| CHANGES FROM SUBMITTED PROPOSAL EXTEN.D.T.2 | | |
|---|---|---|
| **Page** | **Section** | **Change** |
| General | Open University | As the protocol between the United Kingdom and the European Union on UK association with Horizon Europe has not yet been signed, **the Open University (OU) is now registered as Partner 08, an Associated Partner**, with their component of eligible costs now being reimbursed from UKRI in the United Kingdom. Partner numbers have changed throughout accordingly, i.e. in the participant list (p.2), the WP tables (pp.25-36) and the staff effort table (p.41) ***(changes in red throughout)***. |
| 14 | 1.2.4 Research Ethics and Intellectual Property Rights (final paragraph) | In accordance with the evaluators' observation that the project's Intellectual Property Rights planning should receive greater emphasis. Change in ***bold italics: (marked in red on Page 14).*** |
| 18 | 2.2.3 Comms. | Bottom of page: "*Also, a policy **brief** will be prepared by project end, shared with existing national policy contacts **and the Horizon Europe projects with which the project is liaising in a common cluster"*** ***(change in red on page 18).*** |
| 19 | 2.3 Summary: key element of the Impact section | New point 4: additional COVID-19 contingencies ***(addition in red on page 19)***. |
| 24 | 3.0 management | Management structure clarified (SC, OMT, WPL). ***(Addition on p. 24).*** |
| 20 | D&C&E Measures | Bottom of page: communication towards policy makers: "***Liaison with two Horizon Europe projects in a common cluster for wider policy communication". (change in red on p.20).*** |
| 37 | Task 8.1 | More detail is given on the dissemination and communication activities with two projects which are common to this Call ***(activities are marked in red on p. 37).*** |
| 38 | Task 8.3 | More detail is supplied on the policy brief to be delivered, for local Exten.D.T.2 members to use with their national governments, and for the consortium as a whole to use together with the two projects in this cluster and with European policy bodies and agencies ***(changes marked in red on p. 38).*** |
| 38 | Deliverables 8.1-8.3 | Amended to refer also to the cluster activities with common projects ***(red, p.38).*** |
| 38 | D8.4 | Policy brief deliverable M36 ***(added in red on p.38, also to Deliverables list p.39).*** |
| 41 | Table 3.1e Critical Risks | Addition to critical risk on COVID-19 upsurge, and mitigation ***(change in red on p.41).*** |
| 42-43 | Table 3.1h Cost justifications | Cost justifications have been elaborated in more detail by NKUA, UGENT, TCD and SIMPLE - also partner numbers have been corrected ***(marked in red on pp. 42-43)***. |
| 43-44 | 3.2 Capacity of partners | ***"…our associate partner,*** the OU, has deep expertise" ***(change in red on pp.43-44)***. |
| 47-51 | OU/UCL | Information on Open University, now associated partner in the project, and UCL, also an associated partner, including their budgets funded by UKRI. ***Added in red pp. 47-51.*** |

# Proposal template Part B: technical description

***Extending Design Thinking with Emerging Digital Technologies.***

**ACRONYM: EXTEN. (D. T. )² PRONOUNCED 'EXTEND IT SQUARED'**

**List of participants**

| Participant No. * | Participant organisation name | Country |
|---|---|---|
| 1 (Coordinator) | Linnéuniversitetet / Linnaeus University (LNU) | Sweden |
| 2 | Ethniko kai Kapodistriako Panepistimio Athinon (NKUA) | Greece |
| 3 | Universiteit Gent (UGent) | Belgium |
| 4 | Norges Teknisk-Naturvitenskapelige Universitet (NTNU) | Norway |
| 5 | Trinity College Dublin (TCD) | Ireland |
| 6 | Filothei Chalvatza (Simple) | Greece |
| 7 | University College London (UCL) **(associated)** | UK |
| 8 | The Open University (OU) **(associated)** | UK |

## 1.1 Objectives and ambition

### 1.1.1 Project Objectives

*Extending Design Thinking with Emerging Digital Technologies* (acronym: **Exten.(D.T.)²** , pronounced: 'ExtenDT Squared') aims to use: Artificial Intelligence (AI); Augmented Reality (AR); 3D printing; and Virtual Robotics technologies, in order to enhance the pedagogical value, sustainable digitization and potential for wide deployment of **Design Thinking (DT)**, a promising transformative pedagogical innovation based on engaged interdisciplinary learning through co-creation (Sharples et al., 2016). It also aims to contribute to teachers' professional development by providing courses and guidelines for them to become allies in designing, implementing and evaluating DT projects in their classroom. The use of Emerging Technologies (ET), such as AI, AR and educational robotics are amongst the EU targeted actions for supporting the digital transformation of education (Digital Education Action Plan 2021-27, ET2020). Yet, despite these technologies being accessible to education stakeholders, there is a lack of concrete pedagogy and teachers' professional development for their meaningful infusion into the current educational context. **Exten.(D.T.)²** will employ ET to support pedagogical transformation through the deployment of DT projects in schools to foster students' 21st-century skills.

Design Thinking describes a dynamic process with specific steps for the collaborative design of innovative, sustainable and feasible product solutions for an end-user through a human-centred approach (Brown, 2008). It consists of distinct but interconnected and usually repeated stages including empathizing with the user, ideation and brainstorming, prototyping, testing and refinement, sustainability planning and delivering of the final solution. It is considered as a key competency of 21st-century education and a highly valued asset in the industry where it originated (Matthews & Wrigley, 2017). It has also been perceived as a user-oriented approach to grappling with wicked problems (complex, real-life, contentious, socio-scientific issues) such as finding innovative solutions to sustainability challenges, an argument that has not been tested so far (Buhl et al., 2019). DT projects involve students in multi-disciplinary co-creation activities, which are missing from the current educational paradigm despite being valued by educational science as an important element of 21st-century pedagogical transformation (Panke, 2019; Bekker et al 2015). A number of education studies have shown the opportunities and benefits of implementing educational DT projects in order to enhance students' 21st-century skills (Scheer, A., Noweski, C., & Meinel, 2012), such as computational thinking, collaboration, critical thinking and creativity, putting STEAM knowledge to use (Cook & Bush, 2018), and better understanding of real-world problems (Magnussen & Stensgaard, 2018; Goldman

& Kabayadondo, 2017). Yet, the necessary transformation from its origins in industrial design in order for it to gain added pedagogical value in schooling has not been fully understood or put into practice. A key problem has been the focus on tangible industrial productions, which for the education system is rather narrow, and also quite vague for teachers to monitor and evaluate.

In **Exten.(D.T.)$^2$** we argue that the enhancement of DT with ET could make it a feasible, accessible and inclusive approach for all students and teachers, while at the same time preserving and expanding at scale the dynamic, multifaceted and immersive aspects of this approach. The **Exten.(D.T.)$^2$** partners will employ already institutionalized, home-grown and open-access digital expressive media of advanced technical readiness as the main tools with which students will engage in DT projects. The project will uniquely integrate Emerging Technologies including AI in the form of Learning Analytics, Augmented Reality, 3D printing/scanning and virtual robotics, with these expressive media aiming to leverage the digital implementation, monitoring and evaluation of DT projects, but also our understanding of how they can support 21st-century skills development. This will in turn increase the scope, educational potential and applicability of DT in mainstream schooling.

**Exten.(D.T.)$^2$** thus aims to combine existing with emerging technologies in order to enhance DT pedagogy in the following three axes:

**Axis 1** concerns the Monitoring, Assessment and Evaluation (MAE) of Design Thinking student activities and learning processes, which will be enhanced by AI algorithms to support **Authorable Learning Analytics (ALA)** (Karkalas & Mavrikis, 2016) and a **customizable Dashboard** for digital open-ended constructivist student activities, such as programming 3D models, authoring socio-scientific 'choices with consequences' games, classification games and programming virtual robots. Most current Learning Analytics designs for educational environments focus on quantifying student performance in closed tasks, lacking algorithms for evaluating and supporting learning in open-ended constructionist activities (Mavrikis & Holmes, 2019). **Exten.(D.T.)$^2$** will go beyond the state of the art by capturing, analyzing and visualizing information relevant to the student's creative and construction production processes, a research objective which has been given little attention so far (Blinkstein & Worsley, 2016). The LA will further be "*authorable*", in the sense of affording educators the ability to configure which data will be captured and visualized, and what feedback will be provided to the students during a learning activity. The aim is to provide teachers with a cost- and time-effective means of ongoing monitoring and coaching of their students online, an important issue of current DT implementations in school settings and LA in general (Herodotou et al., 2019). In addition, teachers' input on both collected data and data analysis will be analyzed by the researchers to develop understanding of teachers' perceptions and possible biases for students' learning process and performance.

**Axis 2** concerns student Knowledge, Competencies and Skills development (KCS), which will be supported through the use of expressive digital educational tools enhanced with emerging technologies. The project will extend existing, already institutionalised and studied digital learning environments, with emerging technologies to enrich the representation repertoire and learning opportunities afforded to the students. These will involve:

a) Two digital game-authoring tools developed by NKUA: ChoiCo (Choices with Consequences http://etl.ppp.uoa.gr/choico/) for socio-scientific simulation games, and SorBET http://etl.ppp.uoa.gr/sorbet/ for classification games, which will be extended with **Augmented Reality** features (i.e., motion/voice recognition and GPS-location tracking) allowing for embodied and location-based learning in online or blended settings. These games will be used to enhance empathy, immersion and informed decision-making process of DT;

b) A widely-used online programming tool to create and animate 3D dynamic figural models, developed by NKUA (MaLT2 , http://etl.ppp.uoa.gr/malt2/) which will be extended with algorithms for **3D printing/scanning,** allowing for the connection of digital artefacts with tangible affordable objects during the prototype phase of DT; and

c) Educational robotics solutions will be extended to go digital via an open-source **Virtual Robotics** application, to enable the development and testing of realistic prototypes in virtual spaces (WeBots, https://cyberbotics.com/).

All digital learning environments described in a), b) and c) will be tied together in one Learning Platform to generate and provide data for analysis to the AI component.

**Axis 3** concerns Collaboration, Communication and Sharing processes (CCS) which will be enhanced by the use and extension of two existing online platforms, the award-winning and highly-used **nQuire** citizen inquiry platform (https://nquire.org.uk/) and the recently developed innovative **co-creation planet** platform

(http://cocreationplanet.eu/) for organizing design thinking resources, allowing for community building and online sharing of tools, artifacts and design products.

To achieve these ambitious aims, **Exten.(D.T.)²** will engage with multiple stakeholders, i.e., education policy makers, school networks, teachers, technology and education scientists, parents, and students to:

(a) co-create DT cases and relevant educational material to mobilise 21st-century skills not only for the use of STEAM concepts but also for grappling with socio-scientific wicked problems such as climate change, migration and biodiversity, with the use of emerging technologies, developing and evaluating students' problem-solving skills and knowledge of these issues;

(b) use and evaluate the two online platforms, nQuire and co-creation planet as "safe spaces" for communication and sharing of personal creations, that will enable large-scale democratised engagement with responsible, ethical and personally relevant scientific investigation; and

(c) orchestrate, evaluate and refine what student information (data) is valuable to be captured while they engage with learning tools and materials, how this information should be treated and visualized in the dashboard, and what type of recommendations to be provided to the student, during digitally-supported Design Thinking (DT) activities, in order to ensure adoption and use by all stakeholders, especially teachers. Authoring tools integrated into the LA component, e.g. UI elements, block-based coding and draggable components, will enable teachers to author for each learning activity i) the data to be visualized so that they acquire meaningful insights about students' learning and engagement, and ii) the recommendations to be provided to the students by the environment during the learning activity. For example, which student data should be collected during the design of 3D prototypes that can inform teachers about students' facing difficulties and requiring support and what recommendations to provide to students during a 3D prototyping activity. Our strategy will enable teachers and other stakeholders to actively and critically engage in, and contribute to, the development of AI algorithms with added value for Digital DT activities.

The project will contribute to stakeholder engagement and mass deployment of digitally enhanced DT by designing and implementing integrated teacher Professional Development (PD) programmes that will support pre- and in-service teachers of different disciplines to develop digital skills for using the extended technologies in efficient and meaningful ways. The partners have established training initiatives both at academic level, i.e. bachelor and master teacher training courses, and at policy level, i.e. national teacher training programmes.

The project will also intervene in current educational institutions adopting a sustainable transformation approach and maintaining an inclusive, counter-hegemonistic resilient ethos addressing all learners and teachers transcending times of societal normality and crisis. The **Exten.(D.T.)²** consortium contains unique, complementary educational and scientific expertise that can leverage involvement of a large number of students, teachers and parents through the nQuire platform, engaging more than 20K people with scientific investigations, and forming connections with the OSOS school network (https://www.openschools.eu/) with more than 1000+ schools, the European Schoolnet (http://www.eun.org/home) and Scientix (https://www.siic.lu.lv/en/projects/scientix). The project partners have designed and developed internationally acclaimed, award-winning and widely applied digital tools and platforms and will use and extend these to digitally enhance DT pedagogy in ways that support inclusive online and blended forms of learning.

The **specific objectives** of this project are to:

**1)** Design, develop, implement and scale-up a transformative pedagogical intervention, for supporting the implementation, monitoring and evaluation of Design Thinking projects digitally extended with emerging technologies. This will be done by the following means:

- extending a set of existing expressive digital constructionist learning tools designed to support the implementation of design thinking projects in online or blended learning settings and to foster 21st-century skills in students. The project will extend well-studied and widely used technological tools, namely MaLT2, ChoiCo, SorBET, Cyberbotics, with emerging technologies that bring added value into DT learning, i.e. Augmented Reality games, 3D printing/scanning of programmable models and Virtual Robotics.
- mobilising and extending the existing and already widely used online platform nQuire, where all these tools and DT activities will become available for wide use and learning at scale. It will also be a safe space for students to share digital productions and engage in discussion and discourse around their affordances and embedded socio-scientific content.
- mobilising the co-creation Planet, an existing and already used innovative online platform especially designed

to support DT projects, which will be used in teacher professional development courses.

- developing an Authorable Learning Analytics (ALA) system and a customizable dashboard enabling different educational stakeholders to get involved in the design of digital resources for DT (teachers, researchers, educational designers) with the capability of customizing the kinds of information they need to assess learner's creative learning and the kinds of automated reactions they wish the tool to provide to learners.

**2)** Bring together different stakeholders in rethinking the nature of emerging technologies for design thinking activities by co-creating **Exten.(D.T.)$^2$** resources and technologies for inclusive learning. This will be done through:

- **Exten.(D.T.)$^2$** experts co-designing with stakeholders, i.e. teachers and policy-makers, a set of DT activities and associated material (e.g., lesson plans) that will tackle current wicked problems such as biodiversity, climate change, gender roles and migration, and support the development of 21st-century skills.
- **Exten.(D.T.)$^2$** experts actively involving 250-300 teachers in a participatory process of design, data collection, analysis and feedback for DT activities.
- **Exten.(D.T.)$^2$** experts co-producing with stakeholders a set of digital resources (e.g., AR games, digital 3D printable artifacts) to support the digital implementation of DT activities, by utilizing the project's extended technologies.

**3)** Support Teacher Professional Development (TPD) concerning the necessary competencies for the meaningful exploitation of the project's technologies in DT activities. This will be achieved through:

- A free online course on Open Learn, potentially reaching more than 60M citizens worldwide;
- Integration of the **Exten.(D.T.)$^2$** approach and technologies in at least 5 existing academic courses about effective pedagogies to pre- and in-service teachers;
- Design and develop specialized TPD-accredited modules providing oriented knowledge and experience as well as support for infusing such an activity in mainstream institutions;
- Providing teachers with **Exten.(D.T.)$^2$** experts' research knowledge on teacher's needs and challenges concerning the use of the project's technologies in the context of design thinking education which will be derived from the above channels, and proposing evidence-based mitigation actions emerging from the project evaluation.

**4)** Create a network of schools and out-of-school organisations connected through **nQuire**, that will collaborate on design projects during and beyond the project timeframe and will empower children to define problems that influence their lives and provide them with the necessary 21st-century skills to solve these.

**5)** Develop a Framework for stakeholders and policy makers including guidelines on how to set up, monitor and evaluate DT projects supported by the project's emerging technologies. This will be achieved through:

- **Exten.(D.T.)$^2$** experts' systematic evaluation of how student's design thinking knowledge, skills and attitudes are stimulated and enabled with the use of the **Exten.(D.T.)$^2$** technologies, using innovative methodologies including existing frameworks of learning outcomes, learning analytics, surveys and interviews.
- Critical analysis of the gendered, cultural, geographical and societal effects regarding the use of AI, AR, 3D printing and Virtual Robotics, in DT activities. For instance, possible biases that may be introduced or reinforced by the adaptive feedback feature in the constructionist tools.

### 1.2 Methodology

#### 1.2.1 Main Concepts

**<u>Integrating Emerging Technologies for the digital and inclusive transformation of Design Thinking</u>**

A key strategy of the latest EU and international agendas for education is the transformation of the educational paradigm from the traditional content-specific knowledge-based approach to a holistic, transdisciplinary and inclusive competence-oriented one built on skill-set development for the digital era and focusing on relevance,

inclusive responsible citizenship, entrepreneurship and sustainable development. The latest 2021-2027 EU Digital Education Plan, accelerated by the emerging needs of the Covid-19 pandemic, prioritizes the digital transformation of education through pedagogical goals involving digital skills and competences as intellectual capital for all students, by 2025. These competences include computational thinking and IT skills, basic understanding of emerging technologies, creativity, collaboration, critical thinking and entrepreneurship. Similarly, the development of higher-order skills with ICT tools has a central role in the Education 2030 Framework for Action (Goals 4.4, 4,6, 4.7). Fostering these competences at all levels of education can contribute to the cultivation of a fairer, more sustainable and inclusive educational paradigm. However, as both action plans highlight, it is crucial to support skill development with new approaches that equally involve students of all genders, from all regions and all economic backgrounds, providing resilience even in times of emerging crisis, e.g., a pandemic that requires exclusively distance education. The **Exten.(D.T.)$^2$** project aims to address this challenge by uniquely integrating pedagogically valuable digital solutions, i.e. coding, modelling and game design, with AI analytics algorithms, AR for embodied learning and 3D printing for rapid prototyping, in order to boost and leverage a hitherto promising yet narrowly applied pedagogical innovation, **Design Thinking** (Sharples et al. 2016).

In the last decade there have been significant efforts to integrate DT into formal and informal educational settings (Rusmann & Ejsing-Duun, 2021). In secondary education, DT is being implemented mainly to teach specific computer science or STEM concepts and not as a subject per se (Cook & Brush, 2018). In cases when DT is part of a CS course, students may use known coding tools like Scratch and NetLogo, or robotics kits, like Lego mindstorms and Arduino, for the stages of prototyping and developing their product (Koh et al 2015). However, outside CS education, DT is implemented and supported mainly with physical means. A number of toolkits in book-like form have been created by researchers and design agencies for guiding K-12 or higher education students and teachers throughout the Design Thinking process, such as the "Design Thinking for Educators toolkit" and "Design Method Cards" by IDEO design company, the "User innovation toolkit" by Ghent University and "The Design Thinking Toolbox" book. Sometimes the physical tools are accompanied with or replaced by similar digital tools such as 2D and 3D drawing applications, like SketchUp, online survey and interview tools, brainstorming and mind-mapping tools. Overall, DT implementation in secondary education lacks the use of technologies during its different stages that would enable a sustainable digitization of DT, accommodating online or blended learning requirements.

In **Exten.(D.T.)$^2$,** DT is seen as a vehicle for an identifiable, valuable, multi-faceted, competence-driven and promising pedagogical innovation which has the potential to be realistically extended to wide educational application. The **Exten.(D.T.)$^2$** project will show how the pedagogical and social value and applicability of **design thinking** practices can be greatly enhanced through the use of specially designed assemblages of emerging technologies. In **Exten.(D.T.)$^2$** digital media enhanced with emerging technologies will be used as tools for students to design, prototype and produce models and games embedding STEAM concepts and wicked problems, i.e. wider socio-scientific issues in an effort to solve socio-scientific and other problems (Figure 1). In particular, the following emerging technologies will be employed to enhance existing digital tools: AI algorithms in the form of Authorable Learning Analytics and analytics dashboard components; Augmented Reality features on two existing game authoring tools; 3D printing and scanning on an existing and widely used programming application for creating 3D digital models called MaLT2 (Kynigos & Grizioti, 2018); and virtual robotics applications on existing educational robotics activity plans (Lammer et. al. 2017). The enhanced digital tools will be integrated into the different phases of Design Thinking in a meaningful way that leverages the implementation of DT in online or blended learning contexts. For instance, geo-location-based games will be used for enhancing the "Empathizing" phase, e.g. the player will reveal in-game information by visiting certain places in the city relevant to the DT issue. Similarly, students will program, print and scan 3D prototype product samples, test them and share them online, enhancing the "Prototype" phase of DT. All digital activities will generate data on student activity that will be collected by the Authorable Learning Analytics (ALA) system according to teachers' preferences. The ALA will be connected to a customizable dashboard that will visualize the collected data and will further allow user annotations. In addition, the nQuire platform will be used to bind together all these tools and to communicate the data to the ALA. Finally, the innovative co-creation planet will be used to create a digital DT toolkit for teachers.

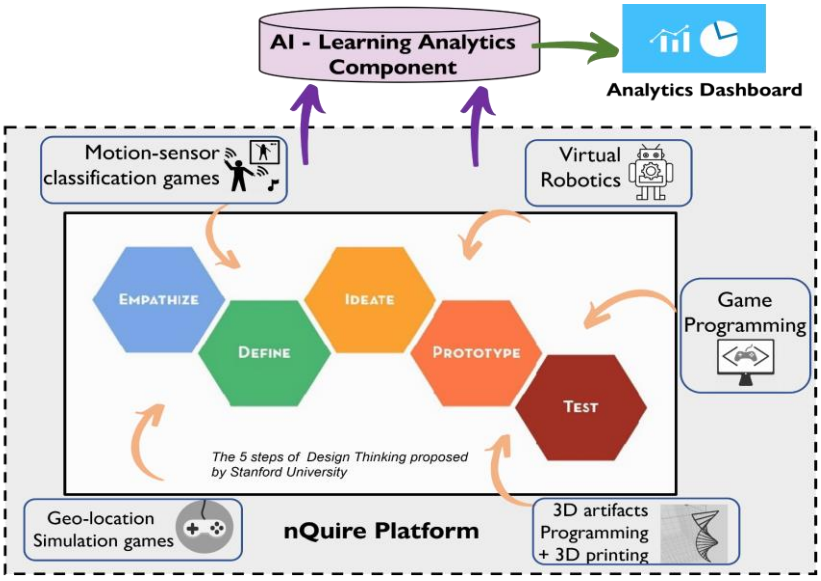


*Figure 1: The* **Exten.(D.T.)$^2$** *approach to a sustainable digitization of education*

The partners have complementary and highly relevant expertise in educational transformation issues and at the same time, maintain specialized background technology at a technical readiness level resulting in them being already established and in wide use. These technologies are custom authoring systems for modelling and game production and safe platforms for sharing, information exchange and collaborative, discursive interaction. In that sense they provide a special custom configuration of digital media and services to enable the education systems to address students as young citizens by means of leveraging the mass deployment of design thinking processes, productions and discourse allowing for added pedagogical value to support co-creation, critical computational thinking and social creativity.

The project will develop a **Framework** (WP2) for the combined use of Learning Analytics, Augmented Reality, 3D printing and Virtual Robotics solutions in the context of digitally supported Design Thinking projects, aiming to support social and economic resilience and sustainability, equitable engagement with meaningful collaborative and co-creation learning activities. To this end, the partnership will co-create original materials with stakeholders (WP3); develop and integrate emerging technologies (WP4); pilot design thinking projects in a variety of schools and contexts (WP5); concurrently design teacher PD courses and materials and pilot them through teacher education networks connected to the partner teams and organizations (WP6); and critically evaluate the tools, resources and their implementations (WP7). The project will demonstrate the extensibility and resilience of such practices based on the use of digital technologies and the internet (WP8).

**Enabling authorable and ethical Learning Analytics for constructionist & creative activities**

The increase of process and product data collected from human-computer and computer-mediated human interaction (big data) provides unprecedented opportunities for knowledge discovery through state-of-the-art data analysis and visualization techniques. However, despite the significant progress on Artificial Intelligence (AI) for Learning Analytics (LA) in the past two decades, the power of these methods has not reached its full potential concerning education and learning. In recent years, the emerging field of LA in education (i.e. the measurement, collection, analysis and reporting of data about learner for purposes of understanding and optimizing learning and the environments in which it occurs) has begun to grow fast in EU countries (Nouri et al 2019; Rienties et. al. 2017).

Yet, there are still important challenges and limitations that negatively impact LA development, uptake and wide-scale use in general education. One of them is that the majority of educational applications that implement LA and intelligent support follow traditional rather than transformative instructional pedagogy, consisting of pre-defined well-structured activities with domain-specific content e.g. math quizzes, linguistic tasks. On the contrary, there is a lack of AI solutions for transformative, open-ended and creative activities in which students construct and share their own digital artifacts, such as game programming, digital model building or educational robotics activities (Blinkstein & Worsley, 2016). These activities have well-established added value concerning the development of multi-disciplinary knowledge and 21st-century skills, but they also involve user interactions, progress, and final products

which are hard to predict and to evaluate. LA could help multiple education stakeholders, e.g. teachers, parents, teacher educators and scientists, to develop a better understanding of the learning process that takes place during students' engagement with those activities. The design and development of LA solutions for such activities remains a challenge with multiple aspects to be addressed including the following questions:

- What information (data) is important to be captured from such activities in order to support constructionist learning activities related to Design Thinking for secondary school students and teachers?
- What feedback needs to be provided to the learner in such activities (during the activity not in the dashboard) and in what form?
- How can the collected data be categorized, visualized and communicated in a meaningful way to non-expert stakeholders (teachers, parents, students, researchers)?
- What ethical aspects, e.g., biases, transparency, trust, are involved in the design and use of LA and visual analytics dashboards for open-ended, creative activities?

To answer these questions the project will co-design, develop and evaluate with teachers and students an Authorable Learning Analytics (ALA) system and a customizable Dashboard, based on previous work of project partners (Mavrikis & Karkalas, 2017), that will collect, analyze and visualize data from students' activities with different educational tools. Particular focus will be given to new forms of data arising from the interaction with other emerging technologies in the project embedded in existing educational tools, including AR technologies extending educational simulation games and 3D printing features extending a programming environment widely used in CS and math education. These technologies were chosen for 2 reasons. First, there is a need to evaluate barriers and enablers to their adoption in education. And second, they can provide different kinds of student data for analysis, such as gestures and movement data, geo-location data, scanned pictures of 3D models and computer code generated by students, allowing for multimodal Learning Analytics techniques (Blinkstein & Worsley, 2016).

Finally, ethical aspects will be examined concerning the collection of student data and their visualization. There are potential ethical concerns when gathering data from different sources, for example aggregating de-identified data from different sources carries an increased risk of re-identification of users (Flanagan & Ogata, 2017). Multimodal LA have been associated with a potentially higher risk of ethical concerns due to the high granularity and temporal nature of the data (Alwahaby et al., 2021). Ethical issues such as privacy, transparency, fairness and bias, and accountability have been studied in relation to AI but according to Alwahaby are sparsely investigated in Multimodal LA. Other ethical issues especially highlighted as a concern in multimodal LA are related to moral principles such as surveillance, accountability and performance-orientation (Spikol et al. 2021). To address this gap we will investigate and problematize which ethical aspects teachers, learners, and other stakeholders consider important and also which biases they may have developed about learning.

**Critical thinking via tinkering with constructionist digital media**

Recently, attention to technology as a constructionist and exploratory medium has been renewed and given much more pertinence as individual and social computational or digital literacy (Angeli & Giannakos, 2020; Grover & Pea, 2018; Wing, 2008). Affordances such as interdependent representations, dynamic manipulation and multimodal narratives have enabled citizens to construct, produce, change (mod) and share digital artefacts as an expression of their ideas and their own creations (Kafai & Bruke, 2017; Resnick & Robinson, 2017). These artefacts have acted as boundary objects, i.e., objects around the making, changing, and sharing through which learners cross boundaries beyond their individual experiences and histories, over to others' understandings, value systems, perspectives, and persuasions (Akkerman & Bakker, 2012). This boundary crossing in the context of sharing and changing learner-made digital artefacts has been recently addressed as a socio-technical environment, sparking and generating social creativity (Kynigos, 2015). An interesting aspect of this type of context is the generation of small or larger communities of interest engaged in a joint enterprise, yet made up of diverse participants, each coming from a distinct community of practice carrying their own experience and history (Essonnier et al., 2017). **Exten.(D.T.)$^2$** strives for equity and inclusivity, addressing a large and diverse community of young people and their teachers, the learning and teaching of whom was unexpectedly driven online due to the pandemic.

The two AR games to be designed and developed in **Exten.(D.T.)$^2$** are innovative as they are constructionist games but focus on socio-scientific wicked problems embedding powerful ideas from STEAM, but placing them at the service of cultivating a critical approach to this kind of authentic problem. It is always a challenge to orchestrate authentic learning activities that engage and empower learners and at the same time, provide them with a context for

personal growth and lifelong learning experiences (Kynigos, 2020). Game-like applications, together with an analytics dashboard and the nQuire platform, will be employed to tackle this challenge. **Exten.(D.T.)$^2$** will infuse elements of DT, creativity, and inquiry, with support from innovative technology, paced so learners may readily engage and contribute, and at the same time find enthusiast spaces to deepen their involvement, gather and share in discussion. In turn, these boundary-crossing learning communities provide illuminative data in the project's research quest to develop and test transformative digital experiences.

## The Exten. (D. T. )$^2$ framework digital transformation and education

We do not yet know how school-based DT activities should be designed and assessed to foster 21st-century skills development and promote creative and sustainable ways of thinking and acting. In this respect, **Exten.(D.T.)$^2$** aims: (a) to capture/analyse the learning processes and outcomes for young people related to the proposed digital transformation and (b) to design, evaluate, and scale-up a transformative digitally-mediated educational programme - demonstrating how the key competences for lifelong learning can be developed through digital inquiry, critical thinking, and creativity, thus contributing to our understanding of how distributed and socially-negotiated learning structured around wicked problems such as sustainability challenges emerges over time. We conceptualise learning processes and outcomes broadly in relation to equity in society. We put at the centre of learning a notion of scientific literacy that involves "being able to use scientific knowledge and ways of thinking for personal and social purposes" (AAAS, 1990). To understand the learning that occurs when people participate in DT activities, we need first to understand how young people participate in these activities, their learning trajectories and outcomes, and how the proposed programme facilitates/hinders learning processes.

To achieve this understanding, we will use the theoretical lenses of Environmental Science Agency (ESA), an environmental science-focused adaptation of Basu and Barton's (2009) concept of critical science agency (Ballard et al., 2016). In developing agency in critical science, young people rely on science subject-matter knowledge to make change and leverage their own science expertise "to reflect and act on injustice in their lives" (Basu & Barton, 2019). Both concepts of critical and environmental science agency explicitly focus on and make space for equity approaches to STEAM learning, where we work to understand what gaining agency with and in the process of DT means. To examine learning as Environmental Science Agency (ESA), we focus on ways that young people use DT learning and participation as a foundation for changes in their lives, that of their families and their communities. ESA includes: 1) understanding the environmental science discipline's content and norms, 2) identifying one's own expertise in the environmental science discipline, and 3) using engagement with science as a foundation for change in their life and community.

In **Exten.(D.T.)$^2$** we will use these three aspects of ESA to help us map changes in knowledge, skills, and attitudes in relation to 21st-century skills and response to wicked problems such as sustainability challenges. We build on existing research (Ballard et al., 2016) to design lifelong learning experiences enabling development of ESA in particular ones that facilitate young people's taking ownership/responsibility for ensuring rigorous data collection (brainstorming or testing phases of DT), reflecting on prototypes and solutions, and disseminating findings to outside audiences.

## A scenario showcasing the Exten. (D. T. )$^2$ transformative approach

The "*biodegradable jewellery scenario*"

Imagine the following scenario. A group of 4 students works on a DT school project about "biodegradable, but also attractive, jewellery". First, they have to understand the problem (why do we need environmentally biodegradable jewellery?). To do so, they play a tetris-like full-body game in which they sort with their body "falling" jewellery made of different materials (e.g., iron, wood, gold, plastic) into different categories/bags that represent the time each material group needs to be degraded by the environment e.g. in case it is lost in the sea. While playing the game they realize, through an embodied experience, that most of the jewels are made with slowly degradable material, causing long-term environmental pollution. Moreover, as they play, the LA component captures data on how students classify the jewellery. The teacher has configured the LA component to collect data of children's movements in space, objects in each category and missed objects, since she thinks they are the most valuable to be captured for this DT project. The data are synchronously visualized into a dashboard with multiple diagrams, giving the teacher a live picture of how the 4 students interact with the game affordances. The teacher can make notes and annotations on the data concerning the students' knowledge, progress and understanding of the biodegradable jewellery issue. The data can

be further compared with those of other teams for analyzing students' views and knowledge. In the meantime, feedback messages, previously authored by the teacher, may appear in the game to support students' understanding of the problem. In the next DT stage of the same project, the students use the online MaLT2 3D modeller to rapidly prototype 3D models of different kinds of jewellery, e.g., earrings, necklaces. In the same way as before, data, indicated by the teacher, are collected and visualized and configured feedback messages may appear to the students. Students upload these digital models on the nQuire platform and ask other students, teachers or parents for their feedback. Other students may also contribute to the design by changing the code of the initial 3D model creating another version of the jewellery. When they finalize the 3D model, the students can print the prototype with a 3D printer that uses biodegradable filaments. They can distribute prototypes of their jewellery into the school or their local community, gather feedback and easily re-design and reprint their jewellery model if necessary. When they have a final solution, they can share the code online for other students to use it in their DT projects.

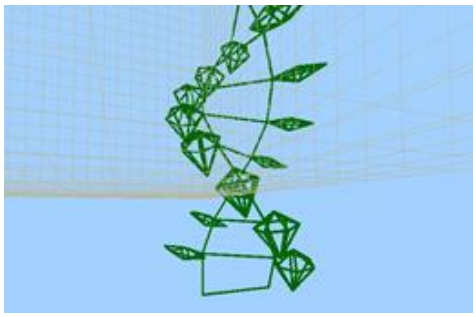

*Figure 2: An example of programming 3D jewellery in MaLT2*

### 1.2.1 Research Methodology

**Participatory design-based research**

The project evaluation aims to develop a critical understanding of the potential, opportunities, barriers, accessibility issues and risks of using emerging technologies for teaching and learning using Design Thinking, from multiple perspectives. It uses a participatory design-based research (DBR) approach (Barab & Squire, 2004) to engage stakeholders who are the main users of the evaluation results (students, teachers, pedagogic partners and technical partners), but who will also conduct aspects of the evaluation, from the outset. Given the vision and objectives of **Exten.(D.T.)$^2$**, there is no existing, standardised method to be applied and therefore a combination of approaches is used and developed. The evaluation will include quantitative and qualitative data from the needs analysis, planning and co-creation activities with stakeholders; professional development activities; and classroom implementations with students, taking place in each country. Results of the evaluation will inform subsequent cycles of the DBR; form an evidence base and provide good practice exemplars for teachers, educational leaders, teacher training institutions, researchers and policy makers.

Teachers will also be involved in evaluating their own implementations of **Exten.(D.T.)$^2$** activities in their schools. Practitioner inquiry is an increasingly popular approach for teachers to develop their professional practice in Europe. In **Exten.(D.T.)$^2$**, an evaluation kit will be created for teachers to use in their own classrooms, developed through a co-creation process with teachers themselves. This will ensure the evaluation kit addresses the immediate needs of the teacher (evidence of learning); their ongoing professional development; and the needs of the project.

**Cycles of implementation and evaluation**

The project will employ a cyclical methodology of participatory DBR involving 3 cycles of iterations through which the pedagogy, activities and tools will be iterated and improved. Each cycle will involve co-design of technologies, resources and material by teachers, pedagogical partners and technical partners (WP 3,4), implementations at 2 levels: teacher training and school interventions (WP 5,6), research data collection, and evaluation (WP7) that will inform the redesign for the next cycle.

**Cycle 1 - Designing & Piloting**

Cycle 1 (M1-11) is about needs identification, framing and initial co-design of technologies, resources, school

interventions and professional development activities. The needs analysis will be done at two levels: i) a literature review on DT with the named emerging technologies to identify potential issues, needs and opportunities (WP2) and ii) a close collaboration of teachers, pedagogic partners and technical partners, to discuss and identify a relevant sub-set of issues, needs and opportunities to the specific school contexts. The analysis will inform a) the initial design and enhancement of existing educational tools with emerging technologies (WP4), *i.e., AR game design tools, programmable 3D printing modeler, virtual robotics, nQuire platform and co-creation planet platform* , b) the initial decisions for the Authorable Learning Analytics and Dashboard component including an ontology of the collected data types from the project technologies (WP4) and c) the initial co-design with collaborating teachers of a first set of digital educational resources for supporting digital DT (WP3), *e.g., digital games, 3D artifacts, supporting and training material,* using existing digital technologies from WP4. The resources will be used in short pilot interventions, engaging about 100 students, in the form of DT projects that deal with current STEAM issues and wicked problems (*e.g. biodiverse products, ecological footprint*) (WP5). This cycle will also involve a pilot of pre-service teacher training on the project technologies and approach delivered in academic courses by 2 partners (WP6). The evaluation (WP7) will take an in-depth look at the implementation of **Exten.(D.T.)$^2$** activities in two classrooms in each country. Exploratory case studies allow the researchers and developers to take a close look at what happens during the activities, pilot tools and remain open to unexpected findings. Data will also be collected from the needs analysis, professional development and co-creation events. A QUAL+quant approach (Creswell, 2002) ensures the rich contextual factors are accounted for and unexpected findings can emerge. Constant comparative analysis with axial coding (Allen, 2017) will be the primary data analysis approach allowing the researchers to develop a nascent understanding of the interplay between pedagogy, technology, content, school context, students and teachers. The results of the analysis will be shared and discussed with partners and teachers at the start of the second DBR cycle.

**Cycle 2 - Development**

Cycle 2 (M12-23) concerns the development of technology, framework, pedagogy and evaluation tools, based on the 1st cycle results and recommendations. The enhanced educational technologies (WP4), i.e. *AR game design tools, programmable 3D printing modeler, virtual robotics, nQuire platform and co-creation planet platform*, will be developed in a stabilized version reaching TRL 5. Based on the collaboration with teachers from the 1st cycle and on the evaluation results of the student interventions, the first version of the Authorable Learning Analytics (ALA) and dashboard will be developed and integrated with the other project technologies reaching TRL4 (WP4). Teachers together with pedagogic and technical partners will co-create new educational activities (WP3) using the latest versions of the project's enhanced technologies. They will also co-author the automated feedback that will be provided to the students during the activities by the recommendation system. All academic partners will design and implement two school interventions in the form of Design Thinking projects delivered by collaborating teachers, and some of the trained teachers from Cycle 1 (WP4). A larger number of pre-service teachers will be trained through academic PD courses or workshops, delivered by 4 partners (WP6). Additionally, a number of in-service teachers will be trained on project technologies and design thinking through the national in-service teacher programme in Greece and through open workshops and online courses that will provide accreditation. The 2nd cycle of evaluation involves four parts: (1) in-depth, instrumental case studies; (2) teacher's evaluation; (3) AI data integration; and (4) survey pilot: (1) Two instrumental case studies in each country will use a refined set of tools from the cycle one evaluation, to look at specific aspects of **Exten.(D.T.)$^2$** activities identified and agreed with partners and stakeholders at the start of Cycle 2. This is to ensure that the needs of the project and the needs of stakeholders are balanced within the evaluation. (2) A teacher's evaluation kit, to be used by teachers in their own classrooms, will be co-created and piloted in Cycle 2. It will be designed to primarily address the needs of teachers in their day-to-day practice, collecting data on student engagement and learning in relation to the subject domain, pedagogic approach and technology used. It will include an analysis guide with a template report. Teachers will then share only an anonymised report with the project team. (3) Data collected from the ALA and the dashboard (i.e. educational tool's data from students' activity and teachers' configurations on the LA component) will be used for the evaluation of both learning activity and teacher's perceptions/biases and needs for supporting digital design thinking projects (4) The final cycle of the DBR looks at scaling **Exten.(D.T.)$^2$** activities and therefore the evaluation needs to function at scale. In preparation, in Cycle 2, teacher and student surveys are co-created and piloted in each country.

**Cycle 3 - Scaling**

The third and final cycle (M24-M36) concerns the refinement of technology, framework, pedagogy and evaluation tools based on the results and recommendations of the evaluation with teachers, pedagogic partners, and technical partners. The enhanced educational tools (WP4) will be refined to address the identified issues, barriers or needs,

reaching TRL 7. The Authorable Learning Analytics dashboard and recommendation system (WP4) will be improved based on teachers' evaluation so that it incorporates their suggestions for data collection, visualization and feedback on the project's educational tools. It will also be refined to avoid possible teacher biases on student learning processes that were identified on Cycle-2 evaluation. The educational resources for DT activities (WP4) will be co-refined by teachers and scientists, leading to the creation of a more general DT toolkit for wide use. All academic partners will design and implement at least four school interventions in the form of Design Thinking projects delivered by collaborating teachers, and some of the trained pre- and in-service teachers from cycle 2 (WP6). The PD programmes will be scaling up to reach a large number of pre- and in-service teachers through a) existing academic courses and teacher training programmes and b) free, online courses. In this cycle, the evaluation moves away from informing development to assessing the sustainability of **Exten.(D.T.)$^2$** activities and gathering data at scale through: (1) teacher evaluations; (2) AI data capture; (3) teacher surveys; and (4) student surveys, as follows:(1) Informed by the pilot in Cycle 2, the teacher's evaluation kit will be developed, integrated into the professional development activities and implemented in participating schools. (2) informed by Cycle-2 analysis, the data collection and visualization algorithms and authoring tools will be improved to provide teachers and researchers meaningful representations of students' learning activity during the DT projects. The dashboard analysis features will allow teachers to actively contribute to learners' evaluation. (3) and (4) Similarly, informed by the pilot in Cycle 2, the teacher and student surveys will be developed and run in all participating schools.

Results of the evaluation will be shared in appropriate formats (see WP7) with the full range of stakeholders and the general public, throughout the project. Periodic summary reports will be shared regularly within the project consortium for DBR purposes; with teachers and schools participating in the DBR cycles; and stakeholders involved in developing teacher professional development. All schools involved in the project and teachers participating in professional development will be provided with materials which provide exemplars of good practice and a clear guide to the evidence base.

### 1.2.2 Inclusivity considerations

Inclusivity is strengthened by targeting activities by, for and about diverse user groups: diversity at the level of all participants (by) and getting to know (about) and properly addressing (for) their specific needs. The evaluation of the tools and activities of **Exten.(D.T.)$^2$** against the project objectives will consider how different learners experience, benefit or are excluded from digitally-enhanced learning including male and female students, students from diverse socioeconomic backgrounds, students with disabilities and learning difficulties, talented students, urban and rural populations, young and adult learners.

Gender equality is a UN SDG area considered a prerequisite for deep sustainability to emerge in a community/society. Traditional engendered roles in establishing a more caring society need to be challenged, as women are often viewed as the ones taking on such roles exclusively. Also, transitions towards more sustainable communities require full input from all genders and diverse backgrounds equally. The educational resources (WP3) and technologies (WP4) in **Exten.(D.T.)$^2$** are facilitated so that issues of bias, privilege, and framing, but also of power and marginalisation, are made explicit in a constructive way that allows joint learning. In particular, **Exten.(D.T.)$^2$** will actively address students, young and adult, as participants to the project to provide equality, diversity and equity amongst different societal groups. In the case of teachers recruited for the co-creation activities, the project team will actively seek to ensure representation of every gender identity, limited by the extent to which applications are received and gender identity is expressed by individuals. We will take an intersectional approach, to ensure a wide range of voices with differing experiences are heard within the co-creation activities. Participation in OpenLearn and existing institutional programmes for teachers do not operate with gender quotas. Therefore, they are open to all who wish to participate and gender will be one of several factors used in the analysis of data. At school age there is roughly a 50:50 gender split within countries throughout Europe, Norway and the UK. Therefore, it is a reasonable assumption that the implementation of pilots in schools will involve both boys and girls in roughly equal proportions. All co-created teaching and professional development materials will be guided and reviewed for explicit and implicit gender biases; including the activity design to ensure counter-hegemonic narratives, images, language, etc. Data analysis will begin by taking the data as a whole and then use multiple lenses to investigate gender and intersecting dimensions (for example, taking into consideration the gender of the teacher and gender of their students; socioeconomic background, etc), using these to problematize the general findings.

The school interventions will engage with secondary school students and teachers in both deprived and remote areas in order to ensure that diverse and hard-to-reach socioeconomic backgrounds are equally represented in the study.

Also, the technologies used and extended in this project are web-based and open-source, allowing access to anyone from any location and device. The extended online communication platforms, i.e. nQuire and co-creation planet, will allow the project to scale up to thousands of users through stratified random sampling processes, to provide secure data storage, and to support research projects through anonymized downloads of data and built-in consent forms.

### 1.2.3 Open Science Practices

Anonymized project data sets (quantitative and qualitative) for academics, teachers and policy makers will be shared following *FAIR* practices using fully funded repositories in the EU. Academic outputs will be made Open Access using either Green or Gold routes, as appropriate, to ensure all stakeholders can engage with the results. All reports, resources, results and anonymized data will be made Open Access via the Zenodo repository or other institutional repositories such as the ORO for the OU.

The Data Management Plan is a living document which will be updated on a yearly basis to take into account the latest developments concerning GDPR and research ethics standards (First version to be delivered on M6 with updated versions in M18 and M36 in WP1). By having a research data management plan, we will protect against data loss, and more and more funding agencies and journals are introducing requirements to make data available. The **Exten.(D.T.)$^2$** Data Management Plan (D1.2-4) explains the type, standards and management of data sharing, and makes data findable, accessible, interoperable and reusable (FAIR). It will operate on the 'as open as possible, as closed as necessary' principle. It will be maintained throughout the project, resulting in a final plan documenting the project's data at the end of the project. Existing resources e.g. CESSDA's Expert Tour Guide on Data Management, will guide the process of FAIR research data management: (https://bit.ly/363TocU). The Data Management Plan will also include details on how non-personal/anonymized data and project results will be made available in compliance with the Pilot on Open Data.

### 1.2.4 Research Ethics & Intellectual Property Rights

A key aspect of any project involving research is to protect all participants. It is important that the work developed takes into account strict ethical standards related with user privacy, confidentiality and consent. Special issues to consider in the **Exten.(D.T.)$^2$** project are the topics of informed consent of both children and adults, data protection including GDPR, user data versus research data, and privacy issues. For all these, we will follow the regulations as given below. Any important national, European and international regulation, and institutional code relating to ethics in research in the countries involved will be adhered to. The members of the Exten.(D.T.)$^2$ project consortium will commit themselves to follow the relevant national legislation and obtain ethical approval from institutional bodies before commencing any data collection activities.

The major requirements raised by the legislations are a) Human rights and dignity: **Exten.(D.T.)$^2$** will obtain informed consent from participants prior to their involvement. During the project the rules of good scientific conduct will be followed and b) Data protection: **Exten.(D.T.)$^2$** has foreseen a detailed plan to handle personal data collected during the research, including GDPR. All partners will obtain ethical approval from their institution, prior to collecting data.In some countries both academic and state agencies may need to give approval, for example in Greece both NKUA ethical review panels and the Ministry of Education must approve research conducted in schools. In addition, a formal letter that the event would not harm or injure the dignity and physical health of the participant from those institutions will be requested a month before the implementation of any empirical study related event.

Key ethical issues concerning data protection, informed consent and children participation in research are explained in detail in Part A Ethics Self-Assessment forms.

Special attention will be paid to ethical issues related to the use of learners' data and its integration in AI systems. We acknowledge that ethics are often not firmly established or adhered to in current AI and learning analytics implementations (Roschelle et al., 2020), and therefore we will review and adhere to existing ethical frameworks and guidelines emphasizing issues of transparency, privacy and informed consent for participants (Tzimas & Demetriades, 2021) right from the start of the project, while we will also be reviewing issues as the project unfolds, as certain issues are likely to be project specific.

Finally, the project consortium agreement will manage ownership and access to key knowledge Intellectual Property Rights (IPR). Design/templates/lesson plans and activities will be **Exten.(D.T.)$^2$** IPR (showcasing the project logo, linked to the website on the relevant nQuire missions); individual contributions (images, ideas, artefacts, modelling)

will belong to the participants who made them, linked to their unique usernames and their nQuire profile page. Overall, **Exten.(D.T.)$^2$** IPR is governed by EU IP policy (https://bit.ly/3ofXVPO). The Coordinator will function as the Intellectual Property Rights Manager dedicated to IPR issues, and will ensure that IPR arising within the project will be identified and managed in line with EU policy. IPR will form a specific part of the Consortium Agreement between all partners.

## 2. Impact

### 2.1 Project's pathways towards impact

**Exten.(D.T.)$^2$ unique contribution to outcomes specified in the call:** (1) Through a participatory DBR approach the project will engage an increasing number of students, teachers and researchers in the process of designing, implementing, evaluating and refining pedagogic innovation based on DT and emerging technologies, ensuring the development of a "shared critical understanding of the potential, opportunities, barriers, accessibility issues and risks of using emerging technologies for teaching and learning" (see Call). The mixed-methods iterative evaluation and an AI dashboard with student data from engaging with the DT projects will provide unique insights as to whether the proposed pedagogical approach is effective and can support teaching and learning in blended and online conditions. Evaluation insights from three cycles of evaluation with teachers and students will feed into the development of a "framework for the sustainable digitization of education and learning in the future" underpinned by constructionist and social constructionist pedagogy, using DT; and detailing the implementation of the proposed approach and how its application can increase students 21st-century skills and competences (See call). (2) The practical implementation and evaluation of the proposed pedagogical innovation across participating countries in Europe at scale will ensure the proposed innovation has been tested and tailored to the needs of diverse learners and teachers and that training material produced from the project such as lesson plans, online tools and a free online course can "support education and training systems...on the adaptation and mainstreaming of the use of digitally enhanced pedagogies". The inclusivity considerations (see 1.2.2) of ExtendDT and its context-specific nature will ensure that the approach will maintain "its human dimension and social relevance" (See call). (3) Work Package 8 (WP8) is dedicated to the ongoing dissemination and communication of project outcomes during and beyond the project period with pre and in-service teachers, secondary students, national policy makers, teacher training, scientific community, to ensure that "evidence and good practice on equipping teachers etc with the skills necessary for the use of technology" is promoted in an inclusive way and at a large scale. (4) The ExtendDT approach to teacher engagement through co-creation and pre and in-service PD will ensure a deep understanding of teachers' requirements and provision of appropriate training, addressing outcomes in the call related to "the needs for adequate teacher training in relation with new educational technologies". Exten.(D.T.)2 goes beyond this by piloting and integrating teacher training into both existing accredited courses at 3 universities and providing free online courses on the OpenLearn MOOC platform, which will continue beyond the lifetime of the project.

**Exten.(D.T.)$^2$ unique contribution to wider impacts: Exten.(D.T.)$^2$** aims to bring short, medium and long-term impact on different stakeholders including pre- and in- service teachers of all ages, teacher trainers, students and their families, educational technologists, national policy makers, scientists and researchers. Specific impacts include: (a) **Scientific:** enhanced understanding about the process of digital DT and its application in school curricula, directly to participating teachers and indirectly to pre and in-service teachers through existing university courses offered by partners and networks with schools and educational policy makers; enhanced scientific knowledge of how to sustainably digitise education through DT to involved researchers, broader academic community and software developers; enhanced understanding of the benefits and barriers to using technologies in education, identifying ways to remove barriers by supporting teachers' professional development and school implementations. (b) **Economic:** enhanced skills to deliver teaching using emerging technologies for participating teachers, schools and the teaching community across participating countries and internationally; development of students' 21st-century skills facilitating future employability and adaptation in an ever-changing society, as well as contribution to solving societal challenges through DT processes. (c) **Societal:** tackling inequalities and promoting social fairness and access to educational opportunities in students through an inclusive and sustainable approach to learning, that is accessible over and above natural disasters; innovative approaches to teaching and learning adopted by teachers, teacher trainers and educational communities; increased engagement of teachers as researchers in the process of designing and implementing innovation at schools. (d) **Environmental:** new methods for monitoring and supporting and promoting students' learning from a distance that are sustainable to environmental threats; changes in educational practices or policies affecting the sustainable delivery of education.

**Requirements:** The proposed approach requires students and teachers to have access to relatively fast computers and a reliable internet connection. This may not be the case for all students and teachers as seen during the Covid-19 pandemic, therefore regulations and governmental financial support are needed beyond this project to ensure each student and teacher has access to technology and internet connection through which to access and use proposed tools and materials. Also, additional financial support is needed for maintaining, upgrading and providing customer support to users of emerging technologies beyond the project period, to ensure a smooth learning experience.

**Scale and significance of Exten.(D.T.)$^2$ contribution to outcomes and impacts:** During the project lifetime the project will directly impact at least 1500 students, 300 teachers, 25 policy makers, and 55 researchers across all participating countries by the end of the project. The longer-term impacts of the project are expected to include changes to policy in each of the partner countries and at EU level; the long-term integration of DT and emerging technologies in teacher education programmes by the partner institutions will set a 'gold standard' within those countries and beyond, which other institutions will seek to emulate; this will ultimately result in teachers across Europe encountering the approaches, but in the relative short term post-project, a yearly cohort of 15000 students in 6 partner countries will engage with the approaches as part of their training, while up to 60M worldwide will have the opportunity to engage with professional development materials via OpenLearn; with an average of 200 teachers receiving professional development each year, we anticipate 10-20% will go on to sustained implementation of the **Exten.(D.T.)$^2$** tools and approaches in the classroom without ongoing support, based on our professional experience; these teachers may, on average, teach around 100 different students each year, thus the project will ultimately impact 4000 students per year in the first year, 8000 (double) in the second year post-projects, and so on.

## 2.2 Measures to maximise impact - Dissemination, exploitation and communication

### 2.2.1 Dissemination and exploitation of results

To maximise impact dissemination and exploitation activities are described in detail in the Plan for the Dissemination and Exploitation of the project's end results (WP8). The draft dissemination and exploitation plan described below will be consolidated early at the start of the project. Due to the importance of these activities to the consortium, a dedicated WP (WP8) will (a) devise and pursue a specific and measurable plan for dissemination and exploitation, (b) create the dissemination tools (website, leaflets, logo etc.), (c) coordinate the publication procedures and exploitation activities, and (d) organise and coordinate project events with support from all other partners. The Plan will include at least: (1) overview of project objectives and scope, (2) description of role of each partner in specific dissemination and exploitation activities, including a risk analysis identifying factors that may threaten the success of the project as well as mitigation actions, (3) market analysis providing information about the targeted market needs and requirements, the unique selling points of **Exten.(D.T.)$^2$** and potential audiences to reach during and beyond the project duration, (4) dissemination plan including publications, conferences, press releases, (5) plan for affiliation with existing EU projects & initiatives and projects funded under this call, (6) competitors' analysis.

The dissemination strategy plan will carefully map the stakeholders on all levels and address how they should be informed, considering the type and format of information, style, channels and timing. This is to ensure we reach the right stakeholders, at the right time and that the message has the desired effect. All stakeholders should receive the information that addresses their needs and that answers any concerns regarding benefits, effort, effectiveness, costs, feasibility etc. they might have. Students for instance will be more interested in how this adds to employability, difficulty and time investment. Teachers are more concerned about how much time it takes and whether they will be able to deliver and monitor the digital design thinking activity properly. All this information has to be collected from the digital based design thinking activities and has hence to be considered during the preparation and analysis phases (WP3 and WP5 WP6).

In the table below, we summarise the dissemination means to achieve maximum impact at national, European and international level. These are further analysed and discussed in Section 2.2.3, with different audiences/levels of reach. We also provide the minimum Key Performance Indicators (KPIs) to reach, and potential contingency plans if they do not reach their targets during the project.

| **Dissemination Activity** | **KPI** | **Target** | **Contingency Plan** |
|---|---|---|---|
| Publication of results in journals, books or special issues | # of publications | 6+ | Analyse all scientific results for possibility of publication, assign lead authorship and |

| | | | |
|---|---|---|---|
| | | | deadline for submission, review process every 6 months. |
| Presentation of results at relevant scientific conferences | # of publications | 9+ | Periodic review of project activities and advance planning i.e., attendance of at least 1 conference per year per partner. |
| Identify workshops with existing relevant projects and projects funded under this call | # of workshops | 6 | Online implementation of workshops to share insights; establish connections right from the start of the project. |
| Present the project outcomes in non-scientific educational events such as teacher/student conferences | # of presentations | 7+ | Follow schools and teachers' networks, participate in teacher events, e.g. ICT teacher conference in Greece or TeachMeets in Ireland. Organize open workshops and seminars. |
| Participation at National Scientix networking events fostering collaboration with other and related projects and activities | # of events | 3 | Contact the National Scientix network and host our own webinars and events for teachers beyond the project to share project results. |
| Present the results at policy events/meetings | # of presentations | 7 | Actively register, attend and present at policy-dedicated events. Host own events with teachers and actively invite policy makers to attend. Publish and policy briefings to policy makers. |
| Participation in open-science events to disseminate the project towards society | # of events | 5+ | Host workshops and seminars open to the public in local or international open-science events such as "Researcher Night" and "EU Hour of code". |
| Make the educational tools available online and easily accessible through the nQuire platform | # of yearly users | 10.000 + | Partners promote activities further through established national and international teaching and learning networks described above and relevant EU-funded and other projects they have contacts with, as well as through the BBC, and projects funded through this call. |
| Promote the project through its own and other social accounts (e.g. university and lab accounts) | # of followers/likes | 2000 | Partners share content using personal and institutional accounts during and after the project; they schedule timing and content to ensure weekly updates. |
| Media releases | # of releases | 10+ | Seek support from institutions' dedicated media teams (e.g., OU media department). |
| Release a freely accessible online Open Learn course (OU) | #of users/viewers | 2000+ | Promotion through a press release and through media teams |

### 2.2.2 Exploitation activities

The exploitation of project outcomes, i.e. technological products, educational activities, learning material and resources involve: a) Exploitation of the digitally-based DT projects is part of the **Exten.(D.T.)$^2$** objectives. This includes re-use of DT projects and associated materials and tools beyond the project period, available through the project website and free OpenLearn course. b) project website maintenance: envisioned to maintain for 4 years after

the finalisation of the project, featuring the project's deliverables. Its maintenance will be the responsibility of the lead of dissemination WP8 c) nQuire activities and relevant data: envisioned to be maintained for 4 years after the finalisation of the project, and promoted through existing national and international partnerships with other universities, organisations and schools interested in using nQuire. d) OpenLearn course: envisioned to be maintained for 4 years after the finalisation of the project and promoted further through other educational activities and educational projects, including exploring the possibility of connecting to existing OU pre-service teachers' courses, national science curricula and teacher training. e) Gathering and dissemination of publications: further publications may be developed beyond the project, and these will ensure referencing the project in papers and deliverables, the scope of which is related to **Exten.(D.T.)²** f) Lesson plans and templates: emailed to schools, linked to the Open Learn course and project website, and used in future funding applications.

### 2.2.3 Communication Activities

**Exten.(D.T.)²** has devised a range of communication measures and activities to promote the project, the hands-on activities, and its findings during the period of the grant and beyond, targeted and tailored to diverse audiences. WP8 sets up and monitors communication activities for dissemination/exploitation, to achieve the greatest possible impact. Also, resources have been allocated across partners to professional assistance (in-house capacity) in designing communication resources (project logo, leaflets, posters, templates for slides etc.) and promoting the project and its findings (e.g. Gold open-access publications; resources for the professional design of the Open Learn course, maintenance of the Enten(DT) website).

**Communication objectives:** (a) To engage diverse stakeholders in digitally enhanced DT activities and systematically share progress and project outcomes (intermediate objective) and (b) to achieve impact during/beyond the project at local, national and international level. The overall aim of the project communication strategy is to network with existing and funded-under-this-call projects and initiatives to support, disseminate and sustain the **Exten.(D.T.)²** approach across Europe and internationally (see below), to actively engage students and teachers with the hands-on activities, develop DT and digital skills and take action on socio-scientific and STEAM issues and achieve impact during/after the project. The communities and networks established below will be engaged in **Exten.(D.T.)²** to facilitate effective project implementation and greatest impact: **a) Open Schools for Open Societies Network of Schools.** The consortium will capitalise on the OSOS Coordination Action (www.openschools.eu) that created a large network of open schools in Europe. It brings together more than 1200 schools from different European countries. These schools are introduced to the open schooling culture and are already involved in numerous related activities promoting the use of open content and open pedagogies, while establishing open cooperation schemes with local stakeholders, industries and research organisations. By involving local communities in the teaching and learning process, European schools are becoming hotbeds of innovation. **b) OU's OpenLearn community** has reached over 60 million learners of diverse ages, gender, socio-economic status and geographical locations. We will direct this community towards **Exten.(D.T.)²** activities by developing an OpenLearn course about Digitally Enhanced DT projects that will also host links to the **Exten.(D.T.)²** activities, reaching a diverse international audience of citizens. **c) Digital school** (dschool.edu.gr) co-managed by NKUA members who will take part in the **Exten.(D.T.)²** project with half a million new users every year including the Ministry of Education in Greece, teachers, parents, children and reaching these communities at a national level and engaging them with **Exten.(D.T.)²** activities. **d)Learning Objects Repository (Photodendro)** http://photodentro.edu.gr/lor/?locale=en is the ministry of education official repository of educational resources in Greece, having more than 6900 learning objects. NKUA partner has already developed and published more than 2000 educational resources on the Photodendro. **Exten.(D.T.)²** will upload and share educational resources to the repository. e) **OU established network of schools** in particular a partnership alongside the Denbigh Teaching School Alliance over four years (2013-2017) that involved 11 schools and more than 6, 500 participants (http://oro.open.ac.uk/53026) as well as 11 other School-University Partnerships across the UK (https://bit.ly/2McVbFw) reaching diverse education institutions across the UK. f) **Växjö Municipality**, with a well-established collaboration with LNU, will be used to link to existing initiatives relevant to the project such as urban farms. Links with Växjö Municipality will be also used to reach and disseminate project activities. g) **The Scientix Network** (http://www.scientix.eu/ ) in each country will be used for disseminating project results, getting external feedback and establishing communication and possible collaboration with other projects. The project will also collaborate with Scientix to host webinars and events for teachers beyond the project and share project results. h) **Greek Wide-Scale National Teacher Training Programme** (years 2022-2024), co-organized with NKUA, will be used as a channel to reach ~13.000 in-service teachers working in ~850 schools across the country. (https://e-pimorfosi.cti.gr/en/the-project/about-b2-level-ict-teacher-training) i) **Centres for ICT in education** in Norway, closely collaborating with NTNU, including the Skole Laboratoriet https://www.ntnu.no/skolelab and the Realfag

Konferansen https://www.ntnu.no/skolelab/realfagkonferansen will be reached to disseminate **Exten.(D.T.)²** activities to teachers, researchers, parents and students. j) The **OU/BBC partnership** network (https://connect.open.ac.uk) embedding findings from this project to TV and radio co-productions related to education, STEAM and sustainability. k) **Pedagogical counseling services and teacher organisations** in Belgium such as GO! KOV, OVS, KVCV, overlegplatform STEM leraren (https://overlegplatformstemleerkrachten.be/).

**Communication activities**: Multiple communication channels will be used to spread development and project results across all involved stakeholders. The communication channels below detail the target audience, key message, and level of reach. A detailed implementation plan will be developed as part of WP8 as to when these activities will take place, outlining also key personnel and key responsibilities. The leader of WP8 will act as the dissemination manager and will coordinate all relevant activities. These include: **a) Exten.(D.T.)² website -** designed to optimise exchange of information between the project members and local and international communities, and systematically disseminate project progress and outcomes.It will contain links to the DT activities and project technological tools, and a forum, a calendar of project and engagement events in each country. It will also present the public project deliverables and academic publications. It will enable: communication, dissemination of progress and findings, recruitment of participants at all levels (local, national, international) to diverse audiences including citizens, scientists, researchers, members of the public, and media. **b) Open access scientific publications** - scientific publications are necessary for international dissemination of project outputs in particular to the academic community and other relevant educational innovation projects. They will target top journals complying with the requirements for Open Access and Open Research Data. Example journals include Computers and Education, British Journal of Educational Technology, Learning Analytics Journal, and UNESCO's ESD for SDGs portal. **c) Conference presentations and publications - Exten.(D.T.)²** partners have allocated resources for participation at international conferences such as: Interaction Design for Children (IDC), International Conference on Education and New Learning Technologies (EDULEARN), International Conference on Learning Analytics & Knowledge (LAK). **d) Social media accounts (e.g., Twitter, Facebook)** will be set up at the beginning of the project and will be updated at least weekly with project progress and news, in order to increase the number of followers and achieve impact at local and international levels across diverse audiences, in particular students, teachers and researchers. **e) Online training material and resources**, including the OU Open Learn online course and the online DT teacher toolkit will enable open-access teacher training on the **Exten.(D.T.)²** technologies and methodology. Teachers and other citizens will be able to access at their own pace, at any time and any location beyond and after the project, reaching citizens of any age, location and socio-economic background at international level. **f)** A **project newsletter** (every 4 months) circulated within participating institutions, as well as through social media and external links. A mailing list will be compiled with existing contacts of partners,and also used to circulate the newsletter, as part of WP8, reaching mainly academics and researchers as well as DT practitioners we work with at national, EU-wide and international level. **g) The nQuire platform** will be available/maintained beyond the project and used by EU and international institutions, therefore facilitating further exposure to and participation in **Exten.(D.T.)²** activities, reaching citizens of any age, geographical location and socio-economic background, at national and international levels. **h) Media releases** - at least one article presenting the project and outcomes will be prepared from each partner and shared through popular media such as the BBC TV and Radio through the OU/BBC partnership, TIMES Higher Education Supplement, and The Conversation, reaching members of the public at a national level. **i) European Commission Communication channels** - we will also use EC services to communicate largely on our project, its results and events: CORDIS News, CORDIS Wire, the European Commission's newsletters, the EC's event pages, and the Europa website, the EU platform for dialogue and discussion. This will be done in close coordination with our project officer, and will allow us to reach a Europe-wide and international audience of citizens, academics, practitioners and policy makers, and other relevant EU-funded projects. **j) Use of national and international resource repositories and teacher forums** e.g. e.g. Photodentro Learning Objects (http://photodentro.edu.gr/lor/ in Greece, 2link2 in Belgium (https://www.2link2.be/index.php ), OER repository (https://www.oercommons.org/ ) **k) Student presentations** created at the end of each design thinking project, presenting the final product of their DT project and the process of co-creating it the project technologies **l) Policy events and report -** partners will participate in national policy events e.g., Ministry of Education activities, to share project outcomes so as to shape policy at national level (e.g. including material to science curricula). Also, a policy brief will be prepared by project end, shared with existing national policy contacts and the Horizon Europe projects with which the project is liaising in a common cluster. **m) End-of-project conference** - with attendees and keynotes from the international technology-enhanced learning and teaching community including academics, teachers, students, to share insights as widely as possible, reaching mainly stakeholders at a national and international level (as the event will be live streaming).

## 2.3 Summary

**KEY ELEMENT OF THE IMPACT SECTION**

**SPECIFIC NEEDS**

*What are the specific needs that triggered this project?*

1) Most teachers have never been taught how to integrate emerging technologies in their lessons. A lot of them are questioning their own capability of using new technologies, do not know, for example, how artificial intelligence works, some of them even have negative feelings about it.

2) EU and national Ministries of Education have set specific goals for the Digitalisation strategy of education. Yet there is a need for understanding the barriers, opportunities and risks of integrating emerging technologies in the current educational paradigm and provide support for any future technology-enhanced implementations.

3) The sudden shift to online learning in a crisis such as the COVID-19 pandemic caused many obstacles for secondary schools to facilitate a seamless transition to distance learning. Especially for hands-on activities and practical project work like Design Thinking projects, this transition was too difficult for both students and teachers. **Exten.(D.T.)$^2$** aims to test, refine and validate a sustainable approach to education, bullet-proof to any future disasters.

4) Additional COVID-19 contingencies: there is the possibility that a global upsurge in COVID-19 cases has a broad effect on European projects such as Exten.D.T.2. In this regard, as the production of design thinking (DT) projects such as Exten.D.T.2 will be digital (artifacts, games, simulations), this not only extends applicability of DT but also makes it more resilient against short-term or even long-term incapacitation of face-to-face engagement. While this has not been the case in most if not all the Erasmus+ projects which are based on mobility and face-to-face implementation, there still might be the need in Exten.D.T.2 to shift the focus of some elements to a greater digital/online vs. presential structure.

The core concept of Exten.D.T.2 is to make design thinking innovation more resilient against global crises such as COVID-19 and climate change by means of:

a) orchestrating ways for online implementation with respect to students, in the framework of on-line schooling. As these are already built into the project, a need for greater online implementation is easily met in the case of a COVID-19 upsurge.

b) maintaining the workflow among the project partners under adverse conditions. With respect to working capacity being affected by a new COVID-19 emergency, the project may prolong some tasks over a longer period, using the same resources as already foreseen in the respective work packages.

If this postponement of some activities appears to be indicating that the final results will take longer to deliver, the consortium will consult with the European Commission on extending the project final deadline and finishing the final tasks using the remaining resources which were not yet used due to the emergency.

5) In DT projects, teachers face issues in monitoring and coaching their students in an efficient and time-effective way. **Exten.(D.T.)$^2$** will develop an innovative dashboard with student data that will enable teachers to monitor progress and intervene and support students when needed.

## D & E & C MEASURES

What dissemination, exploitation and communication measures will you apply to the results?

**Dissemination towards the scientific community:**
Participating at relevant scientific conferences (at least 9 presentations); Publish research articles in scientific journals/books (at least 6 publications); Research workshops with existing relevant projects and projects funded under this call (at least 6 workshops); Participation at National Scientix networking events fostering collaboration with other and related projects and activities (at least 3 events); organize an end-of-project conference.
**Dissemination towards industry:** Participate in exhibitions and conferences; Dissemination of the project results to industry partners, including private schools and companies in direct collaboration with the project partners such as EnginoEducation (https://enginoeducation.com/ ), Hypocampus (https://www.hypocampus.se/ ) and Arduino cc (https://www.arduino.cc/ ).
**Dissemination towards teachers,students and other education stakeholders:** Release a freely accessible online Open Learn course and training material for teachers; Make the project's educational tools available online and easily accessible through the nQuire platform and project website; Use of national and international resource portals to upload educational resources e.g. Photodentro Learning Objects (http://photodentro.edu.gr/lor/ ); School presentations; Participate in teacher/trainers events e.g. ICT teachers conference; Disseminate the project results in national teacher training programmes.
**Exploitation:** Lesson plans and templates emailed to schools and used in future funding applications; project website, Open Learn course and nQuire activities maintenance: envisioned to maintain for 4 years after the finalisation of the project and promoted through existing national and international partnerships, other educational activities and educational projects.
**Communication towards citizens:** Participate in open-science events e.g. "Researchers Night", "EU Hour of Code", "Maker Faire" (at least 5 events); Promote the project through social media accounts; Media Releases with support from institutions' dedicated media teams e.g. BBC TV and Radio through the OU/BBC partnership; 4-month project newsletter distributed via mailing list; organize open workshops and events in collaboration with local Science Centres, libraries, schools and museums.
**Communication towards education policy makers:** Actively register, attend and present at policy-dedicated events; regular communication with education policy-makers meetings in national level including the Director of Diophantus, the Greek Ministry of Education Computer Technology Institute, the British Science Association, the Association for science education, the JISC, the National Agency of Education in Sweden, the National Council for Curriculum and Assessment and the Department of Education in Ireland. Liaison with two Horizon Europe projects in a common cluster for wider policy communication.

## EXPECTED RESULTS

What do you expect to generate by the end of the project?

**Web-based open-source technologies, that can support remote teaching and learning, and monitoring of student progress from a distance**

Authorable Learning Analytics and Feedback system for supporting open-ended Design Thinking activities with emerging technologies

AR-enhanced game authoring platform for creating and playing geo-location choice-driven simulation games

Enhanced game authoring platform for creating and playing body/voice controlled classification games

Educational programming application for creating 3D printable models

Enhanced citizen inquiry platform (nQuire) for sharing and uploading results from the Design Thinking activities and enabling user-centred creations

**Educational resources**

Co-designed teaching resources for DT projects, i.e., AR games, 3D models

Design Thinking scenarios/cases for socio-scientific issues e.g., the design of biodegradable jewellery

Lesson plans that can support the integration of the proposed approach in schools

**Supporting Material in at least all partner's languages**

User manuals, Q&A and instructional videos, activity plans and templates, guidelines for mass deployment

**The Exten.(D.T.)$^2$ Framework**

Evidence-based guidance on the integration of emerging technologies in education, including critical understanding of potential, opportunities, barriers, accessibility issues, ethical concerns and risks

**Teacher Professional Development, Training Plans and Materials**

Teacher's DT toolkit for implementing Design Thinking with Emerging Technologies

Teacher's toolkit for evaluation

Open Learn Online training course

Course plans and material for Professional Development

**~250-300 Trained teachers through PD activities**

**~ 500 Trained teachers through the OpenLearn online course**

**~1700-1900 Trained students through school interventions**

**~50-55 trained researchers/PhD students**

## TARGET GROUPS

*Who will use or further up-take the results of the project? Who will benefit from the results of the project?*

Direct target groups

**Participating secondary students and their families**
**Participating secondary in- and pre- service teachers**
**Participating researchers and institutions**
**Participating secondary schools**

Indirect target groups

**Education Policy makers:** e.g. Greek Policy Makers of IEP (Institute of Educational Policy) http://www.iep.edu.gr/en/ and CTI (Computer Technology Institute and Press "Diophantus") https://www.cti.gr/en/ , Swedish National Agency of Education, the British Science Association, the JISC
**Scientific community:** fields of educational studies, human computer interaction, emerging technologies for education, design thinking
**Software developers and instructional designers**: design guidelines for integration of emerging digital technologies in the educational process
**~ 180-200 Teacher Trainers** reached through dissemination and exploitation actions e.g., open workshops, presentations in teacher trainers events
**~2800-3000 Pre- and In-service teachers** that will be reached through dissemination & communication actions.
**~17.500-18.000 Secondary students** who will be reached through teachers who will act as multipliers and through communication activities
**Industry Partners** reached through their participation/counseling in the design thinking projects and through communication/dissemination activities
**Pedagogical counseling services** e.g. GO!, KOV, OVSG collaborating with some of the partners in teacher training programmes

## OUTCOMES

*What change do you expect to see after successful dissemination and exploitation of project results to the target group(s)?*

- In-service & pre-service teachers registering for the Open Learn course
- More schools reaching to us to help with implementing the **Exten.(D.T.)$^2$** intervention
- ~20.000 users per year will access and use the web-based tools and technologies of the project that will remain available after the end
- Policy maker reports mentioning the proposed digital transformation
- Follow up funds to develop further and sustain proposed technologies
- Integration of approach in teachers' CPD programmes and preservice university qualifications and courses
- Increasing use of DT with emerging technologies in teaching in secondary schools
- Increasing teachers use of analytics as an approach to monitor and support students in secondary years
- Increase of teacher's digital skills and self-confidence in using emerging technologies for supporting DT projects in online or blended learning contexts

## IMPACTS

*What are the expected wider scientific, economic and societal effects of the project contributing to the expected impacts outlined in the respective destination in the work programme?*

**Scientific Impacts**

Enhanced understanding, communication and creativity of the process of digital Design Thinking with the use of emerging technologies

Improved scientific knowledge on the learning process about wicked problems and the use of emerging technologies to support it

Influencing the design and delivery of curriculum and syllabi in schools

Gain insight into factors that influence implementation of emerging digital technologies in educational settings, revealing both benefits and possible dangers that may occur and how to foster or prevent them

Gain insight into the impact of the digital based design thinking methodology on the professionalization of teachers (in- and preservice)

**Economic Impacts**

Teachers and students with more developed 21st century skills that are better prepared on the digital society, leading to better employability

Industry involvement in the design cases may lead to increased take up of design thinking in industry as well

**Societal Impacts**

*Impacts on practitioners and delivery of professional services, enhanced performance or ethical practice:*

Educational or pedagogical practices have changed, or new or improved processes or methods have been adopted, by individuals, or other organisations

Increased involvement of teachers in the research and design of new educational technology tools and technologies

Increased communication channels and communities for teachers to share their resources, artifacts and experiences with emerging technologies in their classes and seek for support by other teachers

Improved quality of tools for class organization, evaluation and monitoring with digital means e.g. Learning Analytics dashboards, Authorable Feedback

*Impacts on social welfare*:

Awareness of wicked problems and a mindset to look for solutions

Multiperspectivism in thinking

Improved student/teacher access and engagement to high-quality learning tools that utilize emerging technologies for co-constructionist and creative learning (aligned with SDG4 and Digital Education Action Plan)

Improved equality and social inclusion through improved access to education opportunities (SDG4)

Research-led engagement with marginalised, under-engaged and/or diverse audiences, leading to increased participation (SDG17)

Improved digital and computational thinking skills (Digital Education Action Plan) to all students cultivated through their engagement with the design of digital artifacts connected to emerging technologies e.g., AR games, digital models for 3D printing

**Impacts on the environment**:

New methods, models, monitoring or techniques to monitor student engagement and learning progress that is digitally enabled and sustainable to any environmental threads such as future pandemics

Changes in educational practices or policies affecting the sustainable delivery of education

## 3. Quality and efficiency of the implementation

The complex character and scale of **Exten.(D.T.)²** demands a well-functioning organisational structure, with a breadth of expertise overarching that of the individual WPs and providing the consortium with an effective instrument to tackle issues covering a range of disciplines, actors and activities (e.g. dissemination, outreach, exploitation). The structure consists of 3 different levels, enabling broad and specific approaches to project management. There will be a strategic level composed of an executive level, represented by a Steering Committee (SC) and assisted by an Operational Management Team (OMT) consisting of the coordinator and professionals at LNU and the implementation level within the WPs, taking care of direct project implementation.

The management levels are composed of:

***Steering Committee*** - leaders from each project partner.
***Operational Management Team*** (OMT) – WP leaders (WPL) incl. Project Coordinator (PC).
***WP group(s)*** – each WP will have individual meetings organised by the WP leader and report to the PC.
***Advisory Group (AG)***: external experts in Educational Innovation, Design Thinking, AI in Analytics for Education, Constructionist and co-creation learning (see Section 3.2).

### 3.1 Work plan and resources

**Exten.(D.T.)²** consists of eight (8) different but highly interrelated work packages (WPs) (Fig. 3 & 4): The **Exten.(D.T.)²** Framework (WP2) provides the foundation for the design and development of WP4 enhanced learning technologies (nQuire platform, associated game apps, 3D printing application, Virtual Robotics and Authorable Learning Analytics and Dashboard) and WP3 DT activities, resources and material making use of the learning technologies (WP4). WP4 & WP3 provide input for the implementation of WPs 5,6 (school interventions and teacher Professional Development) informing the evaluation process in WP7. WP7 evaluates experiences of the WPs 5, 6 and informs the further development and refinement of the **Exten.(D.T.)²** Framework (WP2), the educational resources (WP3) and the technologies (WP4). A dissemination and exploitation package (WP8) ensures major impact during and beyond the project and WP1 (management) ensures effective coordination and communication amongst partners and alignment with funder requirements. **Exten.(D.T.)²** WPs will follow an iterative design-based research process with three major cycles, described in detail in Section 1.2.

| | Year 1 | | | | | | | | | | | | Year2 | | | | | | | | | | | | Year 3 | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WP | M1 | M2 | M3 | M4 | M5 | M6 | M7 | M8 | M9 | M10 | M11 | M12 | M13 | M14 | M15 | M16 | M17 | M18 | M19 | M20 | M21 | M22 | M23 | M24 | M25 | M26 | M27 | M28 | M29 | M30 | M31 | M32 | M33 | M34 | M35 | M36 |
| **WP1** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T1.1 | | | D1.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T1.2 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T1.3 | | | | | | D.1.2 | | | | | | | | | | | | D.1.3 | | | | | | | | | | | | | | | | | | D.1.4 |
| **WP2** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T2.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T2.2 | | | | | | | | | D2.2v1 | | | | | | | | | | | | | | | | | | | | | | | | | | D2.2 | |
| T2.3 | | | | | | | | | D2.3v1 | | | | | | | | | | | | | | | | | | | | | | | | | | D2.3 | |
| **WP3** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T3.1 | | | | | | | | | D3.1v1 | | | | | | | | | | | | | | | D3.1 | | | | | | | | | | | |
| T3.2 | | | | | | | | | | | | | | | | | | | | | | | | D3.2 | | | | | | | | | | | |
| T3.3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D3.3 |
| T3.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D3.4 | | | | | | |
| **WP4** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T4.1 | | | | | | D4.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T4.2 | | | | | | | | | | | | D4.2 | | | | | | | | | | | | | D4.3 | | | | | | | | | | | |
| T4.3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T4.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T4.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T4.6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D4.4 | |
| **WP5** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T5.1 | | | | | | | | | | | | | | | | | | | | | | | | D5.1 | | | | | | | | | | | |
| T5.2 | | | | | | | | | | | | D5.2 | | | | | | | | | | | | | | | | | | | | | | | | |
| T5.3 | | | | | | | | | | | | | | | | | | | | | | | | D5.3v1 | | | | | | D5.3 | | | | | | |
| T5.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D5.4 | | | | | | |
| **WP6** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T6.1 | | | | | | | | | | | | D6.1 | | | | | | | | | | | | | | | | | | | | | | | | |
| T6.2 | | | | | | | | | | | | | | | | | | | | | | | | D6.2v1 | | | | | | D6.2 | | | | | | |
| T6.3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D6.4 |
| **WP7** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T7.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T7.2 | | | | | | | | | | | | D7.1 | | | | | | | | | | | | | | | | | | | | | | | | |
| T7.3 | | | | | | | | | | | | | | | | | | | | | | | | | D7.2 | | | | | | | | | | | |
| T7.4 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T7.5 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T7.6 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T7.7 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D7.3 |
| **WP8** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T8.1 | | | | | | D8.1 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| T8.2 | | | | | | | | | | | | | | | | | | D8.2 | | | | | | | | | | | | | | | | | | |
| T8.3 | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | D8.3 |

*Figure. 3: The Exten.(D.T.)² Gantt chart*

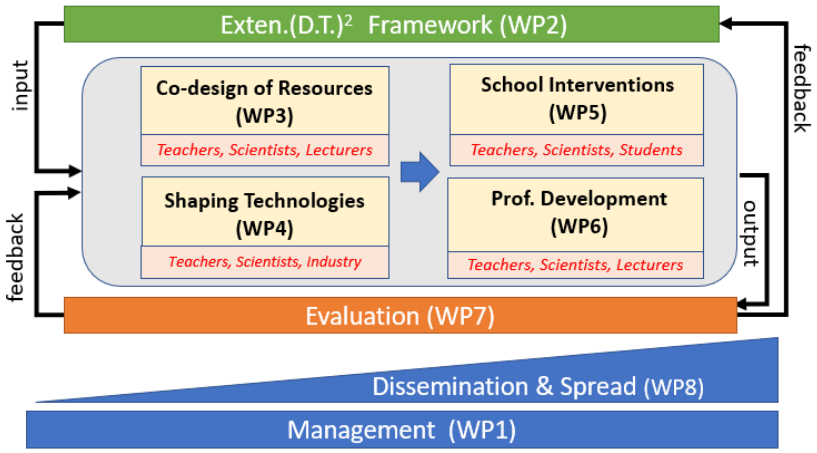


*Figure 4: Pert diagram showing the project's WPs and their interrelation*

**Table 3.1a: List of work packages**

| Work package | Work Package Title | Lead Participant No | Lead Participant Short Name | Person-Months | Start Month | End month |
|---|---|---|---|---|---|---|
| WP1 | Project Management | 1 | LNU | 23 | 1 | 36 |
| WP2 | The Exten.(D.T.)² Framework | 4 | NTNU | 42 | 1 | 35 |
| WP3 | Co-design of Educational Resources and Material | 8 | OU | 52 | 1 | 35 |
| WP4 | Shaping technologies | 1 | LNU | 77,7 | 1 | 36 |
| WP5 | School Interventions | 2 | NKUA | 56 | 1 | 30 |
| WP6 | Professional Development | 3 | UGent | 55 | 1 | 30 |
| WP7 | Evaluation | 5 | TCD | 39,6 | 1 | 36 |
| WP8 | Dissemination and exploitation | 8 | OU | 22 | 1 | 36 |
| | | | Total person-months | 367,3 | | |

**Table 3.1b: Work package description**

| **Work package number** | 1 | | **Lead beneficiary** | | | | LNU |
|---|---|---|---|---|---|---|---|
| **Work package title** | Project Management | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 18 | 1 | 1 | 1 | 1 | 1 | | 1 |
| **Start month** | 1 | | | **End month** | 36 | | | |

**Objectives**

O1.1 To install managerial bodies and project management procedures.

O1.2 To ensure and harmonise the development of activities in all RTD and OTHER work packages.

O1.3 To facilitate communication between partners as well as with the European Commission.

O1.4 To ensure the overall project quality.

**Description of work** (where appropriate, broken down into tasks), lead partner and role of participants

Work Package (WP) 1 concerns the overall management of the project and the provision and monitoring of procedures that will ensure effective and timely delivery of proposed activities.

**T1.1 Project Coordination and administration (Lead: LNU) (M1-M36)**

This task concerns the following aspects of project coordination:

Ensure that the consortium agreement is signed before the project starts; Establish appropriate reporting structures and procedures for reporting within the consortium and towards the European Commission (EC); Perform strategic and day-to-day administrative and financial management of the project; Monitor project status and the fulfilment of the consortium's contractual obligations; Perform financial controlling, timely collection of audits and reporting to the EC; monitor income and expense plan execution; Ensure efficient communication within the consortium and assure effective liaison with the EC, other projects, communities and other bodies as required; Deal with ethical issues that might arise during the project; Prepare the periodic reports.

**T1.2 Monitoring of Scientific Progress (Lead: LNU; all) (M1-M36)**

This task ensures the scientific quality of the project involving the following actions:

Perform strategic and day-to-day scientific and technical management of the project; Ensure the sound management of project activities and the fulfilment of project objectives; Monitor work progress in compliance with the work programme and apply remedial actions to ensure achievement of functional objectives of the WPs; Ensure the quality of the work and the deliverables; Establish the Innovation Management Strategy (IMS) by M3. The IMS will be reviewed in M9 and M15.

**T1.3 Open Access and Data Management (Lead: LNU; all) (M1-M36)**

This task ensures we adhere to open access & data management policy of the EU and to the General Data Protection Regulation (GDPR). Obligatory open access to scientific publications (self-archiving & open access publishing when possible) as follows:

- Open access to research data (taking national guidelines into consideration).
- Research data management plan specifying a) handling of research data during/after the project, b) what data will be collected, processed/generated, c) what methodology and standards will be applied, d) whether data will be shared/made open and how, and e) how data will be curated and preserved.

**Deliverables**

**D1.1 Project Handbook (M3, LNU).** Presents the rules and organisation of the project for the consortium.
**D1.2 Initial Data Management Plan (M6, LNU).** Presents the plan for managing the data generated and collected according to specifications in the Extension of the Open Research Data Pilot in Horizon 2020.
**D1.3 Updated Data Management Plan (M18, LNU).** Presents the plan for managing the data generated and collected according to specifications in the Extension of the Open Research Data Pilot in Horizon 2020.
**D1.4 Final Data Management Plan (M36, LNU).** Presents the plan for managing the data generated and collected according to specifications in the Extension of the Open Research Data Pilot in Horizon.

| **Work package number** | 2 | **Lead beneficiary** | | | | | NTNU |
|---|---|---|---|---|---|---|---|
| **Work package title** | The Exten.(D.T.)$^2$ Framework | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 4 | 6 | 6 | 16 | 4 | | | 6 |

| Start month | 1 | End month | 35 |
|---|---|---|---|

**Objectives**

O2.1. Identify Best Practices, Challenges and Requirements to enhance Design Thinking learning with Emerging Technologies in a valuable way for students', teachers' and educational stakeholders' digital literacy.

O2.2 Develop Exten.(D.T.)$^2$ Framework to reach requirements from O2.1.

O2.3 Develop a set of Guidelines for teachers and other stakeholders to support the deployment of the Framework in different learning contexts (online & blended) and for all students.

**Description of work**

This WP lays the foundations of the **Exten.(D.T.)$^2$** approaches built on the best available research and rooted in the challenges for supporting the digital transformation of the education ecosystem. Its target is the development of a Framework that identifies the key components, perspectives and competencies for supporting Design Thinking Learning in a resilient and inclusive way with emerging technologies.

**Task 2.1 Theoretical Review (NTNU: Lead; all) (M1-M6).**

This task undertakes a comprehensive review of current best practices, approaches and perspectives for integrating the project's technologies (Learning Analytics-Feedback, AR-motion sensors, 3D printing and V-Robots) in STEAM and Design Education, regarding both online and blended learning contexts. The review will aim to identify best practices in pedagogical design and innovations for each technology, current trends in curricula development, frameworks or reports on necessary digital competencies for educators.

**Task 2.2 Development of the Exten.(D.T.)$^2$ Framework (NTNU: Lead; all) (M7- M35)**

This task aims at the development of a holistic Framework that identifies the key components, perspectives and competencies for supporting Design Thinking Learning with emerging technologies. The Framework will take into account the inclusion of all genders, hard-to-reach populations, geographical and societal obstacles regarding the access and use of the proposed technologies. The framework's development will follow a design-based, participatory-research approach including iterative consultations involving stakeholders, teachers, and students as well as evidence-based iterations reflecting findings from the implementation of pilot activities (**WP5**) at schools and teacher training (**WP6**) and their evaluation (**WP7**)

**Task 2.3 Guidelines for mass deployment (NTNU: Lead; all) (M7-M35)**

This task concerns the development of a set of guidelines for supporting the massive and inclusive deployment of the approaches described in the Framework. The guidelines will provide instructions for adapting the Framework content for online and blended learning, aiming to preserve its resilience to possible crises. They will also provide guidance for reassuring the equal and ethical inclusion of all children to the proposed activities, technologies and tools, concerning issues on ethics, data handling, gender equality (e.g., team formation, student collaboration).

**Deliverables**

**D2.1 Report on the theoretical review (M6)**

**D2.2. The Exten.(D.T.)$^2$ Framework (v1. M9, v2. M35)** The Exten.(D.T.)$^2$ Framework will be provided in two versions, the initial before the activities implementation (WP5 and WP6) and the consolidated one after the evaluation and validation of the approach.

**D2.3 Guidelines for Mass Deployment (v1. M9, v2. M35)** This deliverable will be an evolving set of guidelines for mass deployment of the Exten.(D.T.)$^2$ Framework in online and blended learning contexts,

informed from the implementation findings.

| **Work package number** | 3 | **Lead beneficiary** | | | | | | OU |
|---|---|---|---|---|---|---|---|---|
| **Work package title** | Co-design of Educational Resources and Material | | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 4 | 9 | 10 | 8 | 2 | 3 | | 16 |
| **Start month** | 1 | | | **End month** | 35 | | | |

**Objectives**

O3.1 Design a set of educational activities using the project technologies to support DT projects that will be developed and implemented in schools

O3.2 Design a set of training material to support the Professional Development activities that will be developed and implemented with teachers

O3.3 Develop a toolkit for supporting the Design Thinking process with the project's technologies

**Description of work**

This WP concerns the co-design and co-development of a) educational activities about the project technologies, b) supporting material as to how to use these activities with learners, and c) teacher training material to support the design and implementation of Digital Design Thinking activities (**WP5)** and Professional Development activities (**WP6**). The digital resources will be sustainably and freely available online, reusable, changeable, shareable and demonstrable in any digital context including the nQuire platform, usable in project partners' languages and authorable by any student, teacher or citizen. Their design will follow the 3 cycles of DBR, starting with an initial version which will be refined according to the needs and outcomes from the evaluation (**WP7**)

**Task 3.1. Co-design and development of educational activities using project technologies (OU: Lead; all) (M1- M24)**

Education and technology scientists, DT researchers, and teachers will co-design a set of educational resources for supporting the school interventions (WP5) that will involve in total: a) at least 5 *AR GPS-location simulation games* dealing with socio-scientific issues with the game authoring tool "ChoiCo" http://etl.ppp.uoa.gr/choico/ . ChoiCo will be extended to support geo-location features (WP4). The players will make different choices on a map setting with diverse consequences to a set of social and positivist values, enhancing empathy and immersion. In the Design Mode of ChoiCo, teachers and students can easily modify the game components creating their own game versions. b) at least 5 *motion/voice-sensing classification games* with the game authoring tool "Sor.BET" http://etl.ppp.uoa.gr/sorbet/ . SorBET will be extended to support motion and voice controls (**WP4**). In these games, players will classify falling objects in different containers using their body, gestures or physical objects to move them around the screen. In a Design Mode, teachers and students can easily modify the game components creating their own game versions. c) At least 10 *3D dynamically manipulated digital artifacts* with the programmable 3D modeller "*MaLT2"* (http://etl.ppp.uoa.gr/malt2/) that will be extended with 3D printing/scanning features (**WP4**). These artifacts will be used as building blocks for the rapid design, printing and scanning of more complex 3D models in the Prototype and Deliver phases of the Design Thinking projects. d) At least 4 *Virtual Robotics activities* with the virtual robotic platform "*Webot"* https://cyberbotics.com/.

Before the piloting (M9) at least 1 activity with each technology will have been developed. After the 1st cycle of evaluation and before the start of cycle 2 (M12) at least 2-3 more activities with each technology will be developed. After the 2nd cycle of evaluation and before the start of cycle 3 (M24), 2-3 more activities with each technology will be developed.

**Task 3.2. Co-design online supporting material for stakeholders (OU: Lead; all) (M12-M24)**

This task involves the development of online supporting material that will leverage the use of technologies and resources, supporting classroom implementations e.g., video tutorials, brief and extensive manuals, and guidelines for the technologies and the educational resources. The resources will be designed to address different stakeholders, e.g., students, parents, teachers, policy makers, and they will be refined after each evaluation cycle.

**Task 3.3 Co-design teacher training material (OU: Lead; all) (M9- M35)**

This task involves the collaboration of teacher trainers, education scientists and technology scientists to design and develop teacher training material, e.g. tutorials, presentations, exercises, templates/lesson plans, examples of use, videos, to support a) teacher Professional Development activities that will be implemented in **WP6** and b) external teachers in implementing the **Exten.(D.T.)$^2$** activities in their courses during or after the end of the project.

**Task 3.4 Co-design an online (D.T.)$^2$ toolkit (UGent: Lead; OU & NKUA) (M3- M30)**

Technology scientists, education scientists and teachers will co-design an online toolkit that will visualize through the metaphor of an imaginary planet how the project technologies can be used into the stages of design thinking. The toolkit will extend the existing Co-creation planet platform (http://cocreationplanet.eu/) originally created to coach university students during a design thinking process. The platform will be expanded with a planet that guides teachers through the different phases of the development of a digital based DT thinking intervention, using the DT methodology themselves. For every phase, i.e. planet continent, the planet will provide online tools to help teachers through the process.

**Deliverables**

**D3.1 Report on educational activities for students (v1. M9, v2. M24; OU)**

**D3.2 Report on supporting material for teachers and other stakeholders (M24; OU)**

**D3.3 Report on training material and guidelines for teachers (v1. M12, v2. M36; OU)**

**D3.4 Report on the Exten.(D.T.)$^2$ toolkit (v1. M24, v2. M30; UGent)**

| **Work package number** | 4 | **Lead beneficiary** | | | LNU | | |
|---|---|---|---|---|---|---|---|
| **Work package title** | Shaping Technologies | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 20 | 24 | 0,5 | 8 | 2 | 12 | 1,2 | 10 |
| **Start month** | 1 | | | **End month** | 36 | | | |

**Objectives**

O4.1 Extend the nQuire functionality to integrate the project technologies and support the online implementation of the Design Thinking activities (WP5) and teacher training activities (WP6).

O4.2 Iteratively design, develop and evaluate two complementary digital game tools enhanced with AR components, to support immersion and empathy through embodied learning.

O4.3 Iteratively design, develop and evaluate a 3D rapid prototyping environment that will allow the programming, design and print of 3D models.

O4.4 Design and develop an Authorable Learning Analytics and feedback component and a dashboard for supporting the monitoring, evaluation and assessment of digital Design Thinking projects.

**Description of work**

This is the main technology development WP aiming to extend well-established and widely used digital educational solutions with emerging technologies for the digital enhancement and transformation of Design Thinking learning. The aim is to support students develop both design thinking and computational thinking skills while they will be using these technologies to empathize, brainstorm, ideate, prototype, test and deliver solutions to STEAM and wicked socio-scientific problems.

**Task 4.1 - Extend the nQuire platform (LNU: Lead; OU) (M1-M30)**

The award-winning web-based open-access nQuire platform (www.nquire.org.uk ), will be extended to support DT approaches and enable digital transformation of learning. Deployment of existing functionality: Image data collection is already supported by nQuire and will be used to collect artefact images such as 3D printings for discussion and reflection. The platform functionality also supports text-based entries/comments on contributions, allowing citizens to share and discuss ideas, questions, proposed solutions etc. Design of new functionality: the platform will be significantly extended to support: a) Geo-coded (single and multiple) data upload and dynamic map visualisation of data alongside searchable metadata (e.g., filtering, categorisation of comments) that will take advantage of the context within which data are collected. b) Game-based decision making - outputs from game apps (ChoiCo, SorBET) will be uploaded to nQuire. c) The nQuire platform along with new and existing functionality will offer capabilities for interactions between stakeholders (teachers, students, local communities, scientists etc) of diverse ages while providing stand-alone capabilities.

**Task 4.2 - Extend ChoiCo and SorBET game applications with AR components (NKUA: Lead; LNU & NTNU) (M1-M30)**

This task involves the extension of two existing web-based game authoring tools, developed by NKUA-ETL, with AR features, aiming to enhance immersion, empathy and embodied learning. A) The **ChoiCo** environment (http://etl.ppp.uoa.gr/choico/) will be extended to support geolocation and google maps features, enabling the design and play of *GPS location simulation games*. In ChoiCo games the players are engaged with decision making between choices with contradicting consequences to a set of social and positivist values (Kynigos & Grizioti, 2020). It has been widely used in Greek education, embedded also in the official digital books of the Ministry of education. With the geolocation extension the learners will be able to visit certain places in their city to reveal available game choices, see their consequences and decide whether to select them or not. B) The Sor.BET environment (http://etl.ppp.uoa.gr/sorbet/ ) will be extended with *motion and speech recognition* functionalities allowing the players to use their bodies, gestures, voice or any physical objects for controlling the game interface, in any device that has a camera and a mic. The aim is to enhance immersion with the game concepts through embodied learning. Both game design environments will integrate high-level computational affordances, to enable **game modifications by the end-user** (student, teacher, scientist). ChoiCo and Sor.BET extension will start from existing technologies aiming to reach Technology Readiness Levels **TRL4** by M12 and **TRL8** by end of project. The process of design will follow the project design cycles, i.e., M 3-6 (prototype), M 9-15 (pilot), M (18-30) outreach.

**Task 4.3 - Extend MaLT2 programmable modeler with 3D printing/scanning technologies (LNU Lead; NKUA, SIMPLE ) (M1-M30)**

This task involves the design and development of a library for MaLT2 environment (http://etl.ppp.uoa.gr/malt2/?DnaInstance ) that will allow the user to print/scan digital models with 3D printing/scanning devices. MaLT2 is a web-based open-source application, developed by NKUA-ETL, that allows the programming of 3D, dynamically manipulated models with a high-level programming language. It is widely used by Greek secondary education teachers, with more than 200 MaLT2 activities being available in the National Learning Object Repository of the Ministry of Education. It has also been integrated in the Greek math curriculum. MaLT2 has more than 20.000 new users per year according to google analytics. The extended version of MaLT aims to reach **TRL4** by M12 and **TRL8** by the end of the project. The process of design will follow the project cycles, i.e. M 3-6 (prototype), M 9-15 (pilot), M (18-30) outreach.

**Task 4.4. Extend learning tools to capture and generate data for analysis (M1-M6) (LNU Lead; NKUA,**

**NTNU, OU & SIMPLE)**

This task involves the extension of the educational tools that will be used in the DT activities, i.e. AR games, MaLT2 3D modeler, Virtual Robots applications and nQuire platform, to capture and generate data of student activity that will be sent to the Learning Analytics component for further analysis and visualization. Part of this task is to decide which data are meaningful for demonstrating students' learning processes while working with each tool and in what type they will be captured and sent for analysis.

**Task 4.5 - Development of an Authorable Learning Analytics and Adaptive Feedback component for DT constructionist activities (SIMPLE Lead; LNU, NKUA, NTNU & OU) (M3-M35)**

The Authorable Learning Analytics (ALA) component will gather data of student activity generated from the project's educational tools (Task 4.4.) The component will integrate high-level authoring tools e.g. block-based programming and UI tools, that will enable teachers and other non-expert users to author i) which data to be captured for a learning activity and ii) when to provide feedback and what feedback for each activity, aiming to enhance students' engagement with the Design Thinking stages e.g. feedback on how they may increase their empathy or improve the reusability of their prototype as they use the relevant technologies. Teachers' customizations will be stored by the system, allowing for further analysis on teacher preferences, perceptions or possible biases on the learning process. The ALA development will be based on partners previous work and experience on authorable feedback systems for exploratory environments Mavrikis & Karkalas, 2017). The development will follow on the development of the other project technologies (Tasks 4.1-4.4), i.e. take place in two cycles, M 9-15 (pilot) and M (18-30) outreach and they will be revised accordingly after the evaluation of student and teacher interventions (**WP5**, **WP6** and **WP7**), aiming to have reached **TRL4** by M20 **TRL8** by the end of the project.

**Task 4.6 Development of a customizable Dashboard (LNU Lead; NTNU, NKUA & OU) (M3-M35)**

The dashboard will visualize the collected data in meaningful and useful ways for different stakeholders, e.g. teachers, scientists and students. It will allow teachers and students to select the most suitable visualizations for learning activity and to make notes and annotations on the data e.g indicating what they consider as a good teacher progress or a good practice, promoting equal and inclusive access to the data visualization and analysis. The development will follow the participatory design cycles of the whole project i.e. take place in two cycles, M 9-15 (pilot) and M (18-30) outreach and it will be revised accordingly after the evaluation and feedback by students and teachers (**WP5**, Task 5.4). The aim for the dashboard is to have reached **TRL4** by M20 and **TRL8** by the end of the project.

**Deliverables**

**D4.1. Technical specifications for DT platform, LA, AR and 3D printing technologies, (M6; LNU)**

**D4.2. DT platform, LA, AR and 3D printing technologies for DT2 (1st report), (M12; LNU)**

**D4.3 DT platform, LA, AR and 3D printing technologies for DT2 (2nd report), (M25; LNU)**

**D4.4 DT platform, LA, AR and 3D printing technologies for DT2 (final report), (M36; LNU)**

| **Work package number** | 5 | **Lead beneficiary** | | | | | | NKUA |
|---|---|---|---|---|---|---|---|---|
| **Work package title** | School Interventions | | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 8 | 15 | 9 | 8 | 5 | 3 | | 8 |
| **Start month** | 1 | | | **End month** | 30 | | | |

**Objectives**

O5.1 To co-design, with teachers, industry, policy-makers and scientists, Digital-based Design Thinking interventions that deal with real-world problems.

O5.2 To implement O5.1. interventions in school settings and generate data for evaluation (WP7).
O5.3 To evaluate with teachers and students the ALA and Dashboard components.

**Description of work**

This WP concerns the iterative design and implementation of digital-based Design Thinking interventions with students that will provide evidence on the effectiveness of the project's approach and technologies. Following the design-based research methodology, the interventions will undergo **three cycles** of iteration, informing both the design of the tools (**WP4**), the framework (**WP2**) and the educational resources (**WP3**). The interventions will have the form of co-creation projects in which student groups will follow the Design Thinking stages for creating a feasible solution to a socio-scientific problem. The educational resources developed in **WP2**, i.e. Augmented games, coding of 3D models and 3D printing will be incorporated into the different DT stages. The nQuire platform will be the online space for hosting and organizing the activities, providing the necessary tools for collaboration, communication and distant interaction between students (e.g. with nQuire's image data collection feature students will be able to easily scan and upload their 3D printed artifacts, compare them with others from around the world, find similar ones).

**Task 5.1 Design Exten.(D.T.)$^2$ interventions for schools (NKUA: Lead; all) (M3-M24)**

In this task scientists will collaborate with teachers, industry partners and policy-makers to co-design Design Thinking cases that will concern current real-world issues and wicked problems, such as recycling, ecological footprint, biodiversity and migration. They will further design the interventions for implementing the cases in schools utilizing the **Exten.(D.T.)$^2$** educational resources (**WP3**) and technologies (**WP4**).

**Task 5.2 Pilot intervention in schools (NKUA: Lead; all) (M6-M12)**

This task concerns the implementation of pilot interventions (Task 5.1.) by 1-2 partners in a school setting. It will engage a small number of students (~100 students) for the initial testing of **Exten.(D.T.)$^2$** technologies (WP4) and resources (WP3). The pilot study will provide data for analysis to WP7 (evaluation).

**Task 5.3 Second and Third Cycle interventions in schools (NKUA: Lead; all) (M12-M30)**

This task concerns the iterative implementation of the **Exten.(D.T.)$^2$** interventions in a web of schools and the collection of data for the evaluation WP (WP7). The second cycle (M 9-15) will involve 20-25 schools and 500-700 participant students (~25-30 students/school). The third cycle (M18-30) will reach a larger number of schools (40-50) and participant students (1000-1300). The schools will be reached from schools/school networks already collaborating with the partners such as Fagraböckskolan School and Norregårdskolan in Sweden, the 2nd Experimental Junior High School in Greece, school network Panta Rhei in Ghent, Drimnagh Castle Secondary School in Ireland. More schools can also be drawn from the pool of 1200+ in the Open Schools for Open Societies (OSOS, www.openschools.eu) network.

**Task 5.4 Informing the design and testing of the LA and the Adaptive Feedback feature for learner input (NKUA: Lead; all) (M6-M30)**

In this task, researchers will engage with teachers and students to inform and test the learning analytics and adaptive feedback components (**WP4**). The overall process aims at actively involving teachers and students in the design process of the AI algorithm. Teachers and students will make suggestions for the features of the LA, feedback and dashboard components i.e. the set of data to be collected from each technology, the type of visualization on the dashboard, the authoring tools for feedback and data collection, concerning a) usability and accessibility issues and b) added value for the learning process during the DT projects. This process will follow a participatory design method, starting from the involvement of a small number of teachers and students in the first year for the initial design (10-15), following 50-60 in the second year and reaching 200 in the third year. Their suggestions will inform the project evaluation (WP7) and the iterative design of the ALA and dashboard systems (**WP4**, tasks 4.5-4.6).

**Deliverables** (brief description and month of delivery)

**D5.1. Report on the activities plans for school interventions (v1. M6; final version M24; NKUA)**

**D5.2. Report on the pilot implementation (M12; NKUA)**

**D5.3. Report on 2nd and 3rd year implementations (M24;M30; NKUA)**

**D5.4. Report on ALA user analysis (M24; M34; NKUA)**

| **Work package number** | 6 | **Lead beneficiary** | | | | | UGent |
|---|---|---|---|---|---|---|---|
| **Work package title** | Professional Development | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 8 | 12 | 17 | 8 | 3 | | | 7 |
| **Start month** | 1 | | | **End month** | 30 | | | |

**Objectives**

O6.1. Iterative design of pre- and in- service Professional Development activities for established teacher training initiatives

O6.2. Implement Professional Development activities in three cycles; from pilot to wide scale

O6.3. Design and develop online PD courses, available to all teachers for support and self-training

**Description of work**

This WP concerns the support and professional development of teachers and teacher trainers towards the transformation of their roles in the digital transition of education.

This will be done in two levels: 1) Formal synchronous training: injecting established professional development initiatives (e.g. existing courses) with training on the project technologies and approach. This level will provide accreditation through official credentials. 2) Informal wide training: devising and developing new open courses and short training sessions that will be available online targeting a wider audience. This level will not provide official accreditation but it will be appropriate for introducing any teacher to the main concepts, technologies and necessary skills of **Exten.(D.T.)$^2$**approach.

**Task 6.1 Design of Professional Development activities (UGent: Lead; NKUA, OU & TCD) (M3-M12)**

This task involves the development of a learning module that provides pre- end in-service teachers the necessary tools for developing and organizing a design thinking project involving digital tools. The development of the module will be based on the expertise of the project partners who already apply the design thinking methodology in existing higher education courses or PD activities. The result of this task is a methodology for teachers to design DT digital based interventions for secondary education, addressing wicked problems and 21st century skills, supported by a digital dashboard to monitor the progress of the students. The PD activities will utilize the resources and toolkit designed in **WP3**.

**Task 6.2. Three-cycle implementation of Professional Development activities (UGent: Lead; all) (M6-M30)**

This task involves the implementation of PD activities designed in task 6.1. in three cycles. The activities will be implemented in existing courses and training programs for in-service and pre-service teachers by 3 partners (UGent, NKUA, TCD) expecting to train **250-300** teachers in total.

In year 1 there will be a piloting implementation in 2 courses (UGent & NKUA) with 30-50 teachers that will lead to evaluation and refinement of the PD activities (Task 6.1). In year 2 there will be a larger PD implementation targeting 80-100 teachers (in- and pre-service), while in the 3rd year there will be a wide-scale PD implementation, targeting 150-200 teachers. Participants who complete the PD programme will be accredited with the *Europass Digital Credential* (EDCI), evidencing their participation in their course, supporting professional development practices, and contributing to employability demands. The implementation of PD activities will provide data to **WP7** (evaluation) for identifying factors (barriers, opportunities, risks, accessibility issues) influencing the integration of emerging technologies in design thinking methodology by teachers.

**Task 6.3. Design and development of open online courses (OU:Lead; UGent, NKUA) (M24-M36)**

This task concerns the development of an OU Open Learn (www.open.edu/openlearn/ ) free, online course for teachers and interested stakeholders (e.g. parents, informal learning organizations, teacher trainers) to access during or after the project. This free course will concern lectures on the project's outcomes (e.g. Framework, technologies, DT cases) and sharing of insights from the process of design, implementation and evaluation that will enable stakeholders to access at their own pace, at any given time and any location. The OpenLearn course will provide a statement of participation and badges to all enrolled learners. During the project we expect at least **500** teachers and/or teacher trainers to take this course.

**Deliverables**

**D6.1. Report on pilot PD activities (M12; UGent)**

**D6.2. Report on the implementations of PD activities (M24 v1; M30; UGent)**

**D6.3 OpenLearn online course (M36; OU)**

| **Work package number** | 7 | | **Lead beneficiary** | | | | TCD |
|---|---|---|---|---|---|---|---|
| **Work package title** | Evaluation | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 4 | 6 | 6 | 6 | 12 | | 0,6 | 5 |
| **Start month** | 1 | | | **End month** | 36 | | | |

**Objectives**

O.7.1 To design an evaluation framework and tools for **Exten.(D.T.)²** activities.

O.7.2 To conduct an evaluation of **Exten.(D.T.)²** tools and activities in schools.

O.7.3 To provide an evidence base for further developments of the final project outputs.

O.7.4 To identify good practice.

O.7.5 To develop a critical understanding of the potential, opportunities, barriers, accessibility issues and risks of using emerging technologies for teaching and learning using Design Thinking, from multiple perspectives.

**Description of work**

The **Exten.(D.T.)²** evaluation provides evidence for the development and refinement of tools and activities in **WP2, 3, 4, 5 and 6**; as used and implemented by teachers in the project. It uses a participatory-design approach to engage stakeholders who are the main users of the evaluation results (teachers, pedagogic partners and technical partners), but who will also conduct aspects of the evaluation, from the outset. Given the vision and objectives of **Exten.(D.T.)²**, there is no existing, standardised method to be applied and therefore a combination of approaches is used and developed.

The evaluation will include quantitative and qualitative data from the needs analysis, planning and co-creation of tools and activities with stakeholders (**WP 3, 4, 5 & 6**); professional development activities with teachers (**WP 6**); and classroom implementations with students (**WP5**), taking place in each country. Results of the evaluation will inform subsequent cycles of the DBR for **WP 3, 4, 5 and 6** as well as the development of the **Exten (D.T.)²** framework (**WP 2**). The results will also form an evidence base and provide good practice exemplars for teachers, educational leaders, teacher training institutions, researchers and policy makers (**WP 6 & 8**).

**Task 7.1: Development of Cycle 1 Evaluation Toolkit (TCD lead; all); (M1-M6)**

In Cycle 1, the evaluation takes an in-depth look at the implementation of **Exten.(D.T.)²** tools and activities, considering the integration of technology, pedagogy and subject domain; with the purpose of informing the development of other WPs (2, 3, 4, 5 & 6) in Cycle 2. The evaluation uses an exploratory case study approach,

which allows the researchers to pilot and evaluate innovative pedagogic practice, professional development and technologies with QUAL+quant data collection instruments (including semi-structured interviews, observations, artefacts of teaching and learning and short surveys) developed by the project team to meet the needs of each WP and local contexts. The toolkit includes data collection instruments and guides, as well as data analysis guides and reporting templates.

**Task 7.2: Literature Review (TCD lead; LNU, NKUA & UGent); (M7-M34)**
A systematic review of the latest instruments for the assessment of 21st Century Skills, Digital Competencies and Design Thinking will be undertaken to inform the co-design and development of data collection instruments for use in the teacher's evaluation toolkit (Task 7.3), surveys (Task 7.4) and Learning Analytics platform (WP4, Task 4). It will also inform the development of teacher PD resources and dissemination materials (WP6 and 8) and framework (WP2). It will be regularly updated throughout the project lifetime to ensure the integration of evidence informed good practice and innovation.

**Task 7.3: Teacher's Evaluation Toolkit (TCD lead; NKUA & UGent); (M13-M30)**
The teacher's evaluation tool will be co-produced with teachers and expert partners at the start of Cycle 2; implemented and developed based on teacher and partner feedback; and then used at scale in Cycle 3 and as part of the teacher professional development resources (WP6). It will be designed to: meet the needs of teachers who need evidence of learning; meet the needs of researchers to understand the practical realities of using **Exten.(D.T.)$^2$** tools and activities in the classroom (WP5); and to be manageable and achievable by busy teachers, inexperienced in research evaluation. Data collection instruments will include short surveys and assessment tools, student voice activities, reflection guides and suggested artefacts of learning. They will be accompanied by an easy-to-follow guide to analysis and template reports. The main users of the toolkit and resulting reports will be the teachers themselves and so an ongoing co-production process which places teachers at the centre, is key to this task's success.

**Task 7.4 Survey Development (TCD & NKUA); (M13-M30)**
To evaluate **Exten.(D.T.)$^2$** tools and activities at scale, in cycle 3 the evaluation primarily draws on quantitative data collected by the Learning Analytics Platform (WP4) and short surveys completed by students and teachers. Informed by the results of the cycle 1 evaluation (T7.1) and literature review (T.7.2), surveys for teachers participating in professional development activities (WP6) and surveys for teachers and students using **Exten.(D.T.)$^2$** tools and activities in the classroom (WP5), will be developed.

**Task 7.5 Development of Cycle 2 and Cycle 3 Toolkits (TCD & NTNU); (M13-M26)**
Responding to insights from Cycle 1, a series of instrumental case studies are designed, drawing on qualitative and increasingly quantitative data sets. The toolkit brings this together with the teacher's evaluation (T.7.3) and survey pilot (T.7.4). Along with the data collection from the emerging Learning Analytics system, the Cycle 2 toolkit will provide a suite of quantitative and qualitative evaluation tools and guides which support teachers, researchers and developers. Following validation of the data collection instruments in Cycle 2 and with feedback from stakeholders, the final Cycle 3 evaluation kit will focus on quantitative instruments to gather data at scale.

**Task 7.6 Evaluation of activities and tools (TCD lead; all); (M7-M30)**
Integrated into each activity (**WP5&6**) the evaluation toolkit will be used to collect data at each site. The partners are responsible for conducting the evaluations in their countries and providing the WP leader with anonymised data in English ready for analysis.

**Task 7.7 Evaluation data analysis and reporting (TCD lead; all); (M7-M36)**

Beginning with constant comparative analysis of data from Cycle 1, through to the statistical analysis of surveys in Cycle 3; the analysis and synthesis of data collected from T.7.6, along with accompanying short reports will be an ongoing task. A clear and concise evaluation report will guide the partners and teachers in their development of improved content, tools and approaches (**WP2, 3, 4, 5** &**6**). Using sociological lenses, the results will be problematized to ensure a critical understanding of the potential, opportunities, barriers, accessibility issues and risks of using emerging technologies for teaching and learning using Design Thinking is developed and used to inform the framework development (**WP2**) and dissemination tasks (**WP8**).

**Deliverables**

**D.7.1 Cycle 1 Evaluation Report including evaluation kit and initial literature review (M13)**

**D.7.2 Cycle 2 Evaluation Report including evaluation tools and teacher's evaluation kit (M25)**

**D.7.3 Cycle 3 Evaluation Report including evaluation tools and final literature review (M36)**

| **Work package number** | 8 | | **Lead beneficiary** | | | | OU |
|---|---|---|---|---|---|---|---|
| **Work package title** | Dissemination, Exploitation and Impact Generation | | | | | | |
| **Participant number** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| **Short name of participant** | LNU | NKUA | UGent | NTNU | TCD | SIMPLE | UCL | OU |
| **Person months per participant:** | 3 | 5 | 4 | 3 | 1 | | | 6 |
| **Start month** | 1 | | | **End month** | 36 | | | |

**Objectives**

O8.1Develop a dissemination and exploitation plan.

O8.2 Develop the project website, social media presence, newsletters.

O8.3 Develop an OpenLearn online course for dissemination and exploitation.

O8.4 Produce conference and journal publications including a policy report.

O8.5 Ensure wide participation and student and teacher engagement with the DT projects.

O8.6 Ensure the sustainability of the project through the AI dashboard, and associated tools.

**Description of work**

This WP aims to ensure that project activities and outcomes will be effectively disseminated during the project period and exploitation will be achieved by the end of the project, by engaging more young people and teachers with designed activities as well as other organisations such as educational policy makers in using the proposed tools, materials and approach.

**T8.1 Dissemination and exploitation activities (M1-M6).** During the first six months of the project, the exploitation and dissemination plan will be finalized. The goal is to identify the optimal targets and the best-suited mechanisms for an efficient dissemination of the activities of the project. In particular, (a) how to engage students and teachers to participate in the different DT projects, and (b) how to monitor their activities in an optimal manner and allow participants the possibility of involvement in the research process at the level they desire. The interactive project website is the central element in dissemination. It will be an open access web page, containing all relevant information about the project and incorporating the usual tools to share information between the partners and participants (wiki, forum, etc.). It will be connected to nQuire and Open Learn course. It will give access to publications produced by the project and a link to the tools and activities of the project. Translations to the languages of the EU will be open to volunteer contributions through the pybossa platform (pybossa.scientize.eu), hosted by Ibercivis. The project media presence (e.g., Twitter, Facebook) and project newsletter will be established and circulated every 3 months to contacts in partner organisations and beyond. Branding and project identity are particularly important to provide a common image and an easier impact and credibility: Project templates, brochures, etc. will be developed during the first six months of the project. All materials will be gender-inclusive (gender balance in images or case studies used). In addition, the project will develop an OU Open Learn (www.open.edu/openlearn/) free, online course for the dissemination and exploitation of project outcomes beyond the project duration. This free course will facilitate sharing of insights from the process of design, implementation and evaluation that will enable teachers, access at their own pace, at any given time and any location beyond/after the project completion. The OpenLearn course will provide a statement of participation and badges to all enrolled learners, evidencing their participation in their course,

supporting professional development practices, and contributing to employability demands.

A number of activities will ensure exploitation of DT approach and associated technologies beyond the project duration and for 4 years after the finalization of the project: a) project website maintenance, b) DT activities and relevant tools, c) OpenLearn course promoted further through other technology-related learning projects, d) Further publications will be developed beyond the project period.

**Exten.D.T.2 cluster experience-exchange events in Task 8.1:**

Two common events (one on-line and one physical) will be organised twice a year, for knowledge and experience exchange related to emerging technologies for education, and to which members of the other two Horizon Europe projects common to this cluster will be invited. It is proposed that already during October 30th-31st 2022 we organise a physical event at LNU (campus Växjö) in connection to a regional conference we have every year within the field of ICT for teaching and learning for teachers (before COVID-19 500 teachers would gather for this event). For 2022, we expect to gather 300 teachers from the south of Sweden.

A second physical gathering is proposed in Brussels during summer 2024, while the last one may be organised in the UK (London), in connection with the BETT show at the beginning of 2025. Separate two-hour meetings will be organised alongside these events for project partners to share insights from their work and learn from each others' experiences.

The on-line meetings may be organised once a year (two-hours duration) as a research seminar in which each project gives a 30-minute presentation on the on-going research at each project, followed by a 30-minute discussion.

**Common scientific cluster activities:**

Spring 2023, organisation of a common workshop coordinated by representatives of the 3 projects in the context of EC-TEL 2023.

Spring 2023, organisation of a common workshop coordinated by representatives of the 3 projects in the context of ICSL/CSCL 2024.

Spring/Summer 2024, organisation of a common workshop coordinated by representatives of the 3 projects in the context of IDC (Interaction Design for Children) 2024.

Autumn 2023, a special issue will be proposed to *IEEE-TLT* or *Computer & Education* on the topic of ***Emerging technologies for education: current challenges, threats and opportunities.***

A panel discussion or a workshop at the ECSITE conference or leveraging other activities of this network. For example, a panel where we discuss the results after the end of the projects (possibly in 2025) or mid-project to discuss and receive input for future directions. https://www.ecsite.eu/conference

**T8.2 Engagement activities (M7-M18)**. Different partners in the consortium have extensive experience of working with school networks such as the OSOS network, which can provide us with a large pool of students and teachers to reach and engage with in our studies across Europe. The design of the free OpenLearn course will also ensure that any educator or researcher can learn about the DT approach and associated tools. A frequent issue arising with volunteers from several countries relates to language barriers for communication. In **Exten.(D.T.)$^2$** this will be dealt with by using the Pybossa platform that enables translation of materials.

Another core issue of **Exten.(D.T.)$^2$** is engaging and sustaining participation of teachers and students with the project activities. This issue will be addressed through frequent and efficient feedback and communication between students, teachers and scientists. Existing work on nQuire showed that the development of an online community around proposed activities can be achieved through systematic engagement of experts in the community' activities, by raising questions, posting comments, answering volunteers' questions and helping with the task identification. Also, the project is structured upon principles of participatory DBR that can facilitate and sustain engagement, as the codesign process will give participants 'ownership' and the possibility to define and determine personally meaningful activities and goals. To maintain constant communication between students, teachers and scientists: 1) periodic twitter/facebook chat sessions where volunteers and scientists will have the

chance to discuss in real time different topics will be organised, 2) a discussion forum on the project web page will support asynchronous discussions and communication, and 3) communication features on the nQuire platform will enable discussion about the DT projects and provide constant support by scientists.

**T8.3 Production of conference and journal publications, including a policy brief (M19-M36).** This task includes dissemination activities in particular, production of 3 conference papers (and presentations) per year (n=9), at least one journal paper per year (n=3) published Gold open access; the rest of them will be green access through institutional repositories such as the OU ORO (http://oro.open.ac.uk) - and a report with policy recommendations emerging from the project and shared with policy contacts across Europe.

Exen.D.T.2 will liaise with the other two Horizon Europe-funded projects in this cluster throughout the project (see planned events above) and consult on planning with regard to a policy brief.
Towards the end of the project, each partner will invite to a meeting the relevant policy bodies/agencies in their country, presenting the results of Exten.D.T.2 and a policy document.
As a consortium, Exten.D.T.2 will reach out to policy-related bodies at the European Commission, e.g. the Joint Research Centre - European Commission (Sevilla) or in Brussels, to consult on the policy ramifications of Exten.D.T.2.

**Deliverables**

**D8.1 Dissemination and Exploitation plan (M6, OU):** This deliverable presents the exploitation and dissemination plan of the project, including liaison with projects related to this cluster.

**D8.2 Dissemination and Impact Report 1 (M18, OU):** This deliverable presents an interim report on the project dissemination activities (e.g., project website, social media accounts, newsletter, engagement activities and status), impact monitoring, OpenLearn course and publications/presentations during the first half of the projects. It also relates the interaction with the Horizon-Europe projects funded in this cluster.

**D8.3 Dissemination and Impact Report 2 (M36, OU):** This deliverable is a final report of the project dissemination, and exploitation activities, including full report on cluster activities.

**D8.4 Policy Brief (M36, LNU):** this document will be shared with our policy (and other) contacts by end of project via email and during the end of the project event where we will invite policy representatives. The policy brief will propose recommendations about educational reform based on project outcomes.

**Table 3.1c: List of Deliverables**

| Deliverable | Deliverable name | WP | Lead participant | Type | Dissemination level | Delivery date |
|---|---|---|---|---|---|---|
| D1.1 | Project Handbook | WP1 | LNU | R | PU | M3 |
| D1.2 | Initial Data Management Plan | WP1 | LNU | R | PU | M6 |
| D1.3 | Updated Data Management Plan | WP1 | LNU | R | PU | M18 |
| D1.4 | Final Data Management Plan | WP1 | LNU | R | PU | M36 |
| D2.1 | Report on the theoretical review | WP2 | NTNU | R | PU | M6 |
| D2.2 | The Exten.(D.T.)2 Framework | WP2 | NTNU | R | PU | M9; M35 |
| D2.3 | Guidelines for Mass Deployment | WP2 | NTNU | R/DEC | PU | M9;M35 |
| D3.1 | Report on the educational resources and supporting material for students | WP3 | OU | R | PU | M9;M24 |
| D3.2 | Report on supporting material for stakeholders | WP3 | OU | R | PU | M12; M24 |
| D3.3 | Report on training material and guidelines for teachers | WP3 | OU | R | PU | M12; M36 |

| | | | | | | |
|---|---|---|---|---|---|---|
| D3.4 | Report on the (D.T.)2 toolkit | WP3 | UGent | R/DEC | PU | M24; M30 |
| D4.1 | Technical specifications for DT platform, LA, AR and 3D printing technologies | WP4 | LNU | R/DEM | PU | M6 |
| D4.2 | DT platform, LA, AR and 3D printing technologies for DT2 (1st report) | WP4 | LNU | R/DEM | PU | M12 |
| D4.3 | DT platform, LA, AR and 3D printing technologies for DT2 (2nd report) | WP4 | LNU | R/DEM | PU | M25 |
| D4.4 | DT platform, LA, AR and 3D printing technologies for DT2 (final report) | WP4 | LNU | R/DEM | PU | M36 |
| D5.1 | Report on the activities plans for school interventions | WP5 | NKUA | R | PU | M6; M12 |
| D5.2 | Report on the pilot implementation | WP5 | NKUA | R | PU | M12 |
| D5.3 | Report on 2nd and 3rd year implementations | WP5 | NKUA | R | PU | M24; M34 |
| D5.4 | Report on ALA user analysis | WP5 | NKUA | R | PU | M24; M34 |
| D6.1 | Report on Pilot PD activities | WP6 | UGent | R | PU | M12 |
| D6.2 | Report on the implementations of PD activities | WP6 | UGent | R | PU | M24; M30 |
| D6.3 | OpenLearn online Course | WP6 | OU | DEC | PU | M30 |
| D.7.1 | Cycle 1 Evaluation Report | WP7 | TCD | R | PU | M12 |
| D.7.2 | Cycle 2 Evaluation Report | WP7 | TCD | R | PU | M25 |
| D.7.3 | Cycle 3 Evaluation Report | WP7 | TCD | R | PU | M36 |
| D8.1 | Dissemination and Exploitation plan | WP8 | OU | R | PU | M6 |
| D.8.2 | Dissemination and Impact Report 1 | WP8 | OU | R | PU | M18 |
| D8.3 | Dissemination and Impact Report 2 | WP8 | OU | R | PU | M36 |
| D8.4 | Policy Brief | WP8 | LNU | R | PU | M36 |

**Table 3.1d: List of milestones**

| Milestone number | Milestone name | Related WP(s) | Due date (month) | Means of verification |
|---|---|---|---|---|
| M1 | Validation and evaluation plan is released | WP 7 | M6 | Final version of validation and evaluation plan released |
| M2 | Implementation plan is released | WP1 | M6 | Final version of implementation plan released |

| | | | | |
|---|---|---|---|---|
| M3 | Learning activities and resources for school interventions and for Professional Development are ready | WP3, WP5, WP6 | M9 | Learning activities and other resources accessible via the project website |
| M4 | The enhanced educational technologies, i.e. AR Games, programming application for 3D printing/scanning, Virtual Robotics are developed in **TRL4** and have been connected with the nQuire platform | WP3, WP4 | M12 | Functional testing across participating partners |
| M5 | End of Cycle 1 evaluation & Roadmap for Cycle 2 based on evaluation input | WP7 | M12 | Report detailing evaluation outcomes and roadmap for Cycle 2 |
| M6 | Authorable Learning Analytics and Dashboard are developed in **TRL4** and have been connected with the nQuire platform | WP4 | M15 | Technologies available to access via project website, and nQuire |
| M7 | End of Cycle 2 evaluation & Roadmap for Cycle 3 based on evaluation input | WP7 | M24 | Report detailing evaluation outcomes and roadmap for Cycle 3 |
| M8 | All project technologies (educational tools, ALA & Dashboard) have reached **TRL8**, after iterative refinements | WP4 | M35 | Technologies available to access via project website, OpenLearn and nQuire |
| M9 | End of Cycle 3 evaluation and final ExtenDT2 Framework | WP2, WP7 | M36 | Report detailing evaluation outcomes of Cycle 3 |

**Table 3.1e: Critical risks for implementation**

| Description of risk (indicate level of (i) likelihood, and (ii) severity: Low/Medium/High) | WPs involved | Proposed risk-mitigation measures |
|---|---|---|
| Risk of disengagement by teachers/students:<br>- Lack of technological skills to use the tools.<br>- Limited interest in Design Thinking Methodology<br>-Hard to understand **Exten.(D.T.)$^2$** activities and take part<br>-Previous learning difficulties inhibiting participation in activities<br>(Likelihood: Medium, Severity: Medium) | WP5, WP6, WP7 | The project will be engaged with the design of activities and technologies from the beginning of the project promoting their active participation and sense of ownership. Additionally for their participation in Teacher PD programmes, teachers will be accredited with the Europass Digital Credential (EDCI). Continuous communication and exploitation of the project outcomes to school networks and events The Teacher training actions will be part of existing PD programmes, such as Bachelor and MSc courses and Greece's wide-scale training programme, that have a stable number of participants every year. Piloting of DT activities will ensure that risks will be identified and addressed in a timely manner prior to the large-scale implementation. |
| Technical obstacles in the design of AI component, extended constructionist technologies (games, 3D modeler, V robotics) and their connection to the nQuire platform or other public displays | WP3, WP4 | The AI component will continue, extend and combine existing tools, algorithms and analysis techniques developed by NKUA, UCL and LNU and already in TRL 2 or 3. The 4 educational technologies (2 games, 3D modeler and V-Robotics) will extend existing, widely tested technologies |

| | | |
|---|---|---|
| (Likelihood: Medium, Severity: Medium) | | with Libraries and Algorithms for AR or 3D printing. Piloting of technological developments in the first 6 months will ensure that any major problems will be identified early on and resolved for timely project implementation. Advice will be sought from advisory members and colleagues from participating institutions, where an alternative solution cannot be identified within the project team. |
| Urgent measures to educational organisations due to COVID-19 ongoing crisis e.g. local or national lockdown, student/teacher quarantine (Likelihood: Medium, Severity: Low)<br><br>A critical risk can be foreseen to activities due to a possible upsurge in the spread of COVID-19, or a new mutation becoming harder to guard against. This may have an effect on, for example, the numbers of students who can participate at any given time. Estimating a worst-case scenario, there might be a 66% shortfall in the student numbers. | WP5, WP6, WP7 | The project technologies and tools will be designed to be accessible and usable in both online and blended learning contexts. Teacher training material and lectures will be made freely available online.<br><br>To mitigate this risk, the consortium has plans to a) space out the student activities over a longer period of time with smaller groups, b) postpone some activities until more favourable conditions apply. In either contingency, the project will engage with the European Commission on either a new timeline with the lifetime of the project, or a possible extension to the project duration, moving resources to a later period. |
| Inadequate communication among WPLs and within the consortium:<br>- Lack of cohesion and clarity as to what is required in each LiFE activity.<br>- Lack of understanding of reporting requirements. (Likelihood: Low, Severity: High) | WP1 | The Project Coordinator will employ a project manager to facilitate all processes, including communication. Regular meetings (real-life and virtual) and traditional mail communication will be combined with other solutions (such as SLACK or equivalent). Multiple channels in e.g. SLACK will be created for ongoing asynchronous communication about e.g. school implementation, competence framework design, dissemination, management and budget. |

**Table 3.1f: Summary of staff effort**

| | WP1 | WP2 | WP3 | WP4 | WP5 | WP6 | WP7 | WP8 | Total Person-Months per Participant |
|---|---|---|---|---|---|---|---|---|---|
| **1. LNU** | 18 | 4 | 4 | 20 | 8 | 8 | 4 | 3 | 69 |
| **2. NKUA** | 1 | 6 | 9 | 24 | 15 | 12 | 6 | 5 | 78 |
| **3. UGent** | 1 | 6 | 10 | 0,5 | 9 | 17 | 6 | 4 | 53,5 |
| **4. NTNU** | 1 | 16 | 8 | 8 | 8 | 8 | 6 | 3 | 58 |
| **5. TCD** | 1 | 4 | 2 | 2 | 5 | 3 | 12 | 1 | 30 |
| **6. SIMPLE** | | | 3 | 12 | 3 | | | | 18 |
| **7. UCL** | | | | 1,2 | | | 0,6 | | 1,8 |
| **8. OU** | 1 | 6 | 16 | 10 | 8 | 7 | 5 | 6 | 59 |
| **Total Person Months** | 23 | 42 | 52 | 77,7 | 56 | 55 | 39,6 | 22 | 367,3 |

**Table 3.1g: 'Subcontracting costs' items - not applicable**

**Table 3.1h: 'Purchase costs' items (travel and subsistence, equipment and other goods, works and services)**

| **02 NKUA** |
|---|

| | Cost (€) | Justification |
|---|---|---|
| **Travel and subsistence** | 48 000 | Participate in six (6) project meetings (~4 days) involving up to 3 representatives of NKUA. One meeting is estimated at 900 Euro per person (350 flight, 300 hotel 3-4 nights, 250 daily allowances). Total €16.200<br>Additional WP meetings for close collaborative work (2-3 days) up to 2 representatives. 600 E per person. up to 3 such meetings. Total €3.600<br>Participate in scientific/non-scientific events for project dissemination: 6 x Conference/workshop/exhibition (~4 days) up to 3 representatives of NKUA, same rate plus €500 registration fees = 1500 per event per person. Total €27.000.<br>Travel for school visits, between €100 and €200 per school depending on location. Total €1.200 |
| **Equipment** | 10 000 | NKUA will develop the 3 applications of the project with emerging technologies. Thus, apart from the technologies for testing with users that will be provided by SIMPLE, NKUA will additionally need new equipment for developing and internally testing the technologies before the evaluation with users. This technology needs to be up to date, located in the lab and remain dedicated to the ExtenDT project throughout the 3 years. This equipment involves 1-2 laptops (~2500 both) and 2 mobile devices (~1500 both) with the necessary specifications for developing and testing the 2 AR applications, 2 3D printers and scanners permanently installed in the 2 workspaces of ETL for developing the 3D printing application (MaLT2) (~2000 both), 1 server computer for hosting the applications and the collected data during and after the 3 years of the project (~1.000). Total cost: €7000<br>NKUA is also responsible for long-term interventions in schools. Thus, it is necessary to purchase equipment (3D printers) that will be permanently installed in a number of schools and will remain throughout the 3 years of the project and beyond that. This equipment involves (at least) three 3D printers (~500 each) and three 3D scanners (~500 each) that will be installed in 3 schools. Total cost: €3000 |
| **Other goods, works and services** | 9 000 | Consumables such as printing posters and teaching materials: €2.000<br>License for data analysis software: €1.000<br>Host 1 project meeting (hosting services: catering, room renting): €1.000<br>Costs for open access publishing & audit certificate: €5.000 |
| **Remaining purchase costs (<15% of pers. Costs)** | | |
| **Total** | 67 000 | |

| **03 UGent** | | |
|---|---|---|
| | **Cost (€)** | **Justification** |
| **Travel and subsistence** | 21 600 | Consortium meetings with 2 UGent representatives (6*2), additional partner meetings for preparing and evaluating the co-creation activities and tools (3*2), conferences and workshops (3); international travel unit cost €400 flight and train, €300 hotel, 200 daily allowance), conferences €700 registration fee, total: €21 000<br>Local costs for co-creation activities: local travel and daily allowance; €600 |
| **Equipment** | | |
| **Other goods, works and services** | 15 000 | Consumables (conductive textiles, chemicals, textile materials and components) and devices (sensors, actuators, batteries, connectors, electronics eg Arduino etc) for prototyping within the framework of the co-creation cases: €11 250) |

| | | |
|---|---|---|
| | | Publication costs: 3 papers @ €1000 each<br>Teaching materials: €750 |
| **Remaining purchase costs (<15% of pers. Costs)** | | |
| **Total** | 36 600 | |

| **05 TCD** | | |
|---|---|---|
| | **Cost (€)** | **Justification** |
| **Travel and subsistence** | 20 000 | Participate in six (6) project meetings involving up to 2 representatives of TCD with four (4) additional meetings planned for close collaborative work. One meeting is estimated at 900 Euro (350 flight, 50 internal travel, 300 hotel 2 nights, 200 daily allowance). Total 14,400.<br>Travel is also required for conference attendance (x3) at the same rate, plus €500 registration fees Total €4,200.<br>Travel is also required for school visits, between €100 and €200 per school depending on location. Total €1400. |
| **Equipment** | 500 | 3D printer, audio/video recording equipment |
| **Other goods, works and services** | 500 | Consumables such as printing posters and teaching materials |
| **Remaining purchase costs (<15% of pers. Costs)** | | |
| **Total** | 21 000 | |

| **06 Simple** | | |
|---|---|---|
| | **Cost (€)** | **Justification** |
| **Travel and subsistence** | 12 000 | 4 project meetings up to 2 representatives --> 900€ per person for travelling, accommodation, daily allowance --> total 7200€<br>2 conferences 1 representative --> 900€ for travelling, accommodation, daily allowance plus 500€ conference fees --> total 2800€<br>Field visits and Equipment transportation --> 2000€ |
| **Equipment** | 22 000 | 3D scanner equipment will be used to generate digital models of physical objects to be used in learning activities as the starting point for new designs. Simple will provide this service to other members as well as the technical background behind it. €11 000<br>3D printers and CNC routers will be used to generate 3D physical artifacts of models produced in the project using additive and subtractive manufacturing processes respectively. Simple will provide a secure network channel to allow remote printing on those devices as well as monitoring of the printing process. Simple will also provide technical guidance on the process of configuring the models for printing in order to achieve adequate outputs, minimal printing time, minimal materials consumption and maintain adequate mechanical properties of the objects to be produced. €11 000 |
| **Other goods, works and services** | 2 000 | Consumables |
| **Remaining purchase costs (<15% of pers. Costs)** | | |
| **Total** | 36 000 | |

**Table 3.1i: 'Other costs categories' items (internally invoiced items) - not applicable**

**Table 3.1j: 'In-kind contributions' provided by third parties - not applicable**

### 3.2 Capacity of participants and consortium as a whole

The **Exten.(D.T.)²** consortium is made up of seven research labs and a specialized SME comprising complementary academic expertise, on-going contribution to our knowledge on all aspects of this proposal and at the same time active and sustainable connections with educational institutions and policy-making centres across six European countries. Furthermore, the persons and labs taking part know each other and have collaborated before in Networks of Excellence such as 'Kalleidoscope', FP6, FP7, HORIZON 2020 RIA and Erasmus projects and as members of academic communities such as the 'Constructionism', 'Interaction Design and Children', Citizen Science, Computational Thinking and STEM conferences. UGENT and NKUA have the educational expertise on Design Thinking having already established it in schools, undergraduate and postgraduate courses. TCD and NKUA are constructionist experts and will collaborate with UGENT in the piloting and the evaluation process. Our associate partner, the OU, has deep expertise in distance learning, inquiry education and Citizen Science and through the use and extension of the nQuire platform will enable design thinking projects to include socio-scientific wicked problems. UCL-KL together with SIMPLE are the originators of AI & Learning Analytics on constructionist digital media and will provide the partners with background prototype versions of early algorithms connected to two of the expressive media in the project, MaLT2 and ChoiCo which were originally designed and have been developed by NKUA. NKUA and LNU have since collaborated and further developed algorithms for MaLT2 still at prototype level. LNU and NTNU together with SIMPLE have the development expertise to further develop these algorithms, bring them to a technical readiness acceptable for wide use and connect them to the other two media in the **Exten.(D.T.)²** project.

UCL-KL, our associate partner who will advise and follow the project throughout originated and maintained research and development directly connected to AI algorithms for constructionist educational digital media. UCL-KL is part of the Institute of Education in the UK that is a teacher training and education powerhouse and will provide access to schools and teachers and further support the dissemination of project results. SIMPLE is an SME spin-out from UCL. The key postdoctoral researcher there is the developer working for UCL-KL to that effect in the past in FP7 ('METAFORA') and HORIZON 2020 (Mathematical Creativity Squared) projects where both UCL-KL and NKUA-ETL were partners and close collaborators. The group at UGENT are in the final year of a project on design thinking and co-creation, T-CREPE, with digital games in partnership with the NKUA group. The teams at LNU, OU and NKUA have been collaborating for the past four years putting together proposals for the use of digital media in Citizen Science initiatives and have thus connected deeply on both academic and planned collaboration issues. TCD have collaborated closely with UCL-KL and NKUA in the past in an integrated research project on the educational use of digital games in the frame of the Kalleidoscope Network of Excellence and the same key people will join in **Exten.(D.T.)²** . Furthermore, LNU and NKUA have been closely collaborating in the past four years by means of joint publications, joint supervisions and plans for joint research on computational thinking and learning analytics. The NTNU group have also been working on analytics and the design and use of digital media for learning and have collaborated with NKUA during the IDC conference in Trondheim in 2018. TCD will organise the constructionism conference in 2023 and NKUA did so in 2012. Amongst the people who will actively take part in the **Exten.(D.T.)²** project are world-wide initiators of AI for constructionist tools, designers of original constructionist tools across educational domains, researchers in transformative interventions regarding design thinking and are personally engaged in the production of knowledge, experience and policy generation on the uses of emerging technologies for pedagogical 21st century transformations.

The joint expertise of this partnership is comprehensive and focused with respect to the **Exten.(D.T.)²** objectives. It binds expertise on social sciences and education stemming from NKUA, OU, UGENT and TCD with expertise on constructionist learning inherent within NKUA, NTNU, UCL-KL and TCD. It also affords expertise in AI, AR and 3D printing design and development for education purposes inherent in LNU, NKUA, UCL-KL, SIMPLE and NTNU. All partners have access to the necessary technical and personal infrastructure required for the project and will only use project funds to equip the teams with a 3D printer.

LNU has expertise in computational thinking and in the development of AI algorithms for educational media specialising on the issue of ethics. TCD researchers have been central to the 'Constructionism' community regarding expressive digital media and have also maintained professional development activity and expertise in these issues. NKUA have designed and developed expressive constructionist media to be used in the project which are at a technical readiness and educational maturity to have been included in the Ministry of Education digital infrastructure for primary and secondary schools. They are also at the centre of the constructionist community and have been carrying out design research on transformative pedagogies for the past 25 years. The OU are the experts in distance

learning, inquiry learning and have developed the award winning highly used nQuire platform which will be extended to include constructionist activities through the project. UGENT have extensive educational and professional development expertise in design thinking and co-creation in secondary and tertiary education in transdisciplinary and industrial design domains and are the designers of the cocreation planet platform to support design thinking, with strong participation of stakeholders from the quadruple helix. Relevant focuses are access to prototyping facilities and AR/VR for training and education. NTNU has conceptual, methodological and technical knowledge and experience in implementation and development of emerging technologies in education and contributes high-level expertise in the field of constructionism activities for students and the use of LA. NTNU focuses also in the area of scientific investigation on the phenomena surrounding learners' interaction with computational technologies with a mission to design learning environments and improve learning experience by capturing rich data from their interaction.

Furthermore, even though the main partnership comprises University Research Labs, several partners have long standing connections, participation and networks with educational institutions and policy making structures. LNU is in tight collaboration with the local Vaxjo municipality and a network of schools, the director of NKUA-ETL sits in permanent Ministry of Education committees responsible for longitudinal TPD and digital infrastructure initiatives having reached 35% of primary and secondary teachers in the country. UGENT is at the centre of a network of schools and industrial design institutions, OU maintains collaborations with the BBC and other agencies using nQuire, and TCD takes part in wide-scale TPD in the Dublin area. NTNU has years of experience and collaborations with innovative learning spaces and practices in Norway and key stakeholders including the national and local schools, Science Centers, libraries, coding clubs and has strong contributions to national teachers' conferences that happen each year. The **Exten.(D. T.)$^2$** consortium itself also has as much as possible a balance in terms of genders and seniority and cultural backgrounds; major project activities including software design, evaluation of hands-on activities and dissemination are performed by both men and women, ensuring equal gender distribution of responsibilities across the project.

The consortium has also contacted and received agreement from three world recognised leaders in respective project cornerstone elements, to complement its scientific board in an advisory capacity, namely Prof. Barbara Wasson (AI-Analytics), University of Bergen, Prof. Tilde Bekker, (Design Thinking in mainstream education), Eindhoven University of Technology and Prof. M. Mavrikis, (AI analytics for constructionist digital tools), UCL-KL. Along with these three academics the scientific board will comprise of Prof. M. Milrad (LNU), Prof. C. Kynigos (NKUA), Prof. B. Tangney (TCD), Prof. M. Giannakos (NTNU), Prof. C. Herodotou (OU), Prof. L. Van Langenhove (UGENT). The Scientific Board will be led by **Exten.(D. T.)$^2$** 's own Prof. C. Kynigos.

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*A: Mathematical, Physical and Engineering Sciences*, 366(1881), 3717-3725.

## Additional information on associated partner 08 Open University (UK)

| | |
|---|---|
| Legal name | The Open University |
| Department | Institute of Educational Technology |
| PIC code | 999923337 |
| Address | Walton Hall<br>Milton Keynes<br>MK76AA<br>United Kingdom |
| Website | www.open.ac.uk |
| Legal person | Yes |
| Public body | Yes |
| Non-profit | Yes |
| International organisation | No |
| Secondary or higher education establishment | Yes |
| Research organisation | Yes |
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|---|---|---|---|---|---|---|---|---|---|
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| Prof. | Eileen | Scanlon | F | UK | See above | Cat.A | Team member | https://orcid.org/0000-0003-1180-682X | Orcid |

## Role of participating organisation:

Project management
Provision of research and technology infrastructure
Co-definition of research and market needs
Technology developer
Testing/validation of approaches and ideas
Education and training

## Publications and software:

Publications:

This paper describes the functionality of the nQuire platform showcasing how it can support certain stages of the design thinking process. Herodotou, C., Scanlon, E., & Sharples, M. (2021). Methods of Promoting Learning and Data Quality in Citizen and Community Science. Frontiers in Climate, 3, 53.

This paper details the iterative design, adoption and use of predictive learning analytics over 4 years that resulted in teachers using analytics as business as usual at the OU. Herodotou, C., Rienties, B., Hlosta, M., Boroowa, A., Mangafa, C., & Zdrahal, Z. (2020). The scalable implementation of predictive learning analytics at a distance learning university: Insights from a longitudinal case study. The Internet and Higher Education, 100725.

This paper details teachers' perceptions about the use of predictive analytics, factors enabling and hindering use and guidelines for adoption by other institutions. Herodotou, C., Maguire, C., McDowell, N., Hlosta, M., & Boroowa, A. (2021). The engagement of university teachers with predictive learning analytics. Computers & Education, 173, 104285

Software:

Online learning platform. nQuire (nquire.org.uk) is an award-winning citizen science platform designed to support learning at scale. Its authoring functionality enables the design of scientific investigations and the collection of data in the form of images, text, sensor data and map location. Collected data can be open to the public to read, comment, like enabling peer learning and communication. Visualisations show summary data while an investigation is live.

Online analytics platform. OU Analyse is an award-winning predictive learning analytics dashboard used across the OU to support teachers in identifying students at risk of failing their studies and intervening to support them. It has shown to increase student performance and the teaching practice, when teachers access it regularly.

**Projects:**

nQuire

Funded by Nominet Trust and the OU/BBC collaboration, the project enabled the design of the nQuire platform used in this project to support peer learning and communication about design thinking and artefacts (https://iet.open.ac.uk/projects/nquire).

mEvaluate

Assessment of the use of educational apps by children and production of an evaluation framework that can guide the design and use of mobile learning applications (British Academy funded), (https://iet.open.ac.uk/projects/mevaluate).

Democratizing research through citizen science

Democratizing research through citizen science methodologies: The case of Mental Health. Co-funded by the Mental Health Foundation and the OU, the project identified ways research with participants can become more democratic, through engaging end users with the different stages of research such as the problem definition. This approach was piloted online with young people through workshops and the use of the nQuire platform.

Accelerating the transition to Edu 4.0 in HEI

Accelerating the transition towards Edu 4.0 in HEIs (TEACH4EDU4). This Erasmus+ funded project examines innovative pedagogical approaches to teaching computer science in higher education institutions. It has produced a systematic review of the literature of what works and how and is training teachers to adopt new approached in their teaching.

Learn CitSci

A 4-year, international project, funded by NSF, Wellcome, and ESRC examining learning processes and participation of young people in informal learning science activities, in the field and online, managed by three Natural History Museums in London, Los Angeles and California. Evaluation activities online were led by the OU, with support from the University of Oxford and UC Davis.

**Infrastructure and equipment:**

IET Laboratories

IET hosts a range of laboratories: the accessibility lab, the ambient technology lab and the gaming and future technologies lab that enable innovative research into the interaction between people and ambient technologies. They provide services for usability, accessibility and developmental testing.

Training opportunities for project researcher

A Postgraduate Internship Programme run by the OU, co-funded by Santander Universities, offering 3 months paid internships with commercial/industrial organisations. The OU works with the Brilliant Club training and placing researchers in schools to deliver tutorials to pupils.

**Gender Equality Plan?**

No

**Open University budget in Euro: (funding through UK government funds - UKRI)**

| Personnel | Travel and subsistence | Other goods and services | Indirect costs | Total eligible costs | Funding rate | Max. contribution | Requested UK contribution | Max. grant amount | Total |
|---|---|---|---|---|---|---|---|---|---|
| 373 486 | 10 350 | 16 140 | 99 994 | 499 970 | 100 | 499 970 | 499 970 | 499 970 | 499 970 |

**Additional information on associated partner 07 UCL (UK)**

| | |
|---|---|
| Legal name | University College London |
| Department | UCL Knowledge Lab |
| PIC code | 999975620 |
| Address | Gower Street<br>London<br>WC1E 6BT<br>United Kingdom |
| Website | www.ucl.ac.uk |
| Legal person | Yes |
| Public body | Yes |
| Non-profit | Yes |
| International organisation | No |
| Secondary or higher education establishment | Yes |
| Research organisation | Yes |
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**Researcher information:**

| Title | 1st name | Last name | Gender | Nat. | e-mail | Career stage | Role | Ref. identifier | Type |
|---|---|---|---|---|---|---|---|---|---|
| Prof. | Manolis | Mavrikis | M | UK | See above | Cat. A | Lead | https://orcid.org/0000-0003-0575-0823 | Orcid |

**Role of participating organisation:**

Communication, dissemination and engagement
Provision of research and technology infrastructure
Prototyping and demonstration
Education and training
Contributions from the social sciences and humanities

**Publications:**

Mavrikis, M., Geraniou, E., Gutierrez Santos, S. and Poulovassilis, A. (2019), Intelligent analysis and data visualisation for teacher assistance tools: The case of exploratory learning. Br J Educ Technol, 50: 2920-2942. https://doi.org/10.1111/bjet.12876

Cukurova, M., Luckin, R., Millán, E., & Mavrikis, M. (2018). The NISPI framework: Analysing collaborative problem-solving from students' physical interactions. Computers and Education, 116, 93-109. doi:10.1016/j.compedu.2017.08.007

Mavrikis, M., & Karkalas, S. (2017). Reflective Analytics for Interactive e-books. IxD&A, 33, 33–53.

**Projects:**

Various H2020 projects: iHUB4Schools, iRead & other EU projects UCL has coordinated the successful iRead 2020 project and has been a key partner in scientific coord of several H2020 projects (e.g. PELARS). iRead and iHUB4Shools are scaling up digital innovations in schools with the latter involving national stakeholder networks to which ExtenDT2 will have access. Apart from advancing the research in the field, all these projects include industrial partners leading to award-winning exploitation opportunities.

iTalk2Learn: the iTalk2Learn project was a large EU funded project aiming to develop an open-source intelligent tutoring platform that supports maths learning for students aged 5 to 11. iTalk2Learn was an interdisciplinary project that combined expertise from machine learning, user modelling, intelligent tutoring systems, natural language processing, educational psychology and mathematics education to allow students to learn in a more natural way.

Mathematical Creativity Squared: the MCSquared (FP7-ICT) designed, developed and evaluated an intelligent computational environment to support stakeholders from creative industries to engage in collective forms of creative thinking for educational purposes. UCL developed technology for authoring intelligent adaptive support for creative mathematical thinking through constructionist environments and learning analytics tools for visualisation of data from diverse environments, the TRL of which will increase through ExtenDT2.

**Infrastructure:**

UCL hosts the Institute of Education – a powerhouse of teacher training and professional development. This will support dissemination and impact making activities of ExtenDT2.

**Gender Equality Plan?** Yes

## Budget:

### UCL budget in Euro: (funding through UK government funds - UKRI)

| Personnel | Travel and subsistence | Other goods and services | Indirect costs | Total eligible costs | Funding rate | Max. contribution | Requested UK contribution | Max. grant amount | Total |
|---|---|---|---|---|---|---|---|---|---|
| 21 640 | | | 5 410 | 27 050 | 100 | 27 050 | 27 050 | 27 050 | 27 050 |