination with game-based approaches will provide richer and more innovative opportunities for learning. Problem-based learning is seen as helping "people to learn how to learn and to link learning with their own interests and motivations" (Savin-Baden, 2000, p. 5).

3.2 LEARNING REQUIREMENTS

The Beaconing framework aims to contextualize the teaching and learning process, connecting problem-based mechanics, STEM subjects and 21st century learning requirements. It is important that learners develop the knowledge needed for success within this context, and these skills should be taught through interdisciplinary content. These skills are usually covered by the existing curricula in most countries and are combined with themes such as creative thinking, personal responsibility and expressive skills. 21st century skills are usually organized into four main categories; ways of thinking (e.g. creativity, innovation, critical thinking, problem-solving), ways of working (e.g. communication and collaboration), tools for working (e.g. digital literacy) and living in the world (e.g. citizenship, social responsibility, awareness). According to Wagner (2014), the 21st century learner needs seven skills; critical thinking and problem solving, collaboration and leadership, agility and entrepreneurialism, effective oral and written communication, accessing and analyzing information, and curiosity and imagination. Through Beaconing framework, learning will be reshaped to better match the needs of the 21st century knowledge and open societies, and learners will become lifelong learners who are responsible, advanced critical-thinkers, cultural aware, flexible and able to adapt to changes. The

Beaconing project will provide the missing connection between STEM subjects and real-world applications using problem-based learning, and learners will acquire the required STEM, thinking and communication skills that are sought out by employers all over the world.

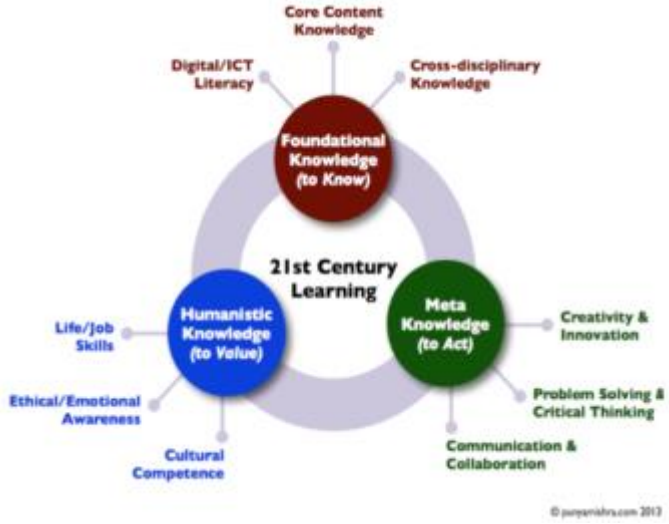

Figure 2 - Beaconing for 21st century learning requirements

3.3 MECHANICS

"Games are a particular manifestation of play, not its totality. They happen to be a good starting point for an investigation of play because the formality of their rules makes the machinery of play easier to observe and analyse" (Upton, 2015). Hence, games are a means by which play can be observed more objectively, leading to purposeful and meaningful engagement and measurement of learning outcomes. In a game situation, the main learning objectives (high-level) can be interpreted and developed through game mechanics (low-level).

Marc LeBlanc and his colleagues (2003) defined game mechanics as "the rules and concepts that formally specify the game-as-system". Game mechanics are usually connected with the game interface as they enable players to move the game's elements, and operate the game system by specifying the processes that affect particular game states. Game mechanics are a synthesis of elements that connect behavioral elements (e.g. players and context) to systemic elements, and they define and regulate rules and performances in order for the game system to be functional.

The Beaconing platform should map the various pedagogical approaches to game mechanics (e.g. quests, leaderboards, goals, levels, badges and so on) and specify how the overall Beaconing ecosystem works and behaves when learners interact with the mini games and gamified activities. The Beaconing platform should identify and emphasize the pedagogical and game features, define their interrelations and include them in the learning activities. A major challenge for this project is to translate the learning objectives into mechanic elements of gameplay, maintaining at the same time the balance between fun and education. Lim et al. (2013) proposed a Learning Mechanics – Game Mechanics (LM – GM) mechanic model evaluated by Arnab et al. (2015) (see Figure 3) which reflects on the various pedagogical and game elements, and tries to map pedagogy, learning and game design patterns. This model includes predefined game mechanics and pedagogical elements extracted from literature on game studies and learning theories.

The Beaconing platform will use this LM-GM model to translate and implement the high-level pedagogical requirements into low-level game mechanics, especially in the gamification design (Task 3.4) and gamified lesson plan integration (Task 4.7). The Serious Game Mechanic included in this model is defined as "the design decision that concretely realizes the transition of a learning

practice/goal into a mechanical element of game-play for the sole purpose of play and fun" and acts as the link between pedagogical practices (learning mechanics) and game mechanics. LM – GM's learning mechanics include various aspects such as objectives, methods, tasks and activities that construct a lesson plan.

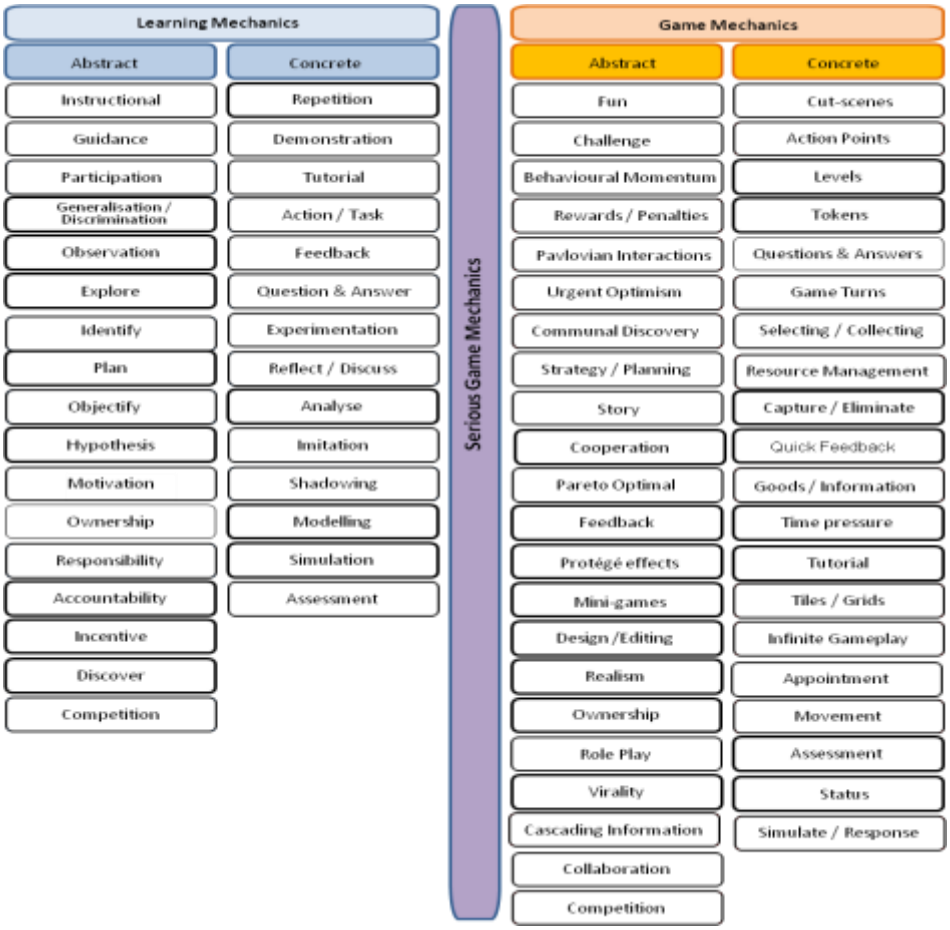

Figure 3 - The LM - GM mapping framework (Lim at al., 2013)

3.4 DYNAMICS

The learning and pedagogical requirements should be correlated with game mechanics and dynamics in order to maintain a balance between the entertainment and serious learning objectives. This approach usually requires an iterative, incremental and user-centric focus (Arnab and Clarke, 2016). Dynamics create aesthetic experiences and can encourage specific behaviors, skills and abilities, or promote learners' needs, goals and objectives during the gameplay.

Marc LeBlanc (2003) defined game dynamics as "the run-time behavior of the game-as-system" while Järvinen defined them as "a pattern or process of change, growth, or activity" (Järvinen, 2008). Dynamics are the different processes that impact the states of the game during the gameplay (i.e. how the state diagram changes when the game system is operated).

Hunicke, LeBlanc and Zubek (2004) developed the MDA ('Mechanics, Dynamics and Aesthetics') framework which is a formal attempt to bridge the gap between game developers and player

experience, and also to enable everybody included in the game development cycle to better understand game designs and artifacts. The MDA framework formalizes games into three distinct components which are then translated into their respective design counterparts (see Figure 4).

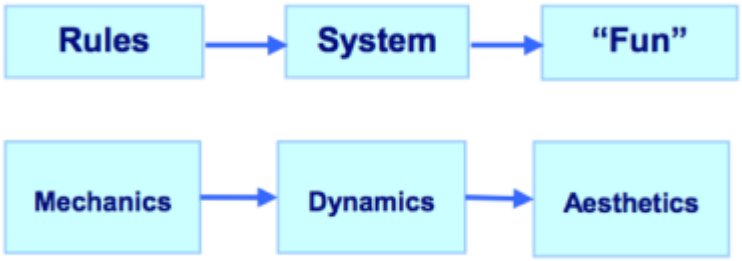

Figure 4 - MDA Framework (Hunicke et al., 2004)

- Mechanics are the particular game components at the level of data representation and algorithms;
- Dynamics refers to the run-time behavior of the mechanics acting on player inputs and outputs over time;
- Aesthetics is the desirable emotional responses evoked in the player, when s/he interacts with the game system.

Mechanics focus on players' action, whereas dynamics focus on the overall game operation, for example how a player moves from one state to another during the gameplay. Games are dynamic systems that change states during gameplay, and mini games operate as subsystems where their dynamics are dependent on the overall game system. Dynamics include game elements, characters, game mechanics which allow and enable players to move these elements and characters, rule sets that define how the components are arranged and managed, the game environment and information about the different game states. Dynamics also define how players interact with their environment and with others, and how they are organized in relation to others; individuals, pairs, groups.

In the Beaconing platform, the game mechanics and dynamics will be dependent on the specific learning objectives and pedagogical perspectives of the learning processes and activities to support the gamified lesson plans. The game mechanics and dynamics would provide teachers with the option to pause the gamified activity to give more time to learners for discussions and constructive debates. Various important aspects define a learning activity such as lesson plan, curriculum, co-curriculum, non- and in-formal learning, and learners' needs. Mapping out lesson plans with associated learning objectives (e.g. what skills to apply, what knowledge to assess) will define the content and context of the learning objectives covered in the formal education curriculum. The next step according to the DoA is the gameful design where the learning mechanics and dynamics will be mapped against the game mechanics and dynamics to guide the user interface design, pervasive engagement and gamified lesson plans. The Beaconing platform will link together formal, non formal and informal activities represented by missions and quests, and dependent on specific learning objectives.

4 TAXONOMY

The aim of the Beaconing Taxonomy is to enable the Consortium to create and share gamified lesson plans over a common framework. The proposed Taxonomy reflects and focuses on the 21st Century learning requirements according to the Beaconing DoA, and merges problem-based mechanics and interdisciplinary context with an emphasis on STEM subjects. This Taxonomy includes specific categories (e.g. skills/competencies, learning objectives, time frame, evidence, location-based technologies, mini games and so on) that can help teachers to design contextualized and gamified lesson plans for STEM subjects.

STEM education focuses on the skills needed for learners' progress and development in an increasingly science and technology driven world. These skills will enable learners to pursue a career in STEM fields, including learning of STEM content and practices. There is a need to increase the number of learners, especially women, who study STEM-related degrees. It is also important that all learners have access to equal and same learning opportunities, in particular those with disabilities or at risk of leaving education early with no more than lower secondary education.

Informed and rational decision making in 21st century requires a certain level of scientific knowledge and STEM literacy. This refers to the knowledge and understanding of scientific and mathematical concepts and processes required for personal decision making, participation in civic and public affairs, and economic productivity for all learners (National Research Council, 1996). Studying STEM or STEM-related subjects will prepare learners to become active citizens and contributors in a science and technology driven world.

The Consortium highlights the need that young people should be encouraged to remain in education and therefore different opportunities should be provided in order for them to enter the higher education and the job market. The Beaconing project recognizes the importance of having specific learning objectives promoted by gamified lesson plans, where learning is delivered in formal, informal and non-formal context breaking the barriers of space and time.

4.1 SKILLS/COMPETENCIES

The Consortium defines STEM competencies as the set of cognitive knowledge, skills, and abilities that are associated with the STEM disciplines. The Consortium pursues a growing interest in these competencies and skills needed for STEM disciplines. The proposed Taxonomy (Figure 5) reflects this interest by covering important STEM competencies that were identified and evaluated by reviewing existing frameworks applied in education (European Parliament & Council of Europe, 2006; National Research Council, 2008; Binkley, 2010).

In the development of the proposed Taxonomy our aim was to focus on the key competencies for STEM (as defined by frameworks, reports, databases, employers, etc.) and the universal competencies both for STEM and non-STEM disciplines in alignment with the Beaconing DoA.

Different frameworks have been developed to address skills needed for life and career success by the Assessment and Teaching of 21st Century Skills (ATC21S, http://www.atc21s.org/) and Partnerships for 21st Century Skills (P21, http://www.p21.org/). These frameworks normally involve a blend of content knowledge, specific skills, expertise and literacies. In the framework proposed by P21, every 21st century skills implementation requires the development of core academic subject knowledge and understanding. Skills such as critical thinking, problem solving, communication and collaboration are also considered essential.

Moreover, ATC21S proposes a model for assessments based on an analysis of the curriculum and assessment frameworks for the 21st Century Skills which are developed worldwide (Binkley et al. 2010). Ten important skills were identified, divided into four main categories:

1. Ways of Thinking (e.g. creativity and innovation, critical thinking, problem solving, decision making, learning to learn, meta-cognition);
2. Ways of Working (e.g. communication, collaboration);
3. Tools for Working (e.g. information literacy, ICT literacy);
4. Living in the World (e.g. citizenship, life and career, personal and social responsibility).

In addition to this, the National Research Council organized a series of workshops to address this topic and defined a set of five broad skills: adaptability, complex communication and social skills, non-routine problem solving, self-management and self-development, and system thinking (Koenig Anderson, 2011).

Jang (2015), through a systematic review of skills and competencies, identified five domains of skills specifically based on STEM disciplines. Jang mapped those skills against a framework developed by Katz and Kahn (1978) and identified five key competencies:

1. Problem solving skills (descriptors: critical thinking, complex problem solving, knowledge of mathematics, skills of science, analyzing information and creative thinking);
2. Social communication skills (descriptors: speaking, coordination, knowledge of customers and personal service, developing and building teams);
3. Technology and engineering skills (descriptors: programming, processing information, practical application of disciplinary knowledge);
4. System skills (descriptors: monitoring processes, judging quality, management);
5. Time, resource, knowledge management skills.

The review of the existing frameworks, as described in the previous paragraphs, indicates that competencies related to problem solving and social and communication skills are the most common ones, whilst cognitive skills and disciplinary knowledge are also considered essential.

All these STEM and non-STEM competencies should be included in the Beaconing framework in order Beaconing learners to acquire the required knowledge and skills beyond Science, Technology, Engineering and Mathematics.

It is expected that the proposed Beaconing Taxonomy will enable users of the Beaconing Authoring Tool to create scenarios with associated missions and quests, and link these scenarios to specific competencies and skills to show learners' progression at specific level. Even though the Beaconing platform focuses on learners' technical skills and knowledge, it is also important that learners can apply these skills in a purposeful way. Working through a number of challenges, learners will acquire knowledge and understanding in areas other than STEM and thus, develop skills needed for bridging the gap between STEM education and skills.

4.2 LEARNING OBJECTIVES

According to the British Department for Education (http://www.gov.uk) a high-quality science-based education will provide learners with the fundamental knowledge for understanding the world through the disciplines of biology, chemistry and physics. Learners should be taught the methods, processes and uses of science, and through a foundational understanding they should familiarize themselves with the natural phenomena, being capable of explaining what is happening and analyzing the causes.

Studying science-based subjects, learners will:

1. Develop scientific knowledge and conceptual understanding through the specific disciplines of biology, chemistry and physics;
2. Develop understanding of the nature, processes and methods of science through different types of science enquiries that help them to answer scientific questions about the world around them;
3. Be equipped with the scientific knowledge required to understand the uses and implications of science, today and for the future;
4. Use science process and thinking skills;
5. Manifest science interests and attitudes;
6. Communicate effectively using science language and reasoning;
7. Demonstrate awareness of the social and historical aspects of science.

Studying science triggers learners to observe over time, seek patterns, identify, classify and group, compare and test (controlled investigations), and research using secondary resources.

The technological achievements and advancements have changed and continue to change the way people live, and employers are looking for individuals who possess a high level of technical skills. The exponential growth of information technology and the continuing need for maintaining the systems and improving the network security, require well-educated and qualified individuals who understand the latest developments in technology. It is important therefore the school curriculum to reflect the latest in technology.

Through technology-based subjects, learners will:

1. Demonstrate an understanding of emerging classroom technologies;
2. Demonstrate knowledge, attitudes and skills of digital age work and learning;
3. Plan, design and assess effective learning environments and experiences;
4. Implement curriculum methods and strategies that use technology to maximize their learning;
5. Apply technology to facilitate a variety of assessment and evaluation strategies;
6. Understand the social, ethical and legal issues surrounding technology;
7. Facilitate instruction in the new literacies that emerge within digital interactive learning environments.

Technology and engineering may be challenging and not the easiest subjects to study but they are always in demand. An engineering-based education will provide learners with various technical skills applicable to industry such as problem solving, decision making, innovation and communication. Learners will acquire the appropriate knowledge for a rapidly changing technological world. There is a high demand for well-qualified and skilled learners who can be employed in sectors such as green engineering (to increase energy efficiency and develop other sustainable resources), safety and security (both for physical defenses and cyberwar fares), high performance engineering (for car and airspace industry) and medical engineering (develop new healthcare technologies and create advanced robots to help for example elderly people).

An engineering-based education will enable learners to:

1. Select and apply appropriate mathematical methods for modelling and analyzing engineering problems;
2. Use scientific principles in the development of engineering solutions to practical problems;
3. Use scientific principles in the modelling and analysis of engineering systems, processes and products;
4. Select and apply appropriate computer based methods for modelling and analyzing engineering problems and the ability to assess the limitations of particular cases;
5. Analyze systems, processes and components requiring engineering solutions;

6. Create new processes or products through the synthesis of ideas from a wide range of sources;
7. Apply and adapt design methodologies in unfamiliar situations.

Mathematics is a creative and cross-disciplined subject that provides solutions to the most challenging problems. Mathematics is essential and necessary for everyday life, economy, employability, science, engineering and technology. A mathematics-based education will provide learners with a solid understanding of the world and the ability to reason mathematically and critically (British Department for Education, http://www.gov.uk). Studying mathematics, learners will acquire an articulating knowledge to solve complex problems and will develop critical thinking, enquiry, argument and justification.

A mathematics-based education will enable learners to:

1. Develop fluent knowledge, skills and understanding of mathematical methods and concepts;
2. Acquire, select and apply mathematical techniques to solve problems;
3. Reason mathematically, make deductions and inferences and draw conclusions;
4. Comprehend, interpret and communicate mathematical information in a variety of forms appropriate to the information and context.

Learners should be able to:

1. Use and apply standard techniques to:
    - Accurately recall facts, terminology and definitions;
    - Use and interpret notation correctly;
    - Accurately carry out routine procedures or set tasks requiring multi-step solutions.
2. Reason, interpret and communicate mathematically to:
    - Make deductions, inferences and draw conclusions from mathematical information;
    - Construct chains of reasoning to achieve a given result;
    - Interpret and communicate information accurately;
    - Present arguments and proofs;
    - Assess the validity of an argument and critically evaluate a given way of presenting information.
3. Solve problems within mathematics and other contexts to:
    - Translate problems in mathematical or non-mathematical contexts into a process or a series of mathematical processes;
    - Make and use connections between different parts of mathematics;
    - Interpret results in the context of the given problem;
    - Evaluate methods used and results obtained;
    - Evaluate solutions to identify how they may have been affected by assumptions made.

4.3 TIME ALLOCATION

Even there is a high variability in the educational approaches in Europe, schools usually have legal and statutory requirements for the time allocated to subjects. Governments determine the time allocation for school programs in the STEM learning areas and subjects and the Beaconing platform should support the recommended curriculum time allocations for the implementation of the gamified lesson plans. Beaconing will provide gamified lesson plans for learners to effectively acquire the needed knowledge both inside and outside of the classroom. Before teachers plan their lessons and allocate the specific time for those, they should identify the specific learning objectives. Then, based on these learning objectives, teachers can design appropriate activities with missions and quests that should be accomplished within certain learning time (estimated and specified by teachers).

4.4 PARTICIPANTS

The Beaconing platform allows teachers to choose whether their students will work individually, in pairs, in small groups or as a whole group. The variation between these options will promote the effectiveness of the gamified activities. When students work on an individual level (e.g. reading, solving problems or case studies), they can demonstrate their ideas, views and arguments. Individual activities enable students to work on their own pace and feel comfortable and confident about their knowledge and skills, and to progress through their preferred learning style. Students interact more with each other when they work in pairs or small groups as they can discuss, compare their answers and mark each other's tasks. Working as a whole group is best for review discussions, role-play tasks and formal debates. At group level learners learn from one another, while the learners' team skills, socialization and professional networking are improved. Homework is shared and thus the work load is decreased.

4.5 PLACES OF INTEREST

The gamified learning activities can be undertaken within a formal setting (e.g. classroom, school) and they can be expended to non-formal and informal setting (e.g. co-curricular, local community, home). Learners will have both individual and collaborative tasks to solve, from classroom-based activities and after school assignment/homework to workplace internships.

The gamified activities can take place:

1. School (e.g. classroom, lab, ICT room);
2. Home;
3. Out and about (e.g. park, museum, zoo, science centers).

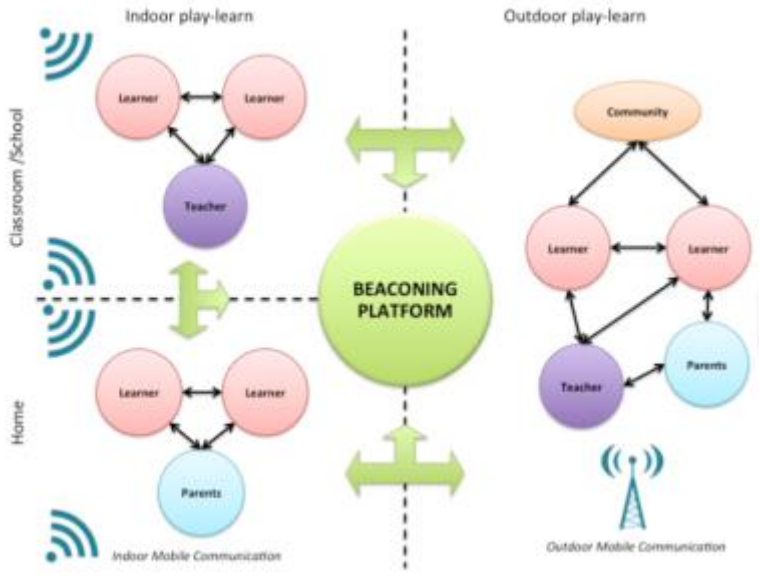

Figure 5 - Beaconing conceptual ecosystem

4.6 TOOLS/RESOURCES

The Beaconing platform will provide various tools and resources to help learners complete their activities. These tools will encourage learners to get involved in the gamified activities in an easier and more engaging way. The platform should provide a range of resources for game-based learning in

STEM topics. Online tools should allow learners to create videos or presentations for the classroom that can be shared among learners. Games and exercises available for computers, mobile devices and tablets will also help teachers to easily assess and track learners' progress. Learners should be able to capture photographs and recordings, keep them organized and access them anywhere.

4.7 EVIDENCE

The Beaconing platform will be designed to be flexible toward assessment as there are many particularities and differences in education across Europe; differences in curricula, legal and pedagogical frameworks that drive assessment, levels of education, age and individual needs of learners including those with disabilities. The Beaconing platform should merge formal, non-formal and informal learning practices and communities.

Therefore, it is important that all Beaconing-supported assessment frameworks and practices should be flexibly adapted to specific contexts and learners, taking into account the individual, cultural and curricular needs and contexts. Teachers should be supported to link the gamified activities (both digital and non-digital) with evidence for specific disciplinary fields, established competence frameworks and well-defined levels of proficiency. The evidence that learners should provide for their assessment will be linked with specific weights/measures that will be different for each gamified activity as the level of difficulty for each activity will be different. These measures will be then linked with the assessment framework to assign the learners' level of progress.

The Beaconing platform should enable learners to upload to the social/discussion platform a variety of evidence formats, such as photos, commentaries, presentations or simple multimedia artefacts (photographs, blog posts, notes, diaries, spreadsheets, videos, demos, prototypes). These evidences will be then submitted for peer review and discussion, or for a traditional and formal grading system undertaken by teachers. Promoting the use of the social/discussion platform will encourage the informal feedback and evaluation from the community as a whole.

4.8 INCENTIVES/REWARDS

During the learning process teachers use different strategies and techniques to encourage and promote appropriate behaviors for positive learning outcomes. In every level of education, learners are usually categorized as intrinsically or extrinsically motivated. Learners who are intrinsically motivated have a desire for learning and in-depth knowledge, whereas extrinsically motivated learners are usually gravitated towards rewards and prizes. Motivation (both internal and external factors) stimulates learners to be continually interested and committed to study and learn, and to make an effort to retain their goals over time. Even though teachers promote intrinsic motivation to learners, there are cases when some form of stimulus or extra motivation is required in order learners to engage with the learning process and educational activities.

Incentives and rewards (usually in tangible form) give to learners a sense of achievement when they successfully complete a task, challenge or mission. Tangible rewards help learners to behave appropriately and develop reasons to complete their homework. Learners can earn rewards in different areas such as homework, extra curricular activities or even behavior. The prospect of an immediate reward encourages learners to try harder and perform better, while a study [1] argues that rewards empower learners to demonstrate all of their abilities and capabilities, something that would not happen without an extrinsic motivation. The recent years, a great emphasis has been given only on positive incentives and rewards (rather than on punishments or sanctions), which fosters learners' attention, concentration and engagement.

But, there are teachers, who believe and argue that rewards undervalue learning, produce short-term changes and serve as motivators only if learners want to. Rewards are seen as bribes, which are used

to control and influence appropriate behaviors. Rewards could lose their power over time and not positively influence learners' behavior, as they do not really promote deeper or meta-level learning. Rewards should be simple, frequently provided, adaptable to learners' needs and preferences, and they shouldn't undermine learners' intrinsic motivation for learning and education.

Recent research focuses on ways in which gamified learning environments can intrinsically motivate learners by nurturing their curiosity, encouraging exploration and providing support. Such gamified learning environments provide effective motivators for learning that maintain learners' attention and interest, and learners become active participants and decision makers. Different incentive mechanisms are introduced to the learning environments to promote the learners' engagement and influence their behavior (learners become more willing and able to adapt their behavior).

The Beaconing reward system will be designed in such a way to motivate learners by recognizing their effort and hard work. Integrating features such as leaderboards, achievements, milestones and certifications, learning and education will become more engaging and interactive than the traditional paper-based educational system. Learners will be awarded points for working hard, vouchers, badges for completing tasks set by teachers, certificates which show the individual achievements, stickers, freebies which acknowledge progress, passes to zoo/museum/aquarium which encourage outside of the classroom activities, and so on. Teachers should apply the correct rewards in each specific learning context and the rewards should be used in different ways to lead learners to change.

The Beaconing platform will provide different mechanics for strong learners' motivation, engagement and effective learning. Through storytelling, rewards, choices, competition/collaboration, feedback, learner-centered pedagogy and extended learning beyond the classroom, learners will be engaged and prepared for lifelong learning.

4.9 LOCATION-BASED TECHNOLOGIES

The Beaconing platform will integrate and advance various internet technologies such as mobile communications, location-based and context-aware systems, and cloud technology. A great emphasis is given on location-based technologies that can be widely used in digital games for taking "place in the physical world, concurrently with the normal activities of players' everyday lives" (http://thelastweblog.com/20111222/whats-the-best-definition-of-pervasive-gaming/). Location-based games with different play-learn activities will be applied to informal learning settings to support problem-based learning. Communication systems and Wi-Fi will support the data flow for both indoor and outdoor communication to the platform. When learners are within a specific location, Beacons will act as a trigger for context-aware systems, and then relevant information with learning resources such as tips or challenges, and gamified activities will be displayed on learners' mobile device. Beacons are usually accompanied with a user-friendly mobile application and can be installed on any smartphone, tablet, room, building, electronic whiteboard and so on.

4.10 MINI GAMES

The Beaconing platform will exploit pedagogy-driven game techniques such as digital games and gamification to provide an adaptive and personalized digital learning ecosystem. Game-based approaches are extensively used to engage young learners with education and training as they appeal to all ages and genres. Digital games based on problem-based learning can improve learners' performance, achievements, motivation and satisfaction. A type of mini game that can be included in the Beaconing platform is for instance, the "whack a mole" game (Maynes-Aminzade et al., 2002). This simple type of game invests in long-term memory that can be extracted quickly without conscious effort and can be used for example in Mathematics. The "strategy-builder" games (Selten, 1990) usually support any type of data flow and can challenge learners to build different structures and comprehend the impact of each individual action. "Puzzle" games (Walker and James, 1999) test the

learners' problem-solving skills such as logic, pattern recognition, sequence solving and word completion. Puzzle games focus on logical and conceptual challenges, and support intellectual mechanics for comparative intellectual process. "Clever-talk" games (Weibull, 1997) encourage the dialogue and debate between two or more people. "Simulation" games (Ahdoot, 1999) simulate real life situations and are used for various purposes such as training, analysis or learning exercises. With "game trees" (Baxter et al., 1999) learners can explore various learning possibilities and opportunities, while in "adventure" games (Moser, 1997) learners are the protagonists in an interactive story with challenges, exploration and problem-solving.

What skills participants will develop? *Skills/Competencies*	**What's the purpose?** *Learning Objectives*	**How much time?** *Time*	**Who is taking part?** *Players/Participants*	**Where is the mission going to take place?** *Places of interest*	**What is available for this mission?** *Tools/Resources*	**What evidence should participants provide?** *Evidence*	**How is achievement rewarded?** *Rewards/Incentives/ Prizes*	**Location-Based Technologies**	**Mini Games**
Communication/Expression - Advanced literacy - Languages - Conversation - Content creation - Self expression - Creativity - Initiative - Mentoring - Leadership - Reflection - Awareness **STEM** - Reasoning - Inquiry - Logical/Spatial Thinking - Information skills **Social/Civic** - Negotiation - Assertiveness - Respect - Integrity - Participation - Collaboration/team working - Adaptability/Resilience **Autonomy/Initiative** - Planning - Organisation - Management - Presentation - Entrepreneurship - Innovation **"Meta"** - Learning to learn - Design thinking - Critical/inventive thinking - Appreciation - Digital literacy - Cross-cultural skills	**Science** • Use science process and thinking skills. • Manifest science interests and attitudes. • Understand important science concepts and principles. • Communicate effectively using science language and reasoning. • Demonstrate awareness of the social and historical aspects of science. • Understand the nature of science. **Technology** • Demonstrate an understanding of emerging classroom technologies. • Demonstrate knowledge and skills of digital age. • Apply technology to facilitate a variety of assessment and evaluation strategies. • Understand the social, ethical, and legal issues surrounding technology. • Facilitate instruction in the new literacies that emerge within digital interactive learning environments. **Engineering** • Select and apply appropriate mathematical methods for modelling and analyzing engineering problems. • Use scientific principles in the development of engineering solutions to practical problems. • Use scientific principles in the modelling and analysis of engineering systems, processes and products • Select and apply appropriate computer based methods for modelling and analyzing engineering problems. • Analyze systems, processes and components requiring engineering solutions. **Mathematics** • Develop fluent knowledge and understanding of mathematical methods. • Acquire, select and apply mathematical techniques to solve problems. • Reason mathematically and draw conclusions. • Comprehend, interpret and communicate mathematical information.	• x Hours • x Weeks • x Months • x Sessions	• Individuals • Small groups • Big groups • Whole class • Whole school • Parents • Peers • Professionals • Others	**School** • Classroom • Lab • ICT room • Schoolyard **Home** • Friends house **Out & About** • Park/Field • Museum/Zoo/Science centres/Galleries • City centre • Shops	**Beaconing** • Presentation • Online tools/Word processing • Online resources (video, newspapers) • Models • Databases • Game apps • Beacons • Mind-mapping **Devices** • Mobile phones/ Laptops/ Camera/Audio Recorder **Teachers** • Lab tools • Pen & paper	• Photographs • Tests • Quizzes • Performance assessments • Portfolios • Journals • Essays • Presentations • Projects • Blog posts • Formulas • Graphs • Charts • Computations • Peer evaluation • Observations • Spreadsheets • Videos • Meeting notes • Feedback forms • Audio files • Demos • Prototypes	• Points • Collectables • Peer prestige • Vouchers • Pass to zoo/aquarium/museum • "No homework" pass • Badges • Certificates • Stickers/ribbon/plaque/trophy • Educational trips • Freebies • Customisation options	• GPS • BLE Beacons • Wi-Fi • Bluetooth	• Wack-A-Mole • Strategy-builder • Puzzle/Reflex • Clever-talk • Gamified quiz • Simulation • Game tree • Adventure (Treasure hunt)

Figure 6 - Beaconing Taxonomy

5 FRAMEWORK

The Beaconing Authoring Tool is the teacher's first interaction with the Beaconing platform. This proposed framework is a guideline and *paper-based* tool which will inform the design and development of the Beaconing Authoring Tool. This framework has been designed to support teachers in designing location-based and gamified learning activities both for complementing classroom-based education and fostering learning outside the usual, formal contexts. The Beaconing Authoring Tool will provide a shared framework for assessment and discussion, and will also promote the creation of communities both for teachers and learners to support the design and evaluation of new challenges and activities. The Authoring Tool will provide a repository of fully structured gamified lesson plans accompanied with missions and quests that can be used by teachers as they are, and also guidelines of how these lesson plans can be adapted to specific needs. Teachers can always create new gamified lesson plans using this tool.

5.1 INSTRUCTIONS

The Beaconing Taxonomy (see Figure 6) is the core of this framework created with the aim to help teachers in creating their gamified lesson plans based on specific context and learning objectives. The Taxonomy includes ten categories with self-contained drop-down menus, labelled and classified appropriately for ease of navigation and choice. Each category will be dragged and dropped in the teachers' working environment for creating easily new activities. Teachers can also propose new options/categories to be included in the Beaconing Authoring Tool.

- **Skills/Competencies:** The Beaconing competency framework focuses on trans-discipline STEM subjects and tries to connect them with other domains that are essential for competent and contextualised real-world developments (communication/expression, social/civic, autonomy/initiative, meta-competencies). The competency framework will have three levels of proficiency (basic, advanced and mastery) and will be linked to a simple game Taxonomy to help teachers select the most appropriate activities (mini games or real-world gamified activities) for specific learning objectives.

  Examples: Logical reasoning, teamwork, planning, critical thinking

- **Learning Objectives:** The learning objectives will focus on a more specific and disciplinary level similar to skills/competencies, but their aim would be to link the Beaconing activities to particular aspects and levels of proficiency within the STEM domains. Specific weights/measures will be mapped against the learning objectives based on the specific curriculum that these objectives will support.

  Examples: Science communication, mathematical modelling, technology application

- **Time:** The Beaconing Authoring Tool enables teachers to define an appropriate timescale for activities, which may be extended beyond the space and time of formal classroom settings, and thus new opportunities for more engaging and playful forms of homework may arise (e.g. flipped classroom). The Beaconing platform supports flexible timescales, ranging from a single session within the school settings (2 hours) to much longer periods for more complicated lesson plans (1 month), taking under consideration the individual learner's needs.

  Examples: 10 minutes, 1 hour, 1 week, 1 month

- **Participants:** Beaconing's objective is to extend the learning experience and involve in that leaners, teachers and/or parents. Depending on the gamified lesson plan context, learners will engage with people outside the formal school settings.

  Examples: parents, classmates, local craftsman, members of the city council

- **Location:** Location is dependent on the requirements of each individual gamified lesson plan. The Beaconing Authoring Tool supports different options for in- and out-of-school activities and teachers will the ones who define the locations.

  Examples: classroom, laboratory, city centre, town square

- **Tools/Resources:** For each gamified play lesson, different tools and resources will be available to learners. These tools may be explicitly needed and be available only within the school or college settings, or may only be a support.

  Examples: cellphones, microscope, pen and paper, instructional videos

- **Evidence:** Evidence is closely connected to teachers' feedback and peer review. The Beaconing mini games will be supported by an automated feedback which will quantify and score specific tasks. More complex gamified activities that are extended around real-world activities cannot be supported by an automatic feedback. A different kind of evidence will be needed, for example uploading a photograph or screenshot to the Beaconing platform which will certify activity completion and will be evaluated and discussed by teachers or classmates.

  Examples: completed mini games, 10 photos, video presentation, interview

- **Rewards:** Rewards are the high level feedback that will link the individual gamified activities to the overarching narrative and meta-game experience. The Beaconing platform will provide points and collectables such as virtual objects found in the game environment or badges when a specific activity is completed. High scores and/or achievements may be connected to real-world prizes.

  Examples: 100 Beaconing points, top score badges, pass for local google branch visit

- **Location-Based Technologies:** Beaconing's objective to break the traditional limits of learning spaces emphasizes technologies that link learning to real contexts. New technological tools should be supported by Beaconing platform to contextualise and ground learning.

  Examples: GPS, beacons, "virtual beacons", QR codes

- **Mini Games:** Mini games are linked to skills/competencies and learning objectives (with four levels of mechanical and dynamical complexity: reflex games, puzzle/quiz, strategy and conversation) and give an indication of how games can be used by teachers to provide a gameful experience.
  Examples: quiz, puzzle, live action role playing game

5.2 ASSESSMENT FRAMEWORK

The assessment framework (Figure 7) represents the learner's progress and how s/he can move from one mission to another based on the Triadic Game Design (Harteveld, 2011) and the Triadic Certification approach (Baptista et al., 2015). Each mission includes different quests and in order for the learner to progress, s/he needs to obtain different skills/competencies in different quest levels. These skills/competencies are obtained when the learner completes a specific quest and achieves a particular score (e.g. completes a quiz, a specific level in a mini game or reading a specific chapter). The level of completion is based on the scores in quizzes, mini games or assessments, the points earned and the time taken for the completion. Each skill/competency has specific weights/measures that will be defined by teachers and we number these weights from 0 to 1 (i.e. 0.1 x s1 + 0.2 x s2 + 0.7 x s3), and they should accumulate to a score of 1 in order to secure a balance between the different skills/competencies. The criteria that would determine how these scores are achieved will be based on specific measures for the particular skill/competency and quests. Some skills/competencies can be obtained when the learner only completes one quest, whereas others to be obtained, the learner should complete different quests in different missions. Figure 7 presents a simple example of how the criteria are used in order for a quest to be completed (s2 is obtained 100% when the learner completes the quest 2 (Q2) in mission 2 (M2) whereas s1 is obtained 100% when the learner fully completes quest 1 (Q1), quest 2 (Q2) and quest 3 (Q3) in mission 1 (M1)). The different levels of quests will ensure the learner's progression towards knowledge acquisition and mastery. This framework will be the basis for further development for Task 4.6 on learning semantics and analytics based on measures defined for the learning plan, dynamics and process, including the technical and game development.

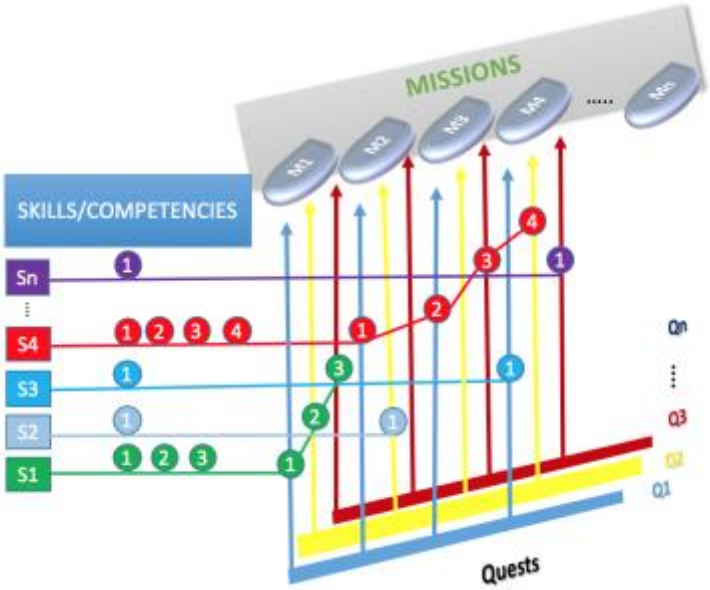

Figure 7 – Assessment Framework (based on Triadic Certification approach (Baptista et al., 2015))

From Figure 7 specific weights/measures are missing, but teachers will define these weights/measures, as each mission/quest will have its distinct weights/measures. The same logic will be applied to the learning objectives, resources, mini games and so on, in order to break down the scenarios into specific and more detailed elements. These elements will be unpicked and the specification of the scenarios will be updated based on further engagement with the teachers from the pilot sites. The mapping of the scenarios with the mini games, resources and technologies are being carried out in Task 3.4 and Task 4.7. The specification for the lesson plan will be updated accordingly in an iterative and incremental manner.

6 SCENARIOS

The Consortium pilot partners provided example scenarios based on the proposed play-lesson path and mission template and have been mapped against the proposed Taxonomy (see Figure 6) and the assessment framework (see Figure 7). Each scenario has been adapted to the particular needs of each pilot (either small or large scale). The specific measures and sub-measures of each quest will be specified later based on further engagement with the teachers from the pilot sites. All the scenarios will be modified and updated accordingly after discussing them with the teachers and will be reflected on further work as they will possibly link to activities in Task 3.4, Task 3.5 and Task 4.7. The scenarios presented below tackle different learning objectives and have been select to show the variety of the play-lesson scenarios the Beaconing platform can support. The scenario on Basic Algebraic Skills provided by ORT tries to address the algebraic difficulties that high school students face, whereas the stonemasonry scenario by HWU focuses on vocational training. The rest of the scenarios are presented in the Appendix.

The example scenarios are:

1. Basic Algebraic Skills – ORT (pilots in France and Greece)
2. Stonemasonry – HWU (pilots in UK)
3. Digital Literacy – ORT (pilots in France and Greece)
4. Physics – SIVECO (pilots in Romania)
5. Chemistry applied to Environmental Health – IMA (pilots in Italy)
6. Organising and Distributing Data – SEBIT (pilots in Turkey)
7. Energy Management – COVUNI (pilots in UK)
8. Graph Theory and Tessellation – COVUNI (pilots in UK)
9. Basic Geometry Skills – SIVECO (pilots in Romania)
10. Water Management – COVUNI (pilots in UK)

6.1 PROPOSED PLAY-LESSON PATH AND MISSION TEMPLATE

A. Domain / Area / Subject *Choose from the icons one of the four main subject areas (e.g. Science, Technology, Mathematics, Engineering).*
B. Topic *Choose a more specific topic that best fits your teaching objective (e.g. Digital Literacy, Chemistry, Geometry, etc.).*
C. Age Group / Key Stage / Year / Background *Indicate the age group/educational stage/background of your students (e.g. high school, math freshmen, vocational school).*
D. What is it about? / What's in your mind? / What's the matter? *Define a specific and contextualised problem/challenge and create different missions to compose a Play-Lesson Path (e.g. Digital Identity Management, Energy Management, Graph Theory, Kitchen Chemistry).*
E. Play - Lesson Path *Provide a description of the narratives used for the Play-Lesson Path.*

Figure 8 - Proposed Play-Lesson Path

Mission A *Background* *Skills*	Quest 1						
	Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**	**Beacons**
	Quest 2						
	Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**	**Beacons**

Figure 9 - Proposed Mission Template

6.2 BASIC ALGEBRAIC SKILLS – ORT FRANCE

A. Domain / Area / Subject *Mathematics*
B. Topic *Basic algebraic skills*
C. Age Group / Key Stage / Year / Background *High school students in a difficult situation math wise, or even a higher level like post-grad.*
D. What is it about? / What's in your mind? / What's the matter? *Today's world requires knowledge based on solid basic skills such as mathematic literacy. An alarming picture of the current situation in math literacy at high school level is provided by the PISA and TIMSS international surveys.* *Some basic mathematical notions learned in primary and secondary schools are still not fully mastered by some students by the time they arrive in high school. This situation will lead those students to be unable to follow properly the math curricula, especially in algebra, are they are not able to build on this pre-existing knowledge.* *This activity will address the problem by providing activities designed to work on essential algebraic notions needed throughout the high school curricula.*
E. Play - Lesson Path *The lesson path is divided in four missions trying to address the basic math deficiencies met in high schools. More missions could be added later to cover a larger ground. The lesson starts with a reminder of the 4 basic operations and continues with a direct application of it through problems with proportionality. Then decomposition of a number in primer factors and the divisibility rules close the lesson path.*

Figure 10 - Basic Algebraic Play-Lesson Path

What curriculum skills will participants develop?	**What's the purpose?** *Aims/Objectives*	**How much time?** *Time*	**Who is taking part?** *Players/Participants*	**Where is the mission going to take place?** *Places of Interest*	**What is available for this mission?** *Tools/Resources*	**What evidence should participants provide?** *Evidence*	**How is achievement rewarded?** *Rewards/Incentives /Prizes*
In France, this corresponds to the end of primary school/beginning of secondary school of crucial math knowledge.	**Knowledge/Understanding** • Analyse • Reflect • Solve • Evaluate • Interpret **Action/Activity** • Use • Share • Teach • Respond • Critique • Cooperate **Creation** • Publish • Develop	• x Hours • x Weeks • x Months • x Sessions	• Individuals • Small groups • Big groups • Whole class • Parents • Peers	**School** • Classroom • Lab • ICT room **Home** • Friends house	**Beaconing** • Presentation • Online tools/Word processing • Online resources (video, newspapers) • Game apps **Devices** • Mobile phones/ Laptops/ Desktops **Teachers** • Face-to-face • Lab tools • Pen & paper	• Formulas • Graphs • Charts • Notes • Spreadsheets • Presentations • Videos • Quiz results	• Points • Peer prestige

Figure 11 - Basic Algebraic Taxonomy

Mission A The 4 basic operations							
With the prevalence of many automatic ways of computing simple operations such as pocket calculators, smartphones, computers and so forth, students very often forget how to realize simple operations by themselves and without help. They tend to commit simple mistakes that can often snowball and make all further computations wrong. Those mistakes could be easily avoidable by practicing the 4 basic operations in a step by step fashion. **The operations can be practiced by hand or by using an electronic device, either directly or in a fill-the-gap fashion.** ***Background*** **Primary school math level** ***Skills*** **A refresher on basic arithmetic**	Quest 1: A refresher course is given and also some support (paper, internet). This gives a reverse-classroom theme to this mission, with lesson to be learnt/relearnt at home and practice being done in the classroom.						
	Time Frame 1 hour of work in 1 session. Very little is done in the classroom itself, maybe 10 min for introduction.	**Participants** Teacher Classmates	**Location(s)** Classroom Home	**Resources** Books Websites Interactive material	**Evidence** Questionnaire if needed.	**Rewards** Points to have accessed or read the lesson material	**Beacons** Beacons will allow to notice when the student is at home and deliver the teaching material
	Quest 2: Exercises to practice and reinforce as an automatism the refreshed knowledge. Practiced both in classroom (reverse classroom) and outside.						
	Time Frame 2 to 4 hours in several sessions.	**Participants** Teacher Parents Classmates Friends	**Location(s)** Lab Mobile phone Home	**Resources** Applet Web-based software Serious game Paper & pen Games can be based on two approaches: • Fill the gap method • Solve calculation	**Evidence** Metric showing the results of students in the games	**Rewards** Points awarded in the game are used for class/school wide leaderboard	**Beacons** Beacons will allow access to the game at home.

Figure 12 - Mission A (The 4 basic operations)

Mission B Proportionality and cross-multiplication **In contrast with some other subjects, proportionality is a field which can prove to be extremely useful in the students every day's life when tackling simple tasks like quickly figuring out the importance of a discount on a price tag. Despite this usefulness, it is often a subject in which some students are lacking. Many practical problems can be used to illustrate proportionality, and the beaconing platform gives the teachers the flexibility to author several scenarios tackling subjects adapting directly to the students most direct interests.** **The exercise could be solved by hand or by using an electronic device, presented as a text or as a table to fill or as a figure to draw. ICT can help the students by showing the immediate result of the data entered by the students in the problem's framework.** ***Background*** **Primary school math level** ***Skills*** **A refresher on basic arithmetic**	Quest 1: A refresher course is given and also some support (paper, internet). This gives a reverse-classroom theme to this mission, with lesson to be learnt/relearnt at home and practice being done in the classroom.					
	Time Frame 1 hour of work in 1 session. Very little is done in the classroom itself, maybe 10 min for introduction.	**Participants** Teacher Classmates	**Location(s)** Classroom Home	**Resources** Books Websites Interactive material	**Evidence** Questionnaire if needed.	**Rewards** Points to have accessed or read the lesson material	**Beacons** Beacons will allow to notice when the student is at home and deliver the teaching material
	Quest 2: Exercises to practice and reinforce as an automatism the refreshed knowledge. Practiced both in classroom (reverse classroom) and outside.					
	Time Frame 2 to 4 hours in several sessions.	**Participants** Teacher Parents Classmates Friends	**Location(s)** Lab Mobile phone Home	**Resources** Applet Web-based software Serious game Paper & pen Games should be based on real life examples around the field of proportionality. Price calculations with a discount.	**Evidence** Metric showing the results of students in the games.	**Rewards** Points awarded in the game are used for class/school wide leaderboard	**Beacons** Beacons will allow access to the game at home.

Figure 13 - Mission B (Proportionality and cross-multiplication)

Mission C Divisibility rules **Sometimes performing a full division is not necessary to solve a certain problem. A divisibility rule is a shorthand way of determining whether a given number is divisible by a fixed divisor without performing the division, by examining its digits. Knowing those rules is a very handy tool in the math tool box of a high school student and can contribute to a faster and accurate resolution of many problems. The decomposition rules can be practiced by hand or by using an electronic device.** ***Background*** **Primary school math level** ***Skills*** **A refresher on basic arithmetic**	Quest 1: A refresher course is given and also some support (paper, internet). This gives a reverse-classroom theme to this mission, with lesson to be learnt/relearnt at home and practice being done in the classroom.					
	Time Frame 1 hour of work in 1 session. Very little is done in the classroom itself, maybe 10 min for introduction.	**Participants** Teacher Classmates	**Location(s)** Classroom Home	**Resources** Books Websites Interactive material	**Evidence** Questionnaire if needed.	**Rewards** Points to have accessed or read the lesson material	**Beacons** Beacons will allow to notice when the student is at home and deliver the teaching material
	Quest 2: Exercises to practice and reinforce as an automatism the refreshed knowledge. Practiced both in classroom (reverse classroom) and outside.					
	Time Frame 2 to 4 hours in several sessions.	**Participants** Teacher Parents Classmates Friends	**Location(s)** Lab Mobile phone Home	**Resources** Applet Web-based software Serious game Paper & pen (Games could be based on time-critical games in order to make the divisibility rules known as a reflex rather than another lesson)	**Evidence** Metric showing the results of students in the games	**Rewards** Points awarded in the game are used for class/school wide leaderboard	**Beacons** Beacons will allow access to the game at home.

Figure 14 - Mission C (Divisibility rules)

Mission D Prime decomposition, integer factorization	Quest 1: A refresher course is given and also some support (paper, internet). This gives a reverse-classroom theme to this mission, with lesson to be learnt/relearnt at home and practice being done in the classroom.					
Identifying numbers as prime or composite is a very basic and important algebra skill. Once a number has been identified as a composite, the students need to be able to decompose it into its prime factors. There are many different ways to represent decomposition into prime factors such as the prime factor tree, Venn diagram and so forth.	**Time Frame**	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**	**Beacons**
	1 hour of work in 1 session. Very little is done in the classroom itself, maybe 10 min for introduction.	Teacher Classmates	Classroom Home	Books Websites Interactive material	Questionnaire if needed.	Points to have accessed or read the lesson material	Beacons will allow to notice when the student is at home and deliver the teaching material
	Quest 2: Exercises to practice and reinforce as an automatism the refreshed knowledge. Practiced both in classroom (reverse classroom) and outside.						
Background Primary school math level	**Time Frame**	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**	**Beacons**
Skills A refresher on basic arithmetic	2 to 4 hours in several sessions.	Teacher Parents Classmates Friends	Lab Mobile phone Home	Applet Web-based software Serious game Paper & pen (Games could be based on time-critical games in order to make the divisibility rules known as a reflex rather than another lesson)	Metric showing the results of students in the games	Points awarded in the game are used for class/school wide leaderboard	Beacons will allow access to the game at home.

Figure 15 - Mission D (Prime decomposition, integer factorization)

The following figure (Figure 16) presents an example of how the learning objectives in Basic Algebraic Skills can me mapped against the proposed assessment framework. The specific measures and sub-measures of each learning objective in this particular scenario will be specified later based on further engagement with the teachers in France and Greece.

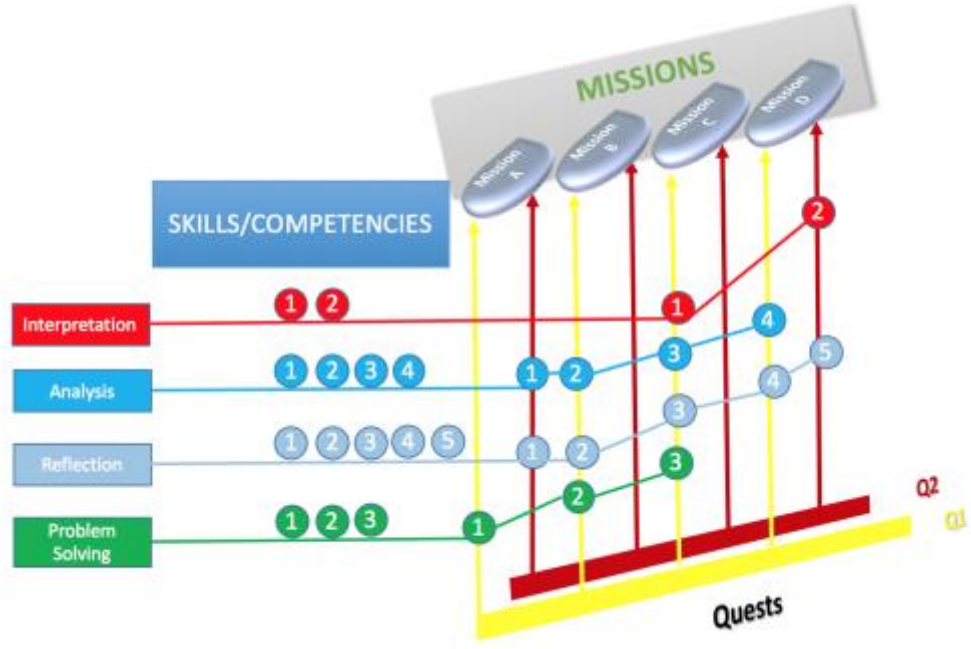

Figure 16 - Learners' progress in Basic algebraic skills

6.3 STONEMASONRY – HWU UK (VOCATIONAL TRAINING)

A. Domain / Area / Subject *Engineering*
B. Topic *Stonemasonry*
C. Age Group / Key Stage / Year / Background *Vocational training*
D. What is it about? / What's in your mind? / What's the matter? *Knowledge and understanding of producing stonemasonry components using 9" Angle Grinder.*
E. Play - Lesson Path *Produce stone project*

Figure 17 - Stonemasonry Play-Lesson Path

Mission A **Research/Standards Interpreting Information**	Quests: Learning tools/machine forms, engineering control and on site protocols						
	Time Frame 6 hours	**Participants** Students Lecturers CITB	**Location(s)** Anywhere	**Resources** Tablet/Mobile Web interface	**Evidence** Correctness of identification and selections	**Rewards**	**Beacons**

Figure 18 - Mission A (Research/standards interpreting information)

Mission B **Adopting industry relevant, safe, and healthy working practices**	Quests: Learning Stone masonry terminology, knowledge of basic waste removal techniques, knowledge of application of removal techniques into industry relevant safe and healthy working practices						
	Time Frame 6 hours	**Participants** Students Lecturers CITB	**Location(s)** Anywhere	**Resources** Tablet/Mobile Web interface	**Evidence** Correctness of identification and selections	**Rewards**	**Beacons**

Figure 19 - Mission B (Adopting industry relevant, safe, and healthy working practices)

Mission C Select/quantify resources	Quests: knowledge of selecting and understanding of stone, tool process, procedures						
	Time Frame 9 hours	**Participants** Students Lecturers CITB	**Location(s)** Anywhere Classroom Workshop	**Resources** Tablet/mobile Workstation Calculation tools Visualization tools	**Evidence** Results of calculations/ identifying and selecting (Errorless learning)	**Rewards**	**Beacons**

Figure 20 - Mission C (Select/quantify resources)

Mission D Applying tools, moving, handling, using, storing, occupational safety	Quests: Demonstrate appropriate methods work practices processes control (HSE, protocols)						
	Time Frame 19 hours	**Participants** Students Lecturers CITB	**Location(s)** Workshop	**Resources** Augmented waste removal tools and grinders Sensors Processing algorithms	**Evidence** Compliance with Standards (Errorless earning)	**Rewards**	**Beacons**

Figure 21 - Mission D (Applying tools, moving handling, using, storing, occupational safety)

The following figure (Figure 22) presents an example of how the learning objectives in Basic Algebraic Skills can me mapped against the proposed assessment framework. The specific measures and sub-measures of each learning objective in this particular scenario will be specified later based on further engagement with the teachers in Scotland, UK.

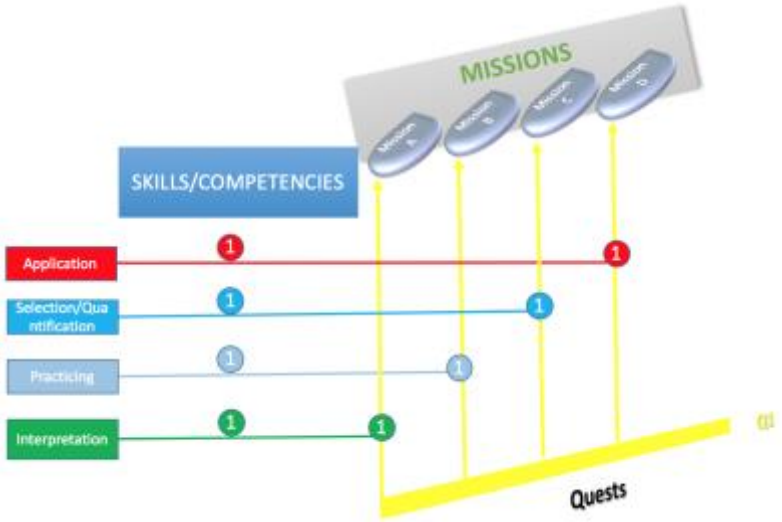

Figure 22 - Learners' progress in Stonemasonry

7 CONCLUSIONS

The main goal of this document was to support the learning design and specification of the Beaconing platform and to propose a Taxonomy used by teachers to create gamified lesson plans based on specific context and learning objectives. This document also provides various gamified learning scenarios with missions and quests based on STEM subjects and close related to the individual needs of each pilot (either small or large scale). A cross-subject and problem-based approach was followed with emphasis on contextualised learning within real world problem solving and application. In Beaconing platform, the learner is active and interacts with a variety of resources and tools in order to solve puzzles or complete challenges. The development of learning scenarios draws on game-based and playful approaches including mini games, open-ended, linear and non-linear experiences and challenges.

The deliverable 3.3 will inform the UX and gamification design in Task 3.4, the technical specification in Task 3.5 and the gamified lesson plan integration in Task 4.7. This is a live document to be updated throughout the duration of the BEACONING project to include specific elements for the play-learn scenarios (measures, technologies, mini games, etc.) based on the updated analysis from the requirements (T3.1) and inventories (T3.2), UX and gamification specification (T3.4, T4.7), technical specifications (T3.5), the evaluation results of the small scale pilots (WP5), and specifically before the large scale testing (WP6) takes place.

As further work, a spreadsheet (see Appendix 9.9) will be used to further break down the learning scenarios in order to include specific measures for missions and quests (progress assessment), required technologies, mini games and other resources. In this ongoing work all the relevant partners will take part such as pilot, technical, game and learning analytics partners. Each pilot partner will organise focused meetings with teachers to discuss the proposed scenarios and to update them according to each country's curriculum requirements and learners' needs.

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9 APPENDIX

9.1 DIGITAL LITERACY – ORT FRANCE

A. Domain / Area / Subject *Technology*
B. Topic *Digital Literacy*
C. Age Group / Key Stage / Year / Background *High school students.*
D. What is it about? / What's in your mind? / What's the matter? *In today's digital world, everyone leaves a certain amount of information about themselves on the Internet, with the data either produced by them or entered by others. All those fragments of information put together constitute a digital identity which, especially where that information is publicly available, can be used by others to discover that person's civil identity. In this sense, a digital identity is a version, or facet, of a person's social identity.* *The ramifications of the concept of digital identities, both legal and social, are a complex and challenging topic.* *Furthermore, somebody owns digital identity is persistent. It is important to know how to manage it at any point of someone's social life: at school, at work, looking for work, being retired, etc. This concept is especially important for people being vulnerable and at risk.* *This lesson plan is about learning the concept of digital identity, how to protect it but also how to improve it.*
E. Play - Lesson Path *The lesson path is made of four different steps. First the students are made aware of the concept of digital identity by looking for information about a made up person all around the Internet. Then they have a look at their own digital identity and how much of their personal information is publicly exposed. Then they will make a presentation to the whole class about their finding. Finally, they'll be taught simple guidelines on data protection and data management in order for them to be able to master and better their own digital trail.*

Figure 23 - Digital Literacy Play-Lesson Path

What curriculum skills will participants develop?	**What skills participants will develop?** *Skills/Competencies*	**What's the purpose?** *Aims/Objectives*	**How much time?** *Time*	**Who is taking part?** *Players/Participants*	**Where is the mission going to take place?** *Places of Interest*	**What is available for this mission?** *Tools/Resources*	**What evidence should participants provide?** *Evidence*	**How is achievement rewarded?** *Rewards/Incentives/Prizes*
In France, this corresponds to secondary/high school ICT knowledge.	**Communication /Expression** • Advanced literacy • Conversation • Content creation • Self expression • Creativity **STEM** • Reasoning • Inquiry • Tool Use **Social/Civic** • Respect • Integrity • Participation **Autonomy/Initiative** • Planning • Organisation • Management **"Meta"** • Learning to learn • Critical thinking • Digital literacy	**Knowledge/Understanding** • Analyse • Reflect • Solve • Document • Discuss • Evaluate • Interpret • Appreciate **Action/Activity** • Use • Share • Teach • Respond • Critique • Cooperate **Creation** • Publish • Develop • Design	• 4 to 8 Hours • 4 to 8 Weeks • 4 to 8 Sessions	• Individuals • Small groups • Big groups • Whole class • Parents	**School** • Classroom • Lab • ICT room **Home** • Home	**Beaconing** • Presentation • Online tools/Word processing • Online resources (video, newspapers) **Devices** • Mobile phones/ Laptops/ Camera/Audio Recorder **Teachers** • Face-to-face • Lab tools	• Photographs • Blog posts • Presentations • Videos	• Peer prestige • Cultural incentives

Figure 24 - Digital Literacy Taxonomy

<table>
<tr><td rowspan="5">Mission A
Understanding the concept of digital identities

The students are given the task to find out as much as they can about a certain person only known by their pseudonym on the Internet, Mister X (or Madam X). All the pseudonyms correspond to fake personas created especially for this activity.
They can work alone or in group, inside or outside the classroom, aided by someone or by themselves. They need to use all possible tools for this detective work: browser, social networks, forums, and so forth.

Background

How to use a computer browser

Skills

Gain and practice knowledge about digital related skills
Search skills
Inquiry
Reasoning
Working together</td><td colspan="7">Quest 1: Learning about digital identity. It can be done either in the classroom, or talked briefly about in the classroom and then at home or entirely at home.</td></tr>
<tr><td>Time Frame
1 to 2 hours in 1 to 2 sessions</td><td>Participants
Teacher
Classmates</td><td>Location(s)
Classroom
Home</td><td>Resources
Browser
Twitter
Social Networks
Forums</td><td>Evidence
Questionnaire about the learnt knowledge</td><td>Rewards
Knowledge Points</td><td>Beacons
The Beacons will allow to notice when the student is at home and deliver the teaching material</td></tr>
<tr><td colspan="7">Quest 2: Tracking Mr. X.</td></tr>
<tr><td>Time Frame
1 to 2 hours in 1 to 2 sessions</td><td>Participants
Teacher
Classmates
Friends
Parents</td><td>Location(s)
Lab
Mobile phone
Home</td><td>Resources
Browser
Twitter
Social Networks
Forums</td><td>Evidence
Their own identity</td><td>Rewards
Knowledge
Competition with other students/group</td><td>Beacons
The Beacons will allow access to the game at home</td></tr>
</table>

Figure 25 - Mission A (Understanding the concept of digital identities)

<table>
<tr><td rowspan="5">Mission B
Understanding the management of digital identities

The students have now to find on the Internet all the possible information about themselves, checking the electronic trail they have left since they started being present on the Internet, or even before by the data their friends or relative left. This trail can be either under their real name or a pseudonym.
They can work alone or in group, inside or outside the classroom, aided by someone or by themselves. They need to use all possible tools for this detective work: browser, social networks, forums, and so forth.

Background

How to use a computer browser

Skills

Gain and practice knowledge about digital related skills
Search skills
Inquiry
Reasoning
Working together</td><td colspan="7">Quest 1: Learning about a friend's digital identity. If the lesson is undertaken outside of the concept of a classroom, the friend can be replaced by a celebrity for example.</td></tr>
<tr><td>Time Frame
1 to 2 hours in 1 to 2 sessions</td><td>Participants
Teacher
Classmates</td><td>Location(s)
Lab
Mobile phone
Home</td><td>Resources
Browser
Twitter
Social Networks
Forums</td><td>Evidence
Everything about a friend</td><td>Rewards
Knowledge</td><td>Beacons
The Beacons will allow to notice when the student is at home and deliver the teaching material</td></tr>
<tr><td colspan="7">Quest 2: Learning about their own digital identity.</td></tr>
<tr><td>Time Frame
1 to 2 hours in 1 to 2 sessions</td><td>Participants
Teacher
Classmates
Friends
Parents</td><td>Location(s)
Lab
Mobile phone
Home</td><td>Resources
Browser
Twitter
Social Networks
Forums</td><td>Evidence
Everything about themselves</td><td>Rewards
Knowledge</td><td>Beacons
The Beacons will check where the students are and give them help about the software to use</td></tr>
</table>

Figure 26 - Mission B (Understanding the management of digital identities)

Mission C Creating a presentation The students have now to present in a clear and concise fashion all their finding about the mysterious pseudonym. They can work alone or in group, inside or outside the classroom, aided by someone or by themselves. They can use all possible tools for this detective work: text, images, presentation software, videos, and so forth. ***Background*** How to use a presentation software ***Skills*** Gain and practice knowledge about digital related skills Planning Management Creativity	Quest 1: Preparing the presentation.					
	Time Frame 1 to 2 hours in 1 to 2 sessions	**Participants** Teacher Classmates Friends Parents	**Location(s)** Lab Mobile phone Home	**Resources** Presentation software Multimedia material	**Evidence** Everything about a friend and themselves	**Rewards**	**Beacons** The Beacons will check where the students are and give them help about the software to use
	Quest 2: Presentation. If the presentation is done outside the context of a classical course or training session, the peer review should replace the teacher interactions.					
	Time Frame 1 to 2 hours in 1 to 2 sessions	**Participants** Teacher Classmates Friends	**Location(s)** Lab Mobile phone Home	**Resources** Presentation software Multimedia material	**Evidence** Everything about a friend and themselves	**Rewards** Points Peer review	**Beacons** The Beacons will check where the students are and give them help about the software to use

Figure 27 - Mission C (Creating a presentation)

Mission D How to protect personal data The students are now taught how to protect as much as possible their own personal data on the Internet by using the adequate security settings in software and learning to be aware about the amount of data unknowingly left behind while using Internet. In application of this teaching, they will need to make sure all their own personal data is protected. They can work alone or in group, inside or outside the classroom, aided by someone or by themselves. They need to use all possible tools for this work: browser, social networks, forums, and so forth. ***Background*** How to use a computer browser ***Skills*** Gain and practice knowledge about digital related skills Management Organization Working together	Quest 1: Learning about digital identity protection.					
	Time Frame 1 to 2 hours in 1 to 2 sessions	**Participants** Teacher Classmates	**Location(s)** Classroom	**Resources** Browser Twitter Social Networks Forums	**Evidence** Questionnaire	**Rewards** Knowledge Points	**Beacons** The Beacons will check where the students are and give them help about the software to use
	Quest 2: Protecting their own identity. The students will also learn how to improve the current standing of their digital identity. Could be coupled with a training session about how to write a CV for example.						
	Time Frame 1 to 2 hours in 1 to 2 sessions	**Participants** Teacher Classmates Friends Parents	**Location(s)** Lab Mobile phone Home	**Resources** Browser Twitter Social Networks Forums	**Evidence** Their own digital identity	**Rewards** Knowledge Competition with other students/group	**Beacons** The Beacons will check where the students are and give them help about the software to use

Figure 28 - Mission D (How to protect personal data)

9.2 PHYSICS – SIVECO ROMANIA

A. Domain / Area / Subject *Science.*
B. Topic *Physics*
C. Age Group / Key Stage / Year / Background *High school*
D. What is it about? / What's in your mind? / What's the matter? *This is about the effects of energy production on the environment, because of rising energy demand. Now the efforts to combat climate changes require a significant increase in low-carbon electricity generation.* *The goal of this lesson is to raise the awareness regarding the environment. It is dedicated to improve the science literacy skill.*
E. Play - Lesson Path *The lesson path has now two missions for 17-18 years old, high school students. More mission could be added later to cover a larger ground.* *Students will search on the effects of energy production, will try to assess the environmental impact and will present them. They will work in small groups (2-3), and they will develop a digital presentation of their results.* *Mission A – Studying the power plants for assessing the impact of energy production and propose solutions for increasing low-carbon electricity generation.*

Figure 29 - Physics Play-Lesson Path

<table>
<tr><td rowspan="2">Mission A (Studying the power plants)

Students will assess the impact of energy production and will design solutions for increasing low-carbon electricity generation.
They will search the effects of energy production by using some websites and interactive material on their own laptops. After that they will make a presentation on their research. They will work in small groups.

Background

They have to know how electricity and energy is produced in power plants. Students also know how to make a presentation or a short movie.

Skills
• Advanced Science and digital literacy
• Content creation
• Self expression
• Creativity
• Reasoning
• Inquiry
• Social/Civic
• Negotiation
• Assertiveness
• Respect</td><td>Quest 1

Studying the power plants for assessing the impact of energy production</td><td colspan="6">Brief overview of Quest 1 activities. At this starting level, the aim is to provide basic links between real world contexts and subject theory, while consolidating them into a shared ground.</td></tr>
<tr><td>Time Frame

2 hours in two sessions</td><td>Participants

• Individuals
• Small groups
• Big groups
• Whole class
• Parents
• Peers
• Professionals</td><td>Location(s)

School
• Classroom
• Lab
• ICT room
• Schoolyard

Home
• Friends house
• Museum Science centres</td><td>Resources

Websites
Interactive material
Web-based software
Short movies
Laptops or tablets</td><td>Evidence

Construction of the final product: movie or PowerPoint on the impact of energy production</td><td>Rewards

Points</td></tr>
<tr><td colspan="8"></td></tr>
<tr><td rowspan="2">Quest 2

Propose solutions for increasing low-carbon electricity generation.</td><td colspan="6">Brief overview of Quest 2 activities. At this level, the aim is to move outside the classroom, providing a first spatial expansion of learning activities while still keeping students in a controlled environment.</td></tr>
<tr><td>Time Frame

3 hours in 3 sessions</td><td>Participants

• Small groups
• Whole class</td><td>Location(s)

School
• Classroom
• Lab
• ICT room</td><td>Resources

Websites
Interactive material
Videos
Laptops or tablets</td><td>Evidence

The presentation of the final product: movie or PowerPoint</td><td>Rewards

Points</td></tr>
</table>

Figure 30 - Mission A (Studying the power plants)

9.3 CHEMISTRY APPLIED TO ENVIRONMENTAL HEALTH – IMA ITALY

A. Domain / Area / Subject Chemistry
B. Topic Organic and Inorganic chemistry applied to environmental health
C. Age Group / Key Stage / Year / Background 20 – 24 years old
D. What is it about? / What's in your mind? / What's the matter? Increase students' awareness about how massive chemistry adoption can affect environmental health. Learn also that not all the chemistry is bad for the environment.
E. Play - Lesson Path This lesson plan will focus on letting students understand how much chemistry there is in their life, and in the spaces that they use every day, and how every single day-by-day choice that they do about waste options, or materials choice, can affect environmental health. Overall objective of this lesson path is to provide to students a way to learn chemistry learning environment issues and ways to face them.

Figure 31 - Chemistry applied to Environmental Health Tool Play-Lesson Path

Mission A **(The environment big killers)** **Discuss about the most used materials used for packaging and their degree of recyclability.** ***Background*** **Organic and Inorganic Chemistry** ***Skills*** **- Organic Chemistry** **- Inorganic chemistry** **- Content creation** **- Self expression** **- Creativity** **- Inquiry** **- Tool Use** **- Logical/Spatial Thinking** **- Participation** **- Entrepreneurship** **- Critical thinking/appreciation** **- Learning to learn** **- Digital literacy**	**Quest 1** Analyze, online research and discuss	***Prepare a presentation to be discussed in the classroom of the most used organic materials used by industry for packaging and sort them by difficulty of recycle.***					
		Time Frame 4 hours	**Participants** 3 groups of about 8 classmates each.	**Location(s)** classroom	**Resources** online resources quiz game chemistry books	**Evidence** presentation quiz results	**Rewards** chemistry points
	Quest 2 territory research, document	***Roaming around the city where you live and photo report the adoption of the previous discussed materials and compose a "moodboard"of the worst recyclable packaging to other teams and to teachers. (To story tell the "environment monsters" moodboard students can choose a monster narrative theme, or other)***					
		Time Frame 1 week	**Participants** 3 groups of about 8 classmates each.	**Location(s)** home around the city classroom	**Resources** -smartphone -beacons -power point or physical paper board	**Evidence** - environment big killers moodboard. - Storytelling of the moodboard.	**Rewards** Environment detective badge

Figure 32 - Mission A (The environment big killers)

Mission B						
(Catch environment big killers in town and learn how to beat them) **Increase awareness about the diffusion of environment big killers and bad waste habits. Learn about new more eco-friendly materials and their distribution in the environment.** ***Background*** **Organic Chemistry** **Inorganic Chemistry** **Minor digital skills** ***Skills*** **Organic Chemistry** **- Inorganic chemistry** **- Content creation** **- Self expression** **- Creativity** **- Inquiry** **- Tool Use** **- Logical/Spatial Thinking** **- Participation** **- Entrepreneurship** **- Critical thinking/appreciation** **- Learning to learn** **- Digital literacy**	**Quest 1** territory research, document	***Roam around the city where you live and make a photo reportage (with geotag) of cases of bad recycle habits of the previous discussed materials, and prepare a "waste bad habits photo map" of your city to present to others teams and to teachers.***				
		Time Frame 2 weeks	**Participants** - 3 groups of about 8 classmates each. - teachers	**Location(s)** around the city home classroom	**Resources** smartphone beacons google maps	**Evidence** "waste bad habits photo map"	**Rewards** Environment detective badge
	Quest 2 Analyze, online research and discuss	**Teamwork research of new and more eco-friendly materials for constructions or packaging.**				
		Time Frame 4 hours	**Participants** 3 groups of about 8 classmates each.	**Location(s)** classroom	**Resources** online resources quiz game chemistry books	**Evidence** presentation quiz results	**Rewards** Chemistry points

Figure 33 - Mission B (Catch environment big killers in town and learn how to beat them)

Mission C						
(Video reportage of chemistry applied to environment) **Creation of a short and funny video reportage about chemistry applied to environment and recycle** ***Background*** **Organic Chemistry** **Inorganic Chemistry** **Minor digital skills** **Minor video editing skills** ***Skills*** **Organic Chemistry** **- Inorganic chemistry** **- Content creation** **- Self expression** **- Creativity** **- Inquiry** **- Tool Use** **- Logical/Spatial Thinking** **- Participation** **- Entrepreneurship** **- Critical thinking/appreciation** **- Learning to learn** **- Digital literacy**	**Quest 1** territory research, document	***During your spare time meet with your team mates and record with your smartphones a set of short video interviews, using the format of the "double interview" with the objective to raise awareness about the best packaging to choose when you buy something.*** ***Provide in a funny and easy to understand way a set of "do" and "don't" to your mates, teachers and parents about waste and recycle habits.***				
		Time Frame 1 month	**Participants** - 3 groups of about 8 classmates each.	**Location(s)** around the city home school	**Resources** smartphone beacons drop box (to store video files)	**Evidence** Dropbox repository with raw video interviews files. - video storyboard	**Rewards** Waste Reporter Master Badge
	Quest 2 Analyze, online research and discuss	**Editing of a final short video with all the interviews, adding slides with technical explanations of why some habits are good and some are not providing evidence of the impact to the environment.**				
		Time Frame about 4 half days slots diluted in about one month	**Participants** 3 groups of about 8 classmates each.	**Location(s)** -classroom -information technology school lab	**Resources** - online resources - basic video editing SW	**Evidence** presentation of the video	**Rewards** Eco Evangelist Badge

Figure 34 - Mission C (Video reportage of chemistry applied to environment)

9.4 ORGANISING AND DISTRIBUTING DATA – SEBIT TURKEY

A. Domain / Area / Subject Mathematics / Statistics / Engineering / Science 7th to 9th Grade
B. Topic Organizing data and distribution of data (averages and data graphs) to discover central tendencies and the overall nature of a process or a variable that the data is obtained from.
C. Age Group / Key Stage / Year / Background 14 - 18 years old
D. What is it about? / What's in your mind? / What's the matter? An average is a number that expresses the central tendency of a data set which is obtained from a process or a particular variable. Therefore, averages are often used when people need to understand the groups of data values. Whenever groups of measurements are collected in biology, physics, engineering, astronomy or any other science, averages are calculated. Averages also appear in grading, sports, business, politics, insurance, and other aspects of daily life. In statistics average occurrence of a case is called the base rate and it forms the basis of all the assumptions made about that case. Data graphs are used to present numerical data in different ways so that the averages can be observed.
E. Play - Lesson Path This lesson plan will focus on letting students understand the nature of a process or a variable by comparing the central tendencies in terms of mean, mode and median. In order to do so, they will get, classify and present data using tables and graphs, and then calculate the mean, mode and median. The game challenge is to discover processes or variables whose mean, mode and median is very different than each other. To get the sources with particularly large differences they will have to learn how these three central tendency measures reflect the nature of a source data set.

Figure 35 - Organising and Distributing Data Play-Lesson Path

What skills participants will develop?	**What's the purpose?**	**How much time?**	**Who is taking part?**	**Where is the mission going to take place?**	**What is available for this mission?**	**What evidence should participants provide?**	**How is achievement rewarded?**
- *Collecting, classifying and presenting a data set.* - *Calculating central tendencies of a source from its data set* - *Relating the differences among averages to the nature of a process or variable* - *Understanding how we build our assumptions about a occurrences using their base rates*	*To develop both behavioral and cognitive high level competencies in working with data*	*6 weeks*	*Whole 9th grade classes in small groups*	*School, Home and Out & About*	*Statistical Tools, Probes, Recorders, Beacons, presentation tools, charts, spreadsheets,*	*Charts, Presentations*	*Trophies, Points, Customization options*

Figure 36 - Organising and Distributing Data Taxonomy

Mission A						
(Tendency of Data and Presenting Data) **Discuss about the most used averages and graphs.** ***Background*** **Statistics & Mathematics** ***Skills*** - Content creation - Self-expression - Creativity - Inquiry - Tool Use - Logical/Spatial Thinking - Participation - Entrepreneurship - Critical thinking/appreciation - Learning to learn - Digital literacy **Variety** **Use online material vs books** **Use drawings vs graph tools** **Use graph paper vs spreadsheets** **Use face2face discussions vs online forum**	**Quest 1** Study online content (e.g. SEBIT Vitamin), do online research and discuss	**Prepare a presentation to be discussed in classroom of the most used averages that expresses the central tendency of a group of numbers (mean, mode, median).**					
		Time Frame 2 hours	**Participants** groups of about 5 classmates	**Location(s)** classroom	**Resources** - online resources - statistics and mathematics books	**Evidence** - presentation - spreadsheets	**Rewards** math points
	Quest 2 online research for graphs to represent data, determine averages and discuss	**Prepare another presentation of the most used graphs to present data and depict central tendency of a data set (mean, mode, median) on the graph**					
		Time Frame 2 hours	**Participants** groups of about 5 classmates	**Location(s)** classroom	**Resources** - online resources - statistics and mathematics books	**Evidence** - presentation - spreadsheets	**Rewards** math points math badge math trophy (best presentation)

Figure 37 - Mission A (Tendency of data and presenting data)

Mission B						
(Obtain data from various sources to record the largest discrepancy between central tendencies) **Small groups trying to get the largest discrepancy between mean, mode and median of data sets that they record** ***Background*** **Engineering & Mathematics** ***Skills*** - Content creation - Self-expression - Creativity - Inquiry - Tool Use - Logical/Spatial Thinking - Participation - Entrepreneurship - Critical thinking/appreciation - Learning to learn - Digital literacy **Variety** **Use physical vs online tools** **Company vs School as context** **Recording medium**	**Quest 1** territory research, document	**Go to a company in your city (or school) and choose departments of this company (e.g. "human resources" or "production" departments). Choose a process or a variable (e.g. ages of employees, number of mails sent, etc.)**					
		Time Frame 1 week	**Participants** groups of about 5 classmates	**Location(s)** - at a company - school	**Resources** - smartphone - beacons - pen & paper - mobile PC	**Evidence** - photo - presentation	**Rewards** math points
	Quest 2 Analyze, cooperate, document	**Draw data on graph and find the mean, mode and median of the numbers. Calculate the discrepancies (mode-mean, median-mean, mode-median). Reflect on the nature of data in relation to the averages obtained. Try scoring the largest differences by choosing proper data source. Replay Quest 1 to find sources with larger differences**					
		Time Frame 2 hours	**Participants** groups of about 5 classmates	**Location(s)** - home - school - classroom	**Resources** - calculators - spreadsheets - pen & paper	**Evidence** - screen capture - tables	**Rewards** Math Badge, High Score Table – Peer Prestige

Figure 38 - Mission B (Obtain data from various sources to record the largest discrepancy between central tendencies)

Mission C (Relate source and tendency. Distinguish ideas, Reflection, Knowledge Integration) *Background* Statistics & Engineering *Skills* • Content creation • Self expression • Inquiry • Tool Use • Logical Thinking • Participation • Critical thinking/appreciation • Learning to learn • Digital literacy Variety Digital Resources vs textbooks Guided discovery vs liberal learning	Quest 1 online study, liberal learning, trial and error learning (inductive reasoning), document	Research types of histogram distributions (or probability distributions), identify the distributions of sources from Mission B. Observe their mode, mean, median differences. Reconcile with naïve ideas on these sources.					
		Time Frame 3 hrs	**Participants** groups of about 5 classmates	**Location(s)** - home - classroom	**Resources** - Online course material - spreadsheet	**Evidence** - spreadsheets - formulas - presentations	**Rewards** math points
	Quest 2 Analyze, debate, mental calculation	Source guessing show down. Groups of students presenting each other a source distribution with mode, mean, median values marked. Then post a natural language description of 3 sources one of which is the source the distribution belongs. The other group tries to guess correctly which.					
		Time Frame 1 hour	**Participants** groups of about 5 classmates	**Location(s)** - classroom	**Resources** - online resources - statistics and mathematics books - face-to-face	**Evidence** - spreadsheets - formulas - presentations	**Rewards** Correct guess high Score Table, Math Badge

Figure 39 - Mission C (Relate source and tendency)

Mission D (Base Rate Fallacy) A challenge among groups to trick the others into Base Rate Fallacy. To avoid the fallacy the responses should consider the nature of the source based on its averages and make mental calculations accordingly. *Background* Science & Engineering *Skills* • Content creation • Self expression • Creativity • Inquiry • Tool Use • Logical/Spatial Thinking • Participation • Entrepreneurship • Critical thinking/appreciation • Learning to learn • Digital literacy Variety in presenting the problem with schemas, text or drawings	Quest 1 territory research, discuss, calculate, document	If presented with related base rate (i.e. generic, general information like tendency to occur) and specific information (information only pertaining to a certain case like an imperfect detector outcome), the mind tends to ignore the former and focus on the latter. This is called Base Rate Fallacy (see Wikipedia for good examples). Try finding good examples to trick the mind of competing groups into this fallacy.					
		Time Frame 2 wks	**Participants** - groups classmates, about 5 pupils each.	**Location(s)** around the city home school	**Resources** smartphone beacons research notebook (online or paper)	**Evidence** Notes, interviews files. - video storyboard	**Rewards** math points
	Quest 2 Analyze, debate, mental calculation	Fallacy show down. Post 2 questions to the other group to guesstimate the probability of an occurrence with known base rate when given an imperfect detector outcome. The group that avoids the fallacy and guesstimates most correctly wins.					
		Time Frame 3 hours	**Participants** groups of about 5 classmates	**Location(s)** - classroom	**Resources** - online resources - statistics and mathematics books - face-to-face	**Evidence** - spreadsheets - formulas - presentations	**Rewards** Math Badge, High Score Table – Peer Prestige

Figure 40 - Mission D (Base rate fallacy)

9.5 ENERGY MANAGEMENT – COVUNI UK

A. Domain / Area / Subject *Physics (with links to Engineering).*
B. Topic *Energy Management.*
C. Age Group / Key Stage / Year *16 years old.*
D. What is it about? / What's in your mind? / What's the matter? Identify the different types of energy in the environment and better understand energy.
E. Play - Lesson Path Students learn that energy use impacts the environment. They discuss the different types of renewable and non-renewable energy sources and understand how energy is transformed from one type to another. *Missions included:* ***A. What is Energy*** ***B1/B2. Energy Conservation/The Energy of Light*** ***C. Get Charged*** ***D. The Energy of Music***

Figure 41 - Energy Management Play-Lesson Path

Mission A **(What is Energy)** Discuss specific types of energy and practical sources of energy. ***Background:*** • Thermal energy (or heat) keeps us warm and drives engines. • Chemical energy fuels automobiles and airplanes. • Electrical energy drives many small machines and keeps lights glowing. • Every form of energy can be converted into other forms. ***Skills:*** • Reasoning • Learning to learn • Content creation • Creativity	**Quest 1** Analyse Document Discuss	***Prepare short demos or presentations around the topic "What is energy".***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		1 session	Small teams of 3 students	Classroom	Word processing/Presentation	Demos/Presentations	"Energy" Badge
	Quest 2 Analyse Critique Cooperate	***Become energy detectives.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		2 sessions	Small teams of 3 students	Classroom and school	Mobile phones, Online resources	Photographs, completion of "Energy Quiz"	Points

Figure 42 - Mission A (What is energy)

Mission B1 (Energy Conservation) Discuss the different types of renewable and non-renewable energy sources and understand how energy is transformed from one type to another. *Background:* • New technologies that are energy efficient and alternative sources of energy. • Energy conservation does not mean "save" energy, since energy cannot be created or destroyed. • Conservation of energy means how efficiently we use energy. *Skills:* • Reasoning • Learning to learn • Content creation • Creativity						
	Quest 1 Analyse Critique Cooperate	*Become energy conservation engineers (identify the ways energy is conserved or wasted in your everyday lives).*				
		Time Frame 3 days	**Participants** Small teams of 3 students	**Location(s)** School and houses	**Resources** Online resources, databases	**Evidence** Spreadsheets, meeting notes	**Rewards** Badge of "Conservation Engineer"
	Quest 2 Analyse Document Discuss	*Alternative energy technologies.*				
		Time Frame 3 days	**Participants** Small teams of 3 students	**Location(s)** School and houses	**Resources** Online resources, databases, smartphones	**Evidence** Poster, Presentation	**Rewards** Points

Figure 43 - Mission B1 (Energy Conservation)

Mission B2 (The Energy of Light) Learn about reflection and refraction, and see how prisms, magnifying glasses and polarized lenses work. *Background/Skills* • Light is a type of energy formed by a combination of electrical and magnetic rays, known as electromagnetic (EM) waves. • Visible light is only one type of EM waves. *Skills:* • Reasoning • Learning to learn • Design thinking • Creativity						
	Quest 1 Analyse Critique Cooperate	*Examine light energy behavior: refraction, magnification, prisms and polarization.*				
		Time Frame 2 days	**Participants** Small teams of 2 students	**Location(s)** Schoolyard, park, field	**Resources** Beacons, smartphones	**Evidence** Notes, Presentations	**Rewards** Points
	Quest 2 Design Develop Prototype Cooperate	*Design and develop a radio transmitter.*				
		Time Frame 1 week	**Participants** Small teams of 3 students	**Location(s)** Lab	**Resources** Online resources, models	**Evidence** Notes, demonstration	**Rewards** Points

Figure 44 - Mission B2 (The energy of light)

Mission C

(Get Charged)

Learn about charge, voltage, current and resistance, and discover that electrical energy is the form of energy that powers most of the household appliances.

Background/Skills

- **In direct current (DC) all electrons move in the same direction while the electricity flows.**
- **In alternating current (AC) the direction of the electron movement changes many times each second.**

Skills:

- Learning to learn
- Design thinking
- Creativity

Quest 1

Design
Develop
Prototype
Cooperate

Design an electrical circuit using a battery and a light bulb.

Time Frame	Participants	Location(s)	Resources	Evidence	Rewards
1 session	Individuals	Home	Online tools	Visual (electrical circuit)	Free entry to Science Museum

Quest 2

Analyse
Critique
Cooperate

Use potatoes to power a LED clock.

Time Frame	Participants	Location(s)	Resources	Evidence	Rewards
2 sessions	Teams of 5 students	Lab	Online tools	Visual	Points

Figure 45 - Mission C (Get charged)

Mission D

(The Energy of Music)

Introduction to sound energy concepts and how engineers use sound energy. Learn to describe sound in terms of its pitch, volume and frequency.

Background/Skills

- **Every sound, whether it is from a rubber band twanging or a loud speaker cone, is created by vibration.**

Skills:

- Learning to learn
- Design thinking
- Creativity

Quest 1

Analyse
Critique
Cooperate

Explore how sound waves move through solids, liquids, and gases.

Time Frame	Participants	Location(s)	Resources	Evidence	Rewards
1 week	Entire class	Lab	Lab resources	Notes, spreadsheets	Points

Quest 2

Analyse
Critique
Cooperate
Develop

Examine how sound exists by listening and seeing sound waves.

Time Frame	Participants	Location(s)	Resources	Evidence	Rewards
1 week	Individuals	House	Beaconing platform, Databases	Notes, Presentations	Points

Figure 46 - Mission D (The energy of music)

9.6 GRAPH THEORY AND TESSELLATION – COVUNI UK

A. Domain / Area / Subject *Mathematics (with links to Science and Engineering)*
B. Topic *Graph Theory & Tesselation. Contextually ties into earth sciences and urban/civic engineering*
C. Age Group / Key Stage / Year *18 years old*
D. What is it about? / What's in your mind? / What's the matter? *Understanding Urban Spaces and Networks*
E. Play - Lesson Path *This play lesson path prompts students to progressively recognise the relevance of geometry in the structure of everyday life, with a focus on the connection and shaping of discrete areas. Starting from everyday objects, the students will progressively widen the range of their activities, obtaining a goof grasp of the structure of the surrounding territory from a geometrical standpoint.* *Missions included:* ***A. Geometry Scavenger Hunt*** ***B1/B2. CityShapes/Wildflows*** ***C. Land Graffiti*** ***D. Crowd Mapping***

Figure 47 - Graph Theory and Tessellation Play-Lesson Path

Mission A **Geometry Scavenger Hunt** **Background:** **This starting quest will help students apply Basic Geometry in real context and exercise their pattern recognition skills** **Skills:** **B. Reasoning** **C. Tool Use** **Logical/Spatial Thinking**	**Quest 1** Analyze Document	***Students are tasked with "ticking off" geometric shapes from a list they are given, documenting their presence in natural or architectural objects.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		1 session	Individuals	School/University and surroundings	Beaconing Platform Mobile Phone	Photographs.	Points
	Quest 2 Analyze Cooperate Document	***Brief overview of Quest 2 activities. At this level, the aim is to move outside the classroom, providing a first spatial expansion of learning activities while still keeping students in a controlled environment.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		Specify the time frame for this quest.	Small teams (3-4)	School/University and surroundings	Beaconing Platform Mobile Phone	Photographs Graphs	Cultural Incentive (art exhibition or art books)

Figure 48 - Mission B1 (Geometry scavenger hunt)

Mission B1 CityShapes Background Starting from simple measurement skills, students will engage with the basics of graph theory and tesselation. Skills: D. Reasoning E. Tool Use F. Logical/Spatial Thinking G. Digital Literacy							
	Quest 1	*Students are tasked to measure distances within inner city landmarks (squares, monuments) along the most direct connection, creating proximity graphs.*					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		1 day	Small Teams (3-4) Parents	City Centre	Beaconing Platform Mobile Phone	Photographs Graphs Blog posts	Points
	Quest 2	*Students are tasked to determine circular areas that contain 3 and only 3 of the above mentioned landmarks, and geotag themselves at their center.*					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		1 day	Small Teams (3-4) Parents	City Centre	Beaconing Platform Mobile Phone	Photographs Graphs Blog posts	Vouchers (public transportation for interesting location within or near the city)

Figure 49 - Mission B1 (CityShapes)

Mission B2 WildFlows Background: Starting from simple measurement skills, students will engage with the basics of graph theory and tesselation. Skills: H. Reasoning I. Tool Use J. Logical/Spatial Thinking K. Digital Literacy							
	Quest 1 Document Cooperate Analyze	*Students are tasked to measure distances between outdoor landmarks (rivers, lakes, hilltops) along the most direct connection, creating proximity graphs.*					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		2-3 days	Small teams (3-4) Parents	"Green Belt" area or equivalent	Beaconing Platform Mobile Phone	Photographs Graphs Blog posts	Points
	Quest 2 Document Cooperate Analyze	*Students are tasked to determine circular areas that contain 3 and only 3 of the above mentioned landmarks, and geotag themselves at their center.*					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		2-3 days	Small teams (3-4) Parents	"Green Belt" area or equivalent	Beaconing Platform Mobile Phone	Photographs Graphs Blog posts	Vouchers (public transportation for interesting location within or near the city)

Figure 50 - Mission B2 (Wildflows)

Mission C **Land Graffiti** **Background** **Building on the basics of graph theory and tesselation learned in the preceding quests, students will use their navigation and abstraction skills to apply them to real world contexts.** **Skills:** **L. Reasoning** **M. Tool Use** **N. Logical/Spatial Thinking** **O. Digital Literacy** **P. Planning**	**Quest 1** Analyze Cooperate Reflect Document Publish	***Using the previously created graphs, students are tasked to "conquer" triangular sections of the area using only above touched landmarks as vertices to geotag, and uploading edited map pictures.***				
		Time Frame 1 week	**Participants** Large Teams (6-8) Teachers	**Location(s)** City and Surroundings	**Resources** Beaconing Platform Editing software Mobile Phone	**Evidence** Photographs Maps Blog posts	**Rewards** Points
	Quest 2 Analyze Cooperate Reflect Document Publish	***Students teams challenge each other with "Bridge of Konigsberg" problems using the above created graphs, then try to demonstrate solving and/or unsolvability through geotagging.***				
		Time Frame 1 week	**Participants** Large Teams (6-8) Teachers	**Location(s)** City and Surroundings	**Resources** Beaconing Platform Mobile Phone	**Evidence** Photographs Maps Blog posts	**Rewards** Cultural Incentive (Urban History Museum or equivalent)

Figure 51 - Mission C (Land Graffiti)

Mission D **Crowd Mapping** **Background** **Building on their experience with graph theory, tesselation and geotagging, students will apply the skills and knowledge obtain to real world contexts and issues (urban planning, transportation)** **Skills:** **Q. Reasoning** **R. Inquiry** **S. Tool Use** **T. Logical/Spatial Thinking** **U. Initiative** **V. Planning** **W. Content Creation** **X. Design Thinking**	**Quest 1** Analyze Cooperate Reflect Document Publish	***Teams are randomly assigned 4-5 relevant landmarks of a set of 10-12. Geotagging themselves (and providing coordinates) at all the margins of a Voronoi Diagram for a landmark and providing a fitting description for the area "conquers" it. First to conquer 3 wins.***					
		Time Frame 1 week	**Participants** Large Teams (6-8) Teachers Professionals	**Location(s)** City and Surroundings	**Resources** Beaconing Platform Mobile Phone (with GPS)	**Evidence** Photos Maps Geolocation Data	**Rewards** Points
	Quest 2 Cooperate Use Share Evaluate Prototype	***Based and building on all the preceding data and practices (measurements, graphs, land subdivision) have the student develop optimal transportation routes/wilderness paths between landmarks and populated areas.***					
		Time Frame 1 week	**Participants** Whole Class Teachers Professionals	**Location(s)** City and Surroundings	**Resources** Beaconing Platform Mobile Phone	**Evidence** (Photos Maps Geolocation Data Filmed presentation	**Rewards** Cultural Incentive (meet with city council urban planner or equivalent)

Figure 52 - Mission D (Crowd mapping)

9.7 BASIC GEOMETRY SKILLS – SIVECO ROMANIA

A. Domain / Area / Subject

Mathematics

B. Topic

Basic geometry skills and principles of their application and solving in practical situations

C. Age Group / Key Stage / Year / Background

Middle school hearing impaired students in a difficult situation math wise.

D. What is it about? / What's in your mind? / What's the matter?

The physical and mental characteristics of the hearing impaired student differ to a great extent from a hearing student both in the remarkable directed self language and at the level of thoughts, representations, analysis and synthesis, memory, imagination, abstraction or generalization.

Some geometry basic learned notions are still not fully mastered by some students by the time they arrive the 8th grade. This situation will lead those students to be unable to follow properly the math curricula, especially in geometry; they are not able to build on this pre-existing knowledge. An overview picture of the current situation in math literacy at secondary school level is provided by the PISA international surveys.

This activity will address the problem by providing activities designed to work on essential geometry notions needed throughout the high school curricula, to grow interest and motivation for studying geometry, to develop logical reasoning and the capacity of read lips.

E. Play - Lesson Path

The lesson path is divided in different missions trying to address the lack in some geometry basic notions observed in secondary school. More mission could be added later to cover a larger ground.

Figure 53 - Basic Geometry Skills Play-Lesson Path

The lesson starts by showing to students some geometrical figures followed by requiring them to draw curved, broken, closed or open lines, a circle, a circle diameter, radius, an arc, a circle sector, to write the formulas for calculating the length of the circle, the arc length, circular disk area sector and it continues with direct applications through problems.

Then, students are asked to make a cone out of the circular sector of the geometric bodies studied the cone resembles. Students are shown a rectangular triangle rotated around a catheter; an isosceles triangle rotated around the median corresponding base. They are required to discover and name square forms and to compare their sides and angles, to draw a dark-broken line of 3 segments, to fold some cutouts (rectangles, squares, parallelograms, triangles, trapezes, circles, pentagons and hexagons) for which to identify sides and tops. They are asked to draw a closed curved line by using a compass (to measure the distance from the sting at the curved line), or a rotational geometrical body (a cone, a cylinder) and identify the elements generators, radius, surface side, base, or peak. The lesson path goes on by requiring students to color the interiors and exteriors of geometric figures, to draw geometric shapes inside other geometric figures / bodies.

The last part of the lesson consists of finding out the side of the cone area after its unfolding, using the formulas for calculating the total area or the volume of the geometrical bodies. The lesson path closes when applications for practical situations are proposed and students are asked to find a relationship between generators, radius and height (in cone or cylinder for example) and to draw on their computers geometrical figures / bodies (rectangular prism, square pyramid, triangular pyramid, hexagonal pyramid) by using graphic editors and also find the relationship between their own parts by applying the specific formulas.

Figure 54 - Basic Geometry Skills Play-Lesson Path (cont'd)

Mission A. Geometric figures and bodies studied							
The lesson starts with remembering the studied figures and bodies, by showing to students some geometric figures or bodies followed by requiring them to draw: curved, broken, closed or open lines, geometric figures (a circle, a circle diameter, radius, an arc, a circle sector, a rectangle, a square, a parallelogram, a triangle, a trapeze, a pentagon and a hexagon) and geometric bodies (a rectangular priam, a square pyramid, a triangular pyramid, a hexagonal pyramid, a cone, a cylinder). In this way, students are reinforced geometric figures and reminded these are bounded by closed curves. They are addressed questions in order to make similarities with different rectangular / circle objects (metal, door, bank, frames, tiles, some glass panes) *Background* Secondary school math level *Skills* A refresher on basic geometry skills	**Quest 1** A refresher course assorted with exercises about the studied geometric figures and bodies	***Brief overview of Quest 1 activities. At this starting level, the aim is to provide basic links between real world contexts and subject theory, while consolidating them into a shared ground.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		1 hour in 1 session.	The teacher Their classmates	Classrooms ICT Lab	Books Geometry kits Flipcharts Websites Interactive material (drawings, models) Worksheets with formulas Papers, crayons, glue, scissors	Questionnaires. Exercises Assessment Tests	Points Awards
	Quest 2 Exercises to practice and reinforce as an automatism the refreshed knowledge	***Brief overview of Quest 2 activities. At this level, the aim is to move outside the classroom, providing a first spatial expansion of learning activities while still keeping students in a controlled environment.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		2 hours in 2 sessions.	The teacher Small groups Big groups Whole class Classmates	Classrooms ICT Lab Home	Applet Web-based software Serious game Paper & pen	Answers to an Assessment test	Points

Figure 55 - Mission A (Geometric figures and bodies studied)

Mission B. Representation of geometric shapes							
Students are asked to make a cone out of the circular sector of the geometric bodies studied the cone resembles. Students are shown a rectangular triangle rotated around a catheter; an isosceles triangle rotated around the median corresponding base. They are required to discover and name square forms and to compare their sides and angles, to draw a dark-broken line of 3 segments, to fold some cutouts (rectangles, squares, parallelograms, triangles, trapezes, circles, pentagons and hexagons) for which to identify sides and tops. They are asked to draw a closed curved line by using a compass (to measure the distance from the sting at the curved line), or a rotational geometrical body (a cone, a cylinder) and identify the elements generators, radius, surface side, base, or peak. The lesson path goes on by requiring students to color the interiors and exteriors of geometric figures, to draw geometric shapes inside other geometric figures / bodies. *Background* Secondary school math level *Skills* A refresher on basic geometry skills	**Quest 1** A refresher course assorted with exercises about representations of geometric shapes	***Brief overview of Quest 1 activities. At this starting level, the aim is to provide basic links between real world contexts and subject theory, while consolidating them into a shared ground.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		1 hour in 1 session.	The teacher Their classmates	Classrooms ICT Lab	Books Websites Interactive material Books Geometry kits Flipcharts Websites Interactive material (drawings, models) Worksheets with formulas	Questionnaires. Exercises	Points Awards
	Quest 2 Exercises to practice and reinforce as an automatism the refreshed knowledge	***Brief overview of Quest 2 activities. At this level, the aim is to move outside the classroom, providing a first spatial expansion of learning activities while still keeping students in a controlled environment.***					
		Time Frame	**Participants**	**Location(s)**	**Resources**	**Evidence**	**Rewards**
		2 hours in 2 sessions.	The teacher Their parents Their classmates Their friends	Classrooms ICT Lab Home	Applet Web-based software Serious game Paper & pen	Answers to a test	Points

Figure 56 - Mission B (Representation of geometric shapes)

Mission C. Proper use of calculation formulas							
The last part of the lesson consists of finding out the side of the cone area after its unfolding, using the formules for calculating the total area or the volume of the geometrical bodies (the length of the circle, the arc length, circular disk area sector). The lesson path closes when applications for practical situations are proposed and students are asked to find a relationship between generators, radius and height (in cone or cylinder for example) and to draw on their computers geometrical figures / bodies (rectangular prism, square pyramid, triangular pyramid, hexagonal pyramid) by using graphic editors and also find the relationship between their own parts by applying the specific formulas. The problems could be solved by hand, presented as a text or as a table to fill or as a figure to draw. ICT can help the hearing impaired students by showing the immediate result of the data entered by the students in the problem's framework. *Background* Secondary school math level *Skills* A refresher on basic arithmetic	**Quest 1** A refresher course assorted with exercises about representations of geometric shapes	***Brief overview of Quest 1 activities. At this starting level, the aim is to provide basic links between real world contexts and subject theory, while consolidating them into a shared ground.***					
		Time Frame 1 hour in 1 session.	**Participants** The teacher Their classmates Small groups Big groups Whole class	**Location(s)** Classrooms ICT Lab	**Resources** Books Websites Interactive material Books Geometry kits Worksheets with formulas	**Evidence** Questionnaires. Exercises	**Rewards** Points Awards
	Quest 2 Exercises to practice and reinforce as an automatism the refreshed basic geometry knowledge	***Brief overview of Quest 2 activities. At this level, the aim is to move outside the classroom, providing a first spatial expansion of learning activities while still keeping students in a controlled environment.***					
		Time Frame 2 hours in 2 sessions.	**Participants** The teacher Their parents Their classmates Their friends	**Location(s)** Classrooms ICT Lab Home	**Resources** Applet Web-based software Serious game Paper & pen	**Evidence** Answers to an assessment test	**Rewards** Points

Figure 57 - Mission C (Proper use of calculation formulas)

9.8 WATER MANAGEMENT – COVUNI UK

A. Domain / Area / Subject *Science/Engineering*
B. Topic *Water Management*
C. Age Group / Key Stage / Year / Background *High school students.*
D. What is it about? / What's in your mind? / What's the matter? *Given the challenges brought on by climate change and the risk of future usable water scarcity, there is a need for a deeper understanding of the ecological dynamics of the water cycle, and for the scientific and engineering challenges that making good use of this fundamental resource entail.*
E. Play - Lesson Path *The lesson path is made of four different steps. First the students are made aware of the concept of water cycle, and try their hand at a simple system-based mini-game. Then they have a look at their water usage practices and consumption, both at school and at home. Then they will explore their towns and focus on the wider infrastructure of water management. Finally, they'll contextualize the local water ecology in regard to close water bodies, and the impact of human activities.*

Figure 58 - Water Management Play-Lesson Path

What curriculum skills will participants develop?	**What skills participants will develop?** *Skills/Competencies*	**What's the purpose?** *Aims/Objectives*	**How much time?** *Time*	**Who is taking part?** *Players/Participants*	**Where is the mission going to take place?** *Places of Interest*	**What is available for this mission?** *Tools/Resources*	**What evidence should participants provide?** *Evidence*	**How is achievement rewarded?** *Rewards/Incentives/Prizes*
Secondary/ high school science classes.	**Communication /Expression** • Advanced literacy • Conversation • Content creation • Self expression • Creativity **STEM** • Reasoning • Inquiry • Tool Use **Social/Civic** • Respect • Integrity • Participation **Autonomy/Initiative** • Planning • Organisation • Management **"Meta"** • Learning to learn • Critical thinking • Digital literacy	**Knowledge/Understanding** • Analyse • Reflect • Solve • Document • Discuss • Evaluate • Interpret • Appreciate **Action/Activity** • Use • Share • Teach • Respond • Critique • Cooperate **Creation** • Publish • Develop • Design	• 8 weeks	• Individuals • Small groups • Big groups • Whole class • Parents • Friends • Professionals	**School** • Classroom • School grounds **Home** • Home **Other** • Town centre • Neighboring areas	**Beaconing** • Presentation • Online tools/Word processing • Online resources (video, newspapers) **Devices** • Mobile phones/ Laptops/ Camera/Audio Recorder **Teachers** • Face-to-face • Lab tools	• Photographs • Blog posts • Presentations • Videos	• Peer prestige • Cultural incentives

Figure 59 - Water Management Taxonomy

Mission A **The Water Cycle in Theory** **The students are given the task to play a puzzle based simulation of the water cycle, so as to obtain basic theoretical insights on water ecology. In the second part of the Mission, students are then tasked with completing a water management engineering puzzles, as to obtain basic technical insights** ***Background*** **Common knowledge about water systems** ***Skills*** **Gain and practice knowledge about water systems** **Search skills** **Inquiry** **Teamwork**	Quest 1: Water Cycle Mini-game						
	Time Frame 1 hour	**Participants** Individual Students	**Location(s)** Classroom	**Resources** Beaconing Platform mini game	**Evidence** Puzzle Mini game Completed	**Rewards** Knowledge Points	**Beacons** The Beacons will make the mini-game accessible and collate evidence
	Quest 2: Water Engineering Mini-game						
	Time Frame 1 hour	**Participants** Teacher Classmates	**Location(s)** Classroom	**Resources** Beaconing Platform mini game	**Evidence** Puzzle Mini game Completed	**Rewards** Knowledge Points Collectables	**Beacons** The Beacons will make the mini-game accessible and collate evidence

Figure 60 - Mission A (The water cycle in theory)

Mission B **Water Management at Home and School** The students have now to monitor water usage at school, both in quantitative terms and providing documentation about practices and issues. In the second part of the mission, monitoring will extend to their homes and close neighborhoods They need to use all possible tools for this research work, and provide digital evidence for their surveying. ***Background*** Consolidated knowledge about water systems ***Skills*** Gain and practice knowledge about water management Search skills Inquiry Teamwork	Quest 1: Monitoring water usage at school						
	Time Frame 2 hours in 1 to 2 sessions	**Participants** Teacher Classmates	**Location(s)** School grounds	**Resources** Browser Social Networks Forums	**Evidence** Everything about water usage at school (bills, photos, videos, interviews)	**Rewards** Knowledge Points	**Beacons** The Beacons will allow and centralize data collation on the platform
	Quest 2: Monitoring water usage at home						
	Time Frame Homework – 1week time	**Participants** Classmates Friends Parents	**Location(s)** Home Neighborhood	**Resources** Browser Social Networks Forums	**Evidence** Everything about water usage at home and in the neighborhood (bills, photos, videos, interviews, geotags)	**Rewards** Knowledge Points Collectables	**Beacons** The Beacons will allow and centralize data collation on the platform

Figure 61 - Mission B (Water management at home and school)

Mission C **Water Management in my Town** The students have now to widen their inquiry, and look for how water is managed in the city where they live. In the first part of the Mission they will document the general infrastructure (e.g. waterways, aqueducts, sewage systems) In the second part of the Mission they will be looking specifically for problematic issues (e.g. water loss, environmental impact), grounded both in their exploration of their neighborhood and in contact with professionals. ***Background*** Consolidated knowledge about water systems ***Skills*** Gain and practice knowledge about water systems Planning Management Critical thinking Teamwork	Quest 1: Exploring and documenting the city water infrastructure						
	Time Frame Homework – 1week time	**Participants** Teacher Classmates Friends Parents	**Location(s)** Home Town	**Resources** Browser Social Networks Forums	**Evidence** Everything about the town's water system general functioning (photos, videos, interviews, geotags)	**Rewards** Knowledge Points	**Beacons** The Beacons will allow and centralize data collation on the platform
	Quest 2: Seeking out and documenting malfunctions/environmental issues						
	Time Frame Homework – 1week time	**Participants** Teacher Classmates Friends Professionals	**Location(s)** Home Town	**Resources** Browser Social Networks Forums	**Evidence** Everything about problematic issues with the town water system (photos, videos, interviews, geotags)	**Rewards** Knowledge Points Collectables	**Beacons** The Beacons will allow and centralize data collation on the platform

Figure 62 - Mission C (Water management in my town)

Mission D **The Water Cycle Out There** The students are now ready to create a full picture of the local water system The first Quest in this mission is to document the links between the city water system and the wider water ecology (e.g. rivers, lakes, sea) and its impact and relationship with them. The final Quest of this path consists in framing all the evidence that has been collated throughout the activities in a way that can be deemed useful for the general public and for policymakers, and to publish/present it. ***Background*** Consolidated knowledge about water systems Presentation skills ***Skills*** Gain and practice knowledge about digital related skills Gain and practice knowledge about water systems Management Organization Participation Creativity Critical Thinking Teamwork	Quest 1: Exploring and documenting the local water ecology						
	Time Frame Homework – 2weeks time	**Participants** Teacher Classmates Friends Professionals	**Location(s)** Town Surroundings	**Resources** Browser Social Networks Forums	**Evidence** Everything about the town water system and its links with natural surroundings (photos, videos, interviews, geotags)	**Rewards** Knowledge Points	**Beacons** The Beacons will allow and centralize data collation on the platform
	Quest 2: Bringing						
	Time Frame Homework – 2weeks time 4 hours in 1 to 2 sessions	**Participants** Teacher Classmates Friends Professionals Members of the City council	**Location(s)** Lab Home School Town	**Resources** Browser Social Networks Forums	**Evidence** The presentation of all the data collected	**Rewards** Knowledge Points Collectables Cultural reward	**Beacons** The Beacons will allow and centralize data collation on the platform

Figure 63 - Mission D (The water cycle out there)

9.9 SPREADSHEET – BREAKING DOWN LEARNING SCENARIOS

Partner	Scenario	Missions	Quest	Mini game Type	Mini Game
ORT	Math - Algebra	Basic Operations	A refresh course assorted with exercices about the 4 operation		
			Exercices to practice and reinforce as an automatism the refreshed knowledge	Quiz mini game	Puzzle Game/Reflex Game
		Proportionality and cross-multiplication	A refresher course assorted with exercices about proportionality		
			Exercices to practice and reinforce as an automatism the refreshed knowledge	Quiz mini game	Simulation
		Divisibility Rules	A refresher course assorted with exercices about divisibility rules		
			Exercices to practice and reinforce as an automatism the refreshed knowledge	Quiz mini game	Puzzle Game/Reflex Game
		Prime decomposition / Integer factorization	A refresher course assorted with exercices about decomposition in prime factors		
			Exercices to practice and reinforce as an automatism the refreshed knowledge	Quiz mini game	Game based on the tree representation
ORT	Tech - Digital Literacy	Digital literacy basics	Learning about digital identity		
			Tracking mister x	Quiz	gamified quiz
		Management of digital identities	Learning about a friend's digital identity		
			Learning about their own digital identity		
		Creating a presentation	Prepare a presentation		
			Pitch the presentation		
		Personal data protection	Learning about digital identity protection		
			Protecting their own identity		
SIVECO	Physics	Study power plants	Studying the power plants for assessing the impact of energy production		
			Propose solutions for increasing low-carbon electricity generation		

Figure 64 - Spreadsheet part 1

IMA	Chemistry applied to environment	Environment big killers	Prepare a presentation to be discussed in the classroom of the most used organic materials used by industry for packaging and sort them by difficulty of		
			Roaming around the city where you live and photo report the adoption of the previous discussed materials and compose a "moodboard"of the worst recyclable packaging	Real World Adventure - treasure hunt game. (Eg: Pokemon Go)	Mini game to engage users in doing the real world discovery missions. Maybe not a tipical learning game but more a kind of trainer assistant. Very reusable for all roaming missions quests. For instance a kind of treasure hunt where, when you are in proximity of "beaconed hotspots" configured for that mission something happens (instant quiz?)
		Catch big killers and learn how to beat them	Roam around the city where you live and make a photo reportage (with geotag) of cases of bad recycle habits of the previous discussed materials, and prepare a "waste bad habits photo map" of your city to present to others teams and to teachers.	Real World Adventure - treasure hunt game. (Eg: Pokemon Go)	Mini game to engage users in doing the real world discovery missions. Maybe not a tipical learning game but more a kind of trainer assistant. Very reusable for all roaming missions quests. For instance a kind of treasure hunt where, when you are in proximity of "beaconed hotspots" configured for that mission something happens (instant quiz?)
			Teamwork research of new and more eco-friendly materials for constructions or packaging		
			Roam around the city where you live and make a photo reportage (with geotag) of eco-friendly materials, and prepare a "eco-friendly photo map" of your city to present to others teams and to teachers	Real World Adventure - treasure hunt game. (Eg: Pokemon Go)	Mini game to engage users in doing the real world discovery missions. Maybe not a tipical learning game but more a kind of trainer assistant. Very reusable for all roaming missions quests. For instance a kind of treasure hunt where, when you are in proximity of "beaconed hotspots" configured for that mission something happens (instant quiz?)

Figure 65 - Spreadsheet part 2

SEBIT	Math & Statistics	Tendency of data and presenting data	Prepare a presentation of the most used averages that express the central tendency of a group of numbers (mean, mode, median)		
			Prepare a presentation of the most used graphs to show data and depict central tendency of a data set		
		Obtain data from varius sources to record the largest discrepancy between central tendencies	Go to a school or company in your city and demonstrate the topic choosing a variable or a process (age of employees, number of mail sent ecc ecc)	Real World Adventure - treasure hunt game. (Eg: Pokemon Go)	Mini game to engage users in doing the real world discovery missions. Maybe not a tipical learning game but more a kind of trainer assistant. Very reusable for all roaming missions quests. For instance a kind of treasure hunt where, when you are in proximity of "beaconed hotspots" configured for that mission something happens (instant quiz?)
			Draw data on graph and find the mean, mode and median of the numbers ...		
		Relate sources and tendency	Research type of histograms distributions, identify the distributions of sources from Mission B, observe their mode, mean, median differences. Reconcile with naive ideas on these sources		
			Source guessing show down. Groups of students presenting each other a source distribution with mean, mode, median values marked. Then post a natural language description of 3 sources one of which is the source the distribution belongs.		
		Base Rate Fallacy	Try to find good examples to trick the mind of competing groups into this fallacy		
			Fallacy show down. Post 2 questions to the other group to guesstimate the probability of an occurence with know base rate given an imperfect detector outcome. The group that avoid fallacy and guesstimates most correctly wins		

Figure 66 - Spreadsheet part 3

SIVECO	Mathematics	Geometric figures and bodies studied	A refresher course assorted with exercises about the studied geometric figures and bodies		
			Exercises to practice and reinforce as an automatism the refreshed knowledge		
		Representation of geometric shapes	A refresher course assorted with exercises about representations of geometric shapes		
			Exercises to practice and reinforce as an automatism the refreshed basic geometry knowledge		
		Proper use of calculation formulas	A refresher course assorted with exercises about representations of geometric shapes		
			Exercises to practice and reinforce as an automatism the refreshed basic geometry knowledge		

Figure 67 - Spreadsheet part 4

HWU	VE- Stonemasonry using an angle g	Interpreting information **(Research)**	Research types of power tools + the terminology used in stonemasonry, Research H+S engineering controls for power tool use. Research H+S protocol .	Levels are like game e.g. Candy Crush Saga	Enagement with games important
			Individual/Teamwork research of current legislation (H+S) and Management Controls as well as Operator Controls prior to use of 9 " Angle Grinder	Useful metrics for assessing the students (e.g. number 'lives' taken to complete)	Not a workbased setting - importance of the interface
		adopting industry relevant, safe and healthy working practices**(Plan)**	Whilst working at your place of work, record (photo/video) and report the adoption of the previous discussed materials and plan the work within the allocated time, in accordance with the programme of work	Incidentally learning important	Gameplay is important
			Exercises to practice and reinforce as an automatism the refreshed knowledge	Game with mini games (suite mini games)	What is the hook to get them into the game
		selecting materials, components and equipment **(Select)**	surgery and elevator pitch (5 min presentations, 20 min questioning)	Gam Jam 'brainstorming'	Using angle grinder like chainsaw in Doom etc. - making an structure / Essentials competences to 'cross the line' and the bonuses on top of that
			Exercises to practice and reinforce as an automatism the refreshed knowledge	Unlocking - level of items	Using the language of missions (extrinsic vs instrinsic motivation)
		moving, handling, using and storing occupational power tool **(Apply)**	**Workshop scenario**;comply with the given, relevant legislation and official guidance to carry out your work and maintain safe work practices;Apply and scribe on template and cut a series of chamfers/checks ;Removal of waste;Work to	Make sure the guys can even using the machine until they have actively	Leaderboard (pretty competetive)
			Exercises to practice and reinforce as an automatism the refreshed knowledge	E.g. bonus points for compency 'getting it right' - rather than speed	More time and more structure to help with the student who has difficulty learning (e.g., Students with special needs)

Figure 68 - Spreadsheet part 5