Creative Emotional Reasoning Computational Tools Fostering Co-Creativity in Learning Processes

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GAME DESIGN (EARLY VERSION)

C²LEARN PROJECT DELIVERABLE NO. D4.1.2

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Dissemination level: Public

The C²Learn project has been supported by the European Commission through the Seventh Framework Programme (FP7), under grant agreement no 318480 (November 2012 – October 2015). The contents of this document do not represent the views of the European Commission and the Commission cannot be held responsible for any use which may be made of the information contained therein. Responsibility for the information and views set out in this document lies entirely with the authors.

DOCUMENT IDENTITY

Project category	Details
Deliverable code	D4.1.2
Full title	Game Design
Work package	WP4
Task	T4.1
Consortium partners leading	UoM
Consortium partners contributing	SGI

DOCUMENT HISTORY

Version	Date	Handling partner	Description
1.0	20/11/2013	UoM	Initial draft

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Abbreviations used

A) Abbreviated names of the project consortium partners

Abbreviation	Explanation
EA	Ellinogermaniki Agogi, Greece (coordinator)
UEDIN	The University Of Edinburgh, UK
OU	The Open University, UK
NCSR-D	National Center For Scientific Research "Demokritos", Greece
UoM	University of Malta, Malta
SGI	Serious Games Interactive, Denmark
BMUKK	Bundesministerium Für Unterricht, Kunst Und Kultur, Austria

B) Other abbreviations in alphabetical order

Abbreviation	Explanation
C²Learn	Acronym of the project (full title: Creative Emotional Reasoning Computational Tools Fostering Co-Creativity in Learning Processes)
DoW	Description of Work (Annex I of the Grant agreement no. 318480)
EC	European Commission
FP7	The Seventh Framework Programme for Research and Technological Development (2007-2013)
ICT	Information and Communications Technologies

Abbreviation	Explanation
M#	#th month of the project (M1=November 2012)
TEL	Technology-Enhanced Learning

Executive summary

C2Learn at a glance

C²Learn (www.c2learn.eu) is a three-year research project supported by the European Commission through the Seventh Framework Programme (FP7), in the theme of Information and Communications Technologies (ICT) and particularly in the area of Technology-Enhanced Learning (TEL) (FP7 grant agreement no 318480). The project started on 1st November 2012 with the aim to shed new light on, and propose and test concrete ways in which our current understanding of creativity in education and creative thinking, on the one hand, and technology-enhanced learning tools and digital games, on the other hand, can be fruitfully combined to provide young learners and their teachers with innovative opportunities for creative learning. The project designs an innovative digital gaming and social networking environment incorporating diverse computational tools, the use of which can foster co-creativity in learning processes in the context of both formal and informal educational settings. The C²Learn environment is envisioned as an open-world 'sandbox' (non-linear) virtual space enabling learners to freely explore ideas, concepts, and the shared knowledge available on the semantic web and the communities that they are part of. This innovation is co-designed, implemented and tested in systematic interaction and exchange with stakeholders following participatory design and participative evaluation principles. This happens in and around school communities covering a learner age spectrum from 10-24 years.

About this document

This document outlines some of the potential game design scenarios for the C2Learn project. It also covers related work in the areas of mixed initiative procedural content generation (PCG), co-creativity, and creativity metrics which are directly linked to the C2Learn objectives of co-creation through games. The document also outlines the current state of an initial character co-creation prototype tool that is aligned with the goals of C2Learn and the proposed game design system.

The game design scenarios are based on the C2Learn theoretical framework deliverable D.2.1.1, the education scenarios deliverable D5.1.1 and are, in part, affected by advancements in learning design of deliverable D2.2.1. The game design sketches proposed are built around the main concept of a system that allows students to make creative artefacts using a suite of tools that have playful interfaces and make novel suggestions, supporting elements of lateral thinking as described in the C2Learn theory (D2.1.1). These artefacts are then used as playing pieces in games based on standard game design patterns. The play of these games creates an opportunity for reflection on the curriculum, enabling living dialogic spaces.

Also described is a scenario of how an alternate reality game (ARG) can support classroom practice in enabling living dialogic spaces and journeys of becoming. In addition, an attempt is made to link the concept of journeys of becoming to the C2Learn theory with the idea of a

progression game where the student solves a series of puzzles enabling different forms of lateral thinking.

1 Introduction

The role of the game in the C2Learn project is to contribute to classroom experiences related to creativity. Teachers will be presented with educational scenarios that include multiple activities: readings, videos, participatory exercises, etc. The C2Learn game will be integrated into some of these scenarios where appropriate.

To better understand where it would be appropriate to include a game in the classroom experience, we have studied and built upon the educational scenarios provided by the OU, EA, and BMUKK partners of C2Learn (i.e. Deliverables 5.1.1 and 2.2.1). The system we are proposing is intended to be general enough to support multiple scenarios with minimal effort from the teacher.

Section 2 of this document covers previous work related to the game design and mixed-initiative procedural content generation aspects of C2Learn including background on computational creativity and patterns for creativity in games. Section 3 covers the potential game design scenarios proposed at this phase of the C2Learn project. Section 4 covers educational scenarios, describing how a game can be integrated with curriculum examples. Lastly, section 5 covers the narrowing of the game design space.

2 RELATED WORK

Previous work that the C2Learn game design builds on falls into three broad categories: computational creativity, procedural content generation (PCG), and game design patterns. In the computational creativity section we discuss previous work on using computers as tools to generate creative artefacts, including metrics for evaluating the creativity of a generated artefact. In the PCG section, we discuss approaches to the creation of game content through algorithmic methods. This includes mixed-initiative content generative systems, where the computationally creative system supports a user/designer by making suggestions and maintaining constraints, thereby enabling a co-creative process. The game design patterns section details common patterns in digital and analogue games that enable creative play.

2.1 COMPUTATIONAL CREATIVITY

This section provides a background on computational creativity (CC), in general, and CC in games and then proposes general measures of machine creativity derived from information theory that can be used by the C2Learn games for assessing levels of human creativity in a co-creation (mixed-initiative) process.

Evolutionary art projects have been using computers to spur human creativity, which leads to the question “can a computer itself be creative?” This has given rise to the term computational creativity, and approaches to achieving it have been divided into those deriving it from the process of human creative design (Goel, 1997) and those using

computational techniques unrelated to human cognition (Neural Networks, Genetic Algorithms) to guide the development of a computational creative process.

Regardless of the approach, Boden (2003) distinguishes between three types of creativity: combinatorial, exploratory and transformational. She argues that computers (and artificial evolution) are better suited for exploratory creativity, which revolves around traversing a computationally defined search space. On the other hand, combinatorial creativity which revolves around the combination of different elements (words, mathematical operators or programming commands) is easily accomplished by a computer but due to the vast range of possible combinations, most of them are uninteresting. For that reason Boden (2003) establishes that computational creativity does not only require the generated content to be novel, but also valuable (i.e. useful) – in that regard, most combinations produced by a computer fulfil only the novelty requirement of creativity. Transformational creativity focuses around the transformation of a pre-existing conceptual space, dropping one or more of its defining rules: for that reason, it is widely believed that transformational creativity is the most challenging element of computational creativity. Newell et al. (1963) have identified four criteria for a solution to be creative: 1) The answer has novelty and usefulness (either for the individual or society); 2) The answer demands that we reject ideas we had previously accepted; 3) The answer results from intense motivation and persistence; 4) The answer comes from clarifying a problem that was originally vague.

Evaluating commonly used procedural content generation (PCG) algorithms based on the "creative tripod" of skill, appreciation and imagination (Colton, 2008), a case could be made that most existing algorithms possess only skill. Human game content designers (level designers, 3D artists, sound designers etc.) on the other hand possess both appreciation and imagination, but given the content bottleneck do not possess sufficient skill to produce the required volumes of content.

Procedurally generated art can probably be traced back to the first visual output on-screen; however, the more relevant term evolutionary art has been used to describe the application of genetic algorithms (or genetic programming) to aesthetic design. Kickstarted by the works of Sims (1991) and Todd and Latham (1994) in the 1990s on the evolution of surprisingly complex 2D images and sculptures respectively, artists and researchers alike have explored the possibilities of artificial evolution in many different artistic domains, using diverse techniques for representation and evolution. As the starting point of evolutionary art, 2D images have been a favourite among researchers, with different approaches including mathematical expressions (Unemi, 1999; Sims, 1994), fractal systems (Lutton et al., 2003), neural networks (Lund et al., 1995), and image processing filters (Poli, 1997). 2D shapes have also been evolved to morph cartoon faces (Lewis, 2000) or to create abstract alphabets by breeding different font types (Schmitz, 2004). Extended work has also been made in the realm of 3D objects: either with evolved L-systems and other grammar-based techniques or the combination of primitives, 3D models representing from sculptures (Rowland and Biocca, 2000) to furniture design (Hornby, 2004) and architecture (Gero and Kazakov, 1996) have been procedurally generated.

There are quite a few significant differences in the approach of evolutionary art and other applications of artificial evolution (including search-based computational creativity). While genetic algorithms have been acknowledged for their ability to handle difficult numerical optimization problems, evolutionary art rarely concerns itself with the optimization of a fitness value. The majority of evolutionary art projects prefer to use evolution without an ulterior goal (at least not a quantifiable one): such projects often prefer novelty (Lehman and Stanley, 2011) over subtle changes. This is one of the reasons why the majority of evolutionary art projects require a human user to guide the evolution by choosing – often directly– the members of the population that will breed to create a new generation – e.g. see the *PicBreeder* project (Secretan et al., 2013) or the *Petalz* project (Risi et al. 2013). The other significant reason for the rise of interactive evolution is the difficulty in evaluating beauty with the use of heuristics: since art is an expression of personal taste and aesthetics, humans are much better suited to decide which art pieces (be they sculptures, images or text) are appealing to them.

The quantification of aesthetic values that would lead to "a machine that can make art like, and for, humans" (McCormack, 2008) has only recently begun to be explored by researchers (Machado et al., 2008) – the problems of aesthetic evaluation have been highlighted by McCormack (2008), and the creation of artistic filters is broadly recognized as an open research problem.

2.1.1 METRICS FOR COMPUTATIONAL CREATIVITY

Given the above volume of work in the area of computational creativity we herein proposed a number of computational metrics that a system can use to asses and measure aspects of computational creativity during a mixed-initiative (i.e. player-game) co-creation process. While these could also be used as objective measures for creativity for human evaluation, they are intended to provide the system with objective, deterministic evaluations. This is unrelated to C2Learn's co-creativity assessment methodology, which will be defined in D2.3.1.

The measures of creativity herein proposed are inspired from and built upon theories on computational creativity (Boden, 2003) and backed-up with the theoretical concepts of Deliverable 2.1.1.

Novelty is defined as the deviation from existing knowledge/patterns/experience. In the context of a co-creation process, novelty measures the deviation of a piece of content from earlier experienced or seen content. Novelty is usually measured in terms of a difference metric between what has been generated or seen and the given piece of content. As an example from visual arts, the novelty of an image is measured as the Euclidian distance from the existing images generated by the computational system (or the human creators). Novelty is a generally accepted metric of (aspects of) creativity within the area of computational creativity – e.g. see work of (Boden, 2003) and (Gero, 1996) among many and an obvious candidate for measuring elements of creativity within the human-created content in collaboration with the computational creator.

Novelty has been used as a measure for judging creativity (Liapis, 2013a, b, c) but also as a heuristic for driving the generation of novel artefacts in exploratory creativity (Boden, 2003) – also known as novelty search (Lehman and Stanley, 2011).

Impressiveness is a measure introduced by Lehman and Stanley (2012) composed by two key elements: rarity and recreation effort. According to Lehman and Stanley (2012) impressiveness allows the observer to recognize how much effort is required to perform the action and there is a fundamental asymmetry between recognizing and performing as it is magnitudes easier to appreciate a beautiful artefact than it is to create one. Most importantly for the definition of impressiveness within the C2Learn aims, a generated artefact or game content will have recognizable properties (making it recognizable) which are not obvious how to recreate. Thus "impressiveness can be defined as the difficulty of recreating an easily-recognized property of an artefact" (Lehman and Stanley, 2012).

Rarity as introduced by Lehman and Stanley (2012) is a measure that is closely linked to novelty but it "can only be found in very small pockets of a large search space which may also be difficult to achieve." For example, only a few students can write with both hands, which suggests that this ability might feature some impressive properties. In the context of the C2Learn rarity metrics can be designed to evaluate for the rarity of generated content in similar fashion as introduced in (Lehman and Stanley, 2012) for the rarity of images.

The second heuristic of impressiveness implies that the more effort is required by a baseline (optimization) algorithm to re-generate (or re-create) a given artefact /creation the more impressive that artefact is. That implies that properties of the artefact can be measured on a continuum (Lehman and Stanley, 2012). The **re-creation effort** combined with (or opposed to) rarity provide interesting alternatives for measuring aspects of human creativity via computational means during the interaction with the C2Learn game.

The generated content of the co-creation process has to **valuable**. Under a game context that naturally means that whatever is created can be usable within a game or simply playable. Under an algorithmic perspective the content has to be within particular constraints set by the game itself (i.e. by its designers). Combined with novelty, value can collectively characterise a creative output (Boden, 2003).

The notion of value is constrained by the level of affordances given by the game design. The more the game progresses, naturally, the more pressuring the constraints become and, in turn, the more creative the solution has to be to satisfy increasingly complex constraints. Realising the theoretical concepts discussed in D2.1.1 the C2Learn games will feature a dynamic value system in which the human (and the computational) creator have to provide solutions to an ever-complex problem. In addition the computational creator suggests solutions which are orthogonal to the creation patterns of the player resulting in novel, nevertheless valuable (i.e. within constraints) answers.

The element of **surprise** usually comes as a third critical element for an output (artefact) to be considered creative. In addition to novelty and value, surprise offers a temporal dimension to unexpectedness. Surprise, being an emotional construct, however, can be expressed by humans but it cannot be trivially represented computationally. One way of

representing surprise as the deviation from the expected is for one to construct a temporal predictive model of forthcoming creations and measure the deviation of each of the generated creations from the predictive model. The higher the deviation the higher the perceived surprise it creates to human (and potentially computational) creators (Maher et al., 2013). Models of surprise might be considered in C2Learn games to measure the temporal deviation from expected solutions/creations.

The notion of **artificial curiosity** introduced by Schmidhuber (2006; 2007) may provide a set of creativity metrics which are linked to the aforementioned measures. Schmidhuber (2006; 2007) advances an ambitious and influential theory of beauty, interestingness and creativity that arguably holds explanatory power at least under certain circumstances. Though the theory is couched in computational terms, it is meant to be applicable to humans and other animals as well as artificial agents. In Schmidhuber's theory, a beautiful pattern for a curious agent A is one that can successfully be compressed to much smaller description length by that agent's compression algorithm. However, perfect beauty is not interesting; an agent gets bored by environments it can compress very well and cannot learn to compress better, and also by those it cannot compress at all. Interesting environments for A are those which A can compress to some extent but where there is potential to improve the compression ratio, or in other words potential for A to learn about this type of environment.

This can be illustrated by tastes in reading: beginning readers like to read linguistically and thematically simple texts, but such texts are seen by advanced readers as "predictable" (i.e. compressible), and the curious advanced readers therefore seek out more complex texts. In Schmidhuber's framework, creative individuals such as artists and scientists are also seen as curious agents: they seek to pose themselves problems that are on the verge of what they can solve, learning as much as possible in the process. It is interesting to note the close links between this idea and the theory of flow (Csikszentmihalyi, 1996) but also theories of learning in children (Vygotsky et al., 1987) and game-players (Koster and Wright, 2004).

2.2 PROCEDURAL CONTENT GENERATION IN GAMES

Since the 1980s, procedurally generated game content has often been used by the game industry in order to create an engaging but unpredictable game experience. As game titles continue to increase in complexity and scope, the labour-intensive design and production of game content by hand inflates both development time and cost; not only does the generation of content by algorithmic means circumvent this content bottleneck, it allows for faster design iterations, increases design efforts and pushes the limits of human creativity. Recent academic interest has further pushed towards personalization of procedurally generated content based on player preferences. From a computational creativity perspective, while the procedural generation of content can be classified as artefact generation, the generative algorithms are rarely classified as creative.

The game industry has often relied on the procedural generation of game content during playtime to enhance the unexpectedness of the player's experience and increase the game's replayability value. From early games such as *Rogue* (M. Toy and G. Wichman, 1980) and *Elite* (Acornsoft, 1984) to contemporary titles such as *Torchlight 2* (Runic, 2012) and

Civilization V (Firaxis, 2010), game world and level creation has been the principal application of procedural content generation (PCG); other applications include the creation of enemies as in *Darkspore* (Maxis, 2011) and weapons as in *Borderlands* (Gearbox, 2009). Although academic interest in PCG is relatively new, the majority of PCG researchers challenge the mostly random generative algorithms used in the game industry. Whether generating platformer levels, mazes, board games, racing tracks, weapons or spaceships, most projects within academia attempt to control the algorithms' stochastic processes via constraints, objective functions and predicted or reported player experience. In the domain of computer-aided level design, the most promising results have been accomplished through constraint solvers, where the constraints are explicitly described by the designer.

2.2.1 CO-CREATION

The word co-creation has different connotations in different fields. In the context of research regarding marketing and management it is discussed as a mechanism for "added value" (Prahalad & Ramaswamy, 2004). It has been discussed as a method for enhance learning (Kangas, 2010), and sometimes when discussing Massively Multiplayer Online (MMO) games it refers to the practice of players creating add-ons for games that changes their user interface (Davidovici-Nora, 2009). In this text the word co-creation is used to denote that players and computational processes each have roles in the creation of in-game objects. This can also be referred to as mixed initiative creation, where one initiative is from a machine, and the other from a human.

Co-creation in games is related to the notion of player-created content. A major concern has been how to achieve the right level of editorial control. While many players enjoy creating things in games, other players do not always appreciate the quality of the work. Regarding editorial control for content in virtual world created by others than the game developers it was common in the text based worlds such as Multi-User Dungeon (MUD) (Bartle & Trubshaw, 1978) of the 1980s and 1990s that trusted players were given extended authoring rights. A trusted player can be elevated to "wizard" and get rights to design new areas of the world and populate it with objects. The greater rights, the more permanent the objects created could be. In other words, a very trusted player might be given the right to create a permanent building, while a less trusted player might be allowed to create an object that 'lives' for a limited amount of time. In later (early 2000s) graphical game worlds this practice has generally been abandoned, with exception for that some worlds allow players to create their own 'homes' or mansions for their permanent groupings, or guilds, where they can virtual objects that are graphically represented (Lucas Arts, 2003; Square Enix, 2003). In virtual worlds that are more oriented to socializing than game play, such as Second Life (Linden Lab, 2003), the practice of players creating (and scripting) content is an important part of the activity in the worlds. Providing tools for players to co-create in game oriented worlds is more challenging; players' creations need to tie into the existing game mechanics, which adds complexity and potentially introduces bugs and incoherence. For creating own content for play with friends it is more usual with "modding." Modding is to use technology for existing games, such as *Neverwinter Nights* (Bioware, 2002) or *Half-Life* (Valve Corporation, 1998), for creating own games and game levels. In mods, the game play

mechanics played with and the content created is restricted to that very world, so it is not necessary to make sure it is compatible with everything in an already existing world.

In games in general, players' actions have an effect on the game play experience and on the outcome of the game. The degree and nature of the effects of players' action vary from game to game depending on its design – but it there is always some effect. In case the game is a multiplayer game, the player also interacts with other players via the game system, affecting the other players' experience. Artefacts (where the term is used in Simon's (Simon, 1969) sense) in a game which are co-created by a game system and by players add yet another level - that of co-created artefacts. At the most basic level the item is merely represented (a represented artefact), while at a median level it has properties and functions aligned with the affordances of a particular games (a functional artefact), so that it is usable by players. At its most advanced, the co-created artefact is autonomous, acting within a game system in ways that affects other entities in a game, for example player-representations (an autonomous digital artefact). Existing games allowing for the creation of functional artefacts include *Minecraft* (Persson & Bergsten, 2011), *Little Big Planet* (Media Molecule, 2008), and *Creatorverse* (Linden Lab, 2012), while games where players create autonomous artefacts include *The Sims* (Maxis, 2009), and the research prototype *Pataphysic Institute* (Eladhari, 2012).

Co-created autonomous artefacts are products of the combined efforts of the game designers, making a system allowing for emergence of art, and players creating using the system, making things that become hybrid artefacts, living a "life" of their own in the system. The combinations of efforts of result in co-created artefacts on basic, median and advanced levels are seldom possible to predict, sometimes surprising, sometimes novel, and more often than not, unique.

2.2.2 MIXED INITIATIVE PCG

Since its early stages of development, the computer was expected to assist in solving engineering problems by being involved in the creative design process and by automating tedious tasks. Computer-aided design tools have often been identified by their dual role as "the designer's slave"— performing simulations, analysis and constraint satisfaction tests — and as advisors when certain requirements are not met. As computers are becoming efficient at performing the former role, more researchers focus on the latter: the most ambitious role for the computer is that of the "colleague". According to Lubart (2005), as a colleague a computer should contribute equally to the design discourse but could also incite creativity via "semi-random search mechanisms to generate novel, unconventional ideas."

In commercial games and game-like applications, computer-aided design speeds up the development process in the form of game editors. Game editors use an intuitive graphic interface, allowing designers with little programming experience to script behaviours and create content, usually as part of a game level. Many of these tools ship with the final game, allowing end-users to generate content which increases replayability and fan loyalty. Modding via the provided game editors has often transcended the original game's concept and mechanics, leading to new game titles such as *CounterStrike* (Valve, 2000) or new

subgenres such as Multiplayer Online Battle Arenas. Over the years, game editors have become very sophisticated, driven by a desire to support the modding community or to reuse code across products. As an example, the Unreal Development Kit supports landscape sculpting, asset organization, scaling rendering accuracies and code-free visual scripting. On the other hand, game-specific editors such as the Creation Kit of *The Elder Scrolls V: Skyrim* (Bethesda Softworks, 2011) allow less customization but offer game-tailored easy-to-use automations such as levelled item lists, navigation path generation and quest scripting.

Building on this work, some systems have been created that allow the designer to work with the system to create game content. The two best examples of these are Tanagra (Smith, 2011) and Sentient Sketchbook (Liapis, 2013a). The former allowed a designer to create a platformer game level in conjunction with the system. The designer could set the basic rhythm of the level, including the length of specific beats, and place platforms in specific locations. The Tanagra system would then fill in the rest of the level with generated content that matches the designer's specification. The designer can then modify parts of the level as they wish. The system will warn the designer if their changes violate any constraints: either those determined by the system, e.g., a gap is to wide for the player avatar to jump, or those set by the designer, e.g., the rhythm specified for a section of the level.

In Sentient Sketchbook (Liapis, 2013a; see Fig. 1), the designer worked with the system to create a real-time strategy (RTS) game map. The designer can specify the location of bases and resources, as well as passable and impassable areas of the map. The system maintained constraints, e.g., a base for each player, and made multiple recommendations based on various fitness functions. Among these are novelty, i.e., something uniquely different from the current map, or gameplay based factors, such as resource balance or the distance between bases. The designer could select a recommendation to replace the current version of the map and continue their work on the new map.

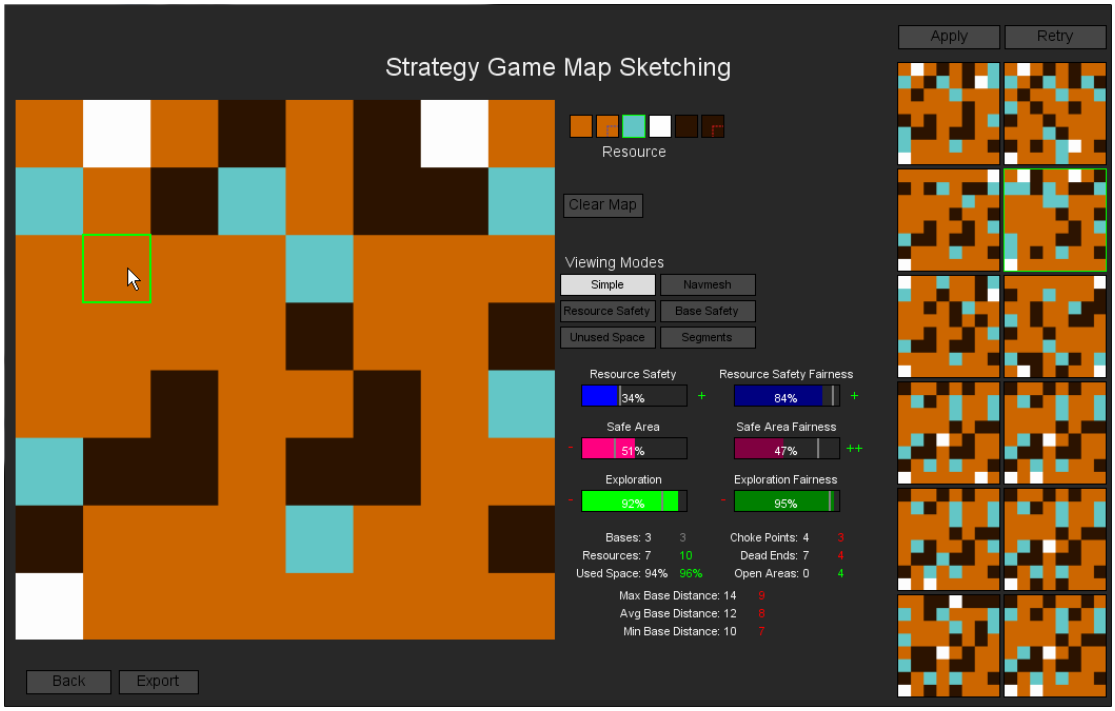

Figure 1. A Screenshot of Sentient Sketchbook. The user designs maps on the left and recommendations (that e.g. maximize map novelty, map balance etc.) are provided on the right.

2.3 PATTERNS FOR CREATIVITY IN GAMES

Numerous existing games involve creative thinking, or otherwise enable creativity in some way. When looking at a wide variety of these games, certain patterns of game mechanics become apparent. This section will explore some of these patterns and how they might be used in the C2Learn project.

The identification of patterns for this work builds on earlier work by Björk (2004), Hullett (2010), and others. These authors have presented design patterns as a useful framework for understanding design decisions and their effects on player behaviour. Design patterns can be used as a tool for designers to conceptualize their design ideas at an earlier stage in the design process than normal.

The patterns identified for creative games include:

- Construction
- Free Expression
- Customization
- Storytelling
- Combining
- Bluffing
- Puzzle Solving
- Disruption/Subversion

Not every example falls neatly into one pattern; in many cases games contain elements of multiple patterns. For the discussion below, games are grouped with the pattern that is most apparent, with other patterns present mentioned in the description.

2.3.1 CONSTRUCTION

Construction games involve the building of some artefact. The constructed artefact may then be used as part of the game, or the construction could be and end goal in and of its self. This category also includes a number of non-games or playful activities that lack a specific goal.

Construction games often involve working with representations of the object being constructed, relating to Diagrammatic Lateral Thinking and Re-Conceptualization as part of Semantic Lateral Thinking as described in D2.1.1. Some construction games also require collaboration with other players, enabling Living Dialogic Spaces.

Construction toys

The most basic constructive play involves construction toys like *LEGOs* (see Fig. 2), *Lincoln Logs*, or *Tinker Toys*. These enable free-form creative play, but are not games. Constructed artefacts may be used as part of a game, but that is generally not the goal of free-form play.

Figure 1: A *LEGO* construction

Creatorverse

A step up from general construction toys would be a system like *Creatorverse* by Linden Labs (2012) (see Figure 2). This is an app that runs on iOS and Android devices. The system allows users to make images and animations using basic shapes and lines. It is even possible to create games by including user-interactable elements in an animation.

Users can also upload their artefacts to the *Creatorverse* shared space, and download other user's artefacts. In this way, users can learn new ways to use the system by examining other users' artefacts and even modify them for their own purposes.

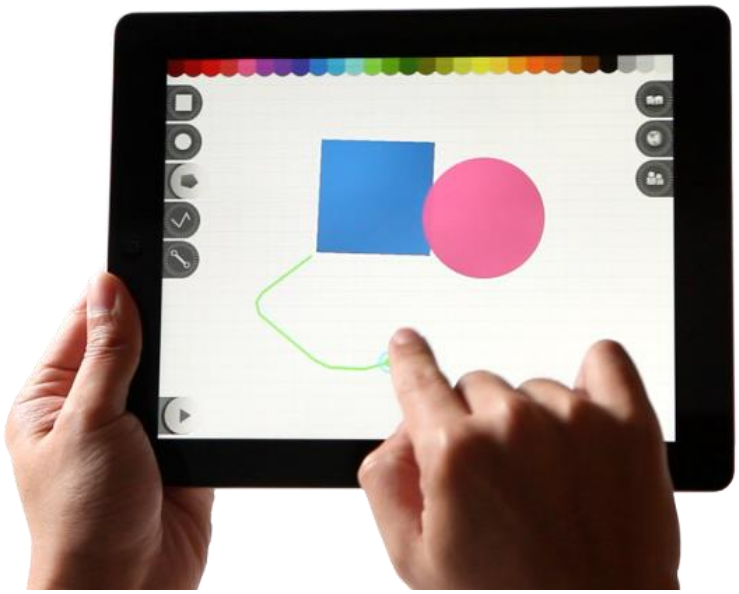

Figure 2: *Creatorverse* on an iPad

Although *Creatorverse* has game-like elements, it is not a game, due to lacking rules or a specific end goal. In this way it is similar to the various construction toys, though the playful interface and sharing makes it more game-like.

Minecraft

Another step up from *CreatorVerse* would be *Minecraft* (Persson & Bergsten, 2011; see Fig. 4). While still primarily used for free-form construction, it does contain some elements of a game. These elements can be largely ignored though, and most users participate in collaborative constructions as their primary interaction with the game. Large construction projects with several players contributing on shared servers are common in *Minecraft*. Arguably this is a game, though players are setting their own goals rather than those intended by the game designers. Collection of resources in *Minecraft* also has playful elements – players must search for and find the needed resources for their construction and in some cases transform raw materials through the game's crafting interface.

Figure 4: *Minecraft*

Galaxy Trucker

While construction games are well suited to digital implementation, there are examples of analogue games in this pattern. One example would be *Galaxy Trucker* (see Fig. 5) by Czech Games (2007). In this game, each player takes the role of a space ship owner. They build spaceships by randomly drawing components and trying to fit them on their ship. They can reject components they don't need or want, but once they have placed a component they cannot move or remove it from their ship. Each player must balance guns, engines, power sources, crew capacity, and cargo space if they are to succeed in the game.

Once the ships are constructed, the players then compete head-to-head to see who built the best ship. Random cards represent different encounters the ships face on their journey, such as a meteor shower that can damage or destroy parts of the ships, or planets where a player can choose to land and collect cargo. If their ship survives the journey, players get paid for their finishing position and the cargo delivered.

Figure 5: *Galaxy Trucker*

Ugg-tect

Another analogue example would be *Ugg-Tect* (Heidelberger Spieleverlag, 2009)(see Fig. 6), also sometimes called *Aargh!-Tect*. In this caveman-themed game, one player takes the role of leader while the other players are builders. The leader has a card showing the structure to be built using the coloured wooden shapes available to the players. They (the leader) must guide the other players to complete the construction, but they are not allowed to speak. They must convey their instructions through the use of gestures, grunts, and an inflatable club.

Figure 6: *Ugg-Tect*

2.3.2 FREE EXPRESSION

Related to the construction pattern is free expression. Games in this pattern allow the player to decorate or customize aspects of the game, but the customization has no effect on gameplay. *Farmville* (Zynga, 2009) – see Figure 3 – Is a classic example of this, but many other games support this pattern. It is very common among social games as visiting other players' areas is a common feature, though generally these visits are separate from the mechanics of the game.

Figure 3: *Farmville*

Aspects of this pattern also appear in many otherwise non-creative games (e.g., *Ravenwood Fair* (Lolapps, 2010) or *Free Realms* (Sony Online Entertainment, 2009)) that allow players to change the clothing or appearance of an avatar despite the change having no effect on gameplay.

Free Expression in games allows for Escapism and Role-Play as part of Semantic Lateral Thinking. They also relate to the playfulness and possibilities of Wise Humanising Creativity and enable 'what if' and 'as if' thinking.

2.3.3 CUSTOMIZATION

This overlaps heavily with the free expression pattern, but here the customization does have an effect on gameplay. In these games, the players' choices determine the abilities or attributes of their avatar or options available in the game.

Customization strongly relates to the idea of Possibility Thinking, namely the "what if" and "as if" thinking that is central to Wise Humanising Creativity. As well, many games may give players random starting choices, thus enabling Random Stimulation as part of Semantic Lateral Thinking.

Spore

In the Maxis game *Spore* (2008) (see Fig. 8), players begin the game by designing their creature. They drag body parts onto the figure and position them. The selected body parts and their configuration effect how the creature behaves. For example, giving your creature sharp teeth means it will be a carnivore and therefore more aggressive than a herbivore creature.

Figure 8: *Spore* Creature Creator

The Sims

In another Maxis game, *The Sims* (2000)(see Figure 9) players design both their avatar and the house they live in. The avatar customization affects their ability and personality traits, while the layout and items placed in the house affects how the avatar lives and how they spend their time.

Figure 4: Avatar creation in *The Sims*

Computer Role Playing Games

In most computer role playing games (CRPGs), players determine their avatars initial skills and have the option of improving attributes or gaining new abilities once they gain a new level. This allows customization of the character to suit the player's preferred playing style. For example, in *The Elder Scrolls V: Skyrim* (Bethesda Softworks, 2011)(see Figure 5), a player who prefers a ranged-attack style might invest in improving their archery skill as they gain new levels.

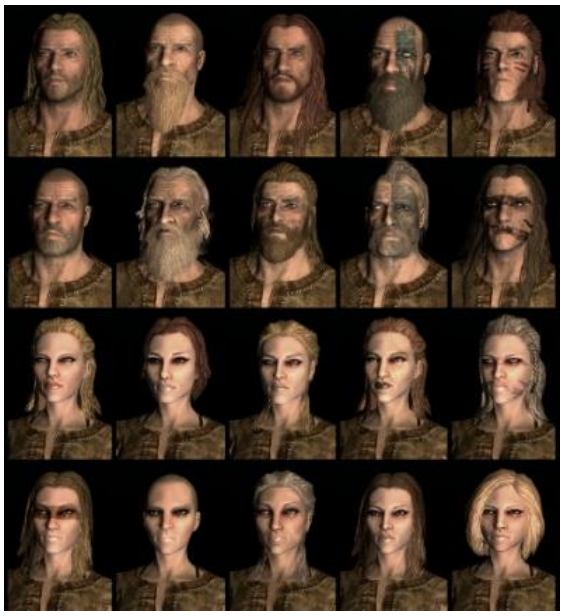

Figure 5: Character appearance options in *The Elder Scrolls V: Skyrim*

Many CRPGs (e.g., *World of Warcraft* (Blizzard, 2004)) also allow the player to set the appearance of their avatar, though in many cases this has no effect on gameplay, making this customization more suited to the free expression pattern. Though in some games this customization can affect gameplay, such as through different options for male or female avatars, or bonuses gained from certain clothing or equipment.

2.3.4 STORYTELLING

Games in the storytelling pattern require the player to craft a story from a given set of elements, often randomly determined. Many games in this pattern overlap with the combining pattern as the player is trying to connect random elements into a coherent whole. Some games that could be placed in either pattern have been placed here because the storytelling aspect is the main focus of the game.

Storytelling games often involve connecting random elements, so the Random Stimuli and Re-Conceptualization components of Semantic Lateral Thinking are present. These games also enable the Possibility Thinking of Wise Humanising Creativity due to the strong narrative thread.

Story Cubes

Story Cubes (Gamewright, 2005)(see Figure 6) are a set of nine dice, each with a unique image on each of its six faces, for a total of 54 images. To play the game, a player rolls all nine dice and creates a story that ties the resulting images together. Whether this is a game or not is debatable as there isn't a clear goal – the player could succeed or fail at making a story, but there is no means to rank the stories against others or determine a winner.

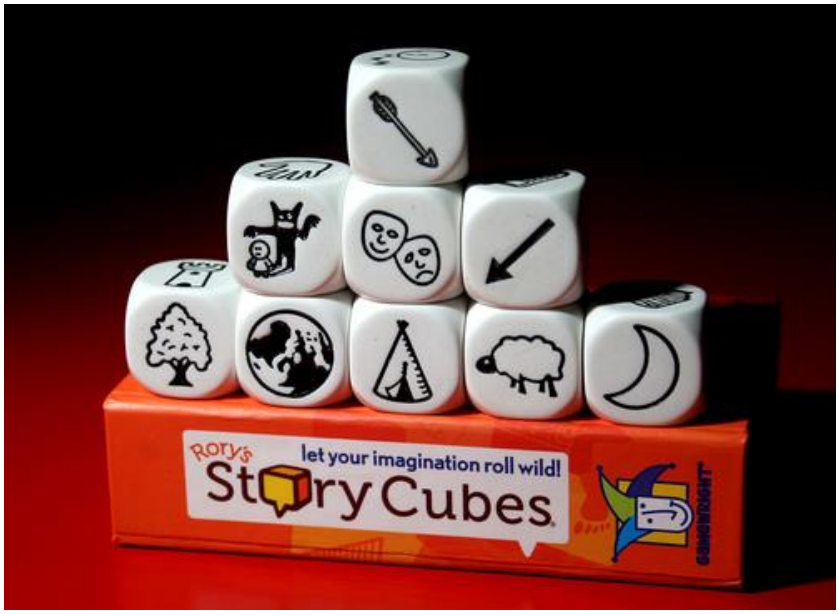

Figure 6: *Story Cubes*

Once Upon A Time

In the card game *Once Upon a Time* (Atlas Games, 1995), see Fig. 12, each player gets a random hand of cards that they need to incorporate into the story being told collectively by all the players. The cards include story elements like characters, plot twists, and resolutions. One player begins telling the story, but may pass it along to the next player if they are no longer able to connect the cards in their hand. Players may also interrupt the current storyteller if they (the storyteller) mention an element that the player has in their hand. The goal is to be the first player to use all their cards.

Figure 12: *Once Upon a Time*

Nanofictionary

Nanofictionary (Looney Labs, 2002), see Figure 7, is another storytelling card game that also includes elements of the set collection mechanic of standard card games. Players complete to collect a complete set of story elements: setting, characters, problem, and resolution. Once each player has a card of each type, they all tell their stories that tie the four together. Players listen to all the stories and vote on the best one.

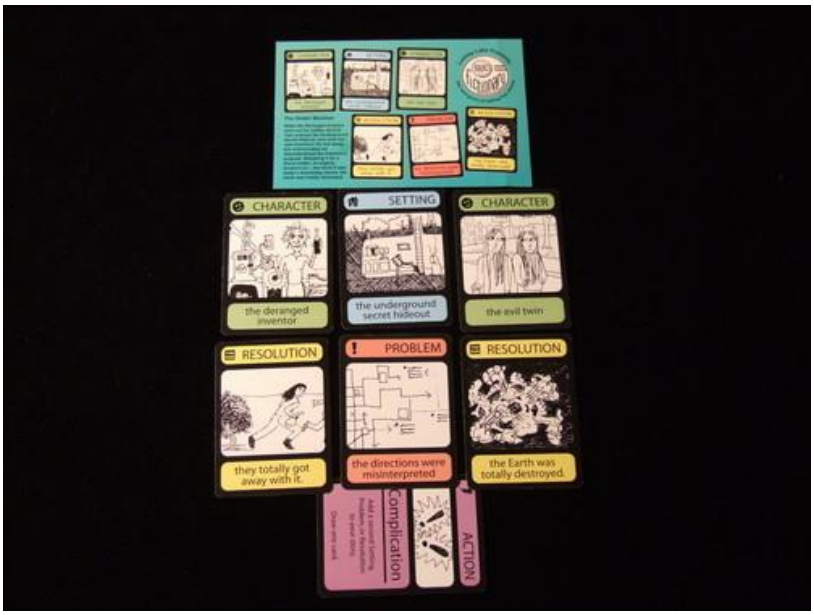

Figure 7: *Nanofictionary*

Fiasco

Fiasco (Bully Pulpit Games, 2009), see Fig. 14, is a role playing game with strong storytelling elements. It is based on the standard screenwriting tropes common in crime movies. After selecting a scenario, players roll dice to determine characters, settings, and plot points. They then act out the story, trying to reach the agreed upon conclusion while also completing their individual characters' goals.

Figure 8: *Fiasco*

Tabletop RPGs

More general than *Fiasco* is the wide variety of tabletop role-playing games. *Dungeons & Dragons* (TSR, 1974) is perhaps the best known of these, but there are numerous others, including *Call of Cthulhu* (Chaosium, 1981), *Vampire: The Masquerade* (White Wolf Publishing, 1991), and *Traveller* (Game Designers' Workshop, 1977). While many of these games have complex combat systems or other mechanics based on die rolling and numeric representations of characters' abilities, the main focus is on the story being created by the players and the dungeon master (DM). The DM sets the scene and takes on the role of any non-player characters (NPCs) the players encounter. The players each take on the role of a character and act according to that character's personality. Generally there is some sort of common goal the players are working towards in a given session, but often players have open-ended campaigns that can go on for years.

2.3.5 COMBINING

Games in the combining pattern usually require players to connect disparate random elements into some coherent whole. Storytelling games often have elements of combining as well as the players may be asked to form a story from random elements.

Like storytelling games, Random Stimuli and Re-Conceptualization from Semantic Lateral Thinking and possibilities and participation from Wise Humanizing Creativity are present in many of these games.

Man Bites Dog

In the card game *Man Bites Dog* (University Games, 2002), see Figure 9, players compete to create humorous newspaper headlines from a random hand of cards containing words or phrases. Each card has a point value based on the obscurity and potential difficulty to use it in a headline. Players get the point value of the cards they are able to use.

Figure 9: *Man Bites Dog*

You've Been Sentenced

Similar to *Man Bites Dog*, *You've Been Sentenced* (McNeil Designs, 2005))(see Figure 16) requires players to build sentences out of random cards. Here the goal is to form the longest sentence that is grammatically correct. Each card has five sides, each with a different conjugation of the base word, so players have flexibility in how they use it in a sentence. Players may vote to reject a sentence if it is not grammatically correct or otherwise nonsensical.

Figure 10: The cards of *You've Been Sentenced*

Cards Against Humanity

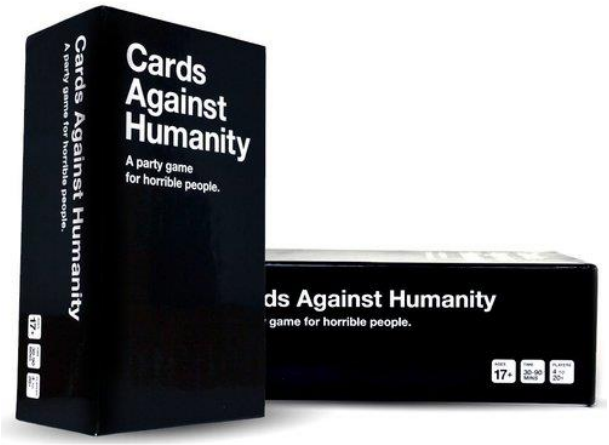

Figure 11: *Cards Against Humanity*

In the game *Cards Against Humanity* (Cards Against Humanity, LLC, 2009), see Figure 17, one player reads a sentence that contains a blank. The other players submit a card from their hand that fits in the blank. The lead player then selects the submitted card that they like the best. As the leader's judgement is the only determining factor, players will generally attempt to give the most humorous submission or try to appeal to the leader's personality in some way.

2.3.6 BLUFFING

Bluffing games require the player to be creative in how they represent themselves and the fictions they tell. There are some overlaps between bluffing games and storytelling games in that players might be required to tell a story to provide clues or deceive other players.

Bluffing games involve understanding of the players own emotional state and the emotional states of other players. In particular the Second Order Emotive Lateral Judgement may be in play here as players need to consider what will be accepted by the group. The pluralities, participation, and possibilities of Wise Humanizing Creativity are present.

Werewolf/Mafia/The Resistance

In the classic party game *Werewolf* (see Figure 18) (also commonly called *Mafia*, in addition to other names, and produced commercially in a modified form as *The Resistance* (Indie Boards and Cards, 2010)). Some players are secretly selected to be werewolves, while the rest are villagers. Each night, the werewolves secretly vote to kill a villager, and each day all players discuss who they think the werewolves are and have the option of lynching one player. If they succeed in lynching all the werewolves, the villagers win, otherwise the werewolves win once they are the majority of the remaining players (at which point the outcome is inevitable).

Figure 12: Accusing another player in *Werewolf*

As the werewolves need to avoid detection, they must be creative in how they present themselves during the daytime discussions. They want to direct accusations towards players they know are not werewolves without appearing to be so aggressive that the other players suspect they are werewolves themselves.

Dixit

The card-game game *Dixit* (Libellud, 2008)(see Figure 19) also combines elements of the storytelling pattern with the bluffing pattern. One player is the storyteller for a round. They select a card from their hand and tell a story about it. Then each other player selects a card from their hand that also fits the story and submits it. The players then have to guess which card was the one originally submitted by the storyteller. Both players and storyteller get points for correct guesses, but the storyteller gets no points if everyone guesses the correct card. So the storyteller must be creative in creating a story that allows some players to guess the correct card, but not so obvious that everyone guesses.

Figure 13: Cards in *Dixit*

Linq

In *Linq* (Endless Games, 2003), see Figure 20, players are randomly dealt cards that are organized into pairs with the same word. Each player has a partner with the same word, but they do not know who it is. The players then try to clue their partner by giving words related to the correct word, hoping that the connection will be obvious to their partner but not to the other players. All players then guess at the partnerships, with players gaining points for correct guesses and losing points if other players guess their partnership correctly.

Figure 14: *Linq*

2.3.6.1 PUZZLE SOLVING

In puzzle solving games, players have an objective they are trying to reach or a goal they are trying to accomplish. The path to the goal is not clear and players must figure out how to accomplish with the resources available. This may involve the Re-Conceptualization of Semantic Lateral Thinking. Many puzzle solving games involve construction, so the conceptual representations of Diagrammatic Lateral Thinking may also be present. From Wise Humanizing Creativity, possibilities and playfulness are strongly represented.

Bad Piggies

In *Bad Piggies* (Rovio, 2012), see Figure 21, players must construct a machine to transport their avatar from the start position to the goal. The machines use wheels, engines, structural components, power sources, and more in a series of increasingly complicated puzzles. Once the player constructs their machine, they start the level and the game's physics engine determines the outcome. In some puzzles, the player has a degree of control in when they activate some parts of their machine, but they can never make major changes en route.

There is no one solution for any given puzzle; it is up to the player's creativity to find a way to use the components available to achieve the goal. Some players may find techniques that they prefer and try to use them as much as possible. Other players may explore different techniques.

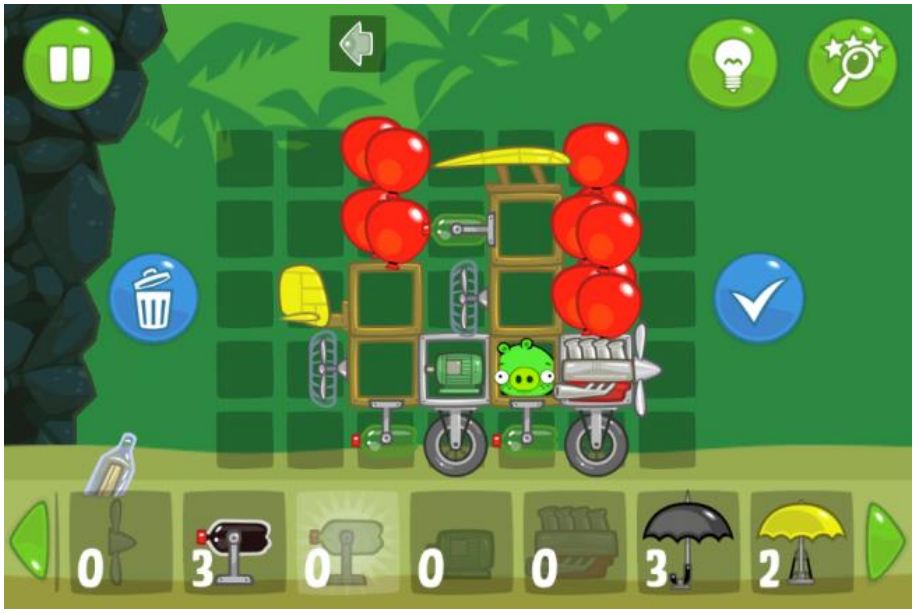

Figure 15: *Bad Piggies*

Crayon Physics

Similarly, *Crayon Physics* (Purho, 2008)(see Figure 22) relies on players drawing elements needed to solve a puzzle which are then acted on by the game's physics. For example, a player may draw a box that then falls and knocks over an obstacle. Like *Bad Piggies*, there is no one correct solution; the player's creativity determines the approaches they use.

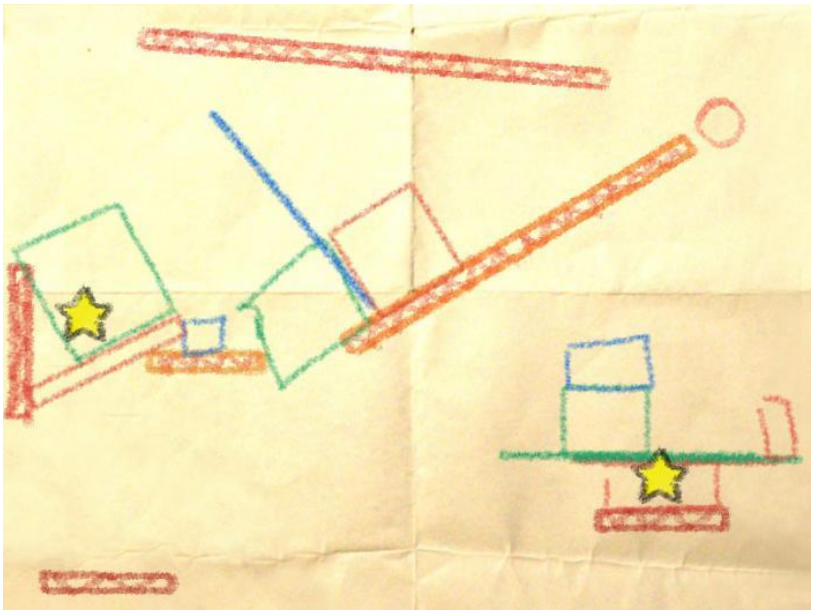

Figure 16: *Crayon Physics*

2.3.6.2 DISRUPTION/SUBVERSION

Disruptive games are a form of serious game, which are a mainstay of the indie-game developer community. Typically adhering to a 'lo-fi' design ethos, they span a very broad

range of game genres, including shooters, text-based adventures, console clones, rhythm games, point-and-click, and so on, with the common feature of at some point diverging from the established norms of their genres in order to shock or provoke the player. Another common feature is little or no documentation – the player must determine how to play and 'win' the game without assistance.

These games can be used to subvert or disrupt established patterns and expectations of the players. This is of interest in C2Learn, as one of the envisaged use for games in the educational scenarios is to quickly 'jolt' the player from existing, well-established thought patterns, to new, unexpected ones. As such, the Re-Conceptualization and Random Stimuli of Semantic Lateral Thinking are strongly present in these games. The playfulness and possibilities of Wise Humanising Creativity are also present.

000000052573743

In *000000052573743* (Hasetrum, 2013)(see Figure 23) the player begins the game in a confusing situation, one human figure in a large group of other, seemingly identical avatars, and surrounded by armed guards. Should they player move, explore, or remain still? Immediately they must start to think 'outside of the box' in order to unveil the narrative which is hidden within the game's structure.

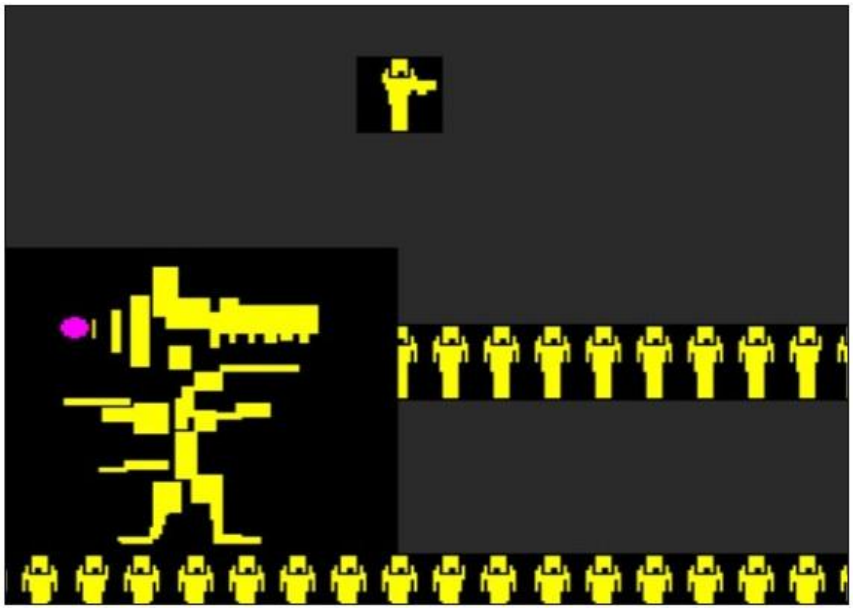

Figure 17: *000000052573743*

Phone Story

Disruptive games are also a staple of the well-known games for change movement. In *Phone Story* (2011) Paolo Pedericini tells the dark story behind the production of smart phones, placing the player in the role of armed guards of child miners in Africa, as a 'suicide watch' assistant in Chinese factories, and so on (see Figure 24). Needless to say, the game was removed from the iOS AppStore almost immediately after release, and is now only available for Android devices. The game works on several levels, not least being played on the very

device itself which is responsible for the suffering in the game, but also uncomfortable sensation that unpleasant subjects can still be fun when contextualised as simple games.

Figure 18: *Phone Story*

Unmanned

Molleindustria's *Unmanned* (2012), see Figure 25, has been called "one of the most realistic depictions of war … encountered in a video game"[1] and yet it breaks most of the conventions associated with war games across genres. Like the previously cited disruptive games, the length of play is fairly short (in the area of 10 minutes), and yet in that time it successfully manages to take the player on a journey from ignorance to realisation about the realities of modern warfare in stark contrast to the heroic, macho image created by most media formats. While not requiring creative think *per se*, *Unmanned* demonstrates not only the potential 'jolt' effect of short games, but also the use of a short gaming session as a spur for further reflection and critical thinking.

Figure 19: *Unmanned*

[1] http://arstechnica.com/gaming/2012/02/unmanned-presents-a-nuanced-psychological-perspective-on-modern-warfare/

3 C2Learn Game Design

Arguably, there is no obvious clear optimal way to incorporate a digital game into an educational scenario (or in particular, into the proposed educational scenarios of D5.1.1). As such, this initial game design document will explore (rather than exploit) multiple scenarios and attempt to provide links to the C2Learn theory of creativity so that the scenarios are properly contextualised under a game design, a pedagogical and a theoretical perspective. From this the consortium can decide the best way to move forward with the project and select the most appropriate scenarios that satisfy theoretical, evaluation and pedagogical goals. From the three initial ideas presented in this deliverable, we expect to develop a final set of game design scenarios by the time deliverable D4.1.2 (Final Game Design) will be submitted (month 18 of the project).

It is also important to mention that it will not be possible to develop digital games that will be able to support all possible educational scenarios, so the goal is to select a subset that will be impactful enough to justify their use for enhancing creativity according to the C2Learn theoretical framework (D2.1.1) – by realizing the C2Learn educational scenarios (D5.1.1) – but also flexible enough to support multiple curriculum topics and age groups.

3.1 MAPPING PATTERNS TO C2LEARN THEORY

Error! Reference source not found. attempts to summarize the aspects of C2Learn theory that may be enabled by games in specific patterns. This is by no means meant to be conclusive; individual games within a pattern can vary greatly in terms of gameplay and may enable or not enable different aspects of creativity. And given the inherent subjectivity of these mappings, it might be possible to argue that any arbitrary game enables an arbitrary theory concept. This chart is meant to summarize the discussion above and provide a starting point for discussion with UEDIN and OU about what forms of gameplay would need to be present in the C2Learn games in order for various aspects of creativity to be enabled.

Table 1: C2Learn Theory Concepts and Game Design Patterns

	Construction	Free Expression	Customization	Storytelling	Combining	Bluffing	Puzzle Solving	Disruption/ Subversion
Semantic Lateral Thinking								
Random Stimulus			X	X	X			X
Re-Conceptualization	X			X	X		X	X
Escapism ('What if')		X						
Role Play ('As if')		X						

Diagrammatic Lateral Thinking								
Multimodality								
Diagrammatic reasoning	X						X	
Emotive Lateral Thinking								
First Order Emotive Lateral Judgment								
Second Order Emotive Lateral Judgment						X		
Living Dialogic Spaces	X							
Journeys of Becoming								
4 Ps								
pluralities						X		
possibilities		X	X	X	X	X	X	X
participation					X	X		
playfulness		X					X	X

3.2 STAGES IN THE DESIGN PROCESS

UoM has organized two workshops for game design. The design process is divided into four phases. The first workshop, initiating the first phase, was held in January 2013 in Malta. This participatory game design workshop was attended by representatives from the partners central to the game design process: UoM, SGI, UO, EA, and UEDIN. Based on the discussions initial prototypes where constructed, a possibility sketch was outlined, and the most promising game design patterns for co-creativity were identified.

The second workshop was held in July on Crete, where end users (teachers) were introduced to the possibility sketch. In the same workshop EA gathered end users' feedback on possible scenarios for the game design (WP5). Based on this feedback the design process could enter a second phase, informed by both user and by deliverables from partners that further clarified theoretical concepts, evaluation strategies and technology-derived opportunities. In the second phase aspects of creativity in relation to certain game design patterns were coupled with those scenarios teachers found to be most useful in classroom settings. The partners focusing on theoretical aspects (UEDIN and UO) gave feedback, as described in Section 5, that helped further narrowing down the design space to include game design

patterns, or abstracted main play activities, concerning cooperative storytelling and construction.

The design process is currently (M12) in a third phase, when prototypes are constructed, which will be subjected to initial ad hoc play tests during November in preparation for further refined designs to be used in the first pilots (WP3). The process will enter into fourth stage in December, concluding with the deliverable of the Game Design Document in April 2014.

3.3 C2LEARN GAME SYSTEM

Based on the C2Learn Description of Work (DoW) as a whole, the proposed initial C2Learn game system is an attempt to realize most aspects of the project by incorporating all necessary elements and research activities. The proposed system consists of three main elements: the **Creative Suite**, the **Shared Space**, and the **Game Template Suite** (see Figure 20). The three together form a system that helps teachers enable creative activity in their students and create opportunities for reflection upon the curriculum. As envisioned, the system is highly flexible and could support a wide range of curriculum topics for students of all ages.

In brief, the Creative Suite consists of tools that enable the making of creative artefacts. They use the creativity tools developed in WP3 and the mixed initiative PCG techniques of WP4 to make recommendations and prompt lateral thinking in students. The Shared Space would allow students to view other student's artefacts. They could be downloaded and used as a starting point for a student's own work.

Finally, the Game Template Suite would enable dialogue around curriculum topics be allowing the student to play games using their creative artefacts. The games would be based on standard game patterns that curriculum topics can be mapped onto. The following sub-sections present the three key elements of the C2Learn game system in more detail providing examples of potential game design scenarios.

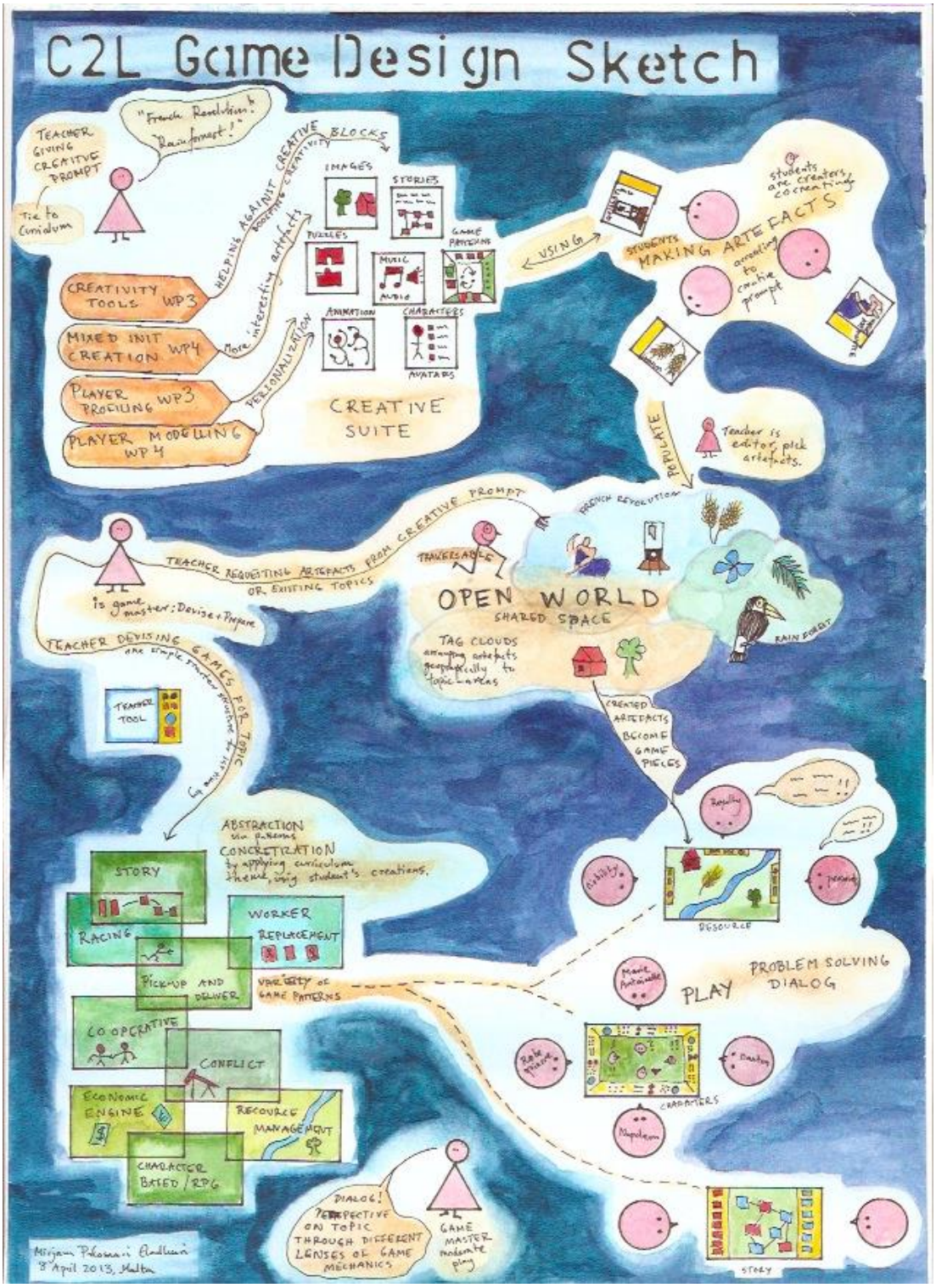

Figure 20: A sketch of the C2Learn Game System

The system attempts to incorporate as much of the C2Learn theory as possible (D2.1.1). Numerous concepts from the Co-creativity framework are supported, namely **Possibility Thinking**, as students are given opportunities for **'What if'** and **'As if'** thinking in deciding what artefacts to make and how to use them in a game. The **Four Ps** of *pluralities*, *possibilities*, *participation*, and *playfulness* are all present as well, as students engage both

with the system and other students in a playful manner and explore new ways of looking at curriculum.

For Creative Emotional Reasoning, aspects of **Semantic**, **Diagrammatic**, and **Emotive Lateral Thinking** are all present (D2.1.1). Students will work with **Random Stimuli** as the WP3 tools will be used to prompt creativity and provide unexpected connections to the curriculum. The need to incorporate these unexpected connections and produce creative artefacts will require **Re-Conceptualization** on part of the student. As they become engaged in the creative tools and the games, they will experience **Escapism** and **Role-Play**. Working with the creative tools will involve visual representations of the artefacts – e.g., stories may be represented as graphs. Students will experience **First** and **Second Order Emotive Lateral Judgement** as they consider the impact of the artefacts they create and use them collectively with other students as part of the game.

3.3.1 CREATIVE SUITE

Students will have the ability to create artefacts of different types using the Creative Suite. These tools will employ mixed-initiative procedural content generation (PCG) to make recommendations to the student and encourage creativity. The exact set of tools to be developed for the Creative Suite has not been decided yet, but some possibilities include:

- images
- animations
- characters
- music
- puzzles
- games
- stories

At the beginning of each cycle, the teacher will set a creative prompt related to the current curriculum. The students may then use the creative tools to create whatever artefacts related to the prompt they want. During the creative process, the mixed-initiative PCG (co-creation) system will make recommendations to the students, either to improve what they are working on or to inspire them if are having trouble getting started. The system will also enforce any constraints necessary to guarantee that the artefacts can be used with the game templates. At this phase, co-creation occurs between the computational creator and the human creator. Linking to the theory of C2Learn (D2.1.1), this co-creation process supports lateral thinking and enhances the possibility space of students. The computational creator suggests recommendations that can be **orthogonal** to the students' lateral path (as e.g. informed by the creativity metrics of novelty, value and surprise and task-specific heuristics such as balance and symmetry). The co-creation process can also dynamically constrain the possibility / creativity space of students thereby, forcing them to consider alternate paths towards a goal or solution. The Creative Suite can support both *diagrammatic* and *semantic* reasoning approaches to creativity (D2.1.1) as co-creation, as already mentioned, can involve anything from images to stories and puzzles. Creative Emotive Reasoning (CER)

(D2.1.1) is also supported at large as students can be asked to make emotive analogies to their creations.

Both the computational tools of WP3 and WP4 can be integrated at this phase of the C2Learn game; the Creative Suite can host computational tools such as a random word (or image) stimulus and also be informed by player models as those will be developed in WP4 – as in Yannakakis and Togelius (2011). Below we provide a Creative Suite example tool that could be realised in the C2Learn game design.

3.3.1.1 EXAMPLE: CHARACTER DRAWING TOOL

The Creative Suite could, for instance, include a tool for creating characters. Based on the creative prompt, a student might use this tool to create a historical person, established fictional character, or an original character (possibly a personal avatar). While the student is drawing their character the tool will enforce constraints. Constraints might include physical aspects of the character, e.g., symmetry, appropriate number of limbs, or size relative to the canvas, or aspects of how the character will be used in the game, e.g., points allocated to various attributes.

The mixed-initiative co-creation system can also make recommendations based on various fitness functions that enhance the creativity value of the final outcome (e.g. novelty, value, surprise etc.). Based on the student's creation, the system will evolve new recommendations along each fitness function. With characters, these will largely depend on how they will be used in the game. Each fitness function would correspond to an aspect of gameplay that could be optimized for, e.g., making a character more physically inclined vs. intellectually inclined. A working prototype of such a character creation tool is presented in deliverable 4.3.1.

3.3.2 SHARED SPACE

The Shared Space allows students to share their creative artefacts and explore those created by their classmates and other students. When the student has completed their artefact, they will upload it to the Shared Space, though it must be approved by the teacher before it can be viewed by other students. This curation prevents inappropriate or irrelevant artefacts from being shared.

Artefacts in the Shared Space could be tagged with relevant keywords so students can find related material easily. Possible tags include the subject of the artefact, the type, etc. When exploring, students can search for relevant keywords or just see what artefacts have been given a specific tag.

The Shared Space may have social network attributes incorporated. For instance, each student may have a wall that shows the artefacts they've uploaded. Students can upvote other student's artefacts they find when exploring and share them with friends. This activity will also be shown on the student's wall and optionally shared in the space for their specific class.

This idea of a Shared Space realizes the concept of an **open world** as described in the DoW. There is no need to create a 3D explorable landscape to present student artefacts and this presentation is not desirable for many reasons. For one, a 2D social networking-style interface is much more straightforward to create and simpler to navigate. Also, without the constraint of a 3D landscape, connections between related artefacts will be made through tag clouds of related topics, allowing an effectively unlimited number of dimensions for students to navigate. Another useful view would be what artefacts have been used together in a game.

3.3.3 GAME TEMPLATE SUITE

The students' creative artefacts can be used as playing pieces for the games. The games will allow opportunities for cooperative lateral thinking (D.2.1.1) and encourage the students and teachers to have a dialogue about the curriculum topic (D5.1.1).

The system will provide several generic game templates based on common board game design patterns. The teacher can map curriculum topics to the game concepts, creating games that are relevant for any topic. The teacher can select what creative artefacts will become the playing pieces of the game. While the game templates themselves may involve the creativity patterns described in section 2.3, they mainly exist to provide a venue for playful interaction and dialogue between students. The co-creativity in this proposed system lies mainly in the Creative Suite

Having multiple games based on the curriculum will allow students to explore different aspects of the same topic. For example, with a creative prompt of “French Revolution,” students might play a resource management game that explores the economic conditions surrounding the revolution, or a role-playing game where the students take on the roles of various important figures in the revolution.

The type and number of game templates that the C2Learn system will support has not been determined, but some possibilities include:

- storytelling
- racing
- worker placement
- pick-up and deliver
- cooperative
- conflict
- economic engine
- role playing
- resource management

Describing each of these in detail is beyond the scope of the document, but some short examples are presented here.

3.3.3.1 EXAMPLE 1: COOPERATIVE GAME

In a cooperative game, each player takes on a role with unique abilities and works with the other players to accomplish some goal or overcome an obstacle. Players take separate turns, but they may discuss their available options and agree on a course of action with the other players. Player abilities often involve interaction with other players, e.g., one player's ability may be to move other players. Player abilities may also be complimentary, e.g., one player may have an increased ability to trade cards while another can use cards more efficiently while accomplishing the goal.

In the C2Learn game system, if the teacher wanted to use this game pattern as part of their curriculum, they would need to select the roles available to the players from a larger set defined in the system. They would also set the goal from a predefined set. These large predefined sets of roles and goals allow the game pattern to be used with a wide variety of curriculum.

This game template strongly enables Living Dialogic Spaces, an important component of Wise Humanising Creativity. Students will need to engage in dialogue and consider possibilities while reflecting on the curriculum. Second Order Emotive Lateral Judgement is also strongly represented as students need to consider how their actions will be accepted by the group. Also, since the game will involve figuring out the best use of random elements, Random Stimuli and Re-Conceptualization are also present.

3.3.3.2 EXAMPLE 2: STORYTELLING GAME

In a storytelling game, the system selects a random set of creative artefacts. The players must then connect them in a way that tells a coherent story. In a classroom setting, this might mean reconstructing a historical event by selecting artefacts relating to aspects of the event in the correct order. Alternatively, each student could receive a separate hand of artefacts, and take turns playing or passing with the common goal of constructing the correct sequence.

Strongly present in this game template are the Random Stimuli and Re-Conceptualization of Semantic Lateral Thinking. Also the First Order Emotive Lateral Judgement is key as students are evaluating the emotive value of each element of the story. As this game pattern involves a representation of a story, Diagrammatic Lateral Thinking is also strongly represented.

3.3.3.3 EXAMPLE 3: RESOURCE MANAGEMENT GAME

Resource management games allow players to gather limited resources and decide how to best utilize them in pursuit of some long-term goal. Generally, the goal is not obtainable in the early game, so players must pursue the short-term goal of using their resources to increase or diversify their resource production capabilities before pursuing the long-term goal. When setting up a resource management game, the teacher would specify what the basic, intermediate, and advanced resources are and what the ultimate goal of the game is.

Aspects of the C2Learn theory present in this game template include Escapism and Role-Play, as students take on roles they cannot have in real life and engage with a simplified model of real-world interactions.

3.3.4 TEACHER TOOLSET

There are three major aspects of the system that the teacher would have to manage, and the toolset must support these in an intuitive way. Teachers will be expected to have some familiarity with game design concepts, but the tools should be simple enough to be used by a non-expert.

For the first part of the system, the teacher would need to set the creative prompt. From the prompt, the students decide what artefacts to create. The Creative Suite tools will be integrated to the social network aspect of the Shared Space, so the mechanism for the teacher setting the prompt and the student viewing it can be through the same interface. When the student logs into the system, they will see the creative prompt and can go right into a tool and begin working on their creative artefact.

When the student is done and has submitted their artefact, it goes into the queue for teacher approval. The teacher may either wait until all the students are done or approve them as they are submitted. There will be a file management-type interface where the teacher can select multiple artefacts to be approved, rejected, or returned to the student for small changes. The teacher can also add appropriate tags to artefacts individually or in groups. Once approved, artefacts will be viewable in the Shared Space.

The third aspect of the teacher toolset is the ability to create games. This requires the most care to create a tool that is powerful enough to create interesting games but is simple enough for non-experts to use. The main task of the teacher (or a student, if the teacher delegates this task) is to map curriculum concepts and the creative prompt they specified earlier to aspects of the selected game. A large set of templates will be available, with several preconfigured examples that can be remapped easily.

3.4 C2LEARN JOURNEYS OF BECOMING

The C2Learn theory includes the idea of “Journey of Becoming”, where students experience the different features of co-creativity from within the theory, including aspects of CER and WHC eventually arriving at quiet revolutions. This notion of progression maps well to the concept of player progression in a game.

In many digital and non-digital games, players progress through discrete levels in order to improve their character or advance through the game. This can take the form of character level, as in a role-playing game (RPG) or game level, as in a first-person shooter, platformer, or various other game types. In RPG games, players collect experience, and once a certain amount has been acquired, their character moves to a higher level, often gaining new abilities or improved stats along the way. In games that have distinct game levels, they are generally represented as a virtual space with a distinct start and finish, and once the player has reached the end, they may progress to the next level.

For the C2Learn theory, the most logical mapping would be for students to “level up” via completion of tasks related to aspects of the theory. For example, students could be expected to complete a series of tasks related to the three aspects of Creative Emotional

Reasoning: conceptual, diagrammatic, and emotive. Once they have completed the set of tasks, they level up, gaining access to the next set of tasks.

For a game to facilitate Living Dialogic Spaces (LDS) some interesting ideas present themselves – archetypal game constructs which seem to be present in the theory. The concept of a journey is present in many games, of course, and can be thought of as quests of discovery, or simply quests. Many games are based around the idea of receiving quests, gaining experience, levelling up, receiving rewards, transparent feedback on progress, gaining access to new abilities and new quests with deeper and more exciting content – can this be the case with a journey of becoming? One example implementation could be that the players need to complete several quests in order to reach 'level two'. The quests could be determined by the teacher in advance, or generated by the students themselves, or a range of possibilities such as recycling previous quests and so on. The trick would be that the students need to demonstrate that they have solved one quest by each of the methods described as kinds of LTC², i.e. using a conceptual reasoning method, a diagrammatic method, and an emotive method. Once they have done that they receive the game rewards – levelling up, achievement badges, points, avatar improvements, access to new quests, and so on. This form of game also suggests a reason to integrate the use of tools into a virtual environment as part of the facilitation of LDS, and as a means to demonstrating mastery of different kinds of CER. In addition these game constructs also make sense in an ARG-type design, and are mutually compatible.

The key to this scenario is designing tasks related to Semantic, Diagrammatic, and Emotive Lateral Thinking. While some examples for conceptual lateral thinking are presented in deliverable D2.1.1, they are too open-ended to be workable as game scenarios. We are presently working to develop game scenarios that enable these types of creativity.

3.5 C2LEARN GAMES BEYOND THE DIGITAL SPACE: ALTERNATE REALITY GAMES

For this third proposal, consider that one aim of the C2Learn project is to foster Wise Humanizing Creativity (WHC) as one part of co-creativity, through what is termed "journeys of becoming". It is apparent that a game will not be able to support the entire process due to the time and budgetary constraints on the development. Even without these restrictions it is unlikely that a game environment would be the best medium to realize each step of the process. It is therefore desirable that the C2Learn game act either as a tool or facilitator to the journey process, or as a mediation object/series of objects around which the journey can unfold. Previous experience has shown that learning games are more successful when teachers conceptualise them as "tools in the practitioners' tool box" and that understanding also fits well to the C2Learn context.

In studying WHC, the concept of living dialogic space (LDS) emerges as perhaps the key feature of both the theory and the praxis. It is through the LDS that dialogue, collaboration, investigation of ethics, engagement and empowerment emerge. It is not an abstract concept, but an essential part of classroom praxis, and must be sustained throughout the journey of becoming. It is, therefore, a prime candidate for mapping to game forms. Freeform open dialogic spaces are rarely encountered in computer games for numerous

reasons, including the complexities of developing narratives, overly restrictive rules which are required for the game world to function but restrict free evolution of conversations, and the fact that such spaces are difficult to navigate without sufficient scaffolding which is usually only possible with a human moderator (freeform dialogic spaces are more commonly seen in table top role-playing games). There is one exception to this, which is the Alternate Reality Gaming genre (ARGs), as exemplified by McGonigal (2011).

McGonigal (2011) posits six key features of ARGs, which can be considered in the C2Learn context[2]:

1) Cross Media: ARGs can be designed to use a wide range of digital media forms – this seems acceptable, maybe desirable (for example, integration of tools produced by the research activities of WP3).

2) Pervasive: gameplay extends into the real world and utilises geospatial positioning technologies – this aspect would most likely need to be removed for a C2Learn implementation.

3) Persistent: the game is 'always on' – could be considered as 'always on during classroom hours' if necessary. In general the idea that the game is responsive to players fits well with the basic principles of WHC.

4) Collaborative: self-organisation and collaboration of WHC map well to ARGs.

5) Constructive: collaborative problem solving seems to be a good match for WHC.

6) Expressive: necessary for living dialogues.

Overall, therefore, the specific features of an ARG seem to map relatively well with the realisation of a game space to support Living Dialogue Spaces (LDS), with the notable exception of the pervasive aspects. Designed and implemented well, ARGs have the potential to produce "players who feel more capable, more confident, more expressive, more engaged and more connected in their real everyday lives" which seems to fit rather well alongside key concepts of WHC and LDS, such as participation and playfulness, engagement and control, and journeys of becoming.

Focusing on the proposed activity developed in the current version of D2.2.1, the case of exploring the theme of racism, the most apparent place for game content would be in place of the video content, or as a final activity. Additionally the role of ARG as facilitator for LDS is indicated in the following table:

Proposed Activity	**Game Supported Activity**
Brainstorm	Brainstorm

[2] http://www.avantgame.com/McGonigal%20ARG%20MacArthur%20Foundation%20NOV%2004.pdf

Watch Video	Play Mini-game
Possibility Thinking (LDS)	Possibility Thinking (ARG-type LDS)
'Removing Racism' Game	'Removing Racism' Game

The question to address in this case is whether a game based component creates a value-added to the pedagogic process, and while some low-level game mapping is possible in the racism example, the result is not really conclusive. In replacing the video content with a short game as an object of mediation, the game seems to offer little over the video. The video is already available, and suitable to the proposed praxis. The game would have to be produced to the specific case and therefore have low reusability, incurring additional cost for little obvious benefit. The main activity proposed – the possibility thinking - is grounded in the LDS, reinforcing the idea that a game facilitating the LDS could be a strong candidate for adding value to the process. Finally, there is the 'Removing Racism' concept described in D2.2.1. This game seems to suffer from some of the issues described for the mediation object, specifically that the content appears to be too 'locked down' to a single scenario with the knock-on effect of low reusability and high overhead in production which are traditionally signs of a game which will not be successfully deployed in a real classroom.

4 EDUCATIONAL SCENARIOS

Deliverable 5.1.1 describes educational scenarios proposed by EA, BMUKK, and OU. In this section we will take some of these proposed scenarios and show how they can be implemented in the C2Learn game system described in section 3.3 above. As expected, the game component is intended to supplement the educational scenario, not replace it. The burden remains on the educational scenarios to implement C2Learn's goals. The three example scenarios we have selected to discuss are as follows: "Biology: Being a Genetic Engineer," "Astronomy: Space Mission," and "Geography of Civilization."

4.1 BIOLOGY: BEING A GENETIC ENGINEER

In this scenario, students take on the role of "a genetic engineer who wants to create a genetically modified fruit." To engage this scenario, the teacher might give "genetic engineering" as the creative prompt. Students would then create artefacts based on this prompt: pictures of genetic modified food, genetically modified creatures, characters based on famous scientists, etc.

The creative artefacts would then be used by the students to play games based on those in the Game Template Suite. Templates that would suit this scenario include worker placement, where students would have to allocate resources across several projects in order to achieve their goals, or a racing game, where students create genetically modified creatures and then pit them against an obstacle course.

4.2 ASTRONOMY: SPACE MISSION

In this scenario, students "assume various roles and collaborate for successful space missions." This scenario is a natural fit to the cooperative game pattern. Following the standard creation of artefacts by the students, they would play a game where each student takes on a role with unique abilities. Each turn, students would discuss the current obstacles presented and their available resources and decide on a course of action.

4.3 GEOGRAPHY OF CIVILIZATION

In this scenario, students "[visit] different countries [and] solve challenges associated with ideas, discoveries and cultural accomplishments that originated in that country." This could be realized as a storytelling game, where the students collect artefacts related to a country and have to fit them into a coherent. Then the student could move on to the next country, with a level progression towards larger countries and/or ones that are more different from the student's home country.

5 NARROWING DOWN THE GAME DESIGN SPACE

The table of game design patterns (Table 1) and the Game Design Sketch as presented in section 3.1 have been used to, in discussion with partners, narrow down the game design space in order to provide starting points for the first concrete prototypes. Also the feedback gathered from teachers during the summer school on Crete has been instrumental in the process of constraining the possibility space. The process of narrowing down the design space has been conducted in the following steps.

Firstly, the feedback from the teachers on the scenario seeds of D.5.3.1 was used to identify the most promising game patterns and the game forms most feasible within the project. Teachers rated 18 scenarios according to creativity, feasibility for classroom use, and perceived usefulness for a game. In Table 2 the yellow markings in the table signify the feedback from the teachers, as well as from representatives of WP5.

Secondly, creativity theory experts (representatives from UO and UEDIN) were consulted in examining the table of section 2.4 in order to give a second round of feedback. As a result of these discussions, the table was expanded in order to cater for more of the desired effects on creativity that a given game design pattern might result in. In table 2, the feedback from UEDIN marked in red and the feedback from UO is marked in green. Furthermore, the table was updated to encompass the concepts of creativity presented in D2.3.1, effects of game activites such as feeling in control, attending to ethics and being engaged.

At this point in time, when other project partners had been able to access the material in 4.1.1, and UoM and SGI researchers had been able consider the content in relevant deliverables produced up until month 9 of the project, it was possible to narrow down the large design space presented in Section 3.1 in an informed manner.

In summary, the game design patterns identified as the most promising starting points for C2Learn game design are Storytelling, Construction, and Combining. These three game

design patterns are used as starting points in the first prototyping stage in the game design process. As described in D.4.4.1 the first prototypes are concerned with activities of collaborative storytelling where players combine different story elements that can be represented as cards or domino tiles. These cards and domino tiles can, in turn, be constructed using the mixed initiative creation tools of which the first prototype is the character creator, as described in D.4.3.1.

Revisiting the C2L Game Design Sketch in 3.1, the staring points for the prototyping stage are to implement the mixed initiative character creator tool as described in D.4.3.1 (see top left of sketch), to prototype games focussing on patterns of storytelling, construction and combination, (bottom left of sketch, though not all patterns are listed there), resulting in storytelling games that will be subjected to play testing (see bottom right). The prototype game designs are facilitated (game mastered) by teachers or students assigned the roles in a group (see middle left). The instructions and tools for the game masters are also subject to play testing in order to ensure usability. When setting the starting points for storytelling games themes and scenario seeds suggested for classroom use provided by the focus groups of UO, EA, and BMUKK can be used. Finally, the artefacts, such as cards or dominoes, as well as stories resulting from play sessions would be shared (see middle right of sketch).

Table 2: Narrowing down the C2Learngame design space. Yellow represents feedback from teachers and educators. Red and green represents the views of the C2Learn theory experts UEDIN and OU, respectively.

	Construction	Free Expression	Customization	Storytelling	Combining	Bluffing	Puzzle Solving	Disruption/ Subversion
Semantic Lateral Thinking								
Random Stimulus			X	X	X			X
Re-Conceptualization	X			X	X		X	X
Escapism (‘What if’)		X						
Role Play (‘As if’)		X						
Diagrammatic Lateral Thinking								
Multimodality								
Diagrammatic reasoning	X						X	
Emotive Lateral Thinking								

First Order Emotive Lateral Judgment								
Second Order Emotive Lateral Judgment						X		
Living Dialogic Spaces	X			X	X	X		X
Journeys of Becoming				X	X	X		X
4 Ps								
pluralities	X		X	X	X	X		X
possibilities		X	X	X	X	X	X	X
participation	X		X	X	X	X		X
playfulness	X	X		X	X	X	X	X
Quiet revolutions	X			X	X	X		X
Intervention and reframing								
Attending to ethics and impact of ideas	X			X		X		X
Engaging in dialogue	X			X		X		X
Being in control	X		X	X	X	X		X
Engaged Action	X			X	X			X

6 CONCLUSIONS

The intention of this document has been to provide information on possible game design scenarios for the C2Learn project. Three major game design scenarios are outlined, the C2Learn game system, the journeys of becoming, and the alternate reality game, though there is overlap where they ideas could be combined. Game design will continue on the project, incorporating the theory, learning design, computational tools, and educational scenarios provided by the other work packages.

This document has also provided a comprehensive background on topics related to mixed initiative PCG, computational creativity, game design patterns, and other areas. Understanding the related works this project will build on will help participants envision what form the technological components of will ultimately take. While much of the project

is still in a formative state, this careful study of existing projects can help guide the project away from pitfalls and towards successful implementation.

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