Digital Environment for Literacy and Future Education. A Pilot Experience of Serious Game Co-design

Stefania Capogna[1], Giulia Cecchini[2], Maria Chiara De Angelis[2(✉)], Vindice Deplano[3], Giovanni Di Gennaro[2], Michela Fiorese[3], and Angela Macrì[3]

[1] Link Campus University, Via del Casale di San Pio V, 44, 00165 Rome, Italy
s.capogna@unilink.it
[2] Roma TRE University, Via del Castro Pretorio, 20, 00185 Rome, Italy
{giulia.cecchini,mariachiara.deangelis, giovanni.digennaro}@uniroma3.it
[3] Entropy Knowledge Network, Via Asmara, 26, 00199 Rome, Italy
vindice.deplano@ext.entropykn.net, {michela.fiorese, angela.macri}@entropykn.net

Abstract. The quality of teaching and the digital skills of teachers and students are increasingly taking priority in contemporary society, especially if related to the need to fight against functional and emotional illiteracy and unequal access to education. These areas of intervention are the objective of the DIG4LIFE - *DIGital Environment for LIteracy and Future Education* research-action project, which is co-founded by the Erasmus+ programme.

The project team has created a Serious Game by translating the DigComp 2.1 framework into an interactive digital simulation to support teachers in the assessment and training of students' digital skills and digital maturity through a gamified learning strategy. DIG4LIFE Serious Game (SG) is the concrete result of a highly structured Co-Design process that involves teams of teachers in 6 different countries. SG, which has been created ad hoc for the project, offers high school teachers the opportunity to use an engaging tool with students that concretizes a methodological approach in line with nowadays educational needs and the intrinsic demand for digital maturity. Serious Games give the possibility of situating the content learned, thus allowing those involved in training/education/instruction to evaluate the level of knowledge, know-how and mindset with respect to the subject/topic dealt with, as well as to train digital skills and digital maturity. The paper describes the process of co-design of the DIG4LIFE Serious game, which effectively becomes an "object to think with" and concrete opportunities for co-design and collaboration between teachers, trainers and students.

Keywords: Serious game co-design · Teachers' 'professionalization · Digital competences

M. Temperini et al. (Eds.): MIS4TEL 2022, LNNS 580, pp. 139–148, 2023.
https://doi.org/10.1007/978-3-031-20617-7_18

1 Introduction

DIG4LIFE is an action research project, co-founded by the Erasmus+ programme, that aims to create the best conditions for sharing best practices in teaching digital skills by the innovation and dissemination of innovative tools, such as simulator and teaching editor for digital gamification environment [1].

DIG4LIFE has built a transnational partnership among universities, research centres, training institutions, schools, including various approaches and experiences in the development of digital Technology Learning Environment (TEL).

The main objective of DIG4LIFE is to contribute by research and innovation to the improvement of teaching quality and digital skills of educators and students from upper secondary and VET school, so as to fight against functional and emotional illiteracy and unequal access to education.

The project also supports the adoption of European frameworks on digital skills of educators, citizens and organizations, including the development and use of open educational resources, open textbooks and Open-Source educational software.

DIG4LIFE provides different actions strongly correlated with each other: 1) the definition of a theoretical framework for self-assessment to share the entire design of research and to clarify methodology, instruments, tools, expected results; 2) a self-assessment of teachers' digital skills based on the DigCompEdu and the PIAAC Online; 3) the release of an open digital self-assessment tool based on the DigCompEdu framework.

The third one regards the co-design of a Serious Game (SG) or the digital skills self-evaluation as systematic approaches and opportunities for the initial and continuous professional development of teachers, who will be able to develop effective, open and innovative digital education methods and pedagogies, as well as practical tools.

The release of an open serious game for the digital skills self-assessment consists of three main tasks: 1) trainers training and co-design of the blended learning path for teachers; 2) teachers training and co-design of the serious game episodes; 3) testing of the prototype by upper secondary school and VET students (Fig. 1).

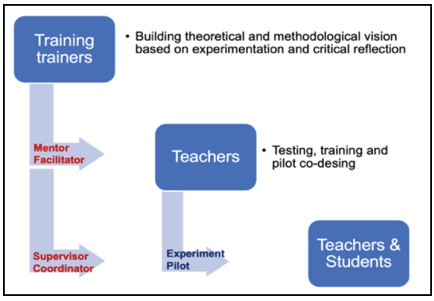

Fig. 1. DIG4LIFE Serious Game co-design process

The following paragraphs describes briefly the research question that inspired this work (Sect. 2), the co-design methodologies applied and the genesis of the serious game pilot (Sect. 3) that will be tested by students in the following months.

2 From Evaluation to Self-assessment

2.1 The Self-assessment as Connectors Between Teaching and Learning Process

For over twenty years, the evaluation has been at the center of debates and institutional investments to improve teaching quality, processes, and results. A new way of thinking about evaluation has developed under the weight of the critical issues that have always accompanied the evaluation theme in educational contexts. This new perspective focuses on *self-evaluation* to free the resources present in subjects and contexts, activating an actual development process and continuous improvement [2].

It has been proved that self-evaluation enhances motivation and progress in the learning process for teachers and students. Several studies have highlighted the positive relationship between teachers' self-assessment and professional growth [3–5].

Self-assessment tools connect teaching and learning process. Integrated with other personal growth strategies, they can improve teaching practices by a) increasing the teacher's awareness of teaching excellence levels, sense of efficacy and performance; b) helping the teacher in building improvement paths and in defining the necessary actions; c) facilitating communication between peers and the construction of professional communities of practice; d) stimulating constructive strategies to improve teaching effectiveness also through the influence of external change agents on teacher practice.

On the other hand, through the self-assessment strategy, students can evaluate their own work, reflect on their own learning and provide teachers with the perception of their learning. According to approaches based on the idea of *Self-directed learning* [6, 7], self-assessment methodology and tools can help both students and teachers to become aware of their strengths and weaknesses, set realistic goals for themselves and can define the stages and methods for achieving them, motivating their own learning process.

Based on this theoretical framework, the DIG4LIFE action research project wants to study the possible role that serious game could play as a *formative assessment tool*, to promote teachers' professional growth and student self-regulation and engagement, through a *self-reflection and co-design* working methodology that could impact positively on a) involvement and motivation; b) ubiquity and personalisation; c) creation of new ideas and knowledge; d) sharing and collaboration and e) increased experimentation.

2.2 A Co-design Methodology Through a TEL Experience

The origin of co-design dates back to the 1960s when trade unions in Scandinavia fought for *cooperative design*, the right of workers to co-design IT systems that impacted their work [8].

In the United States, starting from the 1970s, the term changed to *participatory design* and the need to involve end users in research is gaining more and more support. In the 80s Donald Norman published his famous book *Design of Everyday Things* in which he coined the term *user-centred design* and thus marked the transition to a design mentality [9].

The term has subsequently evolved into *human-centred desi*gn [10] due to the attention given to a) focus on end users who brings their point of view into the design; b) multidisciplinary collaboration between people who bring their specific skills into

the creative session; c) creation of a prototype that will be tested and improved by the beneficiaries.

In summary, among the advantages of co-design we point out the ability to respond in a targeted way to the needs of the reference target; to increase the interconnections between the participants in the co-design sessions; to reduce the time required for the development of ideas and promote innovation in a structured way.

In co-design, therefore, the activities are designed to facilitate sharing among the participants and align their ideas towards a common goal. At the same time this favours a continuous exchange and comparison between different points of view and requires negotiation skills in situations where diversity can become an obstacle to communication. During co-design sessions, participants feel involved in the process, thus developing a sense of deep responsibility towards the result [11–14].

Serious Game makes it possible to concretely implement a constructionist approach, which is one of the intrinsic methodological objectives of the project itself.

3 DIG4LIFE Serious Game: A Self-assessment Tool to Improve Digital Skills

3.1 DIG4LIFE Serious Game Prototype

DIG4LIFE Serious Game aims to translate a tool created for self-assessment (DigComp), into an interactive digital simulation that allows teachers to evaluate and train students' digital skills and digital maturity in a gamified way. The content of Serious game has been co-designed by the teachers of 6 different countries (Italy, Austria, Finland, Italy, Lithuania, Slovenia, Spain).

DIG4LIFE Serious Game has been inspired by three technological pillars that enhance creativity according to Papert [15, 16]:

- *Low Floors:* easy ways to get started for beginners
- *High ceilings:* works on increasingly sophisticated projects over time
- *Wide walls:* provide multiple paths from floor to ceiling. In this way, it will be possible to obtain highly personalised learning objects, improved learning through practice and greater motivation given the playful and emotional involvement of the participants.

These features are the best guarantee of success and transferability of the product to other teachers and students. Furthermore, the use of digital simulations allows teachers to put computational thinking and collaborative learning into practice. DIG4LIFE develops a methodology that, at the same time, defines the form and content around computational, creative thinking and digital maturity.

3.2 DIG4LIFE Serious Game: The Main Features

The DIG4LIFE challenge was to guide non-game designers in writing a good Serious Game story. National team were involved in co-writing a storyboard, which have three main functions:

1. to be a guide for designers to visualise the flow of the story and the crucial point (decisions to be made);
2. to have a detailed document that can be consulted by those who will realise the Serious Game and that provides instructions for its development (audio video contributions, editing and tests);
3. to be a useful repository for other countries involved in the DIG4LIFE project, also for peer review.

The storyboard of each episode took care of a general subject, two defined characters (protagonists) and two defined environments.

Concerning the subject, the SG six episodes took place in a digital future characterized by a very modern and technological smart e-society, in which characters must test a series of skills and competences to advance within the story, as well as to complete missions and challenges:

"Year 2050: a young boy aged 13 or over, is living in a campus with his peers. As we know, the school does not exist; there are no classrooms or lectures. The students live in the campus for about 3/5 years during which they receive assignments as concrete life experiences (informal training). Through experiences they acquire skills, knowledge and credits. The mentor interacts through a hologram, comments on the experience and assigns the score for passing the challenge, which means acquisition of competence. When the students reach a specific level of maturity (knowledge/skills) according to the evaluation of the mentor, they conclude the learning path."

DIG4LIFE Serious Game has:

1. two protagonists and a robot in common with every episode in the series, as well as a specific character added by each country, if needed;
2. two environments in common (a, b), plus a specific one, if needed, for every episode (c):

   a Cafeteria, indoor tables, chairs, cups on table, tablets, computers, mobile phones, screens/pictures on the wall (to make objects clickable)
   b Campus room: computer, tablet, posters on the wall;
   c Hacker's "Cave": large tables with computers and pieces of computers. Laboratory neon lamps

Technical Specification

DIG4LIFE Serious games are made up of a proprietary architecture called "learning Brick, which provides a set of "prefabricated" modules in order to create a game with an assembly operation rather than with a technical development from scratch [17, 18].

Each game is built as a "learning object" that meets the Scorm interoperability standard: if inserted into a platform like Moodle, equipped with a compatible Learning Management System, it tracks all the main usage data for monitoring, evaluation, reporting and certification purposes: completion, times, scores, etc.). For maximum flexibility,

these learning objects provide settings also to allow you to trace with xAPI standard [19]. With the xAPI standard, the eLearning content does not communicate directly with the LMS platform but with an intermediate level called Learning Record Store (LRS). This allows you to use the content even with a non-persistent connection and have a complete and updated tracking when the connection to the platform is re-established [20, 21]. Since only the classic languages of web applications are used (Html5, Javascript, Css), a PC or a mobile device equipped with a common browser and an internet connection are required. Alternatively, it is possible to develop versions for local use on personal computers (as portable Windows applications) or on Android smartphones and tablets (as installable apps).

3.3 Train the Teachers: The Training Path

DIG4LIFE Serious Game was created in collaboration with upper secondary and VET teachers as primary beneficiaries, who will use it as a tool for assessing their students' digital skills. Participatory design allows the creation of an innovative product tailored to the real needs of students.

The main co-design goals were to support and update teacher's digital skills, as defined in DigCompEdu [22], exploring and sharing pedagogical skills for educators.

The national teams were invited to join a learning experience based on a problem-based, gamified learning strategy, which created meaningful scenarios for them and consequently for students.

The lead partner assigned a digital competence to the national teachers' team. Each episode of the serious game includes the DigComp five expertise areas, declined into six digital competencies, as described in Fig. 2.

During the teacher training the following topics were addressed: competencies analysis based on the DigComp dimension, didactic design for digital simulations and game design.

Fig. 2. DIG4LIFE Serious Game episodes assigned by national teams

The path was designed as a lab and was structured into two phases: a synchronous phase on Zoom platform and an asynchronous phase on the Moodle platform. The synchronous phase consisted of 10 workshops, 4 of which dedicated to the co-design of the storyboard, and 2 to the fine tuning of Serious Game.

The workshops aimed to:

– present project objectives and, in particular, the Serious Game tool;
– share the specific elements of Game design;
– introduce and support teachers in the storyboarding phase of Serious Game.

During the workshops teachers focused on the exploration of the objectives and the assigned DigComp competencies. The teachers with the help of the trainers analysed the sub-dimensions of the assigned competence, translating them into virtuous behaviours, from which to build subsequently the serious game storyboard.

They also started the activity in subgroups with the mentorship of the project team supporting and debriefing the storyboard (See Table 1).

Table 1. Workshop programme

Workshops	Subjects	Activities	Outcomes
1	*Serious game and co-design intro*	Play a serious game	A common experience of SG
2	*First step of co-design: hands on*	Working on skills and behaviour in subgroups	The SBS scheme
3	*Second step of co-design*	Drafting the plot of the story	Plot document
4	*Third step of co-design*	Creating the story and assigned scores/weights	Storyboard template
5	*Review serious game*		
6	*Fine tuning of the draft of Serious Game*		

The asynchronous phase provided a Moodle platform to give continuity between workshops. This phase focuses on the anticipation-follow up of content pillars, continuous feedback on what is produced and fine tuning of the outcomes. The management of the meetings was entrusted to a multidisciplinary team, consisting of project partners and trainers and/or tutors.

The first session begins with the presentation of the project's vision and strategy on how to transform the DigComp self-assessment questionnaire into an interactive digital simulation tool, allowing teachers to evaluate and develop students' digital maturity and skills. The teachers were accompanied to identify the major game design needs:

1. a subject, representing the idea, the narrative core of the story in which the fundamental components are described – environments, protagonists, context, and vicissitudes;
2. the script, or written elaboration of the subject that outlines the narrative structure of the story.

In this session, participants played the Italian SG pilot episode on *Digital Safety*[1] to better understand the main features are required. Practical experience helped to contextualize the theoretical explanation of the main features of SG.

The second training session got to the heart of the Serious Game design. The starting point was a detailed description of the chosen competence of the partner country, according to the provisions of the European Guidelines on DigComp [23].

Digital Safety is the DigComp competence assigned to the Italian group to build the pilot episode of DIG4LIFE Serious Game. In particular, the goal was to lead participants to a) define in detail the objective of the DIG4LIFE Serious Game episode on the assigned competence; b) describe the expected behaviours and specify the levels of mastery for the management of the assigned competence; c) identify and catalogue the three-four pillars representative of the assigned competence (pillars will be the internal variables of the Serious Game).

In the third training session, the activity was organized in two moments. The trainers presented the incipit of the story and requested the participants to modify or expand it; the teachers wrote the storytelling of the protagonists according to the main subject defined by the consortium, and the environments, characters, and the Skills-Behaviour Schema (SBS). The goal was to write the story starting from the main nodes and challenges that the protagonist had to overcome to "demonstrate" the level of management of the assigned competence.

Before starting the collaborative work in subgroups, the trainers explained the difference between plot and story. In order to write the story, the plot must be defined. The plot is linked to a specific and circumscribed event; while the story reveals how the characters react to this event (it is the emotional reaction to the choices made by the characters). In the plot teachers have to identify the following elements:

- the *exhibition:* information necessary to understand history (partially introduced by the Incipit);
- the *complications,* that trigger the "conflicts" to be resolved;
- the *climax:* the turning point in the history in which the "hero" has to resolve the situation;
- the *resolution:* the events that allow the closure of the story.

The participants, divided into subgroups, had to collaborate in the drafting of the story through a schema organized in three main steps: 1) incipit, constraints of the story, link to the SBS document (padlet); 2) first event (it was recommended to outline a story with 8/10 events; 3) the following event and so on.

The fourth session focused on completing all the elements of the story: steps, events, dialogues according to the SBS scheme proposed. The goal was to 1) finalise the work done before scoring; 2) make it consistent with skills and behaviours; 3) verify that the situations experienced by the protagonists really "measure" the skills assigned and the levels of mastery.

[1] The pilot episode on "Digital safety" is available at: https://www.entropylearningplatform.it/seriousgames/dig4life_it/pagine/lo.htm.

The last two workshops (5,6) were dedicated to review the Serious Game and debriefing of the episode.

The design of the training program has been planned in order to be reusable and to ensure that each iteration involves new members. The multiplication/transferability and the reusability of products are high because they are based on real needs and are produced on a cooperative basis with the target groups. Furthermore, the transfer of results is assured through the presence of partners who have knowledge and competencies for incorporating the learning/teaching methodology into the educational systems of the participating countries.

4 Conclusive Remarks

The DIG4LIFE project is now ongoing. The digital skills assessment tool DIG4LIFE Serious Game was co-designed and it's upload on the project Moodle platform.

The DIG4LIFE project is now ongoing. The digital skills assessment tool DIG4LIFE SG was co-designed and it's upload on the project Moodle platform. In Italy, the 25 teachers (distributed nationwide) who participated in the co-design of the SG, between May and September 2022 will complete the first testing phase of all the episodes, involving 321 high school students. Next step will be the experimental phase with the students of the schools involved in the partner countries.

In the DIG4LIFE serious game design is used a *flipped classroom methodology*. A *prescriptive and use-only approach* is abandoned to adopt a creative game design, an approach that puts co-design centre stage. In this framework the direct beneficiaries are "co-designers" and contribute with their real-world knowledge, perceptions and values across the entire game design process.

Co-creative game design creates a safe space for exploration and experimentation, supporting reflexive and metacognitive practices, opening opportunities to "think outside the box", admitting a multiplicity of representations and therefore a complex, multiform, and articulated image of reality. Co-creative serious game design allows to:

- *Create and not reproduce*: knowledge is 'created' by the mind rather than reproduced from external reality. Individuals are seen as 'builders of reality'.
- *Actively interact* with the environment, to experiment in comparison and construction the multiplicity and complexity of knowledge;
- *Collaborate and share* to negotiate and accept knowledge.

After testing, DIG4LIFE serious game will be available and free to be downloaded to give teachers and students the opportunity to self-assess their digital skills and to image appropriate strategies to became awareness citizens and empower their own digital maturity.

References

1. DIG4LIFE Project Homepage. http://dig4life.eu. Accessed 28 Apr 2022

2. Capogna, S.: La valutazione come strumento di empowerment organizzativo e professionale, pp. 98–117. RIV Rassegna Italiana di Valutazione, Franco Angeli (2020)
3. Festinger, L.: A theory of social comparison processes, in "Human Relations", 7. FLYNN FJ (2005), Identity orientation and forms of social exchange in the organizations. Acad. Manage. Rev. **30**(4), 737–750 (1954)
4. Peterson, K.D.: Teacher Evaluation: A Comprehensive Guide to New Directions and Practices. Corwin Press, Thousand Oaks, CA, London (2000)
5. Connelly, F.M., Clandinin, D.J.: Teachers as Curriculum Planners: Narratives of Experience. Teachers College Press, Ontario and OISE Press, New York (1988)
6. Kerka, S.: Self-directed learning: myths and realities. ERIC Clearinghouse on Adult, Career, and Vocational Education, Columbus, OH, USA (1994)
7. Mentz, E., Oosthuizen, I.: Self-Directed Learning Research: An Imperative for Transforming the Educational Landscape. AOSIS, Cape Town (2016)
8. Ehn, P., Kyng, M.: The collective resource approach to systems design. In: Bjerknes, G., Ehn, P., Kyng, M. (Eds.) Computers and Democracy - A Scandinavian Challenge, pp. 17–58. Gower Publishing (1987)
9. Norman, D.: The Design of Everyday Things. Basic Books, New York (1988)
10. Goodwin, K.: Designing for the Digital Age: How to Create Human-Centered Products and Services. Wiley, Indianapolis, IN (2009)
11. Krath, J., Schürmann, L., von Korflesch, H.F.O.: Revealing the theoretical basis of gamification: A systematic review and analysis of theory in research on gamification, serious games and game-based learning. Comput. Hum. Behav. **125**, 106963 (2021)
12. https://doi.org/10.1016/j.chb.2021.106963
13. Dichev, C., Dicheva, D.: Gamifying education: what is known, what is believed and what remains uncertain: a critical review. Int. J. Educ. Technol. High. Educ. **14**(1), 1–36 (2017). https://doi.org/10.1186/s41239-017-0042-5
14. Sailer, M., Homner, L.: The Gamification of Learning: a Meta-analysis. Educ. Psychol. Rev. **32**(1), 77–112 (2019). https://doi.org/10.1007/s10648-019-09498-w
15. Papert, S.A.: The Children's Machine: Rethinking School in the Age of the Computer. Basic Books, Pennsylvania State University (1993)
16. Papert, S.A.: Mindstorms: Children, Computers, and Powerful Ideas. Basic Books, Pennsylvania State University (1980)
17. Deplano, V.: Learning bricks: oggetti riusabili per simulazioni efficaci. Je-LKS **5**(2) (2009)
18. Deplano, V.: La simulazione come gioco e come modello di apprendimento. In: Castello, V., Pepe, D. (Eds.) Apprendimento e nuove tecnologie. Modelli e strumenti, Franco Angeli, Milano (2010)
19. Deplano, V.: I serious game nella didattica. Docete 21 (2020)
20. xAPI overview. https://xapi.com/overview/. Accessed 10 June 2022
21. xAPI solved and explained. https://xapi.com/?utm_source=google&utm_medium=natural_search. Accessed 10 June 2022
22. Redecker, C.: European framework for the digital competence of educators: DigCompEdu (No. JRC107466). Joint Research Centre (Seville site) (2017). https://doi.org/10.2760/178382
23. Carretero Gomez, S., Vuorikari, R., Punie, Y.: DigComp 2.1: the digital competence framework for citizens with eight proficiency levels and examples of use. EUR 28558 EN, Publications Office of the European Union, Luxembourg (2017). https://publications.jrc.ec.europa.eu/repository/handle/JRC106281. Accessed 28 Apr 2022