ICT-INOV
MODERNIZING ICT EDUCATION FOR HARVESTING INNOVATION

D2.2 Institutional strategies on building innovation skills in ICT education

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1. Introduction

ICT is a highly innovative sector expected to drive economic growth in the coming years. It is driven by the rapid evolution of digital technology and the improvement of network speeds, which contribute to the growth of demand and supply of ever more powerful digital products and services in diverse areas ranging from government to education, health, business, and finance. The sector's high growth has led to high demand for skilled ICT professionals as businesses strive to attract the talent necessary for pursuing emerging entrepreneurial opportunities.

Given the continuous technological advances, which render products and services obsolete in a short period of time as new, more effective solutions emerge, one of the most important goals of higher education is to build student capacity to stay at the forefront of their highly evolving field throughout their careers. Critical thinking, learning-to-learn capacity, and innovative mindsets help students turn ideas into action, grow professionally, support economic development driven by human capital in today's knowledge economy, and contribute to the well-being of their communities. In this context, the higher education sector needs to modernize curricula and educational offerings to develop the foundational and soft skills that industry and society demand for addressing 21st-century challenges.

Project ICT-INOV aims to promote the development of innovation skills in ICT higher education in Asia and Europe. This goal is pursed through a learning intervention that aims to support innovation-building practices at higher education institutions vertically. More specifically, the project develops a methodological learning framework that is based on design thinking and gamification for promoting entrepreneurial mindsets and long-term engagement in educational processes. This framework is applied in practice towards designing and implementing a digital platform that fosters student collaboration in the context of design thinking activities in and out of the classroom. The project further contributes to developing infrastructure at participating

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universities in Asia by establishing innovation-promoting learning physical labs. In addition, ICT-INOV helps build the capacity of educators to deploy digitally enabled learning solutions that promote innovative mindsets among students through resources, training, and community building.

This report introduces a high-level institutional strategy for promoting the adoption of innovation-building practices among partner organizations based on experiential learning, gamification techniques, and design-thinking approaches. Subsequently, the strategy is individualized to the needs of each participating organization, considering current practices and needs. For partners located in Asia, the individualized institutional strategies further include plans for deploying the physical labs under development.

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2. Innovation skills

Following is an analysis of desirable skills for innovators, namely individuals who are able to create something new based on existing knowledge and research.

SKILL	DESCRIPTION
Problem-solving	Synthesizing solutions to complex and difficult problems, often by integrating knowledge and information. Problem-solving skills can contribute to the ability of an individual to synthesize innovative solutions
Critical thinking	The ability to analyze and evaluate facts to form a judgement or introduce a solution to a problem. It involves effective communication and problem-solving skills. Critical thinking contributes to an objective view of problems and challenges, problem definition, synthesis, and evaluation of ideas
Flexibility	The ability to evolve and change, which is significant in innovation practices for enabling an individual to consider alternative implementations, to follow a different path when an initial solution proves to be ineffective, and to be open-minded to new information
Persuasion	The ability to form positive attitudes and beliefs. In innovation, persuasion can help teams to explore different opportunities and potential solutions
Entrepreneurship	Entrepreneurship and innovation are almost synonymous concepts. Entrepreneurship refers to the pursuit of opportunity. Entrepreneurial mindsets can be beneficial in innovation, both in business and social contexts
Creativity	The use of imagination for introducing original ideas. In innovation contexts, creativity can help an individual to think out-of-the-box to develop a pool of ideas that can contribute to solution synthesis

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Counterfactual thinking	The ability to ignore known facts to focus on new concepts and ideas. This can help look at a problem from a different viewpoint, allowing the introduction of innovative solutions.
Divergent thinking	The ability to consider several conflicting ideas in parallel. This can contribute to the design of innovative solutions by creating a pool of diverse ideas from which designers will select one for prototyping.
Emotional intelligence	The ability to empathize with the emotions of others. The ability to understand emotions, manage them, and put them into action towards solution synthesis. In innovation contexts, this skill can contribute to the design of solutions that address users' needs as well as feelings.
Conceptual blending	The ability to integrate diverse concepts and ideas towards the synthesis of a novel solution. In innovation contexts, this skill can contribute to the generation of new ideas from the old.
Unbiased thinking	The ability to listen without logical bias. Being a good listener is a skill that helps designers be open to the description of a problem by users. Active listening is key for designing solutions that address real, as opposed to perceived, needs.
Intuition	The ability to understand something instinctively. Similar to empathy, this skill allows designers to consider a problem from the users' viewpoint.
Problem framing	The ability to define or redefine clearly a problem by considering problem discovery findings. Defining a problem accurately may help introduce solutions to complex challenges, even when none appears to exist at first sight.
Improvisation	The ability to introduce and implement simultaneously new and innovative ideas. It is useful in innovation-related contexts when the need arises to generate solutions that work from limited available resources.

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Hypothesis testing	The ability to evaluate hypotheses through methods such as exploration, experimentation, and validation. It is important in innovation practices to ensure that ideas actually address user needs.
Facilitating idea development	The ability to introduce new ideas. This may involve pure creativity, applying concepts in different contexts and building on the ideas of others.
Establishing associations	The ability to establish associations between individuals, places, and emotions. This skill helps designers in the discovery phase of a problem by challenging them to identify parallels with situations that have similar characteristics, even if they refer to different contexts. It allows transferring a solution from one environment to another.
Lateral thinking	The ability to look at a situation in a different light. For example, the ability to think of alternative uses for an object that goes beyond its original purpose may lead to the creative repurposing of existing solutions.
Problem reduction	The ability to reduce a complex problem to a simpler representation. This skill can help the designer focus on the important aspects of a challenge, allowing them to discover innovative solutions.
Tolerance of ambiguity	The ability to continue focusing on a problem in the face of ambiguous information. Many real-world problems are ambiguous. The parameters of a problem may not be fully understood. A designer needs to develop resilience in the face of ambiguity and find ways to work through it towards a viable solution.
Optimism	Self-confidence in one's ability to solve complex problems. Optimism is necessary for a young generation that will be challenged to address difficult problems in the 21st century.
Openness	Being open to new ideas, situations, and concepts. It is a key skill in ideation practices during which team members may propose rich and diverse ideas. Being open allows a designer to consider alternative solutions to difficult challenges.

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Resilience	Solutions to complex problems may be difficult to synthesize. Prototypes may need to be discarded if their evaluations through user engagement demonstrate that they are not viable. A problem may need to be redefined in the face of new information. All these highlights the need for designers to be resilient and to continue their efforts until they reach a satisfactory result.

Table 1. Desirable skills for innovators.

The above skills can be developed through the proposed gamified design-thinking framework introduced by ICT-INOV. The following table demonstrates how each design stage contributes to developing desirable skills.

Problem discovery	User needs analysis	Problem definition	Ideation and design	Prototyping and evaluation
Critical thinking	Critical thinking	Intuition	Problem-solving	Problem-solving
Intuition	Intuition	Tolerance of ambiguity	Intuition	Lateral thinking
Resilience	Resilience	Problem reduction	Lateral thinking	Resilience
Openness	Openness	Problem framing	Openness	Improvisation
Establishing associations	Unbiased thinking	Counterfactual thinking	Facilitating idea development	Hypothesis testing
Unbiased thinking	Emotional intelligence	Flexibility	Improvisation	Creativity
			Counterfactual thinking	Persuasion
			Entrepreneurship	

Table 2. Innovation skills developed at different stages of design thinking.

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It becomes apparent that ICT-INOV learning design helps develop desirable skillsets among students, preparing them for becoming the problem-solvers of tomorrow.

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3. ICT-INOV strategy for building innovation skills in ICT higher education

The ICT-INOV strategy for promoting innovation skills among higher education students follows a vertical approach that aims to address holistically the challenges that universities face in modernizing their curricula to address 21st-century needs. Based on the analysis performed in the context of D1.1 Analysis of Current Practices on Fostering Innovation in ICT Education, which documents existing strategies, initiatives, and practices at the institutional, regional, and national level in countries in which ICT-INOV has project partners, the challenges faced by higher education institutions today include:

- The need for modern infrastructures that are equipped with state-of-the-art hardware and software that promotes the development of innovation capacity among students through digital exploration, experimentation, and collaboration
- The need for updating instructor skills to empower them to integrate emerging pedagogies, such as experiential learning, design thinking, and gamification, supported by digital technologies in on-going educational practices towards developing innovation skills among students
- The need to update courses and educational offerings so that modern learning designs, such as experiential learning, design thinking, and gamification, are deployed in a manner that enriches classroom interaction and collaboration towards building innovation skills
- The need to develop quality digital services and content that will support the educational process towards building innovation skills

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Based on the above, ICT-INOV has developed an institutional strategy for building the capacity of participating organizations to promote students' innovation skills in a manner that makes them competitive in the job market. The strategy includes the steps described in the following sections.

3.1 Developing physical infrastructures

ICT-INOV aims to develop physical labs at university partners located in Asia. The physical laboratories developed at each partner site differ as they are tailored to:

- Existing infrastructures that will be complemented by the ICT-INOV labs
- Existing curricula courses, and other educational offerings in which the labs will be used for promoting innovation skills
- Courses and other educational activities that will be updated in the future to integrate innovation skill-building activities
- The links of universities with regional communities and businesses, which to a degree influence curricula planning for developing skills needed by industry and society

Despite the potential differences in lab configurations, the objectives that drive lab development are the same for all partners. The labs will promote:

- Collaboration among students through appropriate equipment and the physical set-up of the lab. For example, the labs may be setup in round tables that promote group work, while displays may facilitate the sharing of information among group members or among all class participants
- Exploration and experimentation foster innovative and critical thinking. This will be supported through equipment that promotes synthesis, such as robotics or other
- Research through internet connectivity
- Idea sharing through digital services and devices that promote collaboration, such as smartphones, tablets, or workstations

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The most important aspect of the labs will be that they will provide a space in which students will be encouraged to collaborate and innovate, experiment with new ideas, build on the ideas of others, and be supportive of each other by avoiding criticism and welcoming out-of-the-box thinking. For each partner, all equipment will be installed in a single room marked externally with a plate displaying the project and Erasmus+ funding logos. In addition, stickers with these logos will be placed on each piece of equipment.

The labs will be available for use by students and educators in the context of formal or informal educational activities. Each partner may establish internal guidelines and rules that members of the educational community will need to follow to gain access to the lab, such as lab reservation procedures, lab operation rules, accountability, and more.

Finally, ICT-INOV partners located in Europe will deploy existing infrastructure and labs for implementing project activities on design thinking.

3.2 Developing open digital learning services and content for innovation

A key challenge that inhibits innovation skill development is the lack of quality, open educational services and content. To address this issue, ICT-INOV develops a digital collaboration service that supports educators and students in innovation-building activities. The proposed digital learning service deploys design thinking and gamification elements which foster creativity and promote long-term student engagement in learning processes.

The proposed digital services are being developed through the collaboration of all project partners to ensure that the outcome will be relevant in diverse academic, cultural, and economic contexts. The services will allow educators to define educational activities for each design thinking step of problem discovery and empathy, needs analysis, problem definition, brainstorming, solution prototyping, and evaluation. Given that design thinking is deployed with variations by different institutions, the service will be flexible, allowing each educator to define steps according

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to student needs and course goals. The service will promote real-time collaboration of teams even when team members are not all in the same room. This will be achieved through a common digital workspace that team members will be able to update simultaneously and in real-time through the web. Students will be able to see in real-time additions made by their peers, post their own ideas, build on team members' ideas, and chat. The result will be working canvases that present team understanding of a given problem, the user needs, and suggested solutions through text, images, and videos. On the other hand, the service will allow educators to create educational activities for their students and to monitor student progress in compiling creative solution canvases.

The service will be installed at the University of Thessaly internal servers and will be available to all project partners. A reference guide will be available for supporting partners in the deployment of digital services in educational contexts. In addition, the service will be made available to external organizations, for example, universities not directly involved in the consortium, for promoting innovation skill development widely in higher education. Upon completion of the implementation period, the consortium will evaluate the potential benefits of moving and duplicating the service to a partner site in Asia for empowering project partners located in Malaysia, Vietnam, Pakistan, and Nepal to manage innovation-building digital services.

The ICT-INOV digital collaboration service will be populated with learning activities structured through design thinking principles. The learning activities will be relevant to courses or other educational offerings of partner organizations. Well-designed activities will be publicly available to all educators that have registered to the ICT-INOV platform. They will be able to duplicate and, if necessary, adjust the activities for use in their own classes. Furthermore, they may use the activities as inspiration for designing new ones that address the specific needs of their students in the context of curricula courses. The result will be a rich collection of at least 50 educational activities that will inspire educators and students to engage in innovation creation.

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3.3 Instructor training

To build the capacity of participating organizations to adopt emerging design thinking and gamification practices for promoting innovation skill development, ICT-INOV organizes instructor training, which will take place in 2 phases.

3.3.1 First phase of instructor training

In the first phase, instructor training will focus on educators directly involved in the consortium. Four instructor training events are planned in month 18 of the project. In these events, participants will have the opportunity to be exposed to design thinking and gamification practices, to which most participants will be exposed for the first time. Two of these events will take place on-line. The other two will take place in-person and have 5 days each. These events will train a core pool of instructors on the ICT-INOV gamified design thinking methodologies and the deployment of the ICT-INOV digital learning platform in design thinking contexts. These instructors will then carry the new knowledge to their organizations and disseminate it further during the second phase of instructor training.

Participants will:

- Discuss design thinking principles and benefits in introducing solutions to challenging problems in business or social contexts.
- Be exposed to design thinking cases to develop an understanding of how the process has helped design more effective solutions for the benefit of end-users.
- Analyse well-accepted design thinking practices, such as problem-discovery, empathy, understanding actual user needs, problem statement definition and re-definition, brainstorming, solution design and prototyping, and evaluation.

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- Be exposed to exercises that they can integrate into their educational practices at each step of the design thinking process.
- Be trained to mentor students and to initiate collaboration and classroom discussion towards designing innovative solutions.
- Go through the entire design thinking process by working as students on a specific problem, which they can later use in their classes.
- Design and structure learning activities of their own.
- Be exposed to the ICT-INOV digital collaboration services from the point of view of students and educators. Through this process, participants will become familiar with the environment that their students will experience in class.
- Understand how the ICT-INOV digital solution supports innovation skill development through collaboration in and out of the classroom.
- Build their capacity to transfer this knowledge and practical skills to their peers.

It is expected that at least 25 individuals will be trained through this process.

3.3.2 Second phase of instructor training

In the second phase, instructors participating in the first training phase will act as ICT-INOV "ambassadors" transferring their newly developed knowledge to peers in their organizations. The training will be on-going. It is expected that 4 – 5 training sessions will take place at each partner site. The training sessions will facilitate capacity building among a larger group of educators on deploying the ICT-INOV learning intervention for promoting student innovation skills. The events will further provide an opportunity to fine-tune the ICT-INOV learning intervention by generating feedback from the field. They will prepare educators to deploy the proposed digital learning services and educational content in real-life courses for the benefit of their students. It is expected

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that over 300 educators will be reached in this phase at all partner sites, at least 30 in each organization.

3.4 Educator resources

A pool of resources will be available to educators to deploy design thinking. The educators will be able to use the resources directly or adapt them to address the needs of their students. Resources will be made available for:

- Team-building tools that help break the ice, allow team members to become acquainted with each other, introduce collaboration tools, and support teams define their goals and aspirations.
- Problem discovery through tasks that help students perform research.
- Empathy through tools that help students organize interviews with users, document feedback, and develop a «user persona», namely a description of a characteristic user
- Problem-definition tools.
- Ideation techniques that help students observe a problem from different viewpoints help introduce a rich pool of potential solutions.
- Design tools, such as templates for documenting suggested solutions by framing the problem, defining users, presenting key solution elements, and more.
- Cases that may be used directly or as inspiration.

The above tools will be made available to project participants, who can use them and further distribute them within their organizations and beyond to promote innovation capacity.

3.5 Community building

A community of practice will be developed for sharing knowhow and experiences for maximizing the positive impact of the proposed design thinking gamified learning intervention for innovation

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building. The community will consist of educators, students, policy makers, and external stakeholders. Community activities will have the following forms:

- An on-line community of individuals will directly use the ICT-INOV digital learning services. At least 50 accounts are expected to be created by each partner organization. The community participants will have diverse roles as content consumers or producers. Through ICT-INOV, they will engage in innovation building practices
- A wider community of stakeholders will be reached through community events that will disseminate the proposed design thinking learning methodology beyond the consortium. At least 1 event will be organized per partner, reaching at least 50 individuals. In addition, a final project conference will be organized during the final project meeting

3.6 Deployment in courses

The purpose of ICT-INOV is to encourage the development of educational activities that will help modernize ICT curricula through design thinking for innovation. The project aims at a broad intervention that will reach participating organizations beyond the implementation team. For this reason, each participating university will aim the design activities that will enrich 10 courses. Each participating organization will decide the courses that will be enriched through the ICT-INOV learning intervention. A total of at least 100 students will be reached at each organization through pilot activities that will involve the newly designed learning content.

3.7 Post-project exploitation plans

At the end of the project implementation period, partners will develop exploitation plans that will outline how the ICT-INOV learning intervention, with an emphasis on the labs, will be sustained beyond the project completion. The exploitation plans will outline future deployment of the labs in additional courses, reaching additional students, development of new activities, engagement of support staff, further instructor training, and raising funds for supporting lab operation.

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3.8 Indicators of successful implementation of the institutional strategy

The implementation of the institutional strategy at the project and the organizational level will be monitored through qualitative and quantitative indicators of success. The following table presents qualitative indicators and targets.

INDICATOR	TARGET
Labs to be developed	One lab at each partner located in Asia, for a total of 8 labs in Malaysia, Pakistan, Nepal, and Vietnam
Learning activities to be developed	At least 50
Courses to be enriched	At least 5 per partner
Educators to be trained	At least 300 combined at all partner sites
Students to be reached	At least 1.200 combined at all partner sites
Instructor training events	At least 4 - 5 at each partner site
Community building events	One or more at each partner, reaching at least 50 individuals. A final project conference

Table 3. Indicators of successful implementation of institutional strategies.

Qualitative indicators will document the impact of the intervention at each partner site. Each partner will document the key benefits of the ICT-INOV activities, which will be summarized upon project completion. Examples of positive impact may include internationalization of practices, modernization of practices, educator capacity building, enhanced competitiveness of students in the job market, enhanced links with industry, and more.

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4. Educational practices for building innovation skills

Improving the quality of teaching is one of the main objectives of all European education systems. The challenge of educational innovation is not a purely technological issue, nor is it just a disciplinary or methodological issue. Instead, it is a question of considering a broader dimension linked to the changes taking place in society, which directly or indirectly influences higher education's cultural transformation.

There is a growing need to provide all students with methods, tools and skills that enable them to relate effectively with an increasingly complex society in which digital technologies, the globalisation of relationships, scientific development, the growth of migratory flows, changes in family structures and social behaviour introduce new challenges and needs.

If on the one hand, it is necessary to address emerging educational needs by developing skills that enable students to innovate in a profoundly changed reality with appropriate tools. In this context, there is also a need to overcome the challenges faced in traditional educational systems that introduce the need for new learning strategies and tools.

The ICT-INOV methodological learning design is outlined in report D2.1 Methodological Learning Framework [32]. This section discusses how proposed design thinking approaches supported by gamification may be deployed in classrooms in the context of broader learning approaches already used by universities, such as experiential learning. This early strategic design will evolve throughout the project implementation through partner work, including course design and instructor training. An overview of related methodological learning design is also provided at each section's beginning for completion.

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4.1 Experiential learning

Using the words of Lewis and Williams (Lewis and Williams, 1994) in its simplest form, experiential learning means learning from experience or learning by doing. Experiential education first immerses learners in an experience and then encourages reflection about the experience to develop new skills, new attitudes, or new ways of thinking.

The first experiential learning theories arose in the mid-19th century, allowing learning in its broadest sense to move away from traditional formal education. Teachers presented students with abstract concepts through an immersive method of instruction. Students learn by doing, applying knowledge to develop skills or new ways of thinking (Lewis and Williams, 1994).

Lewin's research discovered that the individual best facilitates learning when there is a conflict between a learner's immediate concrete experience and detached analysis of it. His cycle of action, reflection, generalization, and testing is characteristic of experiential learning.

The central reference point for a discussion on experiential learning comes from David A Kolb (Kolb, 2005), starting from the experiential learning model as proposed in Lewin's research work. As shown in the figure below, Kolb's model called the experiential learning cycle consists of four elements: concrete experience, observation and reflection, the formation of abstract concepts and testing in the new situation.

According to Kolb, the learning cycle can begin at any one of the 4 points of the cycle, which may be viewed as a continuous spiral. In reality, however, the learning process begins with a person carrying out a particular action and then seeing the effect on the situation (1). From this first step, the learner proceeds to the second step of understanding the effects of his action in a particular situation (2). This second step has the intention on the part of the learner to anticipate what would follow from the action if the same action were to be taken under the same or similar

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circumstances. Based on this second step, the learner would proceed to the third step of understanding the general principle under which the particular instance falls (3).

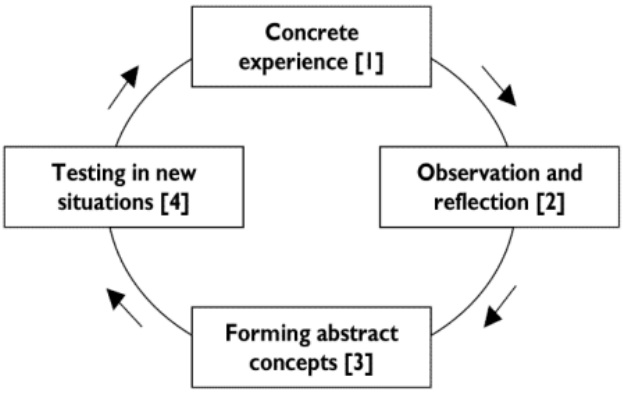

Figure 1. The model of the experiential learning cycle by David A. Kolb (Kolb, 2005).

4.1.1 Ideas for introducing experiential learning into the classroom

The key idea behind experiential learning is not new. But the approach suggests a renewed look at how teaching and learning are organized in classrooms. It is a heavily student-centered methodology that engages students in interdisciplinary exploration, collaboration and field-based opportunities that encourage reflection and self-examination. The deployment of experiential learning in classrooms is gradually increasing.

Examples of experiential learning activities include field trips for conservation, outdoor education or exposure to employment practices, group work in and out of the classroom, open-ended discussion activities and active questioning [6].

In experiential learning, educators become facilitators. They present students with challenges or problems and then allow them the freedom to design solutions. Teachers, as facilitators, can then observe and guide learning. The guiding role of educators ensures that any potential issues and

misunderstandings can be addressed as soon as they arise as part of the learning process rather than corrected later after a project has been completed. Thus, experiential learning is an active problem-solving process.

Well-designed experiential learning activities are comprised of a balanced combination of learning, understanding, doing and reflection. Each aspect enhances the others, resulting in knowledge and skills development, a deep understanding of the subject matter and complex concepts and the ability to apply concepts in practice in a process that encourages critical thinking in future professionals. Today's educators are challenged to design inquiry-based activities that cross the division between theory and practical applications through experiential curricula and engaging practices. Experiential learning design provides learners with opportunities for creativity and academic learning consistently characterized by focus and rigor within and across subjects.

Chapman et al. [7] have provided a list of desirable characteristics in experiential learning. They include:

- Content and process mixture: Balance experiential activities and the underlying content or theory.
- Absence of excessive judgment: A safe space for students to work through their process of self-discovery.
- Engagement in purposeful endeavors: Establishing students as self-teachers. Self-motivation requires that students discover meaning in the learning process. Learning activities must be personally relevant.
- Encouraging the big picture perspective: Allowing students to establish connections between learning and the world. Activities should build students' ability to discover relationships in complex systems and find a way to work within them.

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- Reflection: Reflection during the learning process allows bringing theory to life and gaining insight into personal learning objectives and links to the real world.
- Creating emotional investment: Immersion in the learning experience, not merely executing required activities.
- Re-examination of values: Working within a space that has been made safe for self-exploration allows students to analyze and even alter their values.
- Meaningful relationships: Demonstrate the relationships of learner to self, learner to teacher and learner to the learning environment. This allows students to appreciate their learning in the context of the whole world.
- Learning outside one's perceived comfort zones: "Learning is enhanced when students are allowed to operate outside of their own perceived comfort zones." This doesn't refer just to a physical environment but also social. It may involve, for instance, "being accountable for one's actions and owning the consequences" [7].

Experiential learning can create powerful mindset shifts in learners and affect their understanding of the world around them and their ability to make a positive impact in the present rather than some vague time in the future when they are qualified or have completed their education [6]. Learning by doing creates a rich platform for deeper learning, accelerated learning, real-world skills, and character development. Experiential learning equips and prepares students for becoming successful outside of the classroom. It makes learning meaningful as it connects concepts, passion, skills, knowledge, and dispositions in collaboration with the community and the real world. And it has a lasting impact.

4.2 Gamification techniques

Game-based learning is the idea that students play games to acquire new knowledge, consolidate the previous one or understand a specific concept. This is an incredibly powerful tool, but it's also

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quite limited unless the teacher is also a game developer or fortunate enough to teach a subject with a library of relevant and age-appropriate games to play.

The more general term of gamification refers to harnessing the most engaging elements of games and using them to bring life to activities that students may otherwise try to avoid. It can transform their learning process from something students hate to something they look forward to, which encourages them to improve their skills in different ways. Gamification helps build students' intrinsic motivation and promotes long-term engagement with the learning process. Gamification is the use of game elements in any context that is non-game related. It can help foster user interaction with the learning material in educational contexts.

The use of gamification techniques in learning exploits the potentialities of game elements in all the subjects and study curricula to engage and motivate students.

Based on their study's literature review, Perrotta, Featherstone, Aston, and Houghto [8] describe gamification as an experiential engagement of learning and treating a certain topic not as content but as a set of rules or choices and consequences. In a school curriculum, this means translating an element of a subject, such as a law of physics, into the mechanics of a game, which functions independently in its system, based on choices and consequences. The authors [8] [9] clarify the same idea by defining gamification as borrowing certain gaming principles and applying them to real-life settings for users' engagement.

For Thorton [10], the essential feature of gamification is interactivity. Thornton's theory, Prensky underlines, also provides some key elements characterizing gamification as follows: rules, goals and assignments, results and feedback, conflict situations, such as competition, challenge and opposition, interaction and fantasy frameworks [11].

Immediate reward and feedback are significant motivational factors, whether they are translated into game entities, for example, more life power, access to new levels and more, or as

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neurological impulses, such as happiness, a feeling of achievement, etc. Another feature of games related to learning is the ability to offer short feedback cycles. This allows players to explore the learning environment freely, form assumptions, learn by trial and error and get immediate information that they can use to redefine wrong assumptions in a risk-free environment.

This feature is well-aligned with educational requirements, as most educational approaches require the trainer to provide feedback to students on their results. This can be contrasted with traditional approaches that educators use to evaluate student work, for example, through manual grading, which results in a significant delay in providing feedback to students themselves. Gamification techniques can help to significantly reduce this delay.

Gamification is an ideal means for promoting authentic learning by doing. It puts the student in the position of leader of their learning experience. Gamified learning paths can provide meaningful learning experiences by simulating interactive learning scenarios where students face open and concrete challenges. As a result, gamification is an excellent means for promoting active learning, improving students' problem-solving skills, increasing personal satisfaction and leading to high performance [12] [13].

4.2.1 Ideas for introducing gamification techniques into the classroom

A key component of a gamification system is measurement. The instructor's focus should always be on the students. For example, if the instructor measures on-time homework, then the homework might always be on time. Or if she gives points for completed tasks, students will choose the tasks that provide the most points in the least time [14][15].

Another important element is to understand students' motivation before planning gamification techniques for the classroom. This is because gamification techniques mainly impact the intrinsic motivation of students. Therefore, if a student is already intrinsically motivated, this technique is

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unnecessary [14]. Consequently, it is very important to identify the students' profiles to understand whether gamification can offer benefits or which game elements can work better than others.

For example, gamification might not be the solution if a task requires creativity, lateral thinking, and time. This is perhaps the case where “play” is better than “gamify”. In this case, the open task should rely on creativity and freedom as motivators.

Gamification systems deploy several elements [16]:

Points: Game points are a powerful motivator. Good advice for using them in gamification is not to give 1 or 2 points but 10s to 1000s. If it is assumed that points help students get on board, then they should be given out freely, especially at the start. However, the reward must be substantial and immediate to encourage students and is more effective when failure to achieve it is considered a loss. One of the simplest methods of introducing a point system is to create a menu of tasks and then award points for each task done, as shown in the following table.

TASKS	POINTS
Complete Quizzes® based on the electrical circuits	25
Watch a video on the electrical circuits in Edpuzzle®	50 (25 bonus points upon providing a summary)
Draw up a scheme of an electronic model showing key elements	50 points (25 bonus points upon including annotations)
Build the schemes of basic logical operations using CMOS transistors	75 points
Create a video explaining the basic phenomena behind a single bipolar transistor	75 points

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Table 4. Example of challenges' menu.

Another fun way for students to earn points is to follow a checklist called "flight plan" or "take-off checklist", which allocates points for performing specific tasks. In higher education, students may calculate their points individually based on the checklist. Educators might choose to peer review the checklist of points gained.

CHECK LIST	POINTS
Title	5
Date	5
Clear introduction	10
Used paragraphs	10
Used topic sentences	10
Had a clear conclusion	10

Table 5. Example of a take-off checklist.

Badges: They are rewards that prove that a student has reached a certain level. Unlike other assessment methods, badges focus on this idea of building towards mastery. Using points and badges is a great way to demonstrate learning, student progress and follow-up goals or next steps.

Student progress is important in educational contexts. Student level of achievement can be well demonstrated through badges. An important aspect of badges is their unpredictability. If rewards are predictable, then interest will wane over time. Therefore, having hidden badges allows

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surprise rewards that can be significant motivators. Digital systems may allow the easy creation of badges.

Levels: In games, levels can be used flexibly to divide challenges or introduce a means for gradually increasing difficulty. In learning, levels may be deployed for dividing course content into thematic areas. Levels should have fun names and be challenging. They are also great for showing students that they are building their knowledge and skills by completing levels. This can alleviate feelings of failure in the case of some errors. In practice, a list of levels may be created simply in a spreadsheet, especially for small projects. A menu of levels may be useful for larger projects to make students aware of their progress. Another option is to use a hyperdoc, which is a document with links to levels. Using levels in gamified learning contexts may allow students to skip over chapters they have mastered and proceed directly to content reflecting their knowledge.

Challenges: Challenges provide clear missions and may be linked to educational goals. They can further be linked to real-life problems promoting student innovation skills.

Real-time feedback: The simplest way to create real-time feedback is to design questions related to concepts covered in the class. A variety of digital tools exist through which educators can create individual questions or small quizzes. Popular examples include the digital applications Plickers® and Kahoot®. Another approach is to introduce real-time feedback through educator or peer reviews.

Leaderboards: Leaderboards are related to the social recognition of success. Peers can see the names of successful participants on the leaderboard, which provides the recognized individuals with a sense of satisfaction and achievement. Care must be taken to avoid demotivating students who do not appear on the leaderboard. One way of achieving this is re-initializing the leaderboard at intervals, allowing all students to restart from the same level and providing more chances for recognition to more individuals.

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Stories and context: Games and gamification are powerful tools for telling exciting stories. Role-play often works best with younger students. Older students can benefit from context, which better explains why a concept is important and useful. A realistic scenario is often needed to engage higher education students with exercise. When linked with real-life problems, stories can be a great tool for introducing an activity's educational framework and objectives.

4.3 Gamified design thinking

Design thinking is a design process that aims to introduce innovation and to design solutions that better address actual, as opposed to perceived, needs through a highly user-centered approach to problem-solving. It is used in design contexts, both in entrepreneurship and social entrepreneurship. In learning, design thinking can empower students by exposing them to authentic scenarios and experiences, equipping them with the real-world skills they need to be successful in future careers, and to help address industry and societal challenges for the benefit of their communities [17].

Design thinking aims to generate broad ideas through ideation and brainstorming, then narrow the field of potential solutions to generate a prototype that can be validated in the real world. While design thinking may be implemented in different ways, some well-accepted steps are empathy for problem discovery, problem definition, ideate for generating rich ideas, prototyping and testing by engaging users [18]. These steps help designers put themselves into the users' shoes, either by engaging them to understand their real needs or by immersing themselves in the users' environment.

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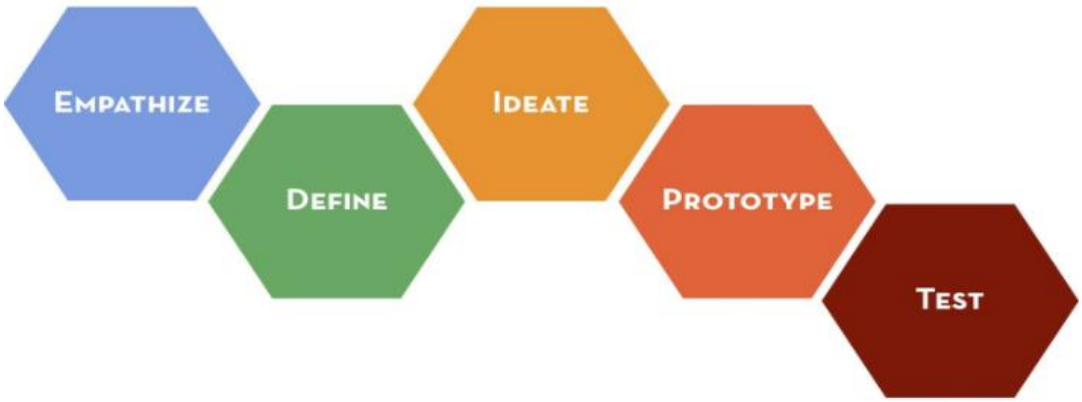

Figure 2. Design thinking five stages [18].

Following is a summary of design thinking steps:

Problem discovery and empathy: In this first step of the design thinking process, educators expose students to the driving question or challenge. Furthermore, educators introduce the target group for which a solution must be designed. Students perform research to better understand the problem and develop the skills necessary for introducing a solution. One of the key aspects of problem discovery is empathizing with users, namely understanding the challenges they are facing, their experiences from any existing solutions and their feelings. By better understanding users' needs, designers can introduce more effective solutions.

Problem definition: After developing a good understanding of the driving question and user needs, students define the problem anew. A redefinition of the problem may be the result of gathering information that was not initially available through problem discovery and empathy practices. An accurate problem definition significantly facilitates the ideation and solution design process. By looking at the problem in a different light, designers may discover solutions even when none appears to exist at first sight.

Ideation, prototyping and testing: Ideation is a process that encourages introducing a rich pool of ideas through which a solution will be designed. It may take several forms, such as

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brainstorming in a group, observing situations with analogies to the problem in focus, observing user groups beyond the target that provide additional insight and more. Ideas may be sorted in groups with similar characteristics. Students must select one idea that will be the key to their proposed solution. It is important to select an idea that can be implemented into a prototype, which will be used with users to generate feedback. A prototype is discardable. If it does not address the problem in focus, designers may revise and improve it based on feedback or start the process again to generate a more effective idea.

ICT-INOV proposes a **gamified design thinking process** in which classic design thinking steps are enriched with gamification elements, such as rewards, feedback, and difficulty adjustment, to promote active learner engagement in the educational process. The approach combines the benefits of design thinking and gamification to promote the development of entrepreneurial and problem-solving capacity while encouraging students to pursue in the long-term the continuous upgrading of their innovation skills, becoming the problem-solvers of tomorrow that are able to address 21st-century challenges.

4.3.1 Ideas for introducing design-thinking into the classroom

The Design Thinking Standards (DTS) provide teachers with the base of what students are expected to learn and do when using the design thinking method [19]. They were inspired by the work and teachings of Stanford d.School [20], a leader in design thinking education.

These standards may be viewed as performance expectations. They are actionable and assessable learning goals. They are composed of core design ideas that students need to understand, design practices they can apply and design mindsets and attitudes essential for the effective application of design thinking [18][20][21].

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4.3.1.1 Problem discover and empathy phase

In the problem discovery phase, students must develop an understanding of the problem in focus and end users' needs, which will help them design a solution that improves real-world experiences. This can be achieved through research, interviews of users, observation of users or immersive experiences [20][21].

Performance expectations:

Upon completion of the activity, students:

- Have developed a better understanding of the problem, its parameters, and the resources available for designing a solution.
- Have identified the needs and perspectives of users.

Practices:

Students engage in the following activities:

- Research the problem through diverse channels.
- Observe user behavior, feelings, and patterns in the context of their lives and the given design challenge.
- Engage with users and/or experts through conversations and interviews that incorporate open-ended questions to dig deeper for stories, feelings, emotions, and problem aspects of importance.
- Submerge themselves into the users' experience.

Core ideas:

Students understand that:

- Empathy brings an understanding of people, their physical and emotional needs and wants, the things that they do in their lives and the context of the design challenge.

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- Engagement with users through interaction and interviews exposes insights that can be utilized to create a more innovative solution.
- Immersing oneself in the user's experience can help to understand the context of the design challenge better.
- A beginner's mindset maintains an attitude of openness and puts aside biases that can restrict a person's ability to empathize.

Mindsets practiced:

Students demonstrate a set of attitudes that help them to:

- Be human-centered: Gain inspiration and direction from users and respond to human needs by placing the user at the center of all empathy work.
- Be mindful of the process: Be thoughtful and reflective of the work being done, how the work is being done and how the work may improve.
- Be capable of radical collaboration: Collaborate and create partnerships with people of different disciplines as well as users to develop innovative ideas and solutions.

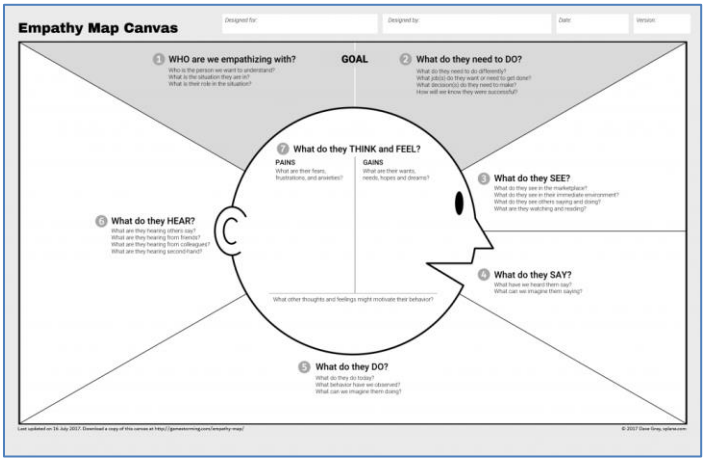

Figure 3. Empathy map canvas template.

Source: Dave Gray from https://gamestorming.com/

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The outcome of this phase may be an empathy map, a graphic representation of the information captured during the empathy work.

An empathy map pictures the user in the center surrounded by characteristics, such as what the user does, feels, hears, sees, and speaks. Through the empathy map, students record their findings from discovery work, including interviews, observation, and immersion.

4.3.1.2 Definition phase

Students synthesize the information obtained through empathy work to develop a problem statement, which identifies the users for whom a solution is designed, their needs and insights that can lead to identifying innovation opportunities [20][21]. An accurate problem statement can drive inquiry, guide design work and initiate students' thinking towards introducing a solution. It is the beginning of the creative process. A problem statement may be expressed through a sentence of the form "____ (user) might need a way to____ (user's need) that/because/but ____ (insight)." Another way to define the problem statement is through a sentence of the form "how might we design a solution that addresses the needs of ____ (user) by ____ (solution)".

Performance expectations:

Upon completion of the activity, students:

- Have synthesized new knowledge and insights towards the identification of user needs.
- Have developed an articulate clear, actionable problem statement.

Practices:

Students engage in the following activities:

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- Integrate learning outcomes, knowledge, and insights towards identifying patterns that can be leveraged to create innovative solutions.
- Articulate a clear, actionable problem statement that defines the target users, their needs and insights that may guide the process of generating high-quality solutions.

Core ideas:

Students understand that:

- User needs definitions to deflect what the user ultimately wishes to accomplish.
- Insights are discoveries that can be used to enhance the design of a solution.
- Problem statements are actionable statements based on what was learned and discovered, bringing clarity and focus to the design challenge.

Mindsets practiced:

Students demonstrate a set of attitudes that help them to:

- Be human-centered: Gain inspiration and direction from users and respond to human needs by placing the user at the center of all empathy work.
- Be mindful of the process: Be thoughtful and reflective of the work being done, how the work is being done and how the work may improve.

4.3.1.3 Ideation phase

Students generate as many ideas as possible towards synthesizing a solution. All ideas are welcome, from rational and mainstream to out-of-the-box. The ideation phase must be inclusive, encouraging student engagement and contribution [20][21]. Criticism of ideas should be avoided.

After generating a rich pool of ideas, students select the most viable ones and integrate them into a limited number of concrete solutions that can be turned into a prototype blueprint. The

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blueprint is not always a technical drawing for tangible objects. It can also be in a strategic plan, advertisement campaign, website, video, or anything else that can positively affect the user.

Performance expectations:

Upon completion of the activity, students:

- Have introduced a rich collection of ideas.
- Have developed visual representations of ideas.
- Have analyzed ideas towards synthesizing through criteria based on user needs.

Practices:

Students engage in the following activities:

- Develop short prompt questions based on the problem statement to initiate brainstorming sessions.
- Visually generate a large volume of diverse ideas that can contribute to designing innovative solutions to the problem statement.
- Identify multiple ideas as candidates for prototyping based on how well they address criteria for success.

Core ideas:

Students understand that:

- Ideation combines empathy with the designers' imagination to generate rich ideas for addressing the problem statement.
- Innovation potential can increase by thinking beyond obvious solutions, uncovering unexpected areas of exploration, and adding upon the ideas of others.
- Innovation potential can be preserved by bringing multiple ideas into the prototyping phase.

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Mindsets practiced:

Students demonstrate a set of attitudes that help them to:

- Be human-centered: Gain inspiration and direction from users and respond to human needs by placing the user at the center of all empathy work.
- Be mindful of the process: Be thoughtful and reflective of the work being done, how the work is being done and how the work may improve.
- Become action-oriented: A leniency to action helps students think and learn quickly as well as make decisions.
- Be capable of radical collaboration: Collaborate and create partnerships with people of different disciplines as well as users to develop innovative ideas and solutions.
- Show, don't tell: Humbly communicate and share visual ideas without trying to convince others of the ideas' value.

4.3.1.4 Prototyping phase

Students convert their ideas into a prototype, an experimental model that users can use and experience, providing feedback. Students have the opportunity to build, create, explore, experiment and test assumptions [20][21].

Performance indicators:

Upon completion of the activity, students:

- Have created and improved prototypes for users to engage with.

Practices:

Students engage in the following activities:

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- Create a prototype of a tangible product or an experience that users can experience and interact with based on criteria for success.

Core ideas:

Students understand that:

- Prototypes can be anything users can interact with, such as a role-playing activity, a gadget or a storyboard.
- The prototyping process provides opportunities to empathize, ideate, problem-solve, discover new insights, and identify valuable variables.
- Creating low-resolution prototypes allows designers to fail faster and learn quicker in less time and with fewer resources and money.

Mindsets practiced:

Students demonstrate a set of attitudes that help them to:

- Be human-centered: Gain inspiration and direction from users and respond to human needs by placing the user at the center of all empathy work.
- Be mindful of the process: Be thoughtful and reflective of the work being done, how the work is being done and how the work may improve.
- Adopt a prototyping culture: Be exploratory and experimental, build things to learn, think through and engage users with prototypes to elicit and receive feedback.
- Become action-oriented: A leniency to action helps students think and learn quickly as well as make decisions.
- Be capable of radical collaboration: Collaborate and create partnerships with people of different disciplines as well as users to develop innovative ideas and solutions.

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- Show, don't tell: Humbly communicate and share visual ideas without trying to convince others of the ideas' value.

4.3.1.5 Evaluation phase

Students collect feedback and insights through a process in which users are exposed to their prototypes. They identify aspects of their prototype that did not work well or that users did not find functional or pleasing [20][21].

Performance expectations:

Upon completion of the activity, students:

- Are able to plan and execute evaluation activities within appropriate contexts and scenarios.

Practices:

Students engage in the following activities:

- Plan and carry out tests in which users interact with prototypes that demonstrate they key ideas of a potential solution.
- Observe users and engage with them while they experience the prototype, providing feedback.
- Use findings from evaluation activities to inform the next iterations of prototypes for improvement.

Core ideas:

Students understand that:

- Testing is another opportunity to gain user empathy and insight into the design challenge through observation and engagement.

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- Designers can solicit user feedback through questions about the experience by continuously asking, “why?”.
- The information gained from the testing phase will help design a follow-up prototype that better addresses user needs.

Mindsets practiced:

- Be human-centered: Gain inspiration and direction from users and respond to human needs by placing the user at the center of all empathy work.
- Be mindful of the process: Be thoughtful and reflective of the work being done, how the work is being done and how the work may improve.
- Adopt a prototyping culture: Be exploratory and experimental, build things to learn, think through and engage users with prototypes to elicit and receive feedback.
- Become action-oriented: A leniency to action helps students think and learn quickly as well as make decisions.
- Be capable of radical collaboration: Collaborate and create partnerships with people of different disciplines as well as users to develop innovative ideas and solutions.
- Show, don’t tell: Humbly communicate and share visual ideas without trying to convince others of the ideas’ value.

The outcome of this activity can be a simple feedback capture grid tool. This is a presentation of findings divided into 4 quadrants. Students document feedback on what users liked about the prototype in the 1st quadrant. In the 2nd quadrant, they document constructive feedback. In the 3rd, questions arose during the testing. And in the 4th quadrant, ideas for improvements emerged from the tests. Using the information organized in the feedback capture grid tool, students can go back to the prototype phase, improve their solution, and test it again.

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Users' feedback: what they liked	Users' constructive feedback
Questions arousing during the testing	New ideas or improvements

Figure 4. Example of a feedback capture grid.

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5. Partner institutional strategies for building innovation skills

This section presents the institutional strategies of project partners. The strategies consider organizational visions and missions, current practices for innovation skill development that can be enriched through ICT-INOV learning design, examples of courses that can be enriched through design thinking and gamification for innovation skill building, and lab development strategies in a manner that complements existing infrastructures and considers existing curricula and educational offerings. Each partner organisation's institutional strategies will be implemented in the early and long-term stages to exploit the ICT-INOV methodology and tools towards developing student innovative mindsets and educator capacity to introduce activities in the classroom that foster the development of new ideas and their active deployment in real-life contexts.

5.1 Partner 1: University of Thessaly (UTH)

5.1.1 Partner description

The University of Thessaly is the only higher education institution in the geographical area of Thessaly, located in central Greece and has 700.000 inhabitants. Very recently, the university absorbed 2 other higher education institutions that existed in the area in the context of wider initiatives by the Ministry of Education to reduce the number of higher education institutions in the country. As a result of the merger, the University of Thessaly is now the 3rd largest higher education institution in Greece, enrolling over 40.000 students at the undergraduate and graduate levels. The university has 33 departments organized in the schools of Engineering, Agriculture, Humanities, Medicine, Economics, Technology, Science, and Physical Education. The departments are spread over 5 towns, namely Volos, Larissa, Karditsa, Trikala, and Lamia. The Department of Electrical and Computer Engineering, which implements the ICT-INOV project, is in the town of Volos, enrolls over 1.000 students, and employs 30 instructors.

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5.1.2 Organizational current practices on building innovation skills in ICT

European policies inspire initiatives and practices for building innovation skills in ICT in education, specifically the Education and Training initiative [22, 23], Modernization of Higher Education [24], Access, Retention and Employability [25], Digital Agenda for Europe [26], and A European Commission Strategy for Youth Investing and Empowerment [27].

The Education and Training initiative (2010)[23] underlines the need for quality and efficiency in education, adopting emerging pedagogies, integration of digital technologies in both teaching and learning, and fostering creativity and innovation. Furthermore, it underscores the importance of higher education for promoting equity, social cohesion and active citizenship. The University of Thessaly follows the initiative's guidelines by adopting innovative learning design, such as active, problem-based, explorative, collaborative and experiential learning supported by digital technologies. These approaches aim to develop the learning-to-learn capacity of students through educational delivery methods that include blended learning, project-based approaches, study visits and student exchanges with other universities in Europe.

The Modernisation of Higher Education (2017)[24] and Access, Retention and Employability initiatives (2014) [25] stress the importance of ensuring that educational initiatives take into account industry and societal challenges. It further highlights the importance for skills reinforcement for growth, employment and well-being. Finally, it recognizes the need for continuous upgrading of educators' skills as a means for career development and quality of education assurance as a result of highly trained human capital. On the other hand, the European Commission Strategy for Youth Investing and Empowerment (2009)[27] focuses on building knowledge and skills to fight unemployment and promote innovation, competitiveness and social fairness. The University of Thessaly, as the only higher education institution in area, has developed close working relationships with regional authorities, municipalities, professional

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associations and educational organizations to ensure that educational initiatives benefit the community. All 5-year undergraduate programs of the university have been updated for developing engineering, educational, managerial and entrepreneurial skills more responsive to industry demands.

The Digital Agenda for Europe (2010) [26] promotes bringing education to the digital age and bridging the digital gap by developing the capacity of all individuals to use digital services at work and in everyday life. The University of Thessaly continuously upgrades digital infrastructures aiming at enriching student educational experiences through enriched interactivity and virtual exploration and experimentation. Digital infrastructure development is supported by national and European funds that the university pursues competitively for upgrading facilities in all departments. The digital competencies built by students are highly demanded by industry and society.

Beyond adopting European policies and strategies for innovation, the University of Thessaly, acting as an innovation pole in the region of Thessaly, has established a Unit for Innovation and Entrepreneurship aiming to support students in developing innovation capacity. The unit offers courses on entrepreneurship, encouraging students, researchers and research groups to think innovatively and work in teams in real-world problems. To achieve that, unit courses are at least partly taught by regional entrepreneurs. Furthermore, the unit has relevant expertise in social entrepreneurship and innovation towards addressing social challenges and has supported several related initiatives [28].

At the department level, the Creative Technologies Learning Lab research group of the Department of Electrical and Computer Engineering focuses on integrating emerging pedagogies and digital technologies for creating effective and rewarding experiences targeting diverse groups. The team focuses on the deployment of emerging learning design, including active and

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problem-based learning, as well as design thinking. The group collaborates internationally with organizations with similar visions and missions towards designing and implementing technology-enhanced learning initiatives. The group leads the teaching of courses that are heavily based on active learning, such as Game Design and Software Engineering. The group also aims to introduce a new course on design thinking in the near future, also exploiting the experience developed through the ICT-INOV project.

5.1.3 Courses in which early adoption of innovation-building practices will be validated

Following are examples of courses in which the ICT-INOV gamified designing thinking methodology for building innovation skills will be applied in an initial step. These courses will be followed by more as the project implementation progresses.

5.1.3.1 Educational Technologies

The Education Technologies course is an elective in the formal curriculum of the Department of Electrical and Computer Engineering of the University of Thessaly. The course is delivered in the 4th year of studies and is attended by approximately 120 students each year. The course focuses on the deployment of technology as an educational tool in lifelong learning contexts that target the needs of specific groups, including school learners, higher education students, adult learners, vocational learners, professionals and others. The course analyses traditional and emerging learning methodologies, including collaborative learning, active learning, mobile learning, problem-based learning, project-based learning, game-based learning and more. It focuses on how technology, and most importantly, information technology, can be combined with emerging pedagogies to enhance learning processes and experiences in formal, informal and non-formal learning. The course focuses on how technology can contribute, in combination with pedagogical

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models, towards developing basic, transversal skills, including analytical thinking, critical thinking, entrepreneurial thinking, problem-solving, the ability to work in a team, and more.

Upon completion of the course, students understand emerging learning pedagogies. They have been exposed to a rich collection of digital tools and services that can enrich educational experiences. They have been exposed to research topics related to educational technologies. And they have the capacity to present to wide audiences the benefits of technology-enhanced learning solutions.

The course already touches upon aspects of design thinking. Students develop an understanding of the need to design human-centered solutions that address real, as opposed to perceived, needs. Students are exposed to the design thinking principles of empathy, problem-statement definition, ideation, prototyping, and evaluation to ensure that solutions more accurately address end-user needs. Design thinking will be further promoted in the course. Students will be challenged to deploy design thinking principles in the context of projects in which they design technological solutions that address the learning needs of diverse groups ranging from school to higher, vocational, and professional education.

5.1.3.2 Game Design for Engineers

The Game Design for Engineers course aims to develop knowledge and skills in understanding, analysing, designing, developing, and evaluating digital games. The course is an elective in the 4th year of studies. It is attended by 100 individuals each year.

The course helps students understand concepts and methods for designing and implementing learning games. It develops the capacity of students to apply methods and procedures related to game concept design, game design, game implementation, and game evaluation. And it exposes students to research topics related to the design and implementation of digital games.

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The course contains theoretical and practical parts. Participants understand the concepts, methods, and good practices of designing and developing learning games in the theoretical part. In the practical part, students apply the theory to design and implement a learning game in a digital programming environment, typically UNITY. Students understand the principles and good practices that govern game worlds, characters, narrative, mechanics, dynamics, puzzles, levels, balancing, player creativity, online collaboration and more.

Upon completion of the course, students can understand concepts and apply practices for designing, implementing, deploying, and evaluating digital games.

The course is heavily collaborative, with students working in groups towards game design and development. It has an inherent and very significant design component. Students start the course by designing a game concept, which they subsequently develop into a full game design document that is the basis for the software implementation of the game. The course challenges students to develop a game that addresses specific interests of their choice, ranging from entertainment to art, business, health, well-being, education and more. In this context, design thinking will greatly contribute to the course. It will allow students to deploy human-centered design, challenge their perceptions of user needs, and brainstorm to introduce a game that best meets the identified goals. Design thinking will be applied throughout the course, from game design to game implementation and evaluation.

5.1.3.3 Serious Games

The Serious Games course aims to develop knowledge and skills in understanding, analysing, designing, developing, and evaluating learning games. The course has a specific focus on serious games, namely games that have been designed and implemented from the beginning for educational purposes. The course is offered in the Master's program on Applied Informatics, which targets professionals with a background other than information technology, such as

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educators, military personnel, and others who wish to complete an information technology degree to complement their diverse backgrounds. The course is attended by approximately 30 individuals each year.

The course's objectives are similar to the ones of the Game Design for Engineers offering. It further builds familiarity with pedagogical methods that govern learning games, such as active learning, problem-centered learning, collaborative learning, and learning through experience. They further build an understanding of how to link game objectives to learning goals and evaluate the knowledge developed among users through the game.

The course has a theoretical and practical component. Students develop their understanding of emerging learning design linked to serious games in the theoretical component, such as active, experiential, explorative, and collaborative learning. They further understand how to link game design to learning goals in the context of learning games. And they build skills that enable them to evaluate the learning benefits of learning games. In the practical part of the course, students design and implement a learning game. In this course, students may elect to build a digital or a board game. In both cases, students apply the same game design principles. The difference between digital and board prototypes is simply in the medium of implementation.

Upon completion of the course, students are familiar with emerging pedagogical design. They further understand game design concepts and can apply best practices for designing, implementing, and evaluating digital and non-digital games. They are further exposed to research topics related to game design. And they can present to wide audiences concepts related to game design for learning.

The course is highly collaborative. Students will benefit from design thinking principles applied in educational contexts for designing learning initiatives supported by digital technology for best

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addressing the learning needs of specific target groups ranging from school to higher, vocational, and professional education. Design thinking will be applied throughout the course.

5.1.3.4 Software Engineering

The Software Engineering course develops knowledge and skills in software design, implementation, and validation. The course is an elective in the 4th year of the Department of Electrical and Computer Engineering studies. It is attended by approximately 70 individuals each year. The course is also offered in the Master's program in Computer Engineering, which targets information technology professionals who wish to gain additional specialisation in their professional expertise.

The course has a theoretical and a practical component. In the theoretical component, the course develops knowledge of software requirements definitions, software architecture design, software validation, object-oriented design, software modelling, agile design principles, software safety, software security, component-based design, service-based design, and more. In the practical component, the course challenges students to deploy theoretical knowledge towards designing and implementing a software tool by going through all stages of the software development process. Students have the option of implementing their projects in the programming language of their choice. The course does not test programming skills; instead, it tests students' capacity to manage software implementation activities.

Upon completion of the course, students understand concepts and apply good practices related to user needs analysis, system design, architectural design, implementation, evaluation, software development approaches and advanced issues such as safety and security engineering.

The course is heavily project-based and collaborative. Students design and develop the software of their choice in groups and present the results to their peers. The course has a strong design element. For this reason, it will benefit significantly from design thinking principles that help

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students more accurately define user requirements, brainstorm effectively, and validate their products in conditions that simulate real-life. Design thinking will be deployed throughout the course, starting with problem discovery, requirements analysis, design, implementation, and validation of software solutions addressing real-world needs.

5.1.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

Design thinking can be deployed in a wide range of courses that are part of the undergraduate and graduate curriculum in the Department of Electrical and Computer Engineering that focuses on human-centered solutions, introduce design principles, and are project-based.

5.1.4.1 Design Thinking

A new Design Thinking course has been added to the Department of Electrical and Computer Engineering. The course will be an elective in the 4th year of students and is expected to be attended by over 100 students each year. The course is pursued by developing students' design skills, which are necessary for engineering principles. The course, which is planned to take place for the first time in the fall 2022 semester, will be influenced by the research conducted in the ICT-INOV project. The course will focus on both theory and practice. It will be heavily project-based and will aim at building innovation capacity through challenges inspired by real-world problems and introduced either by the educator or external stakeholders to which students will be challenged to introduce innovative solutions by following design thinking principles that help introduce solutions to challenging problems even when none appears to exist at first glance [29].

Upon completion of the course, students will understand design thinking concepts and implementation steps. They will further be able to deploy design thinking practices on problem

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discovery, problem-statement definition, ideation, prototyping and evaluation towards designing innovative solutions that address the needs of diverse groups.

5.1.4.2 Special Subjects

Special Subjects is an elective course in 3rd, 4th, and 5th year of studies in the Department of Electrical and Computer Engineering. In fact, students can work on 2 special subjects. Students work as individuals or in teams on a semester-long project. They identify a problem of interest in collaboration with their educators, research needs, design, implement and evaluate a solution. Finally, they present their work. Given the focus of the projects on solution design, student work can benefit from the deployment of design thinking approaches that help them introduce solutions that better address user needs.

5.1.4.3 Diploma Thesis

The final requirement for receiving a Bachelor's degree from the Department of Electrical and Computer Engineering is to work on a thesis project. The project is semester-long. In terms of workload, the project corresponds to 5 courses. In this sense, this is a significant activity that challenges students to perform research and development work. A good thesis project is based on theory and challenges students to integrate knowledge from diverse courses in the curriculum to design and implement an innovative solution. Design thinking can help students better understand the parameters of the problem in focus, analyse needs, ideate, synthesize ideas and evaluate prototypes.

5.1.5 Description of the design thinking lab and examples of use

As the University of Thessaly is a European partner, no design-thinking lab will be established through the ICT-INOV project. Rather, the already existing laboratories and equipment of the Department of Electrical and Computer Engineering will be deployed for building innovation skills.

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The Department of Electrical and Computer Engineering relocated at the beginning of the running academic year to a new building with modern facilities and infrastructures. The department has 1 computer lab that can accommodate 50 students, an electronics lab, and an energy lab. In the computer lab, equipment is installed in rows. This is also the case for the electronics lab, where equipment is placed on workbenches. This setup does not particularly facilitate collaborative learning. However, this challenge will be overcome by allowing students that work in teams to be closely located in the lab space during practical activities.


Figure 5. The computer and electronics labs at the Department of Electrical and Computer Engineering of the University of Thessaly.

The labs are heavily deployed in various courses, ranging from programming to energy, networks, hardware, and electrical infrastructure design. They will also be deployed in the context of ICT-INOV for implementing practical, hands-on activities. As an example of typical use, the labs are deployed during the Game Design for Engineers course. The course starts with students using the computer labs in groups to complete tutorials through which they develop a basic understanding of game development environments, such as UNITY. This process lasts for a few weeks. Subsequently, students use the lab to directly implement a digital game in groups. Students are encouraged to work at least part of the time in the lab, as opposed to their personal computer at

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home, to promote group work and receive appropriate support from educators and tutors present in the lab. Upon completing their work, students are encouraged to present their outcomes to the benefit of the entire class and receive feedback from their peers and the educator.

5.1.6 Plans for the wide deployment of gamified design thinking for building innovation skills at UTH

The integration of active learning activities into teaching strategies and programmes at the University of Thessaly, and specifically the Department of Electrical and Computer Engineering, for promoting the development of innovation skills is still not sufficiently implemented. Design thinking, active learning and problem-based learning are not explicitly discussed in the organisation's strategic documents. The implementation of ICT-INOV will support the University of Thessaly's strategic plan implementation. These methodologies can offer significant benefits in engineering education, contributing to the delivery of quality education that builds skills needed in society and the workplace, both at national and international levels.

Several steps will be implemented to promote the deployment of design thinking and active and problem-based learning at the Engineering School of the University of Thessaly. These include:

- The initial pilot use of design thinking in 5 courses as described above. The experience from this early deployment will inform the broader deployment of gamified design thinking in subsequent stages, with a target of deployment in at least 10 courses by January 2024
- The establishment of good practice guidelines for the broader deployment of design thinking in educational activities. These guidelines will integrate piloting phase experiences to facilitate the seamless integration of design thinking in already existing instructional practices

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- Educator training on design thinking through a series of events that will take place either face-to-face or virtually and will expose faculty members and supporting staff to principles related to human-centered design
- Wider deployment in courses at the Department of Electrical and Computer Engineering during the 2nd half of the project implementation period
- Educator training and community building in other departments of the Engineering School of the University of Thessaly and other universities in Greece for the wider deployment of the proposed learning intervention in engineering higher education

5.2 Partner 2: Porto Polytechnic (PP)

5.2.1 Partner description

Porto Polytechnic is ranked 4th among Portuguese higher education institutions. It is ranked 5th in terms of student enrolment, with approximately 20.000 students actively engaged in various programs. Porto Polytechnic includes in its organogram the School of Engineering (ISEP), an education and research pioneer in Engineering since 1852. Over 6.000 students are enrolled in ISEP. As future engineers, they are actively engaged in designing creative solutions for present or upcoming challenges at the global level.

5.2.2 Organizational current practices on building innovation skills in ICT

Porto Polytechnic statutes promote knowledge development through diversified learning experiences, applied research and exposure to simulated or real professional situations that contribute to the acquisition of innovation skills. The Polytechnic´s statutes also include a reference to the need to implement strategies that lead to improvement of teaching practices in a manner that supports educators in effectively conveying concepts. These objectives, defined at a high level in the Porto Polytechnic vision, are passed on to the schools and special units that

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form the Polytechnic. The special unit that is more directly related to active learning practices is the Porto Design Factory (now PORTIC), a unit that provides education for non-academic degrees, mostly at the post-graduate level, through design thinking. Characteristic learning offerings include a post-graduate program in Product Development and another in Maker!® innovation. Porto Design Factory is a laboratory of ideas based on interdisciplinary work, applied research and industrial collaboration. Students from very different areas cooperate in developing innovative projects with the ambition to promote enterprising. The Porto Design Factory is part of the Design Factory Global Network (DFGN), which is comprised of 20 institutions from 4 continents. This network allows students and teaching staff from different schools to exchange, share knowledge, and cooperate.

The Engineering School of the Porto Polytechnic has a Development Plan for the period 2019 – 2022. The plan includes directives for implementing actions that promote the systematic adoption of active learning methodologies that allows students to acquire transversal competencies needed for their professional future, including innovation skills. The effective implementation of emerging learning methodologies is the programme director's responsibility, who a group of professors supports that he/she nominates.

The GILT (Games, Interaction and Learning Technologies) R&D group focuses on educational technologies and their application in innovative pedagogical methodologies. This mission is integrated with post-graduate programmes at the Master's and PhD levels, instigating students to learn proactively in teams that design, develop and test ongoing projects. In emphasizing the relevance of collaboration, GILT is also part of leading international projects and joint initiatives with other academic and commercial institutions that promote innovations in the education field. Internally, GILT is the promoter and supporter of several game-based learning and gamification approaches.

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5.2.3 Courses in which early adoption of innovation-building practices will be validated

In the early validation phases of the ICT-INOV methodology, the proposed gamified design thinking learning design will be implemented in the School of Engineering due to its experience in deploying active learning methodologies, including problem-based learning. In particular, the Computer Engineering Department will be the one with the most courses using design thinking in the early phase. The methodology will be deployed in specific lab courses. It will also be deployed in the Master's programme that is predominantly taught using active learning methodologies.

5.2.3.1 Serious Games

This course introduces games and serious games as paradigms of graphics and multimedia applications. It is taught in the Master's program in Computer Engineering program of the School of Engineering of Porto Polytechnic. The course introduces students to concepts and practices necessary to understand, analyse, design, develop, test and evaluate games and serious games. At the beginning of the course, students start by evaluating existing serious games, following a predetermined evaluation method that they adjust to the game in focus. They present their findings, highlighting through their contributions serious game concepts. Subsequently, students form small teams of 2 - 3 members to design, develop and evaluate a serious game, following the entire implementation cycle from concept to tested product. Students present their final solutions to the class. They further complete a group evaluation where every team member's contribution is assessed.

Upon completion of this course students can understand and implement concepts, methods and processes for game idealization, design, and development. They understand, identify, and compare concepts, techniques and processes for serious game idealization, design, and development. They can select, use, and evaluate specific environments and tools for game and serious game development. They can conceive, design, implement, test, and evaluate a serious

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game. Students develop other competencies related to project planning and execution, team forming and leading, decision-making, and problem-solving and final product presentation.

5.2.3.2 Multimedia Applications Architecture

This course provides the knowledge and competencies related to specific Graphics and Multimedia Systems software development methodologies and their practical application. The course is taught in the Master's program in Computer Engineering of the School of Engineering of Porto Polytechnic. Upon completion of the course, students can understand concepts and apply the technologies related to manipulating multimedia information, including the production, transmission, storage, standardization, integration, synchronization, and protection of that information. They can apply methods and processes for multimedia design and development. They can analyse and use tools, APIs and technologies for multimedia development. They can explore and use development environments for multimedia applications. And they can develop a multimedia project using specific tools.

This course follows flipped classroom and project-based learning strategies towards designing, developing and evaluating multimedia applications. Material for the theoretical lectures is prepared and given to students beforehand. Classes are used to discuss this content and establish associations with practical implementation. Students are asked to conceive, design, develop and evaluate a multimedia application using specific tools using the theoretical knowledge developed in lectures. Over 8 weeks, students investigate users' needs, identify suitable technologies, and apply appropriate development methods to create a prototype system. The project-based learning approach challenges the students to think about what data they need to capture and how they will analyse the data and infer conclusions for improving their prototype.

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5.2.3.3 Multimedia Authoring and Development

Multimedia Authoring and Development course is focused on multimedia applications using the most common methodologies and technologies. The course is taught in the Master's program in Computer Engineering of the School of Engineering of Porto Polytechnic. The course covers topics such as requirements analysis and management, examples related to specific multimedia areas, quality assurance and testing. Students are presented with the methodological process of conceiving, designing, developing, testing, and evaluating a multimedia application using an authoring tool and agile, rapid prototyping development methods. Students are asked to develop an efficient multimedia approach to solve a problem. They work in groups. The solution of each group is discussed with the whole class. The teacher presents some potential improvements. Subsequently, students use an agile development method to create a prototype that is demonstrated again to the class. Class members assume the role of potential users to evaluate the functionality and usability of the solution.

Upon completion of the course, students can engage in analysis and design, programming and testing, video and audio processing. They understand and can use agile methodologies for software development. They can apply the principles and steps of multimedia design methodologies. They can analyse and understand the specific requirements of design and multimedia authoring. They can apply a project methodology in multimedia design and the development of collaborative or individual projects. They can create elements from various media. And they can evaluate and apply effectively authoring tools and multimedia design suitable for a particular project.

5.2.3.4 Advanced Graphical Applications

This course integrates a set of technologies and development techniques in computer systems and multimedia to develop advanced innovative applications. The course is taught in the Master's

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program in Computer Engineering of the School of Engineering of Porto Polytechnic. It presents advanced concepts and prepares students for working in professional environments. The class is divided into 2 groups that are assigned the same project. Each group, alpha, beta, and pilot tests the solution of the other. The groups then follow a complete agile development approach with 2-week sprint cycles. This active learning methodology allows students to incorporate professional development skills to prepare for their future work lives as software engineers.

Upon completion of the course, students can understand the most common applications and business models of multimedia technologies. They can apply a project methodology effectively in multimedia design and developing a new product. They can present a business plan for a new product/ or to a set of investors. They can use the most common applications and business and business models of multimedia technologies. They can analyse problems, adopting engineering science and best practice. They can evaluate different approaches to solving problems by adopting appropriate engineering sciences and best practices. They can design a solution to a problem by adopting relevant engineering science and best practices. They can lead the developing process of a product or system supported by multidisciplinary teams. They can document processes and results, adopting appropriate engineering science and best practices. And they can evaluate the designed and implemented solution by applying appropriate methodologies.

5.2.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

In a later stage, design-thinking will be extended to other programmes in the School of Engineering and other schools.

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5.2.4.1 Interaction and Graphical Systems

Computer graphics, both 2D and 3D, and Human-Computer Interaction are very important areas of Computer Science, with applications in several human activity domains such as education, medicine, scientific data visualization, computer-aided design (CAD), geographic information systems (GIS) and entertainment (movies, videogames, etc.). The course is taught in the Bachelor's program in Computer Engineering of the School of Engineering of Porto Polytechnic. This course is part of the 3rd year, 1st semester of Informatics Engineering. It is an intermediate-level unit. It aims to establish a solid foundation for more advanced study of specific topics in the scientific area of Computer Science.

Upon completing the course, students can understand the fundamental role that interaction processes between human beings and machines play in the success of informatics applications. They can understand the growing importance of computer graphics in many human activities. They are familiar with concepts related to computer graphics and interaction. They have developed the necessary knowledge to develop interactive 3D graphics systems with OpenGL or any other API. They can analyse, evaluate, and create interactive graphics systems. They can apply standard graphics development tools. They can work in teams, prepare reports, prepare presentations and defend a project to an evaluation jury.

5.2.4.2 Laboratory Project I, II, III, IV, V

This set of 5 courses integrates the knowledge of earlier courses into a complex project paying special attention to the subjects taught in the same semester courses. The course is taught in the Bachelor's program in Computer Engineering of the School of Engineering of Porto Polytechnic. Students exercise their implementation skills and teamwork, realizing an integrated project of significant complexity. They work in teams simulating how projects are implemented in business. Teams develop a software system composed of several applications based on an open

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specification published in a request for proposals. Through course activities, students become aware that a software system is more than one application. It is a collection of different elements, including, for example, a database engine, several applications, a web server, etc., most of the time running in heterogeneous environments and hardware. Students practice iterative development methods and processes as well as project management techniques.

5.2.4.3 Electrical Engineering Project

Engineering study must include activities that help develop soft skills that allow engineers to build integrated work in teams with appropriate working methodologies. The course is taught in the Bachelor's program in Computer Engineering of the School of Engineering of Porto Polytechnic. The course develops soft skills that students will use throughout the curriculum and in the future in their professional roles. The course is taught in the 1st year, 1st semester. The objectives of the course are to integrate newly admitted students into the environment of ISEP and the Department of Electrotechnical Engineering, to make known the regulations and services available at ISEP, such as email, portal, Moodle®, library, and more, to convey important concepts such as ethics and plagiarism, to develop soft skills relevant for the activity of an engineer, including teamwork, project and work management, reporting, communication, research methods, organization and synthesis of information, etc. and to empower students to soft skills in the scientific discussion of a theme related to the course.

5.2.4.4 Integrated Project

This is an aggregative project that is obligatory for completing a degree. It integrates knowledge and skills acquired in the other courses of the curriculum. The course is taught in the Bachelor's program in Computer Engineering of the School of Engineering of Porto Polytechnic. To engage in this project, students must have completed courses across different areas of Engineering to obtain the required knowledge and the foundations required for its implementation. The project

can be developed in a group of 2 students supervised by an ISEP teacher or conducted in a company with the guidance of an ISEP teacher and a company supervisor. The project aims at immersing students in a team, exposing them to a specific problem inspired by real-life encouraging them to apply and synthesize knowledge from diverse domains to create added value. The course aims at complementing the foundational knowledge with soft skills, such as communication capacity, autonomy, and teamwork. A broad range of topics may be addressed by student projects, such as project planning and management, environment and safety, quality management and topics related to Civil Engineering, such as building physics, geotechnics hydraulics and road construction.

5.2.4.5 Social Network Management

This course aims to raise awareness of online communication's growing importance, describing the importance of two-way vs one-way communication and developing critical attitudes in the production and management of on-line content. The course is taught in the Bachelor's program in Communication of the School of Management of Porto Polytechnic. The course allows its participants to become familiar with tools used in managing current social networks, possibly used in their workplaces. During the course, students are exposed to active and problem-based learning in the context of a team project. Students first familiarize themselves with resources provided by the teacher related to a specific problem. Each team selects a problem and discusses potential solutions in the form of a media campaign. Subsequently, the teams choose the most appropriate social media tool and used it to address the given problem. Finally, the teams analyse their results and present them to the entire class.

5.2.4.6 Management of Research Projects

Technical project management skills related to managing the scope, time, risks, communication, and quality of a project have been developed for 50 years and are currently recognized as useful

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for planning and managing projects or programs that people or organizations develop in business. The course is taught in the Master's program in Communication of the School of Health of Porto Polytechnic. The importance of project management for generating knowledge, designing solutions, developing new products, introducing innovation, and earning a competitive advantage is globally recognized. During this course, students increase their knowledge of critical areas of project management, management methodologies and tools and technical and behavioural skills that a project manager must mobilize to implement a project successfully. Based on a case study, students develop a project plan, a useful planning tool at any stage of a Master's or PhD program. In parallel, students discuss various issues related to the success of a project in a dedicated space.

5.2.5 Description of the design thinking lab and examples of use

The Computer Engineering Department currently enrolls approximately 1.200 students. An existing lab will be reorganized for design thinking practices. Approximately 250 students will benefit from this lab, which will be available for 8 different courses per year and the 12 teachers involved in those courses. Collaboration with the Porto Design Factory will also be sought.

The lab to be used in the context of ICT-INOV is Laboratório Multimédia (LAMU), a laboratory jointly owned by the Computer Engineering Department and GILT. The lab will be upgraded in terms of new equipment, such as AR and VR units and new development systems, furniture and layout that will be adjusted to accommodate active learning and design thinking. The lab will be used mainly for the Master's in Computer Engineering programme. It will support teaching activities and autonomous student work on ongoing projects or theses.

The course on Multimedia Applications Architecture taught in the Master's in Computer Engineering programme of the School of Engineering of the Porto Polytechnic will be used as an example for the implementation of ICT-INOV methodologies as the course focuses on the design and development of multimedia applications. Design thinking methodologies will enrich the

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course through ideation, design, prototyping and testing in the context of projects. In this course, students are challenged to conceive, design, develop and evaluate a multimedia application using specific tools. Over 8 weeks, students investigate the users' needs, identify suitable technologies, and apply appropriate development methods to create a prototype system. Project-based learning design challenges students to consider what data they need to collect and how they will analyse the data to infer conclusions for improving their prototype.

5.2.6 Plans for the wide deployment of gamified design thinking for building innovation skills at PP

The integration of activities for building innovation skills is not sufficiently implemented in teaching strategies and programmes at Porto Polytechnic. A high-level innovation strategy exists, however it has yet to be systematized in the different schools and programmes.

The implementation of ICT-INOV will support the implementation of the university's innovation strategy plan initially in the School of Engineering and subsequently in other schools. It will enable educators to adopt emerging teaching and learning practices and be the promoters of innovation skills building considering students' individual needs, experience, knowledge, and abilities. This innovation strategy plan implementation is supported by digital tools that improve, in addition to the innovation capacity of learners, digital competencies that have become increasingly relevant in recent years due to the COVID-19 pandemic. The university's strategic development plan, therefore, addresses the acknowledged importance of both factors, digital literacy, and innovation skills, as drivers of an enriched personal and professional life.

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5.3 Partner 3: Tallinn University (TLU)

5.3.1 Partner description

Tallinn University is the 3rd largest university in Estonia. A total of over 8.500 students are enrolled in the university in humanities, social sciences, engineering sciences, teacher training and educational research. In addition, applied research is conducted in the fields of fine arts, educational technology, health, and social sciences.

5.3.2 Organizational current practices on building innovation skills in ICT

Tallinn University is the 3rd largest university in Estonia but the biggest one in humanities. ICT is taught at the School of Digital Technologies (DTI) and Haapsalu College. The School of Digital Technologies offers several ICT-related programs. On the Bachelor level, it offers a Computer Science program. On the PhD level, it offers a path to Information Society Technologies. On the Master's level it offers Open Society Technologies, Digital Learning Games, Human-Computer Interaction, Educational Technology, Teacher of Computer Science, Information and Knowledge Management and Management of Information Technology. These programs integrate ICT learning to various degrees. Some offered courses are common in several programs. Haapsalu College offers only one educational program, namely Applied Computer Science.

Following is a description of innovation activities in various Tallinn University programs.

The Management and Information Technology curriculum previously included a course on Innovation Technologies. Later, innovation activities were integrated into the curriculum, mostly in courses related to educational technologies, which have since been eliminated from the program. Today, students are mostly exposed to innovation in the IT Strategic Management course, in which students must develop a real IT strategy for a company. The course involves both theoretical and practical parts. The theoretical part includes planning and implementation of

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innovation as a specific, separate topic that addresses concepts related to the definition of innovation, phases of innovation, innovation models, activities supporting innovation and more. In the same curriculum, innovation is also discussed in the courses Introduction to Specialty, in which one of the topics is IT development trends and IT infrastructure development.

In the Computer Science and Applied Computer Science curricula, the latter of which is delivered by Haapsalu College, innovation skills are not developed in a dedicated course. Rather, related activities are part of several subjects. Innovation skills are particularly developed in practical courses in which students are challenged to design solutions.

The Digital Learning Games aims at developing the skills of true gaming and education professionals who know how to integrate pedagogical models, ICT and design knowledge with modern information and communications technology by using innovative educational tools that support learning and creation. Innovation is part of the International Perspectives on Digital Innovations in Schools course.

The objective of the Educational Technology curriculum is to support the development of specialists with knowledge and competencies in educational technology. Participants build their capacity to, together with other stakeholders in their future working places and by involving practice communities in the field, implement, develop, and support effective learning-management and knowledge-building solutions that deploy digital technologies. The solutions designed by participants support organizations in creating, practicing, and leading innovative, learner-centered, and inclusive learning cultures. Students enrolled in the curriculum learn to apply scientific methods and educational technology tools to analyze learning processes and learning environments, evaluate learners´ development and support educational technology innovation. They also build the capacity to deploy innovative hardware and software in their learning design solutions. The curriculum includes a course titled Design of Innovative Learning

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Process that aims to support the shaping of the knowledge and competencies needed for adopting educational technologies. The course further aims at creating innovative learning processes and resources. It prepares students to participate in an interdisciplinary project focusing on innovative learning design. The curriculum also includes a course on Digital Learning Games: International Perspectives on Digital Innovations in Schools, in which innovation skills are also promoted.

The Teacher of Computer Science curriculum aims at developing specialists with knowledge and competencies in educational technology, who can, together with other stakeholders in their future working environment and by involving practice communities in the field, implement, develop, and support effective learning-management and knowledge-building solutions deploying digital technologies for organizations, and create, practice, and lead innovative, learner-centered, and inclusive learning cultures.

Finally, in the Information and Knowledge Management curriculum, innovation skills are pursued in the Information Environment for Innovations course. In the Human-Computer Interaction curriculum, it is pursued in the Civil Society and Social Innovations course. The Open Society Technologies curriculum aims to build student knowledge and skills for designing and developing software solutions to support innovation in an open society is practiced in courses related to governance.

5.3.3 Courses in which early adoption of innovation-building practices will be validated

5.3.3.1 Value Creation in Software Development and Practice of Multimedia

Currently, there is no systematic discussion of design thinking in any course. This demonstrates that the ICT-INOV project offers opportunities for enriching learning experiences. Good examples of courses in which the proposed gamified design thinking approach will be integrated at an early

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phase include Value Creation in Software Development and Practice of Multimedia, in which students develop games. Design thinking will offer advantages in synthesizing solutions that better address the needs and interests of end users.

5.3.3.2 Design Thinking and Generative Research

This course, which is part of the Human-Computer Interaction and Social Entrepreneurship curricula, offers opportunities for the early validation of ICT-INOV gamified design thinking approaches. The course aims to help students gain a deeper understanding of the problems they would like to design solutions for. Students are provided with the tools necessary to look critically at the world and identify opportunities for solutions and innovation. By exploring, recording, and understanding individuals' actions, thoughts, and feelings, students reach solidly framed problem statements that can be used as input for prototyping. The course has 3 main parts: the background, in which students are exposed to underlying principles of generative research, the methods, in which students learn how to use relevant generative research tools and techniques and the procedure, in which they learn how to plan, gather, document, analyse, and communicate the collected data. Innovation can be practiced in all project parts through in-class and lab activities.

5.3.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

5.3.4.1 Civil Society, Social Innovation, and Governance for Responsible Innovation

The Open Society Technologies curriculum develops student understanding of the role of ICT and innovation in ensuring the competitiveness and sustainability of organizations. Students build knowledge on basic concepts and theories related to innovation and innovation management and can apply them in developing new software solutions. Innovation skill development can be

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pursued in Civil Society, Social Innovation, Governance for Responsible Innovation, and e-Governance for Responsible Innovation courses. This demonstrates that design thinking can be deployed not only towards technical subjects but in a broad range of themes related to business and social issues.

5.3.4.2 Integrated Design

Tallinn University is developing a university-wide course titled Integrated Design in collaboration with international partners. The course integrates design thinking, gamification, sustainability, circular economy, and entrepreneurial skills. Course design will be completed in 2021. It will be available to students in 2022 as an elective.

5.3.5 Description of the design thinking lab and examples of use

As the European partner, Tallinn University will use existing labs to develop innovation skills in the context of the ICT-INOV project. Tallinn University has several labs equipped with cutting-edge technology to support student creativity and teamwork.

The Interaction Design Lab is a research, design and innovation unit contributing towards the development of knowledge and skills in the field of Interaction Design.

The Software Development Lab aims at supporting the exploration of state-of-the-art software development approaches. The lab offers the expertise and resources necessary for implementing existing designs as functional prototypes, exploring new algorithms, and deploying enabling technologies that build applications and services. The lab supports students working on their on-going study projects or thesis-related topics, teams engaged in research projects and industry partners wanting to explore specific software development-related challenges.

The Technology Lab supports teaching processes by providing necessary know-how and technical equipment for implementing projects in the field of robotics, the internet of things and

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automatization. The lab also provides instructor support and working space for organizations and individuals interested in developing prototype solutions in these fields. The lab supports teachers and students in their projects and is ready to play a supportive role in developing research projects by teams that might need its resources.

The Game Lab is a meeting place for students who are interested in developing games. It offers facilities for meetings and workshops and high-end gaming technology, such as the Oculus® Rift VR set.

An example of an ICT-INOV activity that may be implemented in the university's labs is related to the course of Design thinking and Generative research. The practical hands-on activities of the course can be executed in the Tallinn University labs.

5.3.6 Plans for the wide deployment of gamified design thinking for building innovation skills at TLU

Desk research demonstrates that there is a need to build innovation skills at Tallinn University. The methodology and platform developed through ICT-INOV resonate with the university's goals, which are focused on educational innovation. The university's development plan for 2020 - 2022 underlines the importance of enabling teachers and education leaders to make evidence-based decisions on new teaching and learning practices and support them as the leaders of innovation processes in the field of education. The strategic plan aims at strengthening inclusive education and promoting the differentiation of education in accordance with the individual needs of students. This is achieved through evidence-based approaches and critical monitoring of digital innovations in education, contributing to the development of digital competencies of teachers and learners. The university promotes and integrates life-long learning in formal, non-formal and informal education. Educational offerings create links between educational research and practice for implementing educational innovations more efficiently and extensively.

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In addition, the university's development plan highlights the fact that the skill to smartly use the possibilities offered by the digital world, the innovativeness and the underlying creativity grant a competitive advantage to an individual, an institution and the state. In this context, Tallinn University aims to contribute to developing innovative information society solutions and introducing a digital media culture in different areas of life. Adapting to change requires the renewal of politics, governance, institutions, communities, and the legal system. It also calls for innovative socio-economic forms of business and social protection measures. Tallinn University supports the adoption of open governance practices at the state and local government level and offers science-based and innovative solutions to public service, politicians, legal practitioners, enterprises, non-governmental organisations, and citizens in the form of social and political innovation.

The above demonstrates a strong focus on innovation. In this context, the solution provided by the ICT-INOV project is welcome for promoting the organisation's role as a pole for driving development and growth. Almost every university school expects to adopt the proposed methodological learning design.

5.4 Partner 4: European Training and Research Association for a Cooperation Key to Business (EU-Track)

5.4.1 Partner description

EU-Track is a multidisciplinary research and development center focusing on geotechnical engineering, robotics, virtual reality, education-pedagogy, sociology, and science education in STE(A)M. The organization organizes teacher and student training, often supported by digital technologies.

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The innovation strategy of the organization is rooted in the United Nations Sustainable Development Goals (SDGs) [30] [31], which also drive Italy's innovation strategy for 2025. Specifically, the digitization of business, innovation in all aspects of public life and sustainable and ethical development of society as a whole.

5.4.2 Organizational current practices on building innovation skills in ICT

ICT skills are the focus of both internal training that targets staff members and external educational offerings that target broad groups. Innovation is evident in the following practices of EU-Track:

The implementation of research and innovation initiatives on ICT. These activities significantly raise the level of technology of EU-Track and allow collaboration at par with other research centers and universities. The goal is to maximize the benefits of ICT technologies in creating value, supporting development, and protecting the environment in-line with evident social transformation.

Increasing investment in ICT allows the gradual integration of emerging technology that supports innovation in training internally and externally.

Hiring and continuous training for highly qualified human resources help support the organization's increasingly advanced digital transformation. Human resource development, combined with research and innovation in ICT, is fundamental for the organisation's evolution.

5.4.3 Courses in which early adoption of innovation-building practices will be validated

5.4.3.1 EduRobot - Exploring, Creating and Constructing

The training course aims to improve knowledge and skills related to educational robotics. The course is introductory. It focuses on multidisciplinary aspects of educational robotics and covers

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in a simplified way that is appropriate to the educational level of student concepts related to electronics, physics, mechanics, and control. It addresses computational thinking, coding skills and the use of robotics elements. The course gradually turns pure coding skills, for example interacting with sprites in Scratch, into real-world artefacts, such as tangible robots. Through course activities, participants learn how to use several tools, such as micro:bit® and Arduino IDE®.

Activities start with creating robots and continue with theoretical deepening, simulations, and practical exercises. Moreover, participants will explore robotics and programming Scratch®, an object-oriented programming environment developed by MIT Media Lab and similar software for building programming skills, such as Scratch for Arduino®.

The course aims at fostering the growth of scientific-technological culture, promoting the understanding of concepts related to robots and robotics, personalising learning processes, promoting multidisciplinary learning and empowering students to be the builders of their own knowledge.

5.4.3.2 Robotics

The content of the course, based fundamentally on a problem-based learning approach, intends to introduce in a unified manner different aspects of physics, electronics and programming directly related to robotics. During the course, students identify the project or problem they wish to work on. The difficulty of the project varies depending on the age of the students. There are 3 types of robots that students become acquainted with upon completion of the course: a programmable bot like Beebot®, a line-follower, and a couple of constructs remotely controlled through IR and Bluetooth®. This course constitutes an evolution of the earlier EduRobot course. It addresses broad age groups. It presents robotics concepts related to electronics and physics, mechanics, control issues and coding in a manner that is age appropriate for participants. The topics covered in the course are presented through different perspectives allowing the audience

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to develop knowledge on a specific topic holistically. For example, control issues may be presented through electronics, coding, or mechanics examples.

The topics covered by the course include electrons as carriers of electric current, current, potential difference, voltage, the difference between current and voltage, lamps, electric circuit power, switches, pushbuttons, relays, electromagnetism, constructing an electromagnet, DC motors, the optical range of electromagnetic spectra as well as its relation to IR-sensors and control, light-emitting diodes, physical oscillation models, and the analogy between the pendulum and an oscillating circuit.

Topics covered in relation to electronics including breadboards, resistance and Ohm's law, serial and parallel connection of resistors, capacitance, the RC time constant, potentiometer, voltage divider, semiconductors, diodes, diode bridges, diode representation of transistors, LEDs, schematic representation of circuits, pulse-width modulation, sensors, and actuators.

In relation to coding skills development, basic programming concepts are introduced using block coding, or Scratch4Arduino®, Micro Python® for Mirobit, Python® for Arduino®, and Arduino® IDE. The concepts covered are directly related to different aspects of robot functionality. For example, conditionals are introduced in the context of a reaction to a certain sensor activation or calibration. Similarly, infinite loops and loops with counters are directly related to the robot's functionality. Programming a robot at this level doesn't require a lot of effort because work consists of programming sensors, reactions, and movement. But the result, being interdisciplinary and requiring the mastery of different subjects and concepts, has proven to be very attractive and satisfying.

5.4.3.3 Enhancing Student Learning through Research-Based Approaches

This training course aims to engage students in research-based learning approaches. Being the extension of the previously described Robotics course, where the participants are directed

towards a final goal, which is the construction of a robot, the research-based approach aims at enhancing student independence, confidence, and self-management.

Participants are assisted in deepening their knowledge and skills to carry out research work in and outside of the classroom. The encouragement of students to use technological tools promotes the internalisation of concepts and develops the understanding of research methods, such as formulating a precise question or monitoring a research skill.

Research-based learning enhances student capacity to deal with uncertainty. It promotes independence, teamwork and organisational skills. It encourages students to be thoughtful, motivated, collaborative, and innovative, capable of engaging in their own inquiries and thriving in a world of constant change.

The course aims at theoretical deepening. Students work in groups on practical exercises. The course builds student skills in performing research, including formulating and defining a question, planning research activities and specifying methods and tools, undertaking investigations, analysing and interpreting data, reporting and presenting results, implementing, guiding the inquiry process, understanding the analogies between creative processes in artwork production and research, discovering, reasoning and thinking, and understanding the difference between real and virtual experiments.

5.4.3.4 Multimedia Learning Environment on Using New Technologies in Education

The course targets students who intend to deepen and enhance their knowledge of using new technologies in learning contexts through multimedia educational environments. The course focuses on theoretical deepening as well as the development of practical skills by using digital tools such as virtual labs, virtual reality, serious games, digital storytelling, and robotics to support the learning process. Participants receive suggestions on technological tools and methods most appropriate for use and outside the classroom.

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More specifically, the course builds knowledge and skills on the use of multimedia educational environments focusing on specific tools and their features, promoting interactivity in the classroom through approaches such as flipped classrooms, deploying digital tools in learning, including digital whiteboards, virtual classrooms, virtual and augmented reality, structuring an eLearning course, understanding pedagogical implications of using digital technologies in teaching for promoting social inclusion, using the web and mobile applications in learning, deploying serious games and gamification techniques, deploying robotics in scientific subjects and organizing on-line evaluation activities.

A rich collection of digital tools is deployed during the course, including the Oculus® Quest VR platform, Oculus® Mixed Reality Capture; Chroma key, Samsung® Gear VR, Octagon® Studio AR sets, Clevertouch® interactive touchscreen, LEAP® motion controller, robotics artefacts such as Arduino®, and combinations of the above.

5.4.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

5.4.4.1 Engaging Students with Augmented Reality

The development of portable devices has made it possible to create AR applications through which users can manipulate physical objects. AR allows the transition from teacher-centered approaches to more active, participatory, and engaging learning. The training course targets schoolteachers who intend to deepen and improve their knowledge and skills in using VR and AR applications in their teaching.

Through the course, educators deepen their knowledge of how to use digital applications in the classroom and acquire teaching skills through practical activities. The course focuses on theoretical deepening, simulation, and practical exercises.

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More specifically, the course develops the understanding of educators on learning applications of VR and AR tools. It further develops their understanding of technical aspects of AR technology, including the differences between georeferenced AR based on tablets and smartphones and AR for accessing digital content through technology such as QR codes. It builds educator skills on managing digital resources for involving and guiding students, using the Access, Curate, Engage and Share (ACES) framework for integrating technology into learning, identifying and selecting tools for introducing VR and AR experiences in the classroom, integrating AR in diverse curricula subjects, bringing abstract concepts to life through AR, facilitating deeper learning through AR by engaging students and stimulating their curiosity and mastering their skills on fully exploiting the possibilities that AR offers in the classroom.

5.4.4.2 STEM through Arts and Mini-game Design

The course aims at developing STEM skills by establishing connections between art and science.

Starting from a specific example that demonstrates how to combine STEM and art for building knowledge on specific mathematics and science topics, the course deploys mini-game development to make scientific study more attractive and, thus, effective.

The core idea behind the approach is establishing connections between the phenomena observed in nature, such as the Fibonacci series or magnetic field lines, and science theory. Students are encouraged to develop interactive mini games that demonstrate science principles during the course.

5.4.5 Description of the design thinking lab and examples of use

A design thinking lab will be set up at EU-Track. It will promote creativity by exploiting the interactivity introduced by digital technologies for building STEM skills. The lab will allow students

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to work on innovative projects and convert their ideas into tangible prototypes. Lab activities will be aligned with students' educational backgrounds.

An example of expected lab use is deploying robotics towards sustainable development. The activity is structured in 2 parts. The first is dedicated to introducing robotics as a technological innovation tool for improving the quality of work and life in compliance with environmental, economic, ethical, and social sustainability. Examples of robotics tools that promote quality of life will be demonstrated, such as NAO humanoids and Pepper, which help enrich the interaction of children in hospitals or who suffer from diseases in the real world. The second part is dedicated to constructing a small robot using Arduino® and partly recycled material in line with the 2030 Agenda for Sustainable Development objectives. The type of robot to be constructed is defined based on the student's age and background.

Another example of lab use is in the context of learning activities on sound and electromagnetism. Noise and electromagnetic pollution are significant environmental problems, particularly in urban areas, causing the quality-of-life deterioration. The activity focuses on studying and analysing the main characteristics of sound and electromagnetism. Experiments are carried out that build the knowledge and skills of participants in collecting and recording data, analysing it with an oscilloscope, and interpreting it. Participants also build knowledge on the scientific use of sensors.

5.4.6 Plans for the wide deployment of design thinking integrated with gamification for building innovation skills at EU-Track

In the framework of the EU-Track development strategy, an innovation lab will be created as a physical space dedicated to creating, developing, and using ideas. This space will be used for conceiving, implementing, and sharing learning opportunities that build relationships within the organization and with external partners, such as universities, research centers and business companies. The educational space will consist of hardware, software and methodological

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approaches based on design thinking. The combination of these will reinforce competences in engineering, programming, and scientific methodologies such as tinkering. To facilitate knowledge development, the lab will be equipped in the long-term with hardware such as 3D printers, CNC machines, laser cutters and electronic consumables.

5.5 Partner 5: University of Malaya (UM)

5.5.1 Partner description

The University of Malaya is a research university that emphasises innovation and provides high-quality teaching and learning by integrating technology and emerging pedagogies. The university aims at internationalising the academic curriculum by introducing new approaches such as design thinking, gamification and experiential learning.

5.5.2 Organizational current practices on building innovation skills in ICT

The Universiti Malaya teaching practices are tightly linked to the eight domains of learning outcomes set by the Department of Higher Education (DHE), Malaysia. Of those, the Department of Higher Education defines practical and problem-solving skills as key for building innovation capacity. Other competencies, such as entrepreneurial skills, social skills, and responsibility, are indirectly related to fostering innovation. The Universiti Malaya follows the standard for skills development set by the Malaysian Qualifications Agency (MQA) established under the Department of Higher Education. Therefore, methods and practices at the Universiti Malaya for building innovation skills are based on practical and problem-solving skills. These skills are promoted in the faculty's 4 departments, namely Artificial Intelligence, Information Systems, Computer Systems and Technology, Software Engineering, and Library & Information Science. Other faculties also promote the development of these skills to encourage innovation.

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5.5.3 Description of courses in which design thinking integrated with gamification will be deployed in an early phase

5.5.3.1 Agile Software Development

The course is an elective in the 1st semester of the Master in Software Engineering program. The course examines agile methods, including extreme programming (XP), Scrum, lean, Kanban methods, Crystal methods, dynamic systems development methods, and test-driven and feature-driven development to develop student understanding of effective, rapid software implementation processes. The ability of agile development teams to rapidly develop high-quality, customer-valued software is examined and contrasted with teams following more traditional methodologies that emphasize planning and documentation. Students develop knowledge of agile development principles and techniques covering the entire software development process from conception to testing and deployment. Issues of adopting agile methods are also discussed.

5.5.3.2 Project Management

This is a core course taught in the 1st semester of the Degree in Computer Science program. The course introduces fundamentals of management concepts. It further addresses topics on organizational structures, project planning, techniques for project implementation time and cost estimation, risk management, staff management, evaluation of project progress and performance, and project control. This course also covers project audit and closure.

5.5.3.3 Principles of Data Science

This is a core course taught in the 1st and 2nd semesters of the Master in Data Science program. The course helps students understand the field of data science. It covers the “what, when, who, where, why, and how” (5W 1H) of data science in the era of big data. It further encompasses the

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fundamental principles of data science that underlie algorithms, processes, methods, and data-analytic thinking. The role and skills of a data scientist are also presented. Diverse technologies, programming languages, as well as tools in data science, are discussed.

5.5.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

5.5.4.1 Advanced Algorithms

This is a core course taught in the 1st and 2nd semesters of the Master in Computer Science program. The course introduces students to the analysis and design of computer algorithms. Students build knowledge on advanced design techniques, important classical algorithms and data structures, and their implementation in modern programming environments.

5.5.4.2 Analysis and Design

This course is taught in the 2nd semester of the Bachelor in Computer Science program. The course introduces students to the analysis and design of computer algorithms. Students build knowledge of basic design techniques, important classical algorithms and advanced data structures and their implementation in the modern programming environment.

5.5.4.3 Mathematics in Networking

This course is taught in the 1st semester of the Bachelor in Computer Science program. The course covers probability theory, stochastic processes, queuing theory, graph theory and their applications to networking. Topics include random variables, conditional probability, discrete and continuous distribution, Little's theorem, Markov processes, Markov chains, birth-death processes, M/M/1 queue, multi-server queue, and graph theory.

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5.5.4.4 Cognitive Science

The course is an elective in the 2nd semester of the Bachelor in Computer Science - Artificial Intelligence program. The course covers the fundamentals of cognitive science. It addresses topics on mind and machine, perception and object recognition, observation and consciousness, memory, including short-term memory, working and long-term memory, learning, forgetting phenomena and knowledge retrieval, mental representation and visual perception, category and schema, language perception, both verbal and non-verbal, emotion and expression, reasoning, problem solving and decision making, intelligence, and creativity.

5.5.4.5 Fundamentals of Programming

This core course is taught in the 1st and 2nd semesters of the Bachelor in Information Technology and Computer Science programs. The course covers problem-solving and the basics of programming. These include problem-solving techniques, structures for programs, concepts of object-oriented programming, data types and operations, optional control structures, such as conditionals and loops, functions, arrays, strings, text files, and programming practices.

5.5.4.6 Software Modelling

This course is taught in the 1st semester of the Bachelor in Computer Science program. The course covers object-oriented modelling concepts in system analysis and design using Unified Modelling Language (UML). Topics include basic concepts on modelling in system analysis and design, key differences between structured and object-oriented analysis and design, analysis and design of a software system using structural and behavioral, use of an object-oriented case tool to construct various UML diagrams and generate source codes, consistency checking of UML models, and software testing.

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5.5.4.7 Mobile Typography Made Easy

The course is taught in the 1st and 2nd semesters of the Bachelor in Computer Science program. The course offers students practical hands-on experience in creating and styling their mobile typographic content interactively using typographic tools. The key design elements of typography covered are typeface, fonts, line length, leading, kerning, and tracking. In addition, the course also provides students with knowledge of typographic developments in Malaysia.

5.5.4.8 Information Systems Control and Security

This is a core course in the Bachelor's in Information Technology - Multimedia and Bachelor's in Computer Science - Information Systems programs. The course includes 10 components information security and risk management, access control systems and methodology, cryptography, physical and environmental safety, architecture and design of enterprise security systems, business continuity and disaster recovery planning, internet telecommunications, networks and security, application security, operational security and law, investigation, compliance, and ethics.

5.5.4.9 Human-Computer Interaction

This course is taught in the 2nd semester of the Bachelor in Computer Science program. The course covers both human factors and the technical methods for the design and evaluation of interactive systems. It is structured into 4 main topics: an overview of Human-Computer Interaction, essential interaction design principles, user interface development process and interface design and programming. Overview of Human-Computer Interaction introduces humans, computers and interactions, user interfaces, usability, user experience (UX) and design thinking. The interface development process discussion focuses on iterative design, user-centered design, design discovery, design exploration and evaluation of user interfaces. Interface design and programming discussion focus on visual information design, form design, interface design

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patterns, prototyping and construction tools and responsiveness issues. Three types of applications are covered: graphical user interfaces, web, and mobile devices.

5.5.4.10 Real-Time Systems

This course is taught in the 2nd semester of the Bachelor in Computer Science program. The course introduces real-time systems. The course explains the differences between soft and hard real-time systems and discusses issues related to system decomposition and scheduling techniques. These include timed Petri Net, clock-driven scheduling, and priority-driven scheduling of periodic, aperiodic, and sporadic tasks. The course also covers multiprocessor scheduling and resource access control, fault tolerance and real-time communication.

5.5.4.11 User Experience Design Studio

The course is an elective in the Master in Software Engineering program. The course covers advanced topics related to human cognition, psychology, software engineering, formal methods, principles, models, and techniques for representing the user and interactive environment. Development projects use agile and lean methodologies considering universal accessibility for different users ranging from novices to experts, children to elderly and individuals with disabilities. Design and implementation of projects include web user interfaces, mobile user interfaces and other intelligent systems. Design and implementation concepts go beyond user interfaces to include sensors, controls, autonomous vehicles, ubiquitous computing in the context of the internet of things, social data analytics and visualization. Interactive input may involve gestures, voice, eye movement and facial expressions. Evaluation of the implemented human-interactive system deploys techniques such as expert review, heuristics, usability testing, acceptance test, survey, active observation, or control environment. Factors that influence user interface evaluation are related to ethical, societal, and cultural as well as usability goals.

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5.5.5 Description of the design thinking lab and examples of use

The design thinking lab will be integrated with the existing lab set up for active learning by the faculty, named the Technology Enable Learning Space (TEALS).

Currently, the lab contains 7 islands with workstations, 3D printers, Arduino®, Raspberry Pi®, drones, and autonomous cars. The current equipment will be enriched through the ICT-INOV project by adding robotics equipment that will be used in all design thinking steps, from problem discovery to design, prototyping, and evaluation.

Specifically, the equipment that will be added to the lab will be a robot DIY set for teaching and learning that includes:

EQUIPMENT	DEPLOYMENT IN THE PROJECT
Robotics DYI set including sensors, ready robots, laser cutter, soldering equipment, industrial controller, industrial sensor and actuator, communications gateway, aluminum structure kits, electronic measuring tools, and DIY CNC PCB maker machine	Prototyping and evaluation phases of the ICT-INOV proposed gamified design thinking process
Robotics kits Raspberry Pi® and Arduino®	Prototyping and evaluation phases of the gamified design thinking process
Five 3D pens and digital sketch pads, including writing pads and equipment for interactive screen	Problem research, ideation, solution synthesis and prototyping phases of the gamified design thinking process
Five mobile phones on Android®, Huawei®, and iPhone® platforms (purchased through own funds of the university, not charged to the project budget)	Design, prototyping and evaluation phases of the gamified design thinking process

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Six sets of high-definition cameras for usability studies	Intra and cross-team communication throughout the gamified design thinking process
One Macbook Air® as a workstation for developing mobile interfaces based on iOS	Design, prototyping and evaluation phases of the gamified design thinking process
One IMAC® as workstation	Design, prototyping and evaluation phases of the gamified design thinking process
One 3D printing pen with OLED display professional	Prototyping and evaluation phases of the gamified design thinking process
Other miscellaneous peripherals to support the use of the above equipment	Support of the above equipment interconnectivity throughout the gamified design thinking process

Table 6. Lab equipment and foreseen use at the University of Malaya.

More specifically, an example of how this equipment will be deployed is in the context of the Agile Software Development course. The course includes a design thinking and gamification session that will be project-based. The activity will demonstrate how agile practices can be deployed in software development. It will include daily practical activities monitored weekly and reporting upon project completion.

Students will deploy the digital sketchpads, Macbook Air®, IMAC®, and communication cameras for exploring, designing, showcasing, and sharing ideas during the problem research, empathy, ideation, and evaluation phases of the design thinking process.

Students will use the entire range of the robotics DYI kit and all the features it provides, including the ®, laser cutter, aluminum construction, welding, and measuring tools during the prototyping phase of the design thinking process. They will program the robotic constructs to perform specific tasks using the controller, sensor and actuator, microcomputer, and microcontroller equipment.

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Students will further use the Arduino® and Raspberry® Pi kits as well as the 3D printer pen in the same context for experimenting with prototypes until they reach a final solution. Upon completion of the activities, students present their construct to the class.

5.5.6 Future plan for the wide deployment of design thinking integrated with gamification for building innovation skills at UM

The wide deployment of design thinking at the Universiti of Malaya will be stepwise pursued. Instructor training will take place early on, focusing on building educator skills in deploying design thinking and gamification in learners. Following the instructor training, these methodologies will be deployed in classes. Knowledge and experience developed through the piloting of design thinking and gamification will be disseminated to parties outside the university. This will be achieved through community events as well as publications to traditional dissemination channels, including bulletins, social media, newspaper articles, webinars, and scientific publications at conferences and in journals. Finally, memorandums of understanding will be signed with external organizations on future collaboration towards innovation capacity building.

5.6 Partner 6: Universiti Tenaga Nasional (UNITEN)

5.6.1 Partner description

Universiti Tenaga Nasional (UNITEN) is a private university in Malaysia emphasising innovation in teaching and learning processes. In particular, its Computer Science department prepares students to become effective ICT professionals.

Fostering innovation involves moving away from the traditional content delivery method and adopting methods that allow students to be more actively involved in the learning process, more creative and more innovative in finding solutions to given problems.

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In line with the UNITEN's vision and mission, UNITEN's strategic plan for the period 2010 - 2030, named Building Opportunities, Living Dreams 2025 (BOLD 2025), which is inspired by the parent company, Tenaga Nasional Berhad (TNB), includes 3 main strategic goals: teaching excellence, research excellence, and financial sustainability.

As a result of the university's strategic plan 2010 – 2030 the university has set up the Digital Learning Center along with the Teaching and Learning Center. The centers support academic staff towards ensuring continuous quality improvement in teaching and learning. In relation to teaching and learning excellence, the university's goals are to enhance enrollment through local and international market growth initiatives and the promotion of digital and flexible learning, to promote breakthrough research through global ranking recognition and the creation of centers of excellence and to ensure operational efficient for financial sustainability through theoptimization of the university's 2 campuses, KSHAS and Putrajaya. These goals are supported by hihg performing staff and board. They promote the global competitiveness of an energy-focused university.

5.6.2 Organizational current practices on building innovation skills in ICT

Various teaching and learning practices and methodologies have been practiced at the University Tenaga Nasional, ranging from traditional to modern methodologies. In summary, the methods known to be practiced in ICT education at the Universiti Tenaga Nasional that can help build innovation skills among students include group assignments, through which students work in teams to solve given tasks, final year project (FYP), through which students design and implement solutions problems individually or in groups, laboratory or practical training, through which students gain first-hand experience on the outcomes of the activities they perform and game-based learning and gamification**,** which is deployed in courses such as Software Engineering,

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Requirements Engineering and System Analysis and Design through the deployment of serious games that students understand better course concepts.

Moreover, Universiti Tenaga Nasional exploits the potentialities of blended learning, a combination of on-line and in-person learning activities delivered via the Moodle® Learning Management System, active learning, through which students are expected to discuss and to present topics in which they are actively engaged and problem-based learning, in which students can be creative and innovative in the search for solutions to given problems they are exposed to in workshops.

5.6.3 Description of courses in which design thinking integrated with gamification will be deployed in an early phase

The deployment of innovation practices supported by ICT is evident from the establishment of the College of Computing and Informatics (CCI) at the Universiti Tenaga Nasional. The College of Computing and Informatics offers the courses presented below. CCI was formerly known as the College of Computer Science and Information Technology. It offers a diverse range of academic programs that are under constant review by industry experts. Students can benefit from the college members' expertise in teaching and research as well as their industry experience. Currently, CCI offers 6 undergraduate programs in 2 departments of Computer Science and Informatics.

5.6.3.1 Software Quality

The Software Quality course prepares students to work in the software industry, addressing software quality assurance processes, activities, and challenges. The course project assignment emphasises quality assurance activities, challenges, processes, and quality assurance standards.

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5.6.3.2 Software Engineering Principles

The Software Engineering Principles course provides students with an introduction to an engineering approach to the development of high-quality software systems. It focuses on important software engineering concepts in the various types of common software process models. The students build knowledge on concepts and techniques deployed in each software development phase, including requirements engineering, software design and software testing. The course also exposes students to object-oriented methods and tools for analysing and designing software. Upon completion of the course, students are expected to appreciate most of the common software engineering concepts and techniques and produce various software artefacts and deliverables.

5.6.3.3 Data Structures and Algorithms

Data Structures and Algorithms aim at teaching the students the introduction to the concepts of abstract data types (ADT) such as arrays, stacks, queues, linked lists, trees, graphs, and essential algorithms in Computer Science, such as sorting and searching. The discussion of each ADT will include its conceptual definition, memory model, advantages, and disadvantages in creating, appending, referencing, searching, sorting, memory efficiency and access-time efficiency. The course also entails applications of the ADT, the actual implementation of some of the ADT's operations and their respective functions, and an introduction to their pre-defined implementations in C++ programming. The course project assignment involves developing data management applications that use ADT.

5.6.3.4 Systems Analysis and Design

The Systems Analysis and Design course introduces students to information systems and applications development. The course exposes students to detailed discussions on structured processes related to analysis, design, development, implementation, and evaluation. Students

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become familiar with methodologies, techniques and tools used in the management, specification, evaluation, implementation, testing, and maintenance of system development processes.

5.6.3.5 Object-Oriented Programming

The Object-Oriented Programming course provides students with a clear understanding of the object-oriented approach and object-oriented programming. The students build knowledge and skills in designing and implementing object classes and using them to develop an object-oriented application.

5.6.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

5.6.4.1 Web Programming

The Web Programming course develops student knowledge of the internet and the world-wide-web (WWW) and their applications. The course emphasizes web programming languages, including basic and advanced HyperText Markup Language® and its features, namely cascading style sheets, JavaScript client-side scripting, and introduction to database design using MySQL® and PHP® server-side scripting. Students learn different programming techniques.

5.6.4.2 Programming Principles

The Programming Principles course provides a foundation for logical thinking. It encourages students to apply their problem-solving skills towards analysing, designing, and coding programs in the C programming language.

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5.6.4.3 Human-Computer Interaction

The Human-Computer Interaction course builds knowledge and skills on designing and evaluating interactive systems. The course emphasizes development processes for user interaction design. It also focuses on development activities, including requirements and task analysis, usability specifications, design, prototyping, and evaluation. The course demonstrates that user interface development is an on-going process throughout the full product life cycle. Students are involved with real problem-solving and software development projects. They are required to gather requirements, identify the problem, form a solution, and present the solution to the class.

5.6.4.4 Algorithmic Problem-Solving

The Algorithmic Problem-Solving course emphasizes basic algorithms and techniques in computer science such as graphs, searching and sorting algorithms and dynamic programming. The course goes beyond pure theoretical problem solving to expose students to practical activities that involve well-known mathematical games, such as puzzle-like towers of Hanoi, the travelling salesman, the gallery problem, and the poison problem.

5.6.4.5 Data Communications and Networks

This Data Communications and Networks course aims at developing a general understanding of data communication concepts covering networking architecture, structure, and functions. The course introduces the principles and structure of IP addressing and the fundamentals of ethernet concepts, media, and operations.

5.6.5 Description of the design thinking lab and examples of use

The design thinking lab is built inside the existing advanced learning center (ALC) at level 5 of the information resource center (IRC). The lab extends the existing problem-based learning lab developed during an earlier project. The existing lab comprises 10 workstations, one multimedia

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projector and one game development PC. The lab will be upgraded to become the design thinking lab.

The lab will include the following equipment:

EQUIPMENT	DEPLOYMENT IN THE PROJECT
Ten (more) workstations, namely PCs with Intel® Core i5-11400F, 8GB DDR4, 512GV NVMe M.2 SSD, NVIDIA® GeForce GTX 1650, 24inch LCD/LED display, and Windows® 10 PRO operating system	Problem research, empathy, ideation, prototyping and evaluation of the proposed ICT-INOV gamified design thinking process
Two large screen displays, namely 6mm Tempered Glass Whiteboard (Magnetic) 6 x 4 ft, for promoting collaboration	Problem assignment, lecturing and support by the educator as well as collaboration throughout the gamified design thinking process
Twenty digital sketchpad kits with passive pen, pressure sensitivity of 8.192 levels, active area 10 x 5.63 inches, and resolution of 5.080 LPI (lines per inch)	Problem research, ideation, solution synthesis, and prototyping phases of the design thinking process
Twenty cameras for communication, specifically Logitech C715 Webcam Full HD 1080P with resolution 1080p/30fps – 720p/30fps	Intra and cross-team communication throughout the gamified design thinking process

Table 7. Lab equipment and foreseen use at the University Tenaga Nasional.

The lab configuration, including existing and new equipment, is demonstrated in the following figure.

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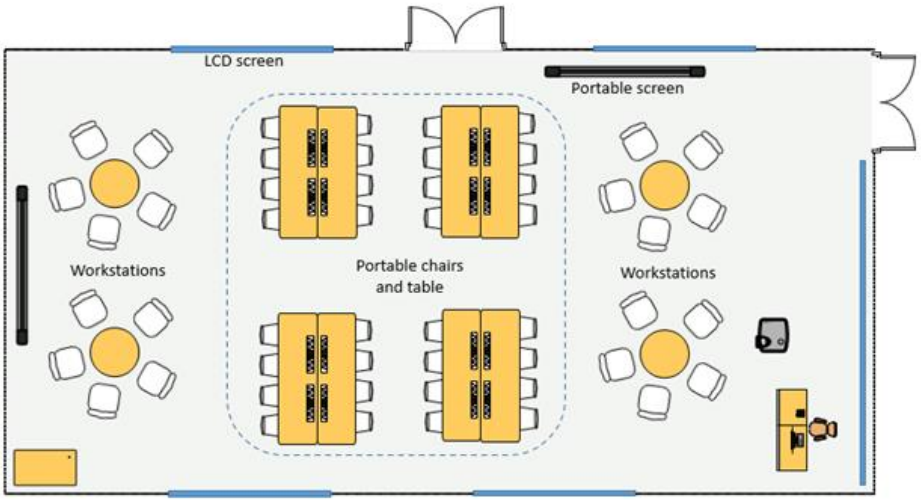

Figure 6. Current lab design.

More specifically, an example of activities that will take place in the lab involves the Principles of a Programming course. Students will use workstations to gather information during the problem discovery phase, for example, to perform desktop research or on-line interviews to gain an understanding of the problem to be solved. The portable tables and chairs foreseen in the lab setup will be purchased with own resources of the organization. They will be used to create and recreate groups to brainstorm ideas during the ideation phase. Students will use digital sketchpads to express their ideas and demonstrate them to others. They will further use the workstations during their project's prototyping phase to implement software solutions to given problems. Other equipment, such as the multimedia projector and glass walls, will facilitate content delivery by the instructor.

In addition, the lab will be used for instructor training.

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5.6.6 Future plan for the wide deployment of design thinking integrated with gamification for building innovation skills at UNITEN

Universiti Tenaga Nasional aims to internally deploy design thinking in many courses to foster innovation skills among ICT students. To achieve this, the university will deliver instructor training activities that will build the knowledge and skills of educational, technical, and administrative staff that support the learning process on design thinking concepts and their practical applications in the educational context. This activity will be followed by piloting the ICT-INOV gamified design thinking methodology in the classroom. Further adoption of the proposed learning design will be promoted through community-building events that will engage both members of the Universiti Tenaga Nasional community as well as external stakeholders. Externally, the university plans to promote design thinking for innovation to 3 other government universities in Malaysia, specifically the Multimedia University (MMU), Universiti Malaysia Kuala Lumpur (UniKL) and Universiti Teknologi Petronas (UTP). Through the Alliance of Government Linked Universities Malaysia, Universiti Tenaga Nasional has on-going strong collaboration with these universities, including joint conferences. It is hoped that through the established connections, the implementation of the ICT-INOV project can be extended to these universities, beyond Universiti Tenaga Nasional, maximizing impact. To achieve this, representatives from these universities will be invited to attend the ICT-INOV planned instructor training and other events.

5.7 Partner 7: ISRA University (ISRA)

5.7.1 Partner description

Isra University (IU) started its operation in 1997 with an enrolment of 30 students. The main campus, Hyderabad, now enrolls over 4.000 individuals. The university has 2 more campuses, in Karachi and Islamabad. The university offers a wide range of educational programs at the undergraduate and graduate levels. The university has 4 faculties, namely the Faculty of Medicine

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and Allied Medical Sciences, the Faculty of Dentistry and Allied Sciences, the Faculty of Commerce Economics and Management Sciences, and the Faculty of Engineering Science and Technology (FEST). The Faculty of Engineering Science and Technology includes the Computer Science Department, one of the university's oldest departments, the Electrical Engineering Department, the Civil Engineering Department, and the Mechanical Engineering Department.

5.7.2 Organizational current practices on building innovation skills in ICT

Educators in the Faculty of Engineering, Science and Technology, specifically in the Department of Computer Science, have been exposed to active and problem-based learning design through Capacity Building in Higher Education project ALIEN: Active Learning in Engineering Education. As a result of this work, educators are better prepared to integrate emerging pedagogical design into their instructional processes to enrich student learning experiences and achieve educational goals.

ISRA University has an Office of Innovation, Research and Commercialization (ORIC), which aims to promote innovation-building activities within the university and strengthen the university's links to industry and society. The ORIC work ensures that research outcomes reach beyond the university network, positively impacting local communities. It further promotes research and innovation activities internationally. The ORIC, the Department of Computer and the Faculty of Engineering, Science and Technology regularly organize seminars targeting faculty members as well as the students, aiming to enhance their innovation skills.

5.7.3 Description of courses in which design thinking will be deployed in an early phase

The design thinking process is planned to be applied in the following courses during an early phase of project-based practices. However, this strategy is subject to modification depending on the courses offered in the semester.

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5.7.3.1 Final year project

The final year project is an activity that takes place, as the name implies, over the final academic year of studies. It allows students to go through all the steps of a typical project design and development process, including brainstorming, planning, requirements engineering, feasibility analysis, design, development and coding, integration and testing, implementation and deployment, and operations and maintenance.

5.7.3.2 Introduction to Algorithms

The course addresses problem-solving and programming through the development of algorithms. It introduces computational problems. The course focuses on well-known algorithms that address diverse problems, algorithmic paradigms, and data structures. It emphasizes the relationship between algorithms and programming and introduces basic performance measures and analysis techniques. Upon completion of the course, students will understand the basics of algorithm design and the deployment of suitable data structures in solving different problems.

5.7.3.3 Object Oriented Software Engineering

The course focuses on using object-oriented principles in building flexible software applications. It further analyzes how object-oriented principles, software design patterns, and different development approaches fit into the object-oriented software engineering lifecycle. In addition, the course discusses how different stakeholders can communicate clearly through the use of UML use cases to deliver the right software that meets every stakeholder requirement.

5.7.3.4 Human Computer Interaction

The objectives of the Human-Computer Interaction course are to provide students with a broad view of both theoretical and practical issues in human factors for the design of human-computer interfaces, to equip students with knowledge and understanding of the nature of human-

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computer interactions, human characteristics, computer systems, and interface architecture, and to develop sound skills in the design, development, and evaluation of user interfaces. Upon completion of the course, students will understand and appreciate the human factors and the theoretical issues involved in human-computer interaction, will be able to apply the theoretical design principles towards the design and evaluation of user interfaces, and will be able to analyze user requirements, design a human-computer interface according to these requirements, and evaluate the design.

5.7.3.5 Formal Methods in Software Engineering

The course is an introduction to formal methods applied in Software Engineering. The focus is to understand how formal methods help produce high-quality software. Emphasis is also given on learning about formal modelling and specification languages in general and Alloy in particular. Students are expected to learn about writing formal requirement specifications and how these specifications can be used for the validation and verification of different components of a software system during the software engineering phases. Focus is also given to mechanical verification of formal specifications to ensure the correctness of the system.

5.7.3.6 Operating Systems

The course is an introduction to Operating Systems Concepts. The focus is on understanding operating systems' working, design, and implementation issues. Students are expected to learn about different operating system components and their working, design, and implementation issues. Various concepts discussed include process management, process synchronization, memory management, storage management, file systems, and security and management.

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5.7.4 Description of courses in which design thinking will be deployed in the long-term

5.7.4.1 Basic Electronics

This course introduces basic semiconductor devices, including diodes (silicon, germanium, LED, varactor, photo, Zener, and tunnel), rectifiers, and bipolar junction transistors (BJTs).

5.7.4.1 Software Quality Assurance

The course focuses on optimizing software quality through hands-on approaches. The course challenges students to establish a software quality achievement plan that is comprised of well-accepted procedures, techniques, and tools, such as Selenium, TestingWhiz®, HPE Unified Functional Testing (HP – UFT, formerly QTP), and others that ensure that a product or service aligns with the requirements defined in the SRS and help assess software quality in relation functionality, performance, adaptability, and other aspects. Students further create plans for monitoring the progress of applied methods for quality assurance and make process changes for future betterment.

5.7.4.2 Object Oriented Programming

This course focuses on fundamental concepts of object-oriented programming with special emphasis on Java®. Topics include control structures, modularity, input and output, exceptions, casting, conversions, and other important programming language features.

5.7.4.3 Artificial Intelligence

The course exposes students to real-world scenarios towards understanding artificial intelligence algorithms for deployment in diverse contexts. Activities encourage students to apply theory to practice by converting algorithms to code. Topics include an introduction to artificial intelligence, classification and regression using supervised learning, predictive analytics with ensemble learning, detecting patterns with unsupervised learning, building recommender systems,

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heuristic search techniques, genetic algorithms, building games with artificial intelligence, natural language processing, probabilistic reasoning for sequential data, object detection and tracking, and artificial neural networks.

5.7.4.4 Programming Fundamentals

This course introduces fundamental concepts of structured programming with special emphasis C++ programming. It provides a comprehensive introduction to programming for Computer Science and Technology majors. Topics include variables, data types, control structures, functions, arrays, and the mechanics of running, testing, and debugging a program.

5.7.4.5 Differential Equations

The course helps students understand the formation of differential equations, become familiar with various types of first and higher-order differential equations, use different techniques to solve ordinary and partial differential equations and apply differential equations to engineering problems and modelling.

5.7.5 Description of the design thinking lab and examples of use

ISRA University Hyderabad campus has a problem-based learning lab established through the ALIEN project. The existing lab offers virtual reality (VR) equipment, high-end desktop systems and a MacBook® Pro to support the development of VR environments for the Windows and iOS platforms. The existing lab is installed in a limited space.

In the context of the ICT-INOV project, a new design thinking lab will be established in a larger space which will include, in addition to the existing facilities, new equipment that fosters student innovation through collaboration in the context of design thinking practices. New equipment purchased through ICT-INOV includes the following.

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EQUIPMENT	DEPLOYMENT IN THE PROJECT
Eight Workstations HP290 G4 MT, Ci7 10th generation, 1TB, 256GB SSD, USB KB-mouse, HP P27h G4 LED with Logitech® wireless keyboard and mouse combo MK-235	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process
One robotics kit original Prusa® i3 MK3S	Prototyping and evaluation phases of the gamified design thinking process
Seven Raspberry Pi® and Arduino® robotics kits	Prototyping and evaluation phases of the gamified design thinking process
One 3D printer 1.75mm PLA filament multicolour	Prototyping and evaluation phases of the gamified design thinking process
Five Webcams Logitech® C922	Intra and cross-team communication throughout the gamified design thinking process
Five graphics tablets GAOMON® S620 6.5 x 4in	Problem research, ideation, solution synthesis, and prototyping phases

Table 8. Lab equipment and foreseen use at ISRA University.

The new lab will allow several groups of students to simultaneously work on design thinking activities using desktop systems, other equipment, and the physical space for enriching collaboration, sharing ideas, and synthesizing solutions.

An example of the deployment of the lab in learning involves the obligatory final-year student project, which spans both semesters of the 4th year of studies. Students work in groups, undertaking project tasks. Each group presents their work twice in a semester and receives feedback for improvement from an evaluation committee. Each group is assigned a supervisor with whom they meet weekly in the design thinking lab to discuss updates, resolve issues and

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work on their project. Each group will have access to the equipment available in the design thinking lab.

Additionally, students will be allowed to use any other equipment necessary to implement the project. Throughout the year, each group will be exposed to several iterations of design thinking, which each iteration ending with a presentation to the evaluation committee. Team members will discuss the feedback they receive from the committee with the supervisor in the context of the weekly meetings and, if necessary, restart the design thinking process to introduce a solution that addresses user needs more accurately.

Students will use the workstations for researching ideas and solutions to the challenge introduced by the instructor during the problem discovery, empathy, and ideation phases of design thinking. They will use robotics equipment, including the Prusa® i3 MK3S, Arduino®, and Raspberry Pi® kits as well as the 3D printer, during the prototyping phase for developing and testing diverse solutions. Students will use the graphics tablets for exploring, showcasing, and sharing ideas with others during the problem-discovery and ideation phases of design thinking. Cameras will support communication and collaboration in groups throughout the learning process.

5.7.6 Future plan for the wide deployment of design thinking integrated with gamification for building innovation skills at ISRA

In order to build the capacity of the organization to adopt an innovation-building learning design, ISRA University will start by organizing instructor training events at the faculty level. Instructor training will take place in the Department of Computer Science, Department of Electrical Engineering, Department of Civil Engineering and Department of Mechanical Engineering. The training will expose participants to design thinking concepts and activities for the practical deployment of the methodology in the classroom. Training will target not only instructors but

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also technical and administrative staff supporting the learning process. In the second stage, training will engage instructors at other faculties in the Hyderabad campus.

In parallel with training, faculty members will deploy the proposed gamified design thinking framework in courses with students' engagement. Feedback will be integrated into the learning design to address student needs and expectations. Furthermore, a community will be developed comprised of students, educators and other stakeholders who share knowledge and experiences through capacity-building events. Community members will also deploy the digital collaborative services developed through the project for structuring and delivering innovation-building learning activities.

5.8 Partner 8: National University of Computer and Emerging Sciences (NUCES)

5.8.1 Partner description

The National University of Computer and Emerging Sciences from Pakistan focuses on acquiring and propagating cutting-edge science and technologies in Computer Science, Engineering, Business Management and Basic Sciences. The university managers of the highest order may be part of the IT Revolution in Pakistan. The university was funded in 2000 and is one of Pakistan's leading higher education institutions. The university has 5 campuses in Karachi, Lahore, Islamabad, Peshawar, and ChiniotFaisalabad. It enrolls over 11.000 students and employs over 500 highly qualified and committed educators. Faculty members are inspired by the professional world. They strive to be up to date with the evolution of technology, in particular, ICT. The university further employs researchers, developers, and other professionals in the context of R&D activities.

Students develop advanced knowledge in Computer Science. More specifically, the Department of Computer Science aims at providing students with sound technical knowledge and practical skills relevant to the industry. The department further aims to develop soft skills, such as critical

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thinking, creativity, teamwork, ability to communicate effectively, problem-solving capacity, management skills and respect for professional ethics, that help students lead successful careers for the benefit of themselves and their communities. Educational programs aimed at empowering students to convert knowledge to innovation, build diverse careers in the ICT sector and be entrepreneurial in business and social contexts. The above is achieved through a curriculum that develops foundations in mathematics, engineering, and computing principles fosters intellectual curiosity and promotes learner commitment and engagement.

The Department of Computer Science further offers Master's level degrees. Graduate studies are organized into 4 core programs Computer Science, Data Science, Cyber Security, and Software Engineering.

5.8.2 Organizational current practices on building innovation skills in ICT

As a higher education institution in Pakistan, the National University of Computer and Emerging Sciences aims to develop the knowledge and skills that can effectively contribute to the country's growth and quality of life. To achieve this, the university focuses on developing innovation skills among students, which help them convert knowledge into action.

The university is very active in research. The organization's research teams are well-recognized nationally and internationally. They are embarked on cutting-edge research with a direct impact on Pakistan's social, economic, and technological needs. The organization's vision is to become a globally recognized research university in the next decade.

The university deploys modern methods for building knowledge and innovation capacity. This includes active, experiential, and problem-based learning. More specifically, students are exposed to real-life challenges under the supervision of educators and research staff. The results of their

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work benefit industries and help address everyday challenges in the country, contributing to raising the quality of life.

The university further offers a range of labs with high-tech equipment that enable the students to explore, experiment and collaborate in diverse ICT activities, such as data science, data analytics, software engineering and others.

5.8.3 Description of courses in which design thinking will be deployed in an early phase

5.8.3.1 Human-Computer Interaction

This course is designed to introduce students to user interface design concepts. It covers topics such as multimodal design, design rules, basic design evaluation techniques and principles, and game design, among other relevant topics. Design thinking is applied throughout the course in a semester-long project. Students work in groups of 3 - 5 individuals on a project specifically selected to address the course's learning objectives, building knowledge on user interface design. To facilitate student work, the project is divided into 4 – 5 intermediate deliverables, each of which focuses on a specific aspect of design thinking.

5.8.3.2 Software Engineering

The course is mandatory in the Bachelor's in Computer Science and Software Engineering programs. It is offered in the 6th semester of undergraduate studies. The course involves a semester-long project that is implemented through design science. The project is based on a real-world problem of the students' choice. Participants design a solution in the form of a digital application. Given that students at this stage of their studies are familiar with front and back-end programming, the implementation of the project requires the development of both a back-end server and the application's user interface. Students work in groups of 3 – 5 individuals. The

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project is divided into 4 – 5 intermediate deliverables to facilitate student work, each focusing on a specific aspect of design thinking.

5.8.3.3 Introduction to Software Engineering

The course is mandatory in the Bachelor's in Software Engineering program. It is offered in the 2nd and 3rd semesters of studies. The course involves the implementation of a semester-long project. In this early stage of studies, students' programming knowledge is basic. Therefore, the semester project aims at steering students through the process of design thinking and less on producing a product in the form of a working application. Students work in groups of 3 – 5 individuals. The project is divided into 4 – 5 intermediate deliverables to facilitate student work, each focusing on a specific aspect of design thinking.

5.8.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

5.8.4.1 User Experience Design

The course is offered is an elective in the final year of various Bachelor's and Master's programs. It has as a prerequisite the Human-Computer Interaction course. The course introduces principles for software product design that leads to enjoyable user interactions. The course involves hands-on exercises for practicing the use of certain tools, such as Wireframe®, Figma®, AdobeX®, and others. Given the course's focus on user experience, the introduction of design thinking will benefit students and build their capacity to design user-centered solutions.

5.8.4.2 Software Engineering for Industrial Automation Systems

The course is offered is an elective in the final year of various Bachelor's and Master's programs. It focuses mostly on Software Engineering practices deployed in industrial automation systems.

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The course covers requirements for engineering, design, coding, and testing. Given the solution-oriented nature of the course, design thinking can enrich learning experiences and outcomes.

5.8.4.3 Elective Subjects

During the 3rd and 4thyear of studies in the School of Computer Science, and more specifically, the Departments of Computer Science, Artificial Intelligence, Software Engineering, Data Science, and Cyber Security, students enrol in 4 elective courses. Students work individually or in teams in these courses on a semester-long project. They identify a problem of interest in collaboration with their educators, research needs, and design, implement, and evaluate a solution. Finally, they present their work to the entire class. Given the focus of the projects on solution design, student work can benefit from the deployment of design thinking approaches that help them introduce solutions that better address user needs.

5.8.5 Description of the design thinking lab and examples of use

A new laboratory for fostering innovation skills will be developed. The lab will be a co-working space for students to sit together and collaborate while they engage in problem discovery, ideation, solution synthesis and prototyping. The lab will include the following equipment:

EQUIPMENT	DEPLOYMENT IN THE PROJECT
Six Arduino and ESP training kits Arduino® UNO R3 board with PS adapter and connector, board with WIFI, Bluetooth with camera module	Prototyping and evaluation phases of the gamified design thinking process
One 3D printer Snapmaker® 2.0 A350 three in one	Prototyping and evaluation phases of the gamified design thinking process

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Twelve 10x6.25in graphics tablets	Problem research, ideation, solution synthesis and prototyping phases of the gamified design thinking process

Table 9. Lab equipment and foreseen use at the National University of Computer and Emerging Sciences.

This equipment will promote student collaboration in design thinking activities. More specifically, an example of the deployment of the lab in learning involves the Software Engineering course. Students will deploy existing workstations for performing research during problem discovery and problem definition. During the ideation phase, they will also use the workstations to explore ideas and potential solutions and share findings. Students will deploy the graphics tablets to describe and communicate ideas during problem research, brainstorming, and solution design. Finally, during the prototyping phase, students will deploy the 3D printer and robotics kits for constructing discardable prototypes to be evaluated by users. Another course in which the lab may be used is Human-Computer Interaction. The course includes a semester project that starts in the 3rd week and has 5 deliverables. Students will deploy design thinking in the lab to develop an app of their choice, considering the design rules and principles taught in the course. The course is being updated to integrate design thinking. Each phase of design thinking is mapped to the human-computer interaction traditional cycle. Course deliverables are redesigned to address student activities at different semester milestones. Finally, students will deploy the lab to work on their final year and semester projects using the design thinking approach.

5.8.6 Plans for the wide deployment of design thinking integrated with gamification for building innovation skills at NUCES

Design thinking will initially be introduced in the Department of Computer Science at the undergraduate and Master's levels. In the first phase, the methodology will be deployed in the

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Software Engineering and Human-Computer Interaction courses, which are being adapted for integrating innovation-building practices. The experienced developed through the early deployment of design thinking and the feedback received by students will drive the integration of the methodology in a wider range of subjects in a follow-up phase.

The integration of design thinking into learning practices will be supported through instructor training. A series of instructor training events will build the understanding among educators of design thinking principles and their capacity to deploy the methodology in practice. The instructor training events will be experiential, allowing participants to engage actively in designing thinking paradigms, which they can later integrate into their courses.

Subsequently, innovation-building activities based on design thinking will be extended to Engineering and Management faculties. This will be achieved by inviting educators from these faculties to the instructor training events and by organizing community-building events in which participants will be encouraged to share their experiences, findings, and suggestions on enriching educational practices for fostering creativity and entrepreneurial thinking.

5.9 Partner 9: Tribhuvan University (TU)

5.9.1 Partner description

Tribhuvan University, as a center of excellence in engineering knowledge nationally and regionally, is Nepal's largest public engineering institution. The university provides quality education and research at the frontiers of technological evolution for national growth. The university was established in 1959 and has since been constantly growing without interruption. It is organized in 4 faculties, namely the Faculty of of Law, the Faculty of Humanities and Social Sciences, the Faculty of Management and the Faculty of Education. The university further includes 5 institutes, namely the Institute of Medicine, the Institute of Forestry, the Institute of Agriculture

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and Animal Sciences, the Institute of Engineering and the Institute of Science and Technology. It enrolls over 30.000 students. Over its lifetime, the university has made significant contributions to Nepalese higher education.

The Institute of Engineering, Tribhuvan University, is Nepal's largest public engineering institution. The institute enrolls over 4.600 students. It offers 11 undergraduate and 27 Master's and PhD level programs at 14 campuses and affiliated colleges. In addition to academic programs, the institution offers sponsored professional courses.

The institute aims at offering quality engineering education nationwide. It is active in research on state-of-the-art engineering technologies aiming at designing solutions for addressing national growth priorities. More specifically, the organization aims at academic excellence in engineering educator, research, and training, developing an academic niche in South Asia, becoming established at the national level as an innovation pole and offering engineering consultancy for growth.

5.9.2 Organizational current practices on building innovation skills in ICT

ICT is a significant tool for improving classroom delivery, maximizing access to teaching, and learning materials, and enhancing educational governance, management effectiveness, and efficiency.

In this context, the university established an Information Technology Innovation Center at the central office in 2016, intending to provide information technology services that support university teaching, learning, and decision-making. Similarly, an independent research organization named National Innovation Center was established in the Tribhuvan University central office premises in 2012. Finally, an Innovation and Incubation Center has been recently established to facilitate the incubation of innovative ideas developed during the thesis and

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dissertation research phases. These centers aim to promote world-class autonomous and self-sustained research innovation.

The organization currently deploys active and project-based learning in relation to emerging pedagogical design. These methodologies are evident in all degree programs at the Bachelor's, Master's, and PhD levels.

In the context of academic courses, active learning is evident in the activities of the Robotics Club of the university, which engages students from different departments in the design and development of projects that can be submitted to national and international competitions.

Innovation activities are further evident in the university's internship programs in collaboration with industry. These exchanges are 2 – 6 months long and are practiced in the Mechanical Engineering and Architecture programs. Participating students are encouraged to introduce solutions to real-world industry challenges. They are exposed to actual business practices and have an opportunity to be mentored by professionals.

The ICT-INOV project will enrich emerging learning design deployment through innovation-building approaches based on design thinking.

5.9.3 Description of courses in which design thinking will be deployed in an early phase

5.9.3.1 Image Processing

Image Processing is an elective offered in the 2nd semester of the Master in Computer Systems and Knowledge Engineering program of the Department of Electronics and Computer Engineering, Pulchowk Campus. The course aims at developing knowledge of image processing and pattern recognition in a manner that allows its practical application in research projects. More specifically, the course develops a theoretical foundation of fundamental digital image processing concepts, mathematical foundations for digital manipulation of images, image

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acquisition, preprocessing and segmentation, Fourier domain processing and compression. Students gain practical experience in software development techniques related to applying theoretical knowledge in real-life contexts.

5.9.3.2 Artificial Intelligence

Artificial Intelligence is a core course offered in the 6th semester of the Bachelor in Computer Engineering program of the Department of Electronics and Computer Engineering, Pulchowk Campus. The course aims at developing a basic knowledge of artificial intelligence, familiarizing students with search techniques and building students' skills in the practical applications of artificial intelligence.

5.9.3.3 Big Data

The Big Data course is an elective in the 2nd and 3rd semesters of the Master's in Engineering program of the Department of Electronics and Computer Engineering, Pulchowk Campus. The course aims to provide an overview of big data and the latest trends in big data analytics. The course introduces students to the technologies for handling big data, the Hadoop platform and its components, algorithms for exploring large, complex datasets and applications of big data tools for advanced analytics on complex datasets. The course develops student understanding of scalable big-data analytics methods and encourages students to deploy in-practice tools for predictive analysis, data mining, text analytics and statistical analysis.

5.9.3.4 Information Visualization

Information Visualization is an elective offered in the 2nd semester of the Master in Computer Engineering program, specializing in Data Science and Analytics of the Department of Electronics and Computer Engineering, Pulchowk Campus. The course aims to develop knowledge on presenting information in an understandable, efficient, effective, and aesthetic manner to explain

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ideas and analyze data. The course develops student skills in information visualization and other forms of visual presentation. Upon completion of the course, students are familiar with core principles and have been exposed to field literature.

5.9.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

The design thinking course will be deployed in the long-term for the following additional courses.

5.9.4.1 Knowledge Engineering

Knowledge engineering is an introductory core course offered in the 1st semester of the Master's in Computer Systems and Knowledge Engineering program of the Department of Electronics and Computer Engineering, Pulchowk Campus. The course aims at familiarizing students with the basic concepts of knowledge engineering, developing basic knowledge of acquisition methods, IR, NLP and machine learning techniques, introducing students to the semantic web and ontology engineering and building logical and reasoning skills.

5.9.4.2 Social Computing

Social Computing is an elective course offered in various Master's programs. This is an elective of the Institute of Engineering. This course focuses on how social groups and networks evolve, interact, and are supported by computer systems. It covers social, scientific, and technical concepts of social computing, such as computer systems supporting social behavior, socially intelligent computing carried out by communities and human computation and crowdsourcing systems.

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5.9.5 Description of the design thinking lab and examples of use

Despite existing innovation practices, the use of modern technology and ICT, including computer systems, the internet, and multimedia, in the learning process is still limited. The ICT-INOV project will address this shortcoming, through which a lab will be established to promote innovation skills. The lab will support comprehensive activities for innovation-building, stimulating creativity in working groups of participants from different programs. Design thinking practiced in the lab will allow the development of new solutions for any given problem.

The equipment that will be purchased for the lab includes:

EQUIPMENT	DEPLOYMENT IN THE PROJECT
Two high-end workstations	Problem research, empathy, ideation, prototyping and evaluation of the proposed ICT-INOV gamified design thinking process
One large interactive flat-panel display	Problem assignment, lecturing and support by the educator, as well as collaboration throughout the gamified design thinking process
Camera for communication	Intra and cross-team communication throughout the gamified design thinking process and educational content development
One robotics development kit	Prototyping and evaluation phases of the gamified design thinking process
Five digital tablets	Problem research, ideation, solution synthesis and prototyping phases of the gamified design thinking process

Table 10. Lab equipment and foreseen use at Tribhuvan University.

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The lab will be used in different courses for creating solutions for design. More specifically, an example of the deployment of the lab in learning is the final year project, during which students will use the lab facilities for designing creative solutions. Students will create concept designs that will be revised in cycles and tested using prototypes that will be developed in the lab, ensuring that the result is tailored to user needs. This holistic approach towards creative solutions enables students and companies to develop innovations.

Students will deploy the workstations throughout the gamified design thinking process to research a given problem, outline ideas, synthesize solutions, and evaluate results. They will use cameras for communication in and outside of the classroom. Students will use the digital sketchpads for drafting and sharing ideas towards a viable solution. Educators will use the flat panel display to communicate information to the class, lecture, and guide students throughout the problem-solving process.

5.9.6 Plans for the wide deployment of design thinking integrated with gamification for building innovation skills on TU

Promoting innovation skills among higher education ICT students is a strategic choice for Tribhuvan University that aligns with the organization's mission to develop human capital with the knowledge and skills to drive growth in the country.

Design thinking for building innovation skills will be initially introduced in the Institute of Engineering in a wide range of courses. The adoption of design thinking approaches will be supported through on-going instructor training that the institute-targeted educators will organize throughout all campuses. The institute will be supported in this capacity-building activity by the Information Technology Innovation Center, which offers experience in innovation management. Training will result in enriched skills among institute educators to practically deploy innovation-building skills in a wide range of courses, promoting quality of education, upgrading curricula, and

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linking education to the needs of industry and society. Adoption will be further promoted through capacity-building events that will be organized in collaboration with the Information Technology Innovation Center and the Innovation and Incubation Center. In addition, community-building events will be organized in collaboration with other higher education institutions, such as Kathmandu University, to promote sharing experiences towards the collective enrichment of educational practices.

In the second stage, design thinking will be promoted through academic writing and information dissemination to other faculties of Tribhuvan University as well as externally to other higher education institutions and the wider academic community of Nepal.

5.10 Partner 10: Kathmandu University (KU)

5.10.1 Partner description

Kathmandu University aims to build knowledge and skills to enhance the quality of life and well-being in Nepal and the wider region. The university's vision is to become a world-class educational institution devoted to bringing knowledge and technology to the service of mankind. In the context of growth policies in Nepal, Kathmandu University aims to provide quality education for leadership. It aims to develop knowledge and skills among higher education students who will deploy it in the future to address the country's challenges for the benefit of all.

The university is organized into schools, namely the School of Arts, School of Education, School of Engineering, School of Law, School of Management, School of Medical Sciences and School of Science.

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5.10.2 Organizational current practices on building innovation skills in ICT

Project-based teaching-learning has been the signature of Kathmandu University. The School of Engineering, particularly the Department of Computer Science and Engineering, has been very closely following this practice. Department graduates have been established in very good positions in different economic sectors, including academia, industry, government, non-government, private, and others in Nepal and beyond. The department employs well-trained and qualified faculty both from within Nepal and abroad. The curriculum is frequently revised and is up to date. The department collaborates closely with industry and software companies to ensure no gap between the skills developed in the offered educational programs and industry requirements.

To promote innovation among students, Kathmandu University has established an internship program through which 4th year students spend 3 months in a company during the final semester of their studies. The program is very beneficial to students as they have the opportunity to be exposed to a real-world working environment solving problems the industry faces.

The university also provides a Video Recording Studio for recording and editing lectures for faculty members interested in disseminating their teaching to students through an e-learning platform, specifically Moodle®. The platform has proved to be a useful tool in the age of the pandemic, in which courses are virtually delivered.

Kathmandu University School of Engineering has practiced the concept of community-based learning in collaboration with Himal Partner in the context of a Community Education project during which students visit the community to identify problems and design creative solutions. Some groups even carry out this community-related problem as their final year project. In this type of learning, students and educators have the opportunity to be exposed to and develop

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understanding of the problems faced by the community and how their learnings and be utilized for solving them.

5.10.3 Description of courses in which design thinking will be deployed in an early phase

The design thinking integrated with gamification will be deployed in early phases for the following courses:

5.10.3.1 System Analysis and Design

The course is offered in the 3rd year of undergraduate studies in the Department of Computer Science and Engineering of Kathmandu University. The course typically enrolls 60 students each year. Through this course, students are exposed to how real systems are developed and become familiar with various factors that need to be considered while designing a system. They further build experience in the user requirements analysis process and systems testing.

The course helps launch the careers of successful systems analysts and other engineering professionals that assume an active role in building systems that satisfy their organization's digital needs by building solid foundations on systems analysis and design.

5.10.3.2 Computer Graphics

The course is offered in the 6th semester of undergraduate studies in Computer Engineering. The course typically enrolls 60 students each year. It is a mandatory course in the formal curriculum of the Department of Computer Science and Engineering of Kathmandu University. Upon completion of the course, students are familiar with basic computer graphics techniques and their application in the field of animation. The course addresses basic concepts, mathematical foundations, fundamental theory and algorithms, software techniques, hardware and system issues, and application examples of computer graphics. It focuses on modelling, rendering, and

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interaction. Learning is delivered through lectures and practical hands-on activities that take place in computer labs. The practical activities encourage students to apply their theoretical knowledge to real-life problems.

5.10.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

The design thinking integrated with gamification will be deployed in the long term for the following additional courses:

5.10.4.1 Operating Systems

The course is mandatory in the 6th semester of the undergraduate program in Computational Mathematics offered by the Department of Mathematics of Kathmandu University. It typically enrolls 10 students each year. The course builds the foundational knowledge of modern operating systems features. Course content covers an introduction to operating systems as well as applications of operating systems fundamentals such as process management, memory and input/output management, scheduling, synchronization, and file systems management. It further familiarizes students with the design and implementation aspects of operating systems. Learning is delivered through lectures and practical hands-on activities that take place in computer labs.

5.10.4.2 Embedded Systems

The course is mandatory in the 3rd year of undergraduate studies in the Department of Computer Science and Engineering of Kathmandu University. It typically enrolls approximately 60 students each year. The course requires a basic understanding of programming languages, computer networking, computer architecture, and microprocessors. This prerequisite knowledge helps participants to be more active in class. The main objective of this course is to introduce the

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general concepts of embedded systems related to hardware and firmware. The course further addresses communication interfaces used in embedded systems for transferring data.

5.10.4.3 Algorithms and Complexity

The course is mandatory in Computer Science, Computer Engineering, and Computational Mathematics undergraduate programs at Kathmandu University. It typically enrolls approximately 60 students each year. The course builds knowledge on designing pseudocode for problem-solving in the context of computer systems design and analyzing pseudocode in terms of time and space parameters with active student participation in thorough discussions among classmates and instructors. Students are challenged to develop an efficient approach in the form of pseudocode to solve a problem on a computer. Participants work in groups. Each solution is thoroughly discussed and explained by group members to the entire class. The instructor suggests possible improvements and enhancements which can render the solution more efficient. The same approach is deployed in analyzing a problem in terms of time and space parameters.

5.10.4.4 Computer Architecture and Organization

The course is mandatory in the 3rd year of undergraduate studies at the Department of Mathematics of Kathmandu University. Approximately 15 students are enrolled in the course each year. The course introduces students to computer architecture, computer organization, and design. Course content covers basic computer architecture elements, such as central processing unit, control unit, input and output organization, and memory organization. Prerequisites include Digital Logic and Microprocessors.

Other courses in which project activities may be deployed include Emerging Technologies, Human-Computer Interaction, and Digital Signal Processing.

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5.10.5 Description of the design thinking lab and examples of use

In Kathmandu University, the existing Active Learning Lab established through the support of the Capacity Building in Higher Education project ALIEN: Active Learning in Engineering Education will be extended into a new Design Thinking Lab. The existing lab is currently deployed in the context of Computer Science and other Engineering courses. Students are exposed to active and problem-based learning. The upgraded lab will now be used to develop, localize course content, and deliver fully developed courses to undergraduate students to support design thinking and gamification for building innovation skills. The lab equipment includes:

EQUIPMENT	DEPLOYMENT IN THE PROJECT
One Dell® gaming laptop with INTEL® Core i7 12th processor, 32GB RAM, 1TB NVME SSD, RTX3060 6GB graphics, 14” display One assembled desktop workstation INTEL® Core i9 12900k processor, MSI Z690 motherboard, 32GB DDR RAM, 1TB hard drive, 512GB NVME SSD, gigabyte RTX 3080Ti graphics, Windows® 10 Pro, antivirus, 22” Dell® display	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process
Three interactive display panels	Problem assignment, lecturing, and support by the educator, as well as collaboration throughout the gamified design thinking process
Two smart display TVs 65inch, non-interactive	Problem assignment, lecturing, and support by the educator as well as collaboration

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	throughout the gamified design thinking process
One smart pen HP-3 for the interactive display panels	Problem assignment, lecturing, and support by the educator, as well as collaboration throughout the gamified design thinking process
One EOS® M6 Mark 2 camera for communication and content development	Content development and communication in all gamified design thinking phases
Five drawing pads	Problem research, ideation, solution synthesis and prototyping phases of the gamified design thinking process
One Intel® workstation Core i9 12900K processor, MSI Z690 motherboard, 32GB DDR4 RAM, 1TB hard drive, 512GB NVME SSD, gigabite RTX 3080Ti graphics, 850 watts gold PSU, 22in Dell® display	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process
One Dell® laptop core i7 12th processor, 32GB RAM, 1TB NVME SSD, 6GB graphic (rtx3060), display 14in	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process
One Microsoft® surface laptop, Intel® 19th generation core i5, 8GB RAM, NVME 256GB SSD, 13.3in display, Windows® 10 Home	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process

Table 11. Lab equipment and foreseen use at Kathmandu University.

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An example of deploying the Design Thinking Lab in learning involves the Combined Engineering project offered to 3rd year Computer Engineering students. In this course, students will use the Design Thinking Lab to solve real-life problems, propose solutions, test their ideas, and finally come up with refined solutions that more effectively address user needs. Students will deploy the workstations for performing research and designing solutions throughout the gamified design thinking process. They will use drawing pads to explore and share ideas during the problem-discovery, empathy, ideation, and prototyping phases. On the other hand, educators will use large displays to communicate information to students, lecture, demonstrate ideas, and promote collaboration. Finally, the camera will be used for communication purposes and for content creation to be used in courses.

5.10.6 Plans for the wide deployment of design thinking integrated with gamification for building innovation skills at KU

Kathmandu University will adapt undergraduate courses to integrate the proposed gamified design thinking-based learning approach. Design thinking activities will be developed based on course content. The activities will challenge students to think creatively to address real-world challenges. A good example of deploying design thinking is in the context of the Community Education project, in which students engage with their regional communities striving to put their knowledge to work for enriching the quality of life. Design thinking is directly applicable in this activity for designing solutions that better address the needs of community members through problem discovery, observation, immersion in the community and empathy that help understand actual, as opposed to perceived, needs.

Adoption will be supported through instructor training that will target educators and supporting staff, both technical and administrative. Training will develop the understanding of educators on emerging innovation-building methodologies. It will further focus on practical activities that help

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instructors integrate design thinking into diverse projects. Activities will further be supported through community building events that strengthen the academic network of Kathmandu University by allowing educators to share experiences as well as promote the proposed design thinking solution to higher and other educational institutions beyond Kathmandu University.

Design thinking will initially be deployed in the Computer Science and Engineering Department. Faculty members of the department will be the first to be exposed to training activities. They will use their experience to transfer their knowledge to colleagues in other departments in the second stage.

In addition to promoting innovation skill development, the Design Thinking Lab will provide an opportunity for researchers focusing on educational design to validate and test emerging concepts related to teaching pedagogy with ICT.

5.11 Partner 11: Von Newmann Institute (JVN)

5.11.1 Partner description

John von Neumann Institute is an institute directly belonging to Viet Nam National University of Ho Chi Minh City. John von Neumann Institute offers 2 scientific programs, which focus on data science-oriented information technology and on quantitative computational finance. Each scientific program includes a Master's curriculum and a lab.

The strategy of John von Neumann Institute is to create a highly interactive environment and provide a more active educational approach for students. Students may actively select the subjects in their learning path. The labs are accessible to students 24/7. Most of the time there are lecturers, researchers, or classmates available to support them. In the labs, each student is equipped with a workstation connected to the system of servers for working on their projects and assignments. The labs further offer space that students can use to work in groups under the

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supervision of lecturers or researchers. Each of the 2 Master's programs includes at least 4 - 5 rigorous courses that require significant effort.

John von Neumann Institute has equipped the 2 existing labs with software and database services of Vietnamese origin. This infrastructure will complement the equipment purchased through the ICT-INOV program for developing a Design Thinking Lab for the QCF program. John von Neumann Institute heavily deploys the labs in its 2 scientific programs. Lecturers, researchers, and students collaborate in the labs beyond strict classroom activities. Students build knowledge through projects, course work, and subjects in the curriculum under the supervision of the lecturers and researchers.

5.11.2 Organizational current practices on building innovation skills in ICT

To promote the development of innovative thinking among students, John von Neumann Institute organizes weekly seminars on Friday afternoons with the participation of industrial experts, lecturers, researchers, and students. They present various topics related to the professional world, skills, and new ideas. John von Neumann Institute also organizes monthly mini-hackathons or competitions for the students to practice their skills and become familiar with the actual conditions in their future work environment.

John von Neumann Institute already deploys design thinking to a certain degree. To promote the innovation potential of students, lecturers are trained in design thinking and are encouraged to use the Design Thinking Lab for programming, communication, and access to open educational content, such as examples and exercises that can be used in their courses. Due to the limited available workstations, academic support staff prepares a plan with multiple time slots that students can book to work on exercises or small projects. This approach allows the maximization of the labs' usage.

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5.11.3 Description of courses in which design thinking integrated with gamification will be deployed in an early phase

The organization has identified 2 courses in each Master's program for piloting the ICT-INOV learning intervention in the short term. Piloting will involve educational activities in the Design Thinking Lab and deployment of the ICT-INOV digital learning platform. JVN is in the process of developing the capacity of educators to adopt design thinking in courses through instructor training events and seminars that will support them in the integration of design thinking into existing learning practices. Starting in the fall 2022 semester, students will have the opportunity to engage in design thinking activities, use the Design Thinking Lab, and provide feedback.

5.11.3.1 Decision Analysis

The course focuses on theoretical and practical aspects of decision analysis, namely methods that assess all aspects of a decision and taking actions based on the decision that produces the most favorable outcome. It focuses on approaches that ensure that decisions are made using all relevant information and options available. The course is offered in the context of the Data Science curriculum. This course is also offered in some Applied Mathematics graduate programs in the University of Economics and Law - VNUHCM and University of Natural Sciences - VNUHCM. The course is delivered by 2 lecturers and engages 20 graduate students each year. The pedagogical methodology deployed is based on increasing visual interaction to help students understand better the related theoretical issues.

5.11.3.2 Time Series Analytics and Forecasting

The course focuses on time series analytics and forecasting, namely methods for analyzing past data generated within a given duration of time to forecast the future. The techniques in focus help analyze time series data and extract meaningful statistical information and characteristics of the data, which can be extremely valuable in the future. The course is offered in the Data Science

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curriculum. The course is also offered in some Applied Mathematics graduate programs in the University of Economics and Law - VNUHCM and University of Natural Sciences - VNUHCM. It is delivered by 2 lecturers and engages 20 graduate students each year. The pedagogical methodology deployed is based on learning by examples and enhancing practical skills through exercises.

5.11.3.3 Advanced Programming in Finance+

The course focuses on the development of programming skills with direct applications in the financial sector. Programming in finance is useful in a variety of professional activities, such as pricing of derivatives or setting up electronic trading systems. The course focuses in languages typically used in finance, which include Java®, Python®, and, less frequently, C++. The course is offered in the 1st semester of the Quantitative Computational Science curriculum. It is delivered by 2 lecturers and engages 20 graduate students each year. The pedagogical methodology deployed is based on learning by examples and enhancing practical skills through exercises.

5.11.3.4 Numerical Methods in Finance

The course focuses on numerical methods with applications in the financial sector, such as binomial and trinomial trees, finite difference, Fourier, Monte Carlo, and linear programming. The course is offered in the 2nd semester of the Quantitative Computational Science curriculum. It is delivered by 2 lecturers and engages 20 graduate students each year. The pedagogical methodology deployed is based on increasing visual interaction to help students understand better the related theoretical issues.

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5.11.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

Design thinking can be deployed in a wide range of courses that are part of the undergraduate and graduate curriculum at different universities, such as the Information and Communication Technology undergraduate program in Ho Chi Minh University of Technology, Vietnam Germany University, University of IT – VNUHCM, and the ICT graduate program in University of Economics and Finance, which focuses on solutions based on theoretical frameworks, introduces design principles, and provides technical input regarding the application of knowledge in practice. Some examples follow.

5.11.4.1 Enterprise Architecture

The course exposes students to the fundamentals of enterprise architecture. Students build knowledge on the definitions, benefits, and disadvantages of enterprise architectures, developing and maintaining an enterprise architecture, exploring uses of enterprise architecture, and roles and responsibilities of an enterprise architecture engineer. The course is offered in the Information and Communication Technology graduate program at John von Neumann Institute. The course is also offered in the ICT graduate program in Polytechnic University of Ho Chi Minh City. 12 students enrolled in semester 1 of academic year 2019 - 2020 and 15 students enrolled in semester 1 of the academic year 2020 - 2021.

5.11.4.2 Business Process Modeling

The course focuses on the development of graphical representations of business processes and workflows. It is offered in the 2nd semester of the Information and Communication Technology graduate program. It enrolls 20 students. The course is delivered by 1 lecturer and 1 academic assistant. The pedagogical approach of this course is learning by applying the theoretical issues in real contexts and practical enhancement through mini projects.

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5.11.4.3 Data Modeling

The course focuses on the creation of models for data to be stored in a database. The course is offered in the 2nd semester of the Information and Communication Technology graduate program. It enrolls approximately 20 students each academic year. The course is delivered by 1 lecturer and 1 academic assistant. The pedagogical approach of this course is learning by applying the theoretical issues in real contexts and practical enhancement through mini projects.

5.11.4.4 Management Information Systems

The course focuses on the study of organizations, people, technology, and relationships. It highlights how management information systems can help organizations manage large amounts of data. The course covers diverse types of systems, including enterprise resource planning, IT management, e-Commerce, and others. The course is offered in the Information and Communication Technology graduate program at John von Neumann Institute. It is also offered in the Information and Communication Technology undergraduate program in Ho Chi Minh University of Technology and the ICT graduate program in University of Economics and Finance. Approximately 20 students enroll in the course each year.

5.11.4.5 IT Management

The course focuses on IT management principles and practical applications. It is offered in the Information and Communication Technology graduate program at John von Neumann Institute. It enrolls approximately 20 students each academic year.

5.11.4.6 Network Programming

The course focuses on programming practices and techniques for communication in a computer network. It is offered in the Information and Communication Technology undergraduate program

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at Vietnam Germany University and University of IT - VNUHCM. It enrolls approximately 35 – 40 students each academic year.

5.11.4.7 Methodology and Skill for Scientific Research

The course focuses on basic scientific research methods. It is offered in both the Information and Communication Technology and Quantitative Computational Finance graduate programs at John von Neumann Institute. This course is also offered in the Information and Communication Technology graduate programs at the University of Natural Sciences - VNUHCM and the Polytechnic University of Ho Chi Minh City. The course enrolls approximately 35 – 40 students each academic year.

5.11.5 Description of the design thinking lab and examples of use

The Design Thinking Laboratory is developed through the ICT-INOV project and is established at the John von Neumann Institute. The lab is located at the John von Neumann Institute building in IT Park of VNUHCMC, Quarter 6, Linh Trung Ward, Thu Duc District, Ho Chi Minh City, Viet Nam. It is identified through the logo of the ICT-INOV project and Erasmus+ program and is co-located with the laboratory of data science.

This laboratory is used by both scientific programs offered by John von Neumann Institute, namely Information and Communications Technology and Quantitative Computational Finance.

The lab can be used in all courses of the 2 graduate programs and all projects of John von Neumann Institute. Through the design of the lab, John von Neumann Institute aims to support physical and virtual working environments. The students can access the ICT-INOV gamified design thinking platform for their courses through laptops in the laboratory or through an internet connection from their own location. This solution has demonstrated advantages, especially in the COVID-19 pandemic.

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The Design Thinking Laboratory is installed in a well decorated space in the wider Tenpoint7 Lab facility and is designed for use by small groups of lecturers and students. Working tables have the form of pentagons to encourage discussion and collaboration. The Tenpoint7 Lab currently includes 5 high performance laptops, one for the lecturer and 4 for students, a high-speed network switch with wireless connection, a server for computational and storage purposes and a smartboard. To enhance interaction and active student engagement, the Design Thinking Lab will include 7 high performance laptops. These devices will be used to support problem research, empathy, ideation, prototyping, and evaluation in the context of the proposed ICT-INOV gamified design thinking process.

EQUIPMENT	DEPLOYMENT IN THE PROJECT
Four laptops DELL® 7430 CTO, 12th generation INTEL® core i7-125U, integrated Intel® Iris XE Graphics, 16BG DDR4, 1 TV, Intel® WiFi 6E AX 211, Bluetooth, 2-in-1 14.0in FHD, Windows 11 Pro, DELL® Active Pen – PN5122W, Dell® multi-device wireless mouse MS5320	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process
One surface PRO X laptop SQ2/16GB RAM/512GR SSD/LTE	Problem research, empathy, ideation, prototyping, and evaluation of the gamified design thinking process
One surface laptop studio, 16GB RAM, 512GB SSD, GPU NVIDIA, GeForce RTX 3050Ti	Problem research, empathy, ideation, prototyping, and evaluation of the gamified design thinking process
One surface PRO X laptop 2021 XSG2, 16GB RAM, 512GB SSD, WiFi	Problem research, empathy, ideation, prototyping, and evaluation of the gamified design thinking process

Table 12. Lab equipment and foreseen use at Von Neumann Institute.

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An example of deploying the Design Thinking Laboratory in learning involves the deployment of the lab workstations by educators for designing, assigning, and reviewing course projects and by students for researching and synthesizing solutions in groups by using the ICT-INOV digital learning platform. This model of work is applicable in all the courses described above.

Following, is graphical representation of the lab.

Figure 7. A graphical presentation of the Von Neumann Institute lab.

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5.11.6 Plans for the wide deployment of design thinking integrated with gamification for building innovation skills at JVN

The idea of building innovative skills in strategies and curricula at John Von Neumann Institute, particularly the Information and Communication Technologies program, is gradually being adopted throughout the organization. The implementation of the ICT-INOV learning intervention will be synchronized with the strategic plan of John Von Neumann Institute, in which design thinking will be specifically covered in the organization's strategical documents. With the goal of providing quality education to develop skills needed in society and in the workplace, both at the national and international levels, several steps can be taken to promote the deployment of design thinking at John Von Neumann Institute as follows:

An initial phase of pilot deployment of design thinking in courses will take place, to be followed by a broad deployment in subsequent phases.

Wider deployment in courses at undergraduate and graduate programs within the framework of cooperation between John Von Neumann Institute and high schools will follow.

Teacher training and community building in joint programs of John Von Neumann Institute and other universities in Vietnam to widely deploy the innovative approaches proposed in technical higher education will complement deployment practices within and beyond John Von Neumann Institute.

5.12 Partner 12: Hanoi University (HANU)

5.12.1 Partner description

Hanoi University aims to improve student educational experiences and build instructor skills by applying technology-supported emerging pedagogies. Founded in 1959, Hanoi University is a non-profit public higher education institution. Officially recognized by the Ministry of Education and

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Training of Vietnam, Hanoi University enrolls over 15.000 students and is considered one of the larger higher education institutions in the country. The university offers programs leading to officially recognized higher education degrees at the Bachelor's, Master's, and PhD levels. The university has a selective admission policy based on entrance examinations. The admission rate range is 30 - 40%. International students are welcome to apply for enrollment. Hanoi University provides rich academic and non-academic facilities and services to students, including a library, housing, sports facilities, study abroad and exchange programs, online courses and distance learning opportunities, and administrative services.

5.12.2 Organizational current practices on building innovation skills in ICT

Hanoi University and the Faculty of Information Technology utilize many approaches to help ICT students develop innovation skills, including restructuring ICT curricula towards an on-the-job training approach, integrating, and building an interdisciplinary knowledge base, utilizing new technologies for teaching, learning, and more. Since 2018, the university has implemented a series of activities for upgrading ICT curricula. For example, one of the approaches deployed for building programming skills is focusing on an in-school or real-world problem related to a software product, a network system, an information system and more. In 2022, the university will establish a new Center for Innovation and Entrepreneurship (HANUCIE). The center's mission is to conduct research through a highly qualified team and build a strong international ICT innovation and entrepreneurship network. The center develops training material to embed design thinking, innovation, and entrepreneurship skills into the university's curriculum. The center also acts as an incubator for ICT innovation projects in the university by providing a co-working space and supporting services.

On the other hand, the university board encourages educators' lifelong training to enrich their instructional practices. This is pursued through workshops delivered by professional speakers that

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aim at developing the skills required for academic leadership. In these seminars, educators can further share experiences and practices on the methodologies they deploy in their classrooms and their pedagogical benefits. In addition, educators develop their skills in integrating technology into their teaching practices to bring education into the digital age and prepare students to enter the job market competitively. The seminars may target instructors in an individual department or be university wide.

5.12.3 Description of courses in which design thinking will be deployed in an early phase

5.12.3.1 Human Computer Interaction

Human-Computer Interaction is a mandatory course for 2nd and 3rd-year undergraduate students in the Department of Information Systems, Faculty of Information Technology. The course addresses interactive interface design requirements between users and software, fundamentals of interface and application design, and development trends in the field of interactive interface design between users and software. Theoretical content is presented in lectures. It is practiced through the design and implementation of actual products. The course involves a broad range of activities, including understanding the context in which a project will be implemented, identifying the design needs and requirements, creating a conceptual design, prototyping a solution, and evaluating it. If necessary, this process is re-iterated to address emerging or changing requirements or to redesign a solution based on evaluation feedback. Design thinking will help students improve their products by analysing and understanding how and in which conditions users interact with solutions.

5.12.3.2 Multimedia Design

Multimedia Design is an elective course targeting 2nd and 3rd-year undergraduate students in the Department of Information Systems, Faculty of Information Technology. During the course,

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students learn the basic components of multimedia communication and how to combine them using well-known tools and techniques. The course further helps students understand how to use pictures, sounds and video clips to convey a message in the most meaningful way. At the same time, students build practical knowledge of the design and management of a multimedia communication project. Multimedia Design involves user needs analysis, design, prototyping and evaluation of solutions. In this context, design thinking will help students introduce interventions that best address user needs.

5.12.4 Description of courses in which design thinking integrated with gamification will be deployed in the long term

5.12.4.1 Information Systems Design and Implementation

Information Systems Design and Implementation is an obligatory course targeting 4th year undergraduate students in the Department of Information Systems, Faculty of Information Technology. The course addresses concepts of systems, information systems, stages of the process of designing and implementing information systems, data models of information systems, including conceptual, logical, and physical models and processing models of information systems, including data flow diagrams and functional models. The course helps students understand and practice methodologies in the field of information systems analysis and design. At the same time, the course introduces students to an environment of practice that simulates working models in the real world, improving learners' professional skills.

5.12.4.2 Software Project Management

Software Project Management is an obligatory course targeting 3rd-year undergraduate students in the Department of Information Systems, Faculty of Information Technology. The course focuses on basic concepts and criteria for managing a software project. Students understand the meaning

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and necessity of software project management. They further acquire the necessary skills to manage a particular software project effectively.

5.12.4.3 Mobile Application Development

Mobile Application Development is an elective course targeting 3rd year undergraduate students in the Department of Information Systems, Faculty of Information Technology. The course provides learners with fundamental knowledge of mobile programming through the Android® platform. Learners develop familiarity with concepts that include interface layout and views, data management, program architecture, interaction, and web interaction through the RESTful API service and graphics. Learners practice newly developed knowledge by engaging in practical application development exercises.

5.12.4.4 Advanced Topics on Information Technology

Advanced Topics on Information Technology introduces the knowledge demanded by the modern information and communications technology industry. The course focuses on research overview, analysis and evaluation of technological solutions, techniques, and in-depth theory on a selected field in the information and communication technology industry. Relevant practical issues are also discussed. The specific content of the course varies depending on the selected topic of focus in a given academic year, such as artificial intelligence, big data processing, the internet of things, information security or the application of information and communication technology to solve real-world problems.

Design thinking can help students develop foundational knowledge, problem-solving, and innovation skills through in-depth questioning and redefining of their problem, thinking out of the box and striving to identify alternative solutions that might not be apparent with their initial level of understanding. Students cooperate in groups in all the above courses to develop a

complete product. They participate in different phases of the product development process, from design to implementation and testing.

5.12.5 Description of the design thinking lab and examples of use

The Design Thinking Lab will be a central hub supporting the growth and implementation of design thinking across the university. Students, staff, and faculty members will build knowledge and skills in integrating design thinking into the course and curricula activities.

The lab will have a dynamic layout. The furniture will be movable, creating new spaces and facilitating new possibilities for co-creation in smaller or larger groups. The lab will include large interactive screens and communication cameras for co-working, workstations, laptops, high-definition cameras, and digital sketch pads for designing and implementing digital products.

The Design Thinking Lab will significantly enrich active learning experiences. Students will be exposed to activities that range from digital fabrication, where they will engage in the practice and art of making, to workshops, where they will get a taste of design thinking, and to full courses, where students will build knowledge that allows them to tackle real-world challenges. The combination of these activities will enable students to develop their innovation capacity.

The following equipment will be purchased for the lab:

EQUIPMENT	DEPLOYMENT IN THE PROJECT
Eight workstations, Intel® Core i5-9800, RAM 8GB DDR4, SSD 120GB SATA, HDD 1TB SATA 7200rpm, INTEL® UHD display and graphics, LAN and wireless N PCI express adapter, USB keyboard and mouse, input/output ports headphone, microphone, USB ports, HDMI,	Problem research, empathy, ideation, prototyping, and evaluation of the proposed ICT-INOV gamified design thinking process

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VGA, audio line-in, audio line out, Windows® 10	
Eight monitors, IPS 24inch, full HD 1980 x 1080, input/output ports VGA, HDMI, display port	Problem research, empathy, ideation, prototyping, and evaluation of the gamified design thinking process
Four laptops as workstations, touchscreen 14inch, Intel® Core i5 1035G4, RAM 8GB DDR4 dual (2 slots), SSD 256GB, Windows® 10	Problem research, empathy, ideation, prototyping and evaluation of the gamified design thinking process
One surface laptop studio, 16GB RAM, 512GB SSD, GPU NVIDIA, GeForce RTX 3050Ti	Problem research, empathy, ideation, prototyping and evaluation of the gamified design thinking process
One digital signage touch display, 65inch, active display area 1428.48 x 803.52mm, maximum resolution and refresh rate 3840 x 2160 @60Hz, input signal composite x1, component x1, VGA x1, HDMI x3, DP x1, audio out, control RS232 x1, RJ45 x2, speaker 15W x2, power supply 100 – 240V AC 100 – 240V+-10% 50/60Hz	Problem assignment, lecturing, and support by the educator and collaboration throughout the gamified design thinking process
One Logitech® PTZ PRO 2 webcam for video conferencing with pan/tilt and zoom, HD 1080p video camera with enhanced pan/tilt and zoom, full HD 1080p 30fps, H.264 UVC 1.5 with Scalable Video Coding	Intra and cross-team communication throughout the gamified design thinking process and educational content development in all design thinking phases
One AV Switcher, multi-format, video inputs 4xSDI and 2xHDMI, outputs 2xSDI, 1x HDMI	Intra and cross-team communication throughout the gamified design thinking process and educational content development
One Logitech® BRIO Ultra HD Pro, HD webcam ultimate HD calling up to 4K, resolution/fps 4k/1080p/720p, diagonal field	Camera for communication and educational content development in all design thinking phases

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of view 65/78/90 degrees, autofocus, auto light correction RightLight 3 + HDR,	
PGM, 1xSDI PVW, 1xSDI and HDMI multiview	PGM, 1xSDI PVW, 1xSDI and HDMI multiview
One WiFi router, 10/100/1000 ethernet ports, USB 2.0 port, WiFi standards 802.11 a/b/g/n/r/k/v/a, wireless security WEP, WPA-PSK, WPA-enterprise (WPA/WPA2, TKIP/AES)	Network connectivity in the lab to support the educational process

Table 13. Lab equipment and foreseen use at Hanoi University.

More specifically, an example of activities that will take place in the lab involves the Mobile Application Development course. Students will be asked to work in groups in the Design Thinking Lab to develop a mobile application. Students will need to understand customer requirements, design the application's interface and functionality, implement an application prototype, and test and improve the application. Students will use the lab to work in small groups on user requirements analysis, conduct research on and evaluate ideas or solutions, implement, evaluate, adjust and reimplement solutions, rediscover problems, identify alternative solutions and try new ideas. The large screen displays will be deployed for presenting, teaching, and creative design. Each desktop workstation will support a group of 8 students in problem-solving and creative design. The laptop workstations will support both teachers and students in synthesizing innovative solutions. The cameras and AV switcher will be used for communication and producing multimedia products. The WiFi router will be used for networking in the lab and for communication.

5.12.6 Plans for the wide deployment of design thinking integrated with gamification for building innovation skills at HU

In the modern world, professionals at all levels need to develop their innovation skills. These include creativity, critical thinking, communication, strategic thinking, and problem-solving

competencies to find and develop creative solutions for addressing complex challenges. Traditional learning does not effectively build the knowledge, and transversal skills students need today to succeed as professionals. To address this gap, Hanoi University has strategically opted to implement design thinking to:

- Establish a new center for Innovation and Entrepreneurship to promote research in innovation and entrepreneurship.
- Develop training materials for embedding design thinking, innovation, and entrepreneurship skills into the university curriculum.
- Act as an incubator for ICT innovation projects.
- Apply design thinking as a pedagogical method to build innovation skills in university courses and curricula.
- Develop training programs for instructors on emerging pedagogical methodologies and techniques such as active and experiential learning, problem-based learning, role-playing and portfolio development.

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Conclusions

This document presented the ICT-INOV institutional strategy for the successful adoption of the proposed gamified design thinking approach for fostering innovation skills among Computer Science and Computer Engineering students among partner organizations. A high-level approach based on holistic implementation that addresses all challenges that hinder the adoption of emerging educational design for innovation has been adopted. The approach is based on the development of physical infrastructures, digital infrastructures, open educational content, and instructor training for community and capacity building purposes. This approach is being adopted by ICT-INOV partners, adapted to the individualized needs, curricula, and existing infrastructures of each organization.

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