Games Fostering Co-Creativity in Learning as Contributions to the 'Maker Movement'

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Abstract. The C2Learn project aims to foster co-creativity in learning through digital gaming activities whose design and development is grounded on rigid theoretical foundations. The project is shaped as a progression from theoretical foundations to design, development, pilot implementation and evaluation in real life educational settings. Careful pedagogical and game designs have defined the elements of learners' gameful digital experiences and produced the specifications for the development of the corresponding technologies and activities. In this process and throughout the project, school communities have been engaged in iterative dialogic cycles leading to design decisions, their implementation and evaluation in real-life educational settings. This paper presents in summary the methodology followed and the results of a core part of the research, with a special focus on the C2Learn games which, despite originating in a different context, directly contribute to the 'maker movement' in education.

Keywords: games · creativity · learning.

1 C2Learn: digital games for co-creativity

C2Learn is a European research project (2013-2015) aiming to foster co-creativity in learning through digital gaming activities whose design and development is grounded on rigid theoretical foundations. In our project, current understandings of creativity in education and creative thinking meet with digital games and intelligent technologies to provide young learners and their teachers with innovative opportunities for *co-creativity* in learning. We aim at producing tangible research-based outcomes readily available for use in and outside classrooms. Therefore C2Learn is shaped as a progression from theoretical foundations to design, development, pilot implementation and evaluation in real life educational settings. Careful pedagogical and game designs have defined the elements of learners' gameful digital experiences and produced the specifications for the development of the corresponding technologies and activities. In this process and throughout the project, school communities have been engaged in iterative dialogic cycles leading to design decisions, their implementation and evaluation in real-life educational

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2 C2Learn theory and pedagogy

The foundations of the project lie in a consolidated theoretical framework encompassing the theories of Wise Humanising Creativity (WHC) [1,2,3] and Creative Emotional Reasoning (CER) [4]. C2Learn theory provides insights into how co-creativity of children and young people can be fostered in formal and informal learning settings. Co-creativity is defined as educational activity in which learners, individually as well as mainly collaboratively and also communally, come up with novelty, new ideas. These new ideas: a) have emerged through asking 'what if' and 'as if' questions and through the use of disruptive techniques resulting in re-framing; b) have emerged from shared ideas and actions in an immersed dialogic rather than hierarchical pedagogical environment; and c) are captured or selected because they matter to the community and have a valuable impact on it. In this, learners take into account the impact of that novelty on the individual, collaborative and communal dimensions of their community.

The theoretical framework defines the vision of the project and frames the design and development of the envisioned C2Learn technological solution. C2Learn theory also defines the wider conceptual and pedagogical framework in which the use of C2Learn technologies and C2Learn-inspired learning and teaching practices are placed. Thus, starting from C2Learn theory, the project produces theoretically framed technological innovation combined with designs for its deployment, use, and evaluation in real educational practice.

C2Learn theory is provided to the project in an operational form so that it can be used for the design and evaluation of the C2Learn solution. Thus, the theoretical framework is manifested as: a) CER Techniques [4,5], which offer ways for the application of CER in practice; b) Learning Design [6,7], which describes how WHC and CER can be enacted in pedagogical practice; and c) co-creativity assessment methodology [8], which is used in the pilots to establish to what extent and in what ways the solution produced by the project has the desired effect.

3 C2Learn technology and gameful design

The technology produced is an innovative digital gaming and social networking environment incorporating diverse tools the use of which can foster co-creativity in learning processes in the context of both formal and informal educational settings.

Digital gaming constitutes the chosen means for the involvement of learners and educators in WHC-CER practices in and around this digital environment. C2Learn theory thus frames game design, so that the designed playful digital experiences can foster co-creativity as theorized in C2Learn.
The C2Learn digital environment and the wider pedagogical environment in which it is used are gameful environments where co-creativity occurs playfully. The pursuit of playfulness is a priority served through explicit gameful design [9,10]. In addition, background Artificial Intelligence (AI) technologies are employed to further empower learners as creators and creative thinkers within the defined frame of co-creativity.

3.1 Co-designing and piloting with school communities

Throughout, school communities are actively engaged in iterative dialogic cycles leading to design decisions, their pilot implementation and evaluation in classrooms. In close reflective collaboration with communities of educators and students in Austria, Greece and England, researchers gather user requirements, co-design locally appropriate solutions for the introduction of the innovation in real life learning settings, negotiate and plan various instances of such an introduction for the purposes of piloting and evaluation.
The aim of piloting in the project is to test and evaluate with users the C2Learn experience, including both the technologies developed and the pedagogical practices enabled by these technologies. In the pilots, educational activities specifically shaped around the use of the C2Learn technologies and methodologies are implemented in educational settings. The aim is to create conditions for evaluation that can provide the project with feedback used for further refining design and development and for introducing adjustments and improvements.
Evaluation is realized through the application of the co-creativity assessment methodology specifically developed on the basis of C2Learn theory. The core aim is to evaluate C2Learn's impact on learner's co-creativity as theorized in the project, by documenting change as well as the lived experience of engaging in C2Learn-enabled activity [8]. The co-creativity assessment methodology is applied in fieldwork during the pilots leading to the collection of rich qualitative data. The data collected is then analysed to lead to critical descriptions of the activities, evaluative findings and conclusions.

3.2 A scenario-based design approach

Educational scenarios [11,12,13] provide the integration of the various parts of the project into a coherent C2Learn user experience in a given educational setting,

orchestrating the various technological and pedagogical parts of the project described in the previous sections. They are concrete designs of pedagogical practice in the context of given educational settings specified in terms of learner age group, curriculum links, the degree of formality of the learning activities, and the wider cultural/country setting. Educational scenarios thus 'translate' learning design and game design into plans for the implementation of educational activities in real life, predominantly in the pilots run within the project, but eventually also in other educational settings. At the same time, scenarios present the world of education with the range of possibilities offered and examples of effective use of the C2Learn solution.

Educational scenarios are designed in close collaboration with the school communities, providing input into the design process directly from educational practice. Indeed, they constitute that aspect of the design of the C2Learn solution which is most strongly shaped by the collaborating school communities and framed by their educational realities. They are a design tool aiming to ensure that the innovative technologies deployed and practices introduced will correspond to the needs, circumstances, expectations and aspirations of the end users. Therefore, their development is interwoven with processes aiming at establishing user expectations and requirements.

As we have described elsewhere [14], setting out from a theoretical perspective and motivation, the project has deliberately adopted a scenario-based approach to engage teachers as designers of learning experiences. In summary, in our approach a scenario is an adequate but flexible structure for sustained engagement and learning within open-ended environments, like the ones designed in C2Learn. In addition, scenarios can also enable teachers to manage the change in the flow of classroom activity induced by the technology-enhanced pedagogical innovation. Further, by shifting the pedagogical emphasis from the transmission of subject matter to the orchestration of experiences around the subject matter, C2Learn scenarios focuses on a crucial dimension that is often neglected in discussing the curriculum: making the learning situation meaningful from the point of view of the students. Scenarios can turn our curricular objectives into personal goals that students understand and embrace. Finally, scenarios can generate useful user input to inform the design of the envisioned technological system, as well as serving as exemplars for communicating pedagogical innovation to a broader population of potential users and other communities of interest.

An important aspect of this design is the distribution of C2Learn practice in the physical and digital spaces of C2Learn. In this context, educational scenarios propose appropriate configurations of the use of digital and non-digital C2Learn assets in the pedagogical environment, based on the affordances and opportunities offered by the various media and how those can be best used in a given educational setting. Attention is paid to the representation in the scenarios of a wide variety of configurations of C2Learn experience, including the use of different combinations of digital and non-digital assets, in various time frames, so as to illustrate the versatility, flexibility and adaptability of the C2Learn solution.

4 Learning through making while playing C2Learn games

The C2Learn games are hosted in C2Space, a web space which integrates all technological constituents into a unified user experience. It is a gameful social networking environment designed to foster co-creativity as theorized in the C2Learn project. C2Space offers playful digital experiences ('C2Experiences') for students to engage with. C2Experiences are structured in C2Space in 'Creative Quests', 'Creative Missions' and 'Creative Challenges', as presented in Table 1.
Among the various Creative Challenges, of particular interest from a 'maker movement' perspective are those based on the games 4Scribes and Iconoscope.

4.1 4Scribes

4Scribes is a story-making game. The objective of the game is to collaboratively create a story, while each player tries to steer the narrative towards their individual secret ending. The premise of the story can be given by a teacher, decided by the players, or generated by computational tools. The winner is decided through the players, who each anonymously vote which ending was the "best".
The Light and Dark variety is a variation on the 4Scribes game, where learner-created endings are randomly attributed a dark or light modifier. This gives the players goals in different directions, and often results in more dynamic play, because of the conflicting goals. Dark and Light endings refer to the tone the learner should take into consideration when writing their secret ending. Dark refers to dark themed endings, working against the ideals of the premise. Light refers to lighter themed endings, working towards the ideals of the premise.
To play 4Scribes, players use the Creative Elements, i.e. cards carrying one word or short phrase each which are meant to disrupt players' conventional thinking. In turns, players advance the story using one of their elements at each time. The words are not meant to be interpreted literally, but are an idea and an archetype that should spark the imagination of players. Thus, using the words or phases appearing on the elements in play serves as a creative seed in story-making.

4.2 Iconoscope

In Iconoscope players make icons to represent concepts given by the system. The player's goal is to make their icon representative of the concept, but not too obvious, so that they make the others guess - and to guess what other players' icons represent. Players score points for guessing right, and for having co-players guess what their own icon is representing.

Table 1. Elements of C2Learn gameful design.

Gameful design concept	Explanation	Example
CREATIVE QUEST	Players set out on Creative Quests, i.e. journeys towards specified goals. Quests can be longer-term ventures (spanning over weeks or months).	Save the Earth from Invincible Invaders!
CREATIVE MISSIONS	Players engage themselves in Creative Missions, i.e. actions with specific objectives contributing towards achieving the goals of the quest.	We will devise new defense methods against Invincible Invaders!
	A Quest can include a number of Missions. Missions are shorter-term ventures (spanning over a day, days, or weeks).	
Problem	In the heart of each mission lies a Problem; one with no obvious 'correct' answers, e.g. a dilemma.	How can we outsmart Invincible invaders' warcraft, which is by far technologically superior to ours?
CREATIVE CHALLENGES	To address the Problem, players choose Creative Challenges to pursue. A Mission can include a number of Challenges. Challenges take a relatively short time to complete (spanning over minutes).	
4Scribes	Playing structured story-telling to generate ideas for innovative scenarios of action. Usual duration: 20-30 minutes.	"You are the last ones still conscious and capable of action on the Earth. You have just received Invincible Invaders' ultimatum before the Attack: the Earth is to be taken. Only one of you will be spared human consciousness to participate in the New Rule - provided you subscribe to the Cult…" Continue the story!
Creative Stories	Playing free collaborative writing to generate ideas for innovative scenarios of action. Usual duration: 10-30 minutes.	You are the last ones still conscious and capable of action on the Earth. You have just received Invincible Invaders' ultimatum before the Attack. Write Earth's Message to Invincible Invaders!
Iconoscope	Playing with the concepts to understand them better. Usual duration: 10-15 minutes.	Dare you look deeper into {concept1: War}, {concept2: Cunning} and {concept3: Threat}? Prove it, outsmart the others!

However, if all co-players interpret the icon correctly, the player loses points - hence the need to make an icon that is representative, but not too obvious.
The game requires participants to internalize the logic of a disruptor, and then produce one. The creativity (disruptive) part comes in through the way this icon is then evaluated. Usually signs or icons are meant to convey unambiguously whatever message they represent. A common measure of success is their having conveyed their message as accurately or fully, to as many people as possible. In Iconoscope the icon has achieved its purpose if it has conveyed the idea to as many people as possible, but not all. So an icon fails if it communicates its intended message to everyone, if it communicates its intended message to no one, or if it communicates its intended message to fewer people than another competing icon.

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