Fostering creativity in learning through digital games

C²Learn creative learning

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

www.c2learn.eu

GAME PROTOTYPING AND TESTING

C²LEARN PROJECT DELIVERABLE NO. D4.4.3

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1.1	…	…	Minor changes based on…
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etc			

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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	Universita ta 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
M#	#th month of the project (M1=November 2012)

Abbreviation	Explanation
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 to 18+ years.

About this document

This document describes the main activities undertaken during Task 4.4 in the final project reporting period.

2 Introduction

Task 4.4 covers all aspects of game development, deployment and support, including system integration. During the final period of the project the focus has been on integration and support of classroom pilots, as well as dissemination activities, with the main areas of work as follows:

- Deployment of C2Space and applications to schools for pilots, via hosted services either at NCSR-D, or at the schools themselves.
- Iterations on game and backend features in response to teacher and student feedback.
- Establishing a procedure for bug reporting and handling in support of a complex architecture.
- Development of a service diagnostic tool to support real deployments.
- Development of a standalone version of Iconoscope to support targeted dissemination actions.
- Preparation for exploitation.
- Other activities.

3 Deployment of the C2Learn Service for School Pilots

School pilots began in earnest in January 2016 following the deployment of the complete integrated C2Learn prototype solution. All envisaged system components were deployed as a single release simultaneously to all participating countries, including localisation of front end components. C2Space services were hosted at NCSR-D in support of the pilots in the UK and Austria, while EA ran several installations on its own internal servers.

This 1.0 release of the C2Learn services included the following features:

3.1 TEACHER INTERFACE

The initial teacher interface focused mainly on simple user management and evaluation of student progress.

Figure 1: Original teacher log-in page

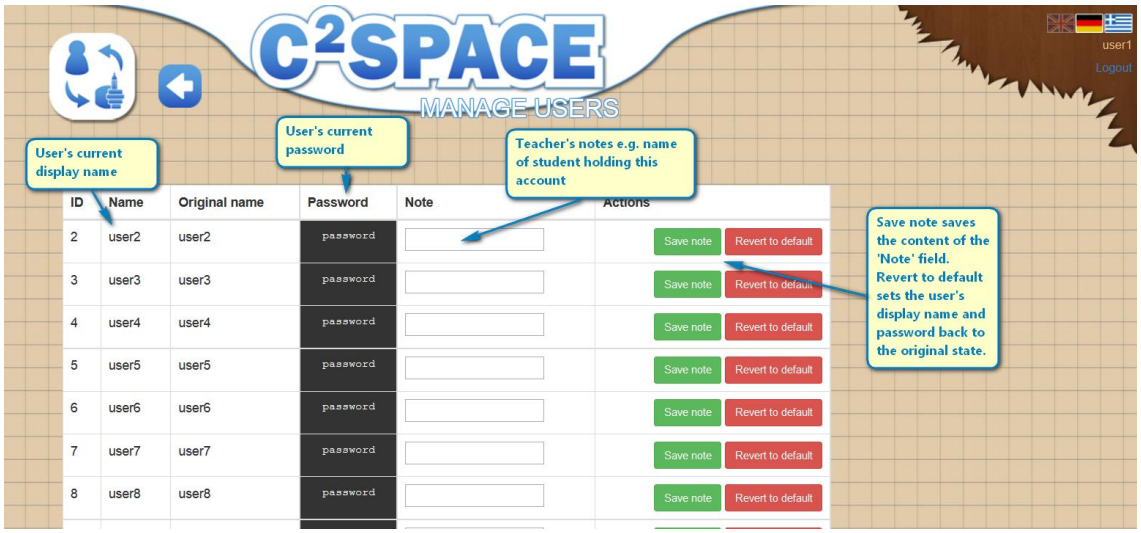

Figure 2: Simple user management

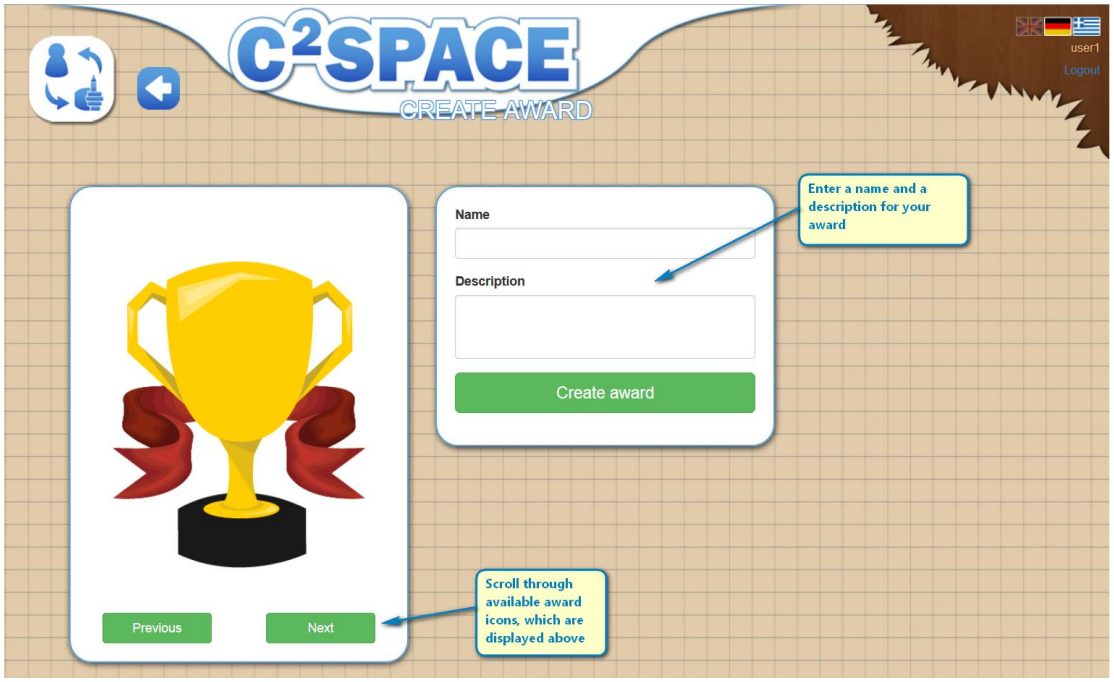

Figure 3: Create awards

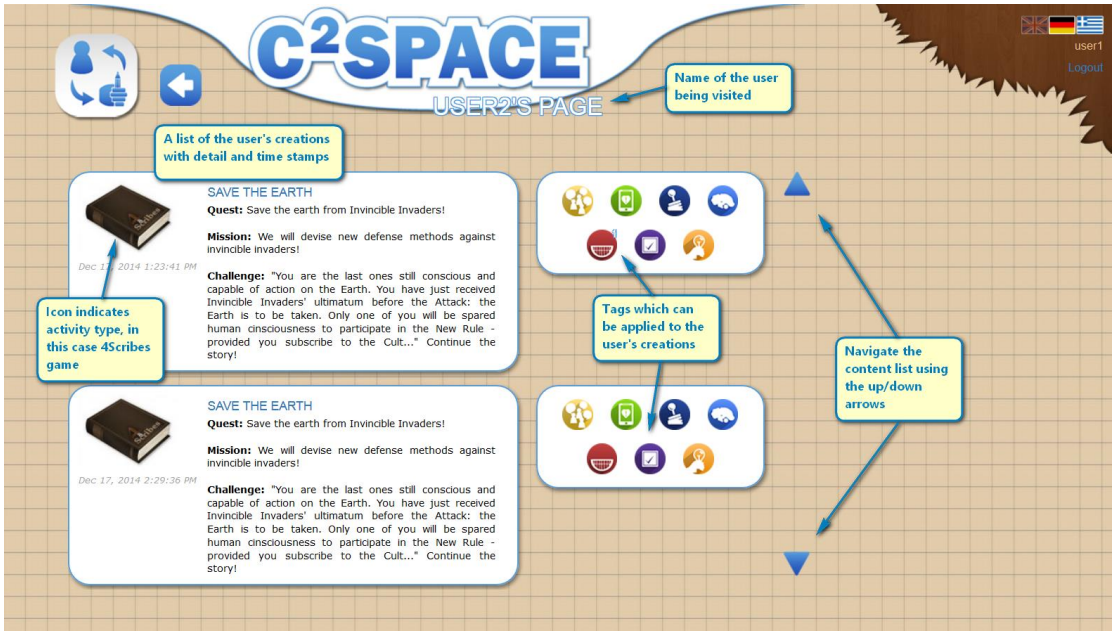

Figure 4: Evaluate student progress

3.2 4SCRIBES GAME

The 4Scribes game as described in previous deliverables in this task, a creative story-telling game with several modes and the ability to modify gameplay based on cards provided. In the initial release the piloting institutions provided card lists and images which were distributed in pre-saved deck options. 4Scribes is played using an Android mobile device shared between the players of the game.

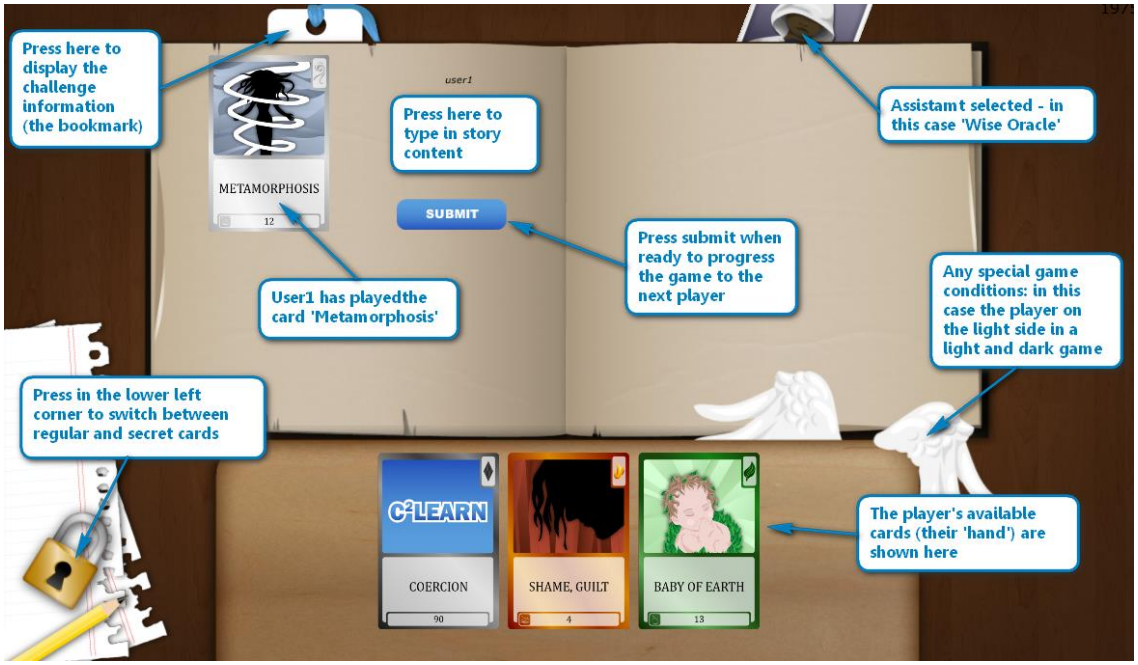

Figure 5: 4Scribes in-game annotated screenshot

3.3 ICONOSCOPE

The Iconoscope game is also designed for play on Android mobile devices. It is a visual creativity game oriented around the concepts of ambiguity, and is very well suited to play using a touch interface.

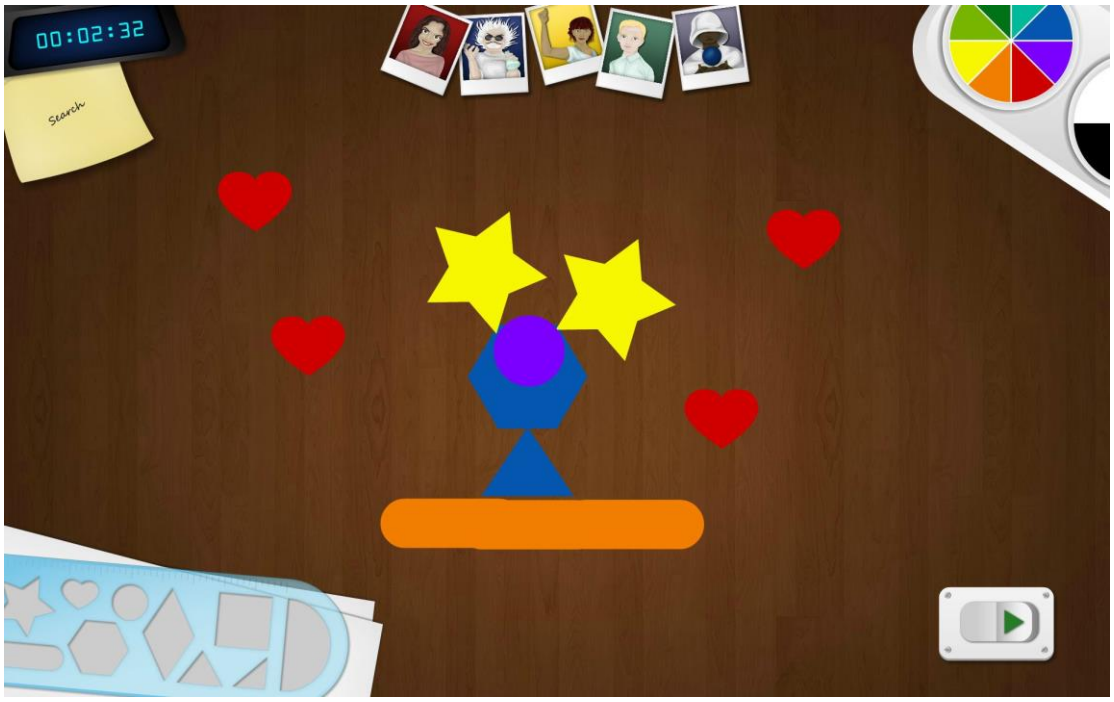

Figure 6: Original Iconoscope canvas during gameplay

3.4 CREATIVE STORIES

The final game accompanying the initial release was Creative Stories, a game which draws heavily upon the semantic reasoning tools developed by NCSR- D during their activities in WP3. As with the previous games, Creative Stories is played on a suitable Android mobile device.

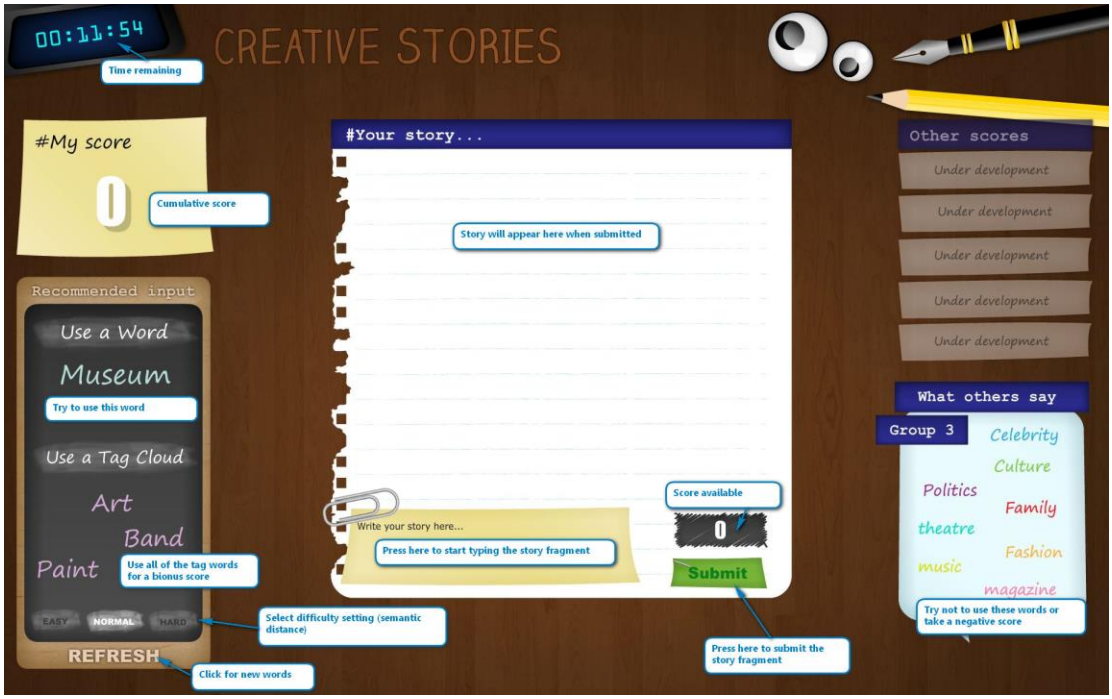

Figure 7: Running game session of Creative Stories

3.5 GUIDELINES FOR EDUCATORS

In addition to the technical deployment a C2Learn Knowledge Kit for educators was also distributed which explained everything a teacher might need to know in order to get ready for use of the system in the classroom. Despite every effort to make the user workflows as simple as possible it was of course important that teachers reviewed this material and understood the reasons behind some of the design decisions.

4 A SYSTEM FOR BUG REPORTING AND HANDLING

A shared google spreadsheet was made available to all contacts and teachers for the reporting of errors and bugs encountered during the pilot tests. The design of the sheet supported verbose error description in aid of debugging activities, transparency in regard to who and what was being done to address issues encountered, and recording of resolved and unresolved issues.

In the left side of the document information was captured with regard to the nature and timing of the problem, the version of software being used, screen images and steps which could be taken to replicate the problem. Additionally, which server installation was in use was also requisite information.

In the right side of the document was recorded information pertaining to the internal processes being followed in order to diagnose and address any issues. A number of hot fixes were issued during the lifetimes of the pilots, and the overall effort was co-ordinated by SGI, although diagnostic efforts were spread between all technical partners.

C2Learn Error Capture Reporting Form

	Date First Encountered	Description of the issue (the problem encountered - include images if helpful)	What you were trying to do? (Describe with as much specific detail as possible)	Add sceenshot that supports the description (imgur.com is a decent site for quick uploading)	Can the problem be replicated (Y/N)	Steps to replicate it (simple list of actions a eveloper can follow)	Device used (device type and screen size, or which emulator)	Reported by (name, email)	School Name (helps us to identify which installation is in use)		Status	Action Should Be Taken By
	EXTERNAL											
6	03/02/2015	Playing 4Scribes player 75 tried to drag card to its space and received this message: 'Code 4: Message: Received an exeption: This action requires it to be your turn. It is user 75's turn (0)' - It was player 75s turn!	Play 4Scribes	Image won't upload - please request via email if needed.	N	N/A	Android tablet	Heather Wren hw344@exeter.ac.u	MID1 Installation 4 - User 80 with users 78 and 75 playing the game too.		Cannot be Replicated	-
7	04/02/2015	School cannot login to 4 scribes	Login to 4 scribes	previously emailed	N	N/A	Android tablet	Karen Kenny kk316@exeter.ac.u	SE1 Installation 1 and installation 2		Cannot be Replicated	-
8			Trying to change the user names and passwords for 16 users in installation 5.Login as user 80, then attempted a per instruction input url http://143.233.226.39/site/cha [seemed strange as this url is that for installation 1]. This resulted in a change username and password page already populated by user 2 details, in installation 1. Screenshat available if requested. THen attempted the same procedure but using url									

Figure 8: Error reporting for end users

C2Learn Error Capture Reporting Form

	Device used (device type and screen size, or which emulator)	Reported by (name, email)	School Name (helps us to identify which installation is in use)		Status	Action Should Be Taken By		Investigated by	Assigned To	Can be replicated? (Y/N)	Initial Analysis	Further Action Required	Fix Tested?	Fix Issued? (version / date)	Next Steps
								SGI INTERNAL USE							
6	Android tablet	Heather Wren hw344@exeter.ac.u	MID1 Installation 4 - User 80 with users 78 and 75 playing the game too.		Cannot be Replicated	-		Damian	CV						
7	Android tablet	Karen Kenny kk316@exeter.ac.u	SE1 Installation 1 and installation 2		Cannot be Replicated	-		Damian	NCSR						

Figure 9: Internal procedure capture

The most commonly reported issues were relating to:

- Game logic not resolving correctly during 4Scribes game sessions – this was addressed by reducing reliance on card loading over the web service and including card images in the application itself
- Overly long response time during Creative Stories game sessions – caused by a Tomcat server configuration error
- Incorrect localisation and/or missing GUI objects, which was caused by a corrupted language JSON file installation
- Game sessions not being saved correctly when created by the new teacher game creator interface – caused by incorrect service update process overwriting existing data
- Web service timeouts – caused by insufficient bandwidth allocation to pilots

All reported issues were resolved during the running of the pilots, although the game session saving error was resolved later than most as it proved impossible to replicate on developer installations.

5 FURTHER SYSTEM DEVELOPMENT BASED ON USER FEEDBACK

In addition to resolving running errors reported during piloting activities, several improvements were also made to the services based on user feedback and evaluator comments.

While the previous evaluation proposed the need to include a teacher interface for monitoring and control during classroom game sessions this was not experienced by the piloting groups and was not considered a high priority for implementation. There were, however, additional services deployed in support of teacher requirements to support both preparation and direct teaching activities.

5.1 GAME SESSION CREATION INTERFACE

Game session creation was a popular request and has been added to the teacher interface for C2Space.

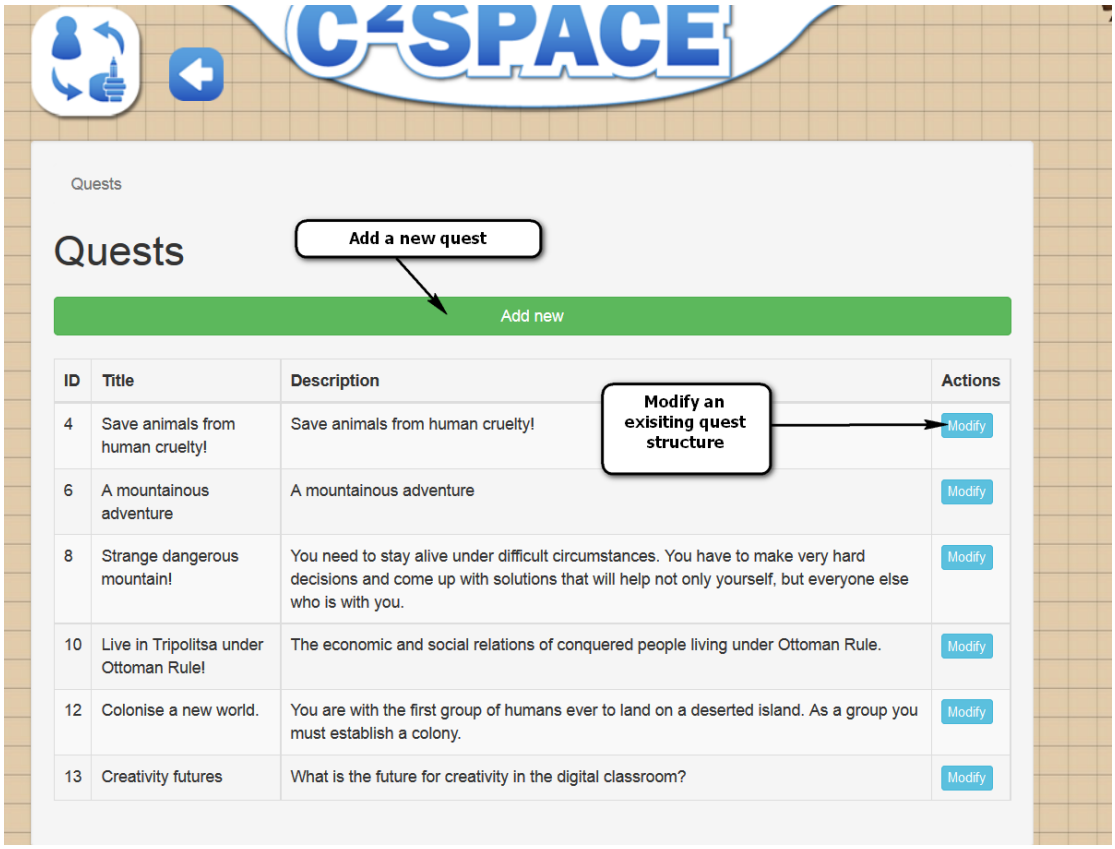

Figure 10: Quest creation

Starting with the creation of a new quest, the teacher can progressively define content up-to and including game sessions. This facilitates the creation of new games in real time (less than 60 seconds) and could very easily also be incorporated into a student interface.

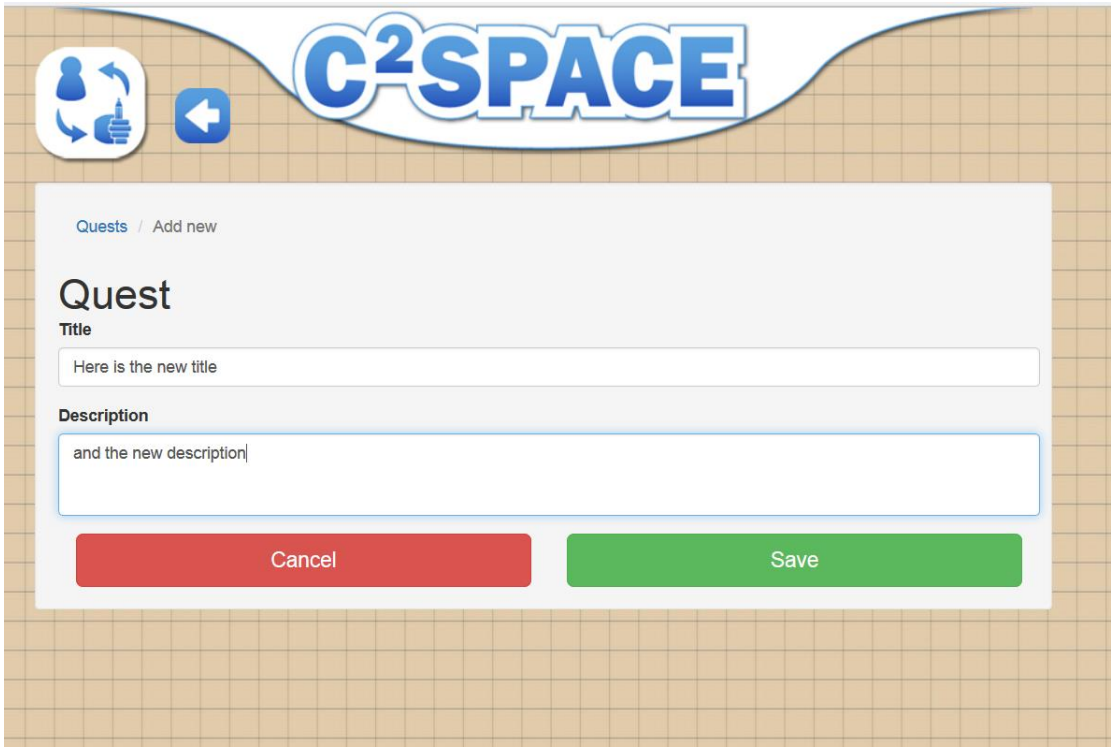

Figure 11: Add a new quest

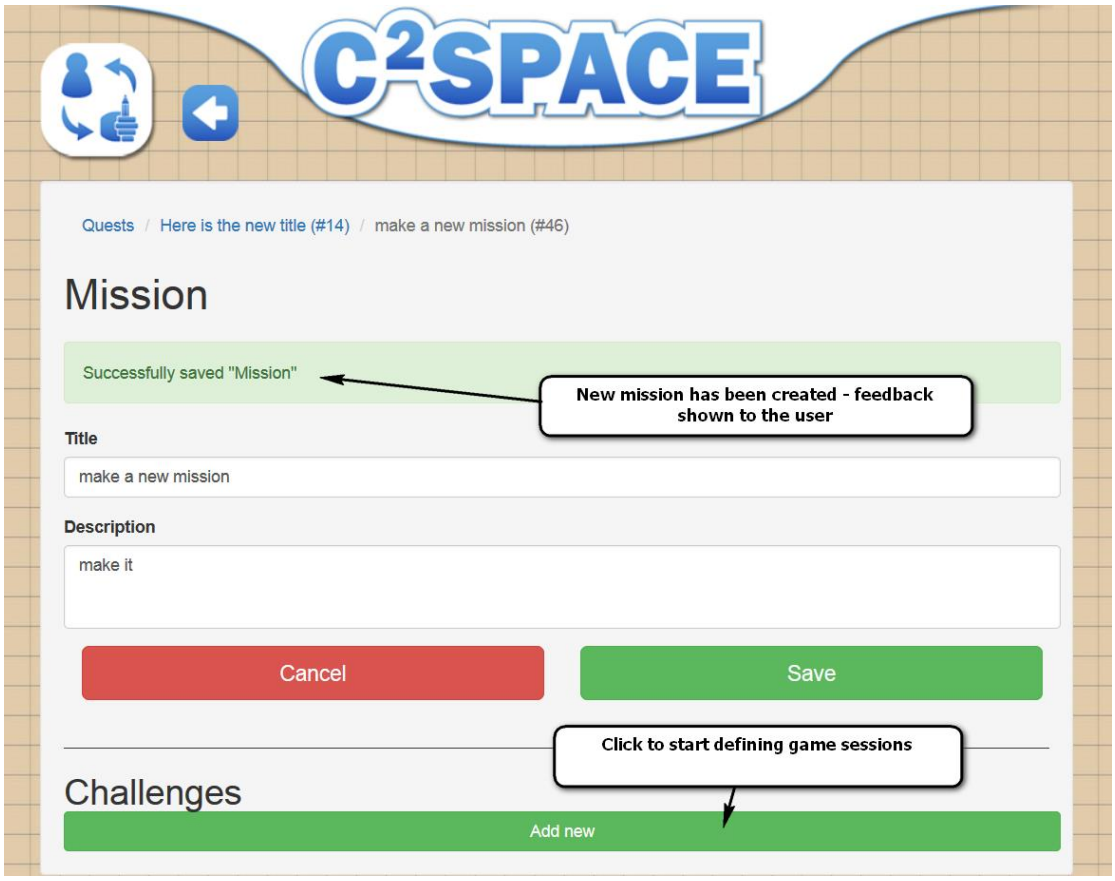

Figure 12: Add a new mission within the quest

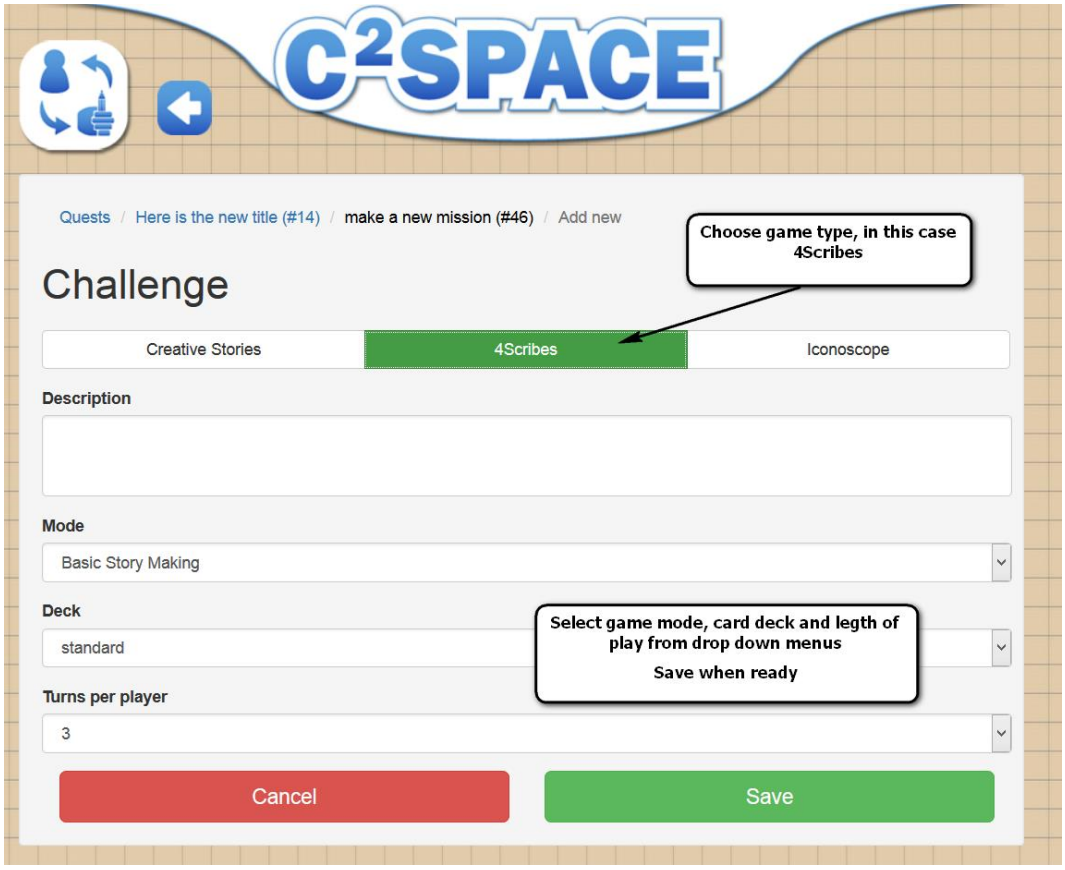

Figure 13: Creating a 4Scribes game

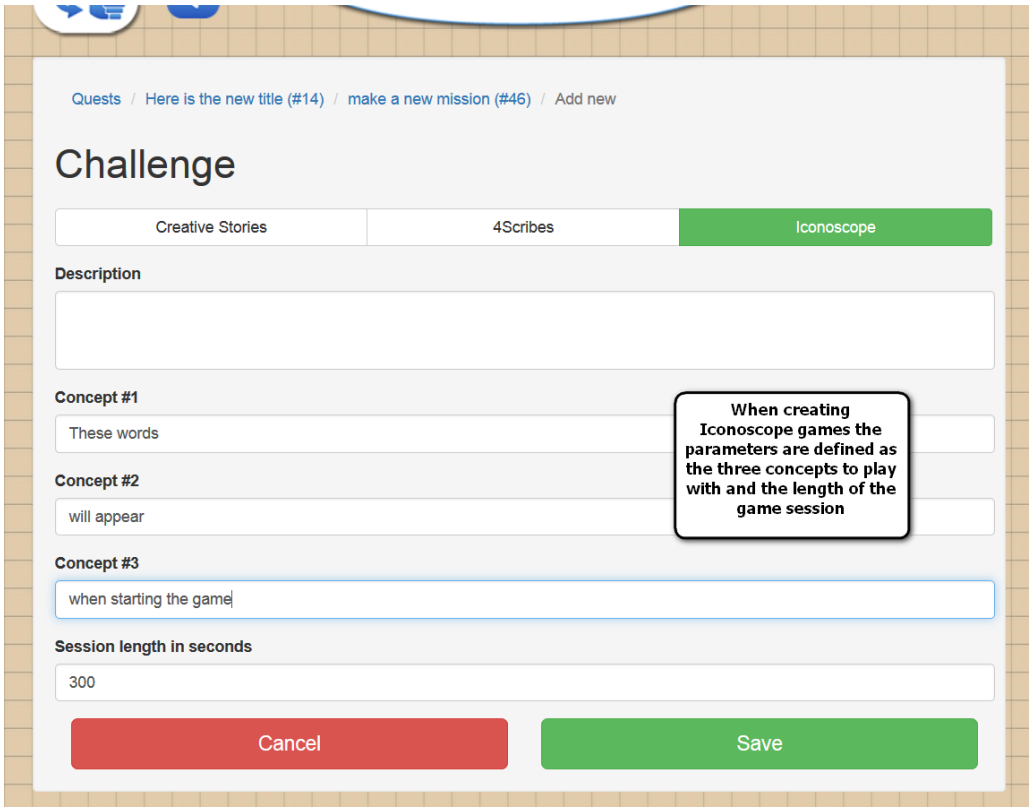

Figure 14: Creating an Iconoscope game

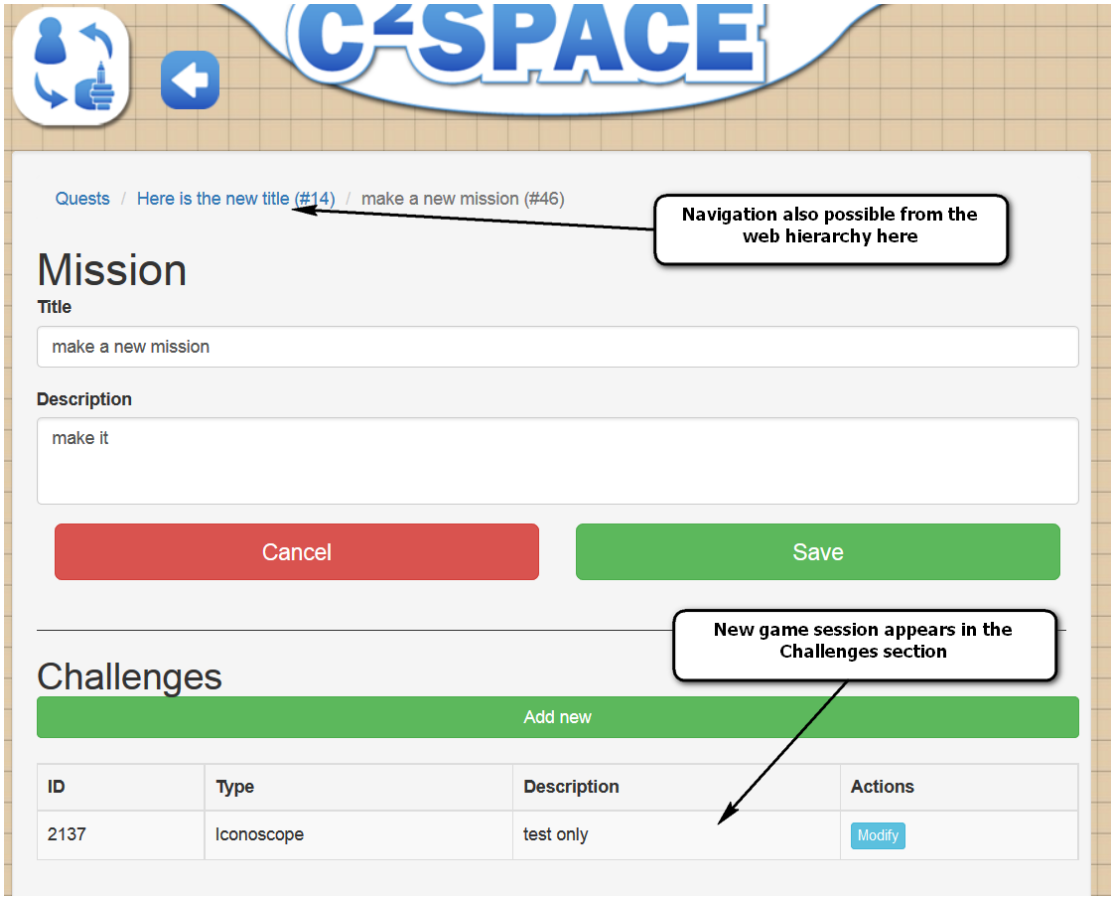

Figure 15: Game session created

5.2 SAVE GAME DURING PLAY

Saving game states during play was the most commonly requested feature for the games themselves and was added to latter versions. Saving game states pushes content to the profile page of the user instantly and therefore can be sued in real time by the teacher to foster a discussion around a game object while being created. Typically this was done by projecting the thumbnail image saved to the student profile from a desktop or laptop logged into the teacher C2Space interface.

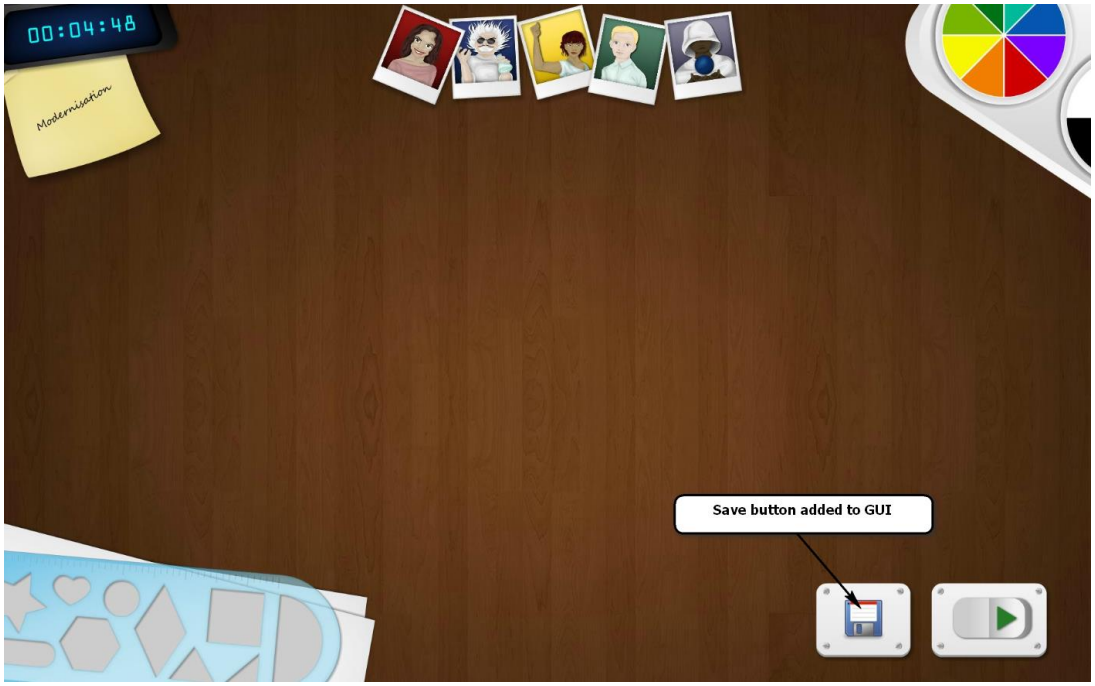

Figure 16: Save button in Iconoscope GUI

5.3 MORE INTERACTIVE ASSISTANTS

One common observation of the games in use in the classroom was that the assistants were commonly overlooked in favour of working either alone or with human collaborators. In the Iconoscope game improvements were implemented which brought the use of assistants much more to the fore during gameplay. Once the game session has commenced the assistants actively monitor the creative activities of the learner and will animate and make statements when they have suggestions to make. Activating and/or using the suggestion provided by a given assistant will make that assistant tend to be less inclined to contribute for a short time afterwards, increasing the chances that the player experiences the input from a number of creativity assistants during one or a small number of games.

5.4 FLEXIBLE SERVICE DEPLOYMENT

In response to teacher requests the applications themselves were made available to download from a C2Learn FTP site hosted by Serious Games Interactive as well as using the Google Play Beta testing service (invitation only). It was commonly experienced that teachers and researchers preferred one or other method.

6 SERVICE DIAGNOSTIC TOOLS

As part of the prototype deployment SGI developed a series of API diagnostic tools which were available to all technical partners to support and improve service delivery. This service was critical to improving web service performance, a key component of deploying games successfully to classrooms remote from the server installations, as well as debugging several important bugs.

C2Learn API

- Thinking Seed Generator
- Web Miner
- Cloud of Thoughts
- Competetive Thinking Spaces
- Creativity Points Computation
- Get Functions
- Get Structs

Thinking Seed Generator

Result

Error

Code

```
C2LearnAPI::getInstance()->thinkingSeedGenerator(
        $seed = 'water boat sail',
        $difficulty = 1
)
```

Timers

- **soapCall**
  - **Total:** 0.32097697 seconds
  - **Min:** 0.32097697 seconds
  - **Max:** 0.32097697 seconds
  - **Average:** 0.32097697 seconds
  - **Sample size:** 1
- **beautifyXML**
  - **Total:** 0.00015092 seconds
  - **Min:** 0.00004601 seconds
  - **Max:** 0.00010490 seconds
  - **Average:** 0.00007546 seconds
  - **Sample size:** 2

Response

string(50) "Property "WebserviceLog.exception" is not defined."

XML

Request

```
POST /c2learn/C2learn HTTP/1.1
Host: cru.iit.demokritos.gr:8080
Connection: Keep-Alive
User-Agent: PHP-SOAP/5.5.9-1ubuntu4.5
Content-Type: text/xml; charset=utf-8
SOAPAction: ""
Content-Length: 325

<?xml version="1.0" encoding="UTF-8"?>
<SOAP-ENV:Envelope xmlns:SOAP-ENV="http://schemas.xmlsoap.org/soap/envelope/" xmlns:ns1="http://webservice.c2learn.eu/">
  <SOAP-ENV:Body>
    <ns1:ThinkingSeed>
      <seed>water boat sail</seed>
      <difficulty>1</difficulty>
      <language>en</language>
    </ns1:ThinkingSeed>
  </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

Response

```
HTTP/1.1 200 OK
Server: Apache-Coyote/1.1
Content-Type: text/xml;charset=utf-8
Transfer-Encoding: chunked
Date: Mon, 16 Nov 2015 10:37:01 GMT

<?xml version="1.0" encoding="UTF-8"?>
<S:Envelope xmlns:S="http://schemas.xmlsoap.org/soap/envelope/">
  <S:Body>
    <ns2:ThinkingSeedResponse xmlns:ns2="http://webservice.c2learn.eu/">
      <return>twelfths,bitter,pesticides</return>
    </ns2:ThinkingSeedResponse>
  </S:Body>
</S:Envelope>
```

Figure 17: Example diagnostic tool - thinking seed generator response

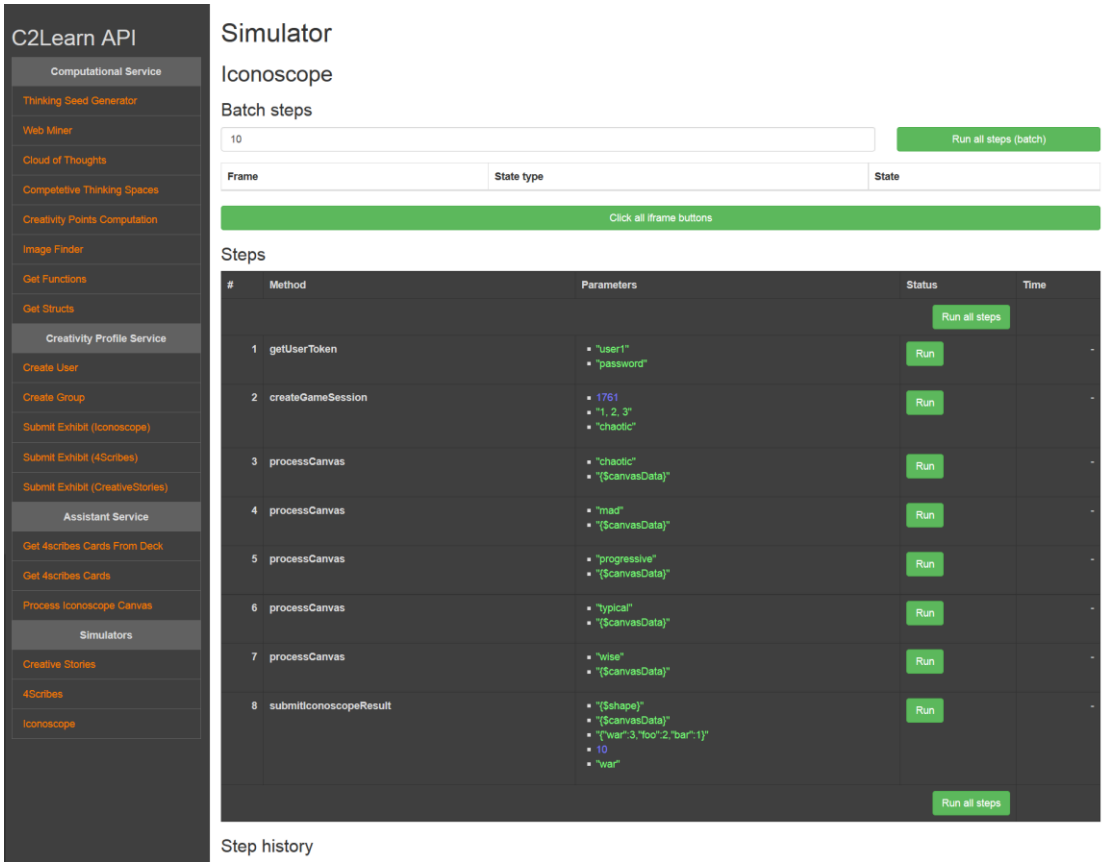

Figure 18: Full game simulator (example shows Iconoscope) - allows the running of thousands of game sessions per minute

The full game simulator facilitated the generation and running of unlimited numbers of full game sessions simulating actual play across the full C2Learn architecture. Even hundreds of simultaneous games failed to stress the system in any significant way, although service response times did increase of course. Overall only one single service error was detected across 17,000 game sessions run by SGI, and this was immediately addressed by handling the timeout event such that the game session could still continue.

The game session test API does NOT include the use of the creativity assistants in the Iconoscope game. All other services are included.

As a result of the extensive service testing it was concluded that only backend service upgrades are likely to cause any significant service interruptions, which is being addressed as part of the distribution of C2Learn database components.

The development and use of the API testing tools alongside more wide-ranging quality assurance efforts was a major task for SGI during the final months of the project (see 'other activities', below).

7 STANDALONE ICONOSCOPE – DISSEMINATION BUILD

The last major development task during the final reporting period was to develop a standalone version of the Iconoscope game for Android and web deployment. Standalone essentially means that the game can be played without being integrated into the C2Space environment, offering a simple and seamless access to key C2Learn concepts in gameplay for any external stakeholder. Standalone

Iconoscope was deployed as part of an inter schools competition programme aimed at maximising exposure to C2Learn across schools and students in the consortium's network and beyond.

Development required several major customisations to the existing Iconoscope game.

7.1.1 NEW INTERACTION METHODS

Building for web required a mouse and keyboard interface to be designed and implemented. Furthermore, the screen flow for the game needs to teach new players how to interact with the game canvas, while simultaneously not slowing down the game experience for more experienced users. This information also needed to be tailored to detect which version of the game was being played (mobile, or web, or even web on a mobile device).

7.1.2 ONBOARD CONCEPTUAL CONTENT

Playing the game without connection to the C2Space backend requires bundling content with the distributable. This required contributions from the pedagogical teams to agree the format of challenges for the inter-schools competition, and additional GUI work to support much more content than is required by any single session of the original game.

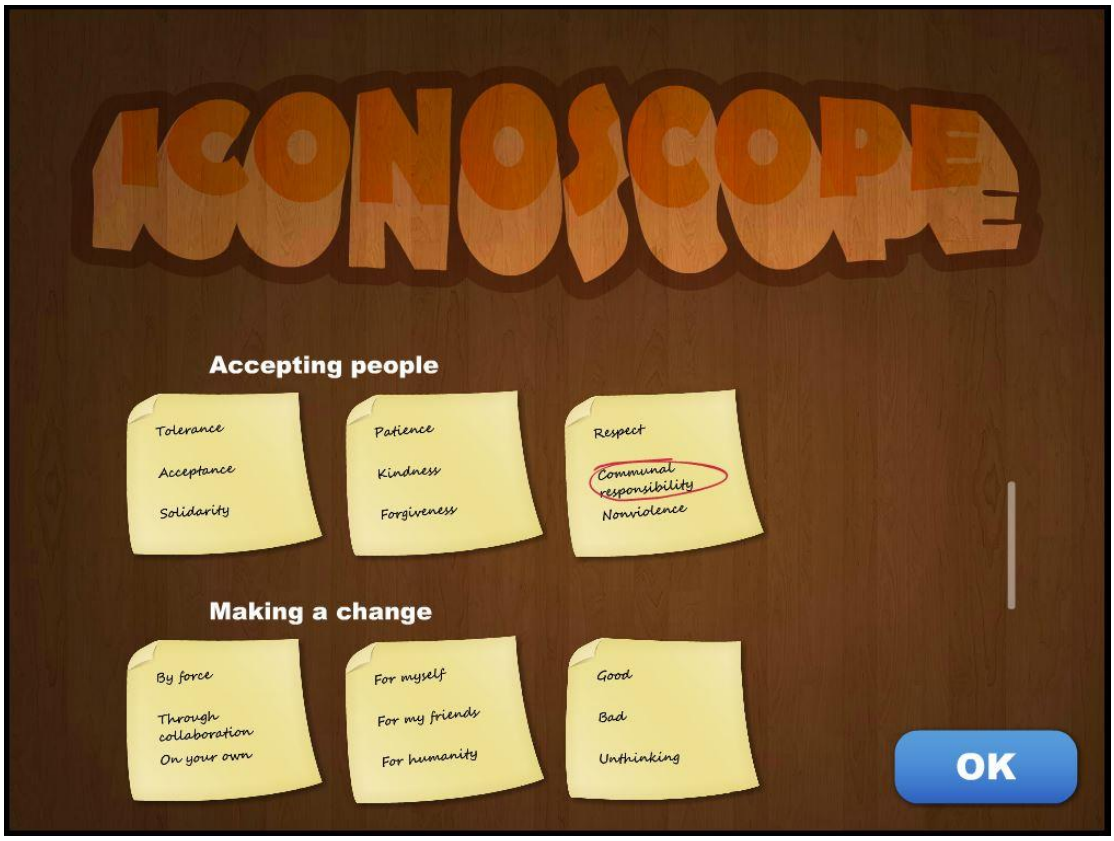

Figure 19: Choose concepts - Standalone Iconoscope

7.1.3 SUPPORT COMPETITION REQUIREMENTS

The competition is hosted at the University of Malta:
http://iconoscope.institutedigitalgames.com/play.php

Additional GUI was implemented to support participation in the inter-schools competition. A username and email address field was added, and the end state of the game now takes the player to view the creations of other competition entrants.

8 PREPARATION FOR POST-PROJECT EXPLOITATION

All SGI system components are in the process of preparation for use in the post-project period. This includes the presentation of manuals, licensing and GitHub hosting. An updated version of this deliverable will be distributed prior to the project's final review with final details on this area.

9 C2SPACE VIRTUAL MACHINE INSTALLATION GUIDE

9.1 HOST SERVER RECOMMENDED REQUIREMENTS

Operating System: Latest version of CentOS (tested in version CentOS 7.0)

RAM: 4 GB

HD Space: 80 GB

9.2 VM INSTALLATION PROCESS

1. Install KVM and configure Bridge Networking in the Host Server. Instructions can be found at: http://www.server-world.info/en/note?os=CentOS_7&p=kvm
2. Download the ZIP file with the C2Space VM dump, available at: *xxx*
3. Unzip the downloaded ZIP file and place the contained VM image (c2learn_en1.img) in any directory of the host server (from here on, **IMG_DIR**)
4. Download the configuration XML file for the VM, available at: *xxx*
5. Place the configuration XML file in the following directory: */etc/libvirt/qemu* of the host server
6. Edit the configuration file, changing the values in the fields highlighted with red on figures 1 and 2. **IMG_DIR** is the directory where the VM image is located, and **br0** is the name of the bridge configured during the KVM installation.

```
…
<devices>
    <emulator>/usr/libexec/qemu-kvm</emulator>
    <disk type='file' device='disk'>
      <driver name='qemu' type='raw' cache='none'/>
      <source file='IMG_DIR/c2learn_en1.img'/>
      <target dev='vda' bus='virtio'/>
      <address type='pci' domain='0x0000' bus='0x00'
slot='0x04' function='0x0'/>
    </disk>
```

Figure 20: definition of the location of the VM image

```
…
<interface type='bridge'>
      <mac address='52:54:00:c1:71:1e'/>
      <source bridge='br0'/>
      <model type='virtio'/>
      <address type='pci' domain='0x0000' bus='0x00'
slot='0x03' function='0x0'/>
</interface>
```

Figure 21: Definition the bridge name used by KVM

7. From the command line of the Host Server give the command `virsh` to start the virsh command line environment
8. From the virsh environment, give the following commands to start the VM:

```
> define c2learn_en1.xml
> start c2learn_en1
```

9. To access the VM from the virsh environment, give the following command:

```
> console c2Learn_en1
```

9.3 VM HARD DISK RESIZE

1. Start the virsh command line environment.
2. Stop the VM giving the following order

```
> shutdown c2Learn_en1
```

3. Give the following order to increase the size of the hard disk by n GB

```
> qemu-img resize 'IMG_DIR/c2learn_en1.img' +nG
```

4. Start the VM giving the following order

```
> start c2learn_en1
```

5. Resize the partition as desired. Instructions can be found at http://www.howtogeek.com/114503/how-to-resize-your-ubuntu-partitions/

9.4 VM COMPONENTS

Operating System Component	C2learn Component
Tomcat 7.0	C2Learn Computational Tools
	Assistances Implementing PSG
	Creativity Profiling Server
nginx	C2Space

10 ADDITIONAL ACTIVITIES

As part of the distribution of the C2Space technology an additional game concept was described, called 'Possibility Space'. This game design was iterated upon, but final implementation never occurred due to the need to allocate remaining resources in support of running pilots. The prototype design is included here for completeness.

Key Features:

- Single player only
- Short session time (maybe only 1-2 minutes)
- A tool to complement the C2Space experience rather than a game itself
- Getting the visualisation and the navigation right will be the key to successful implementation. The space should be intuitive to navigate and aesthetically pleasing

Possibility Space is a simple, visually oriented tool which represents an abstract knowledge landscape to be explored by the user. It is not specifically a game, rather it is a brainstorming tool, and a given session has no specific success criteria. In most cases a session will be considered successful if the user encounters 'something unexpected', but this kind of application allows the user to define success according to their own criteria – surprise, satisfaction, usefulness, anything they can imagine!

The abstract knowledge landscape is visualised as a hexagonal grid using an isometric view.

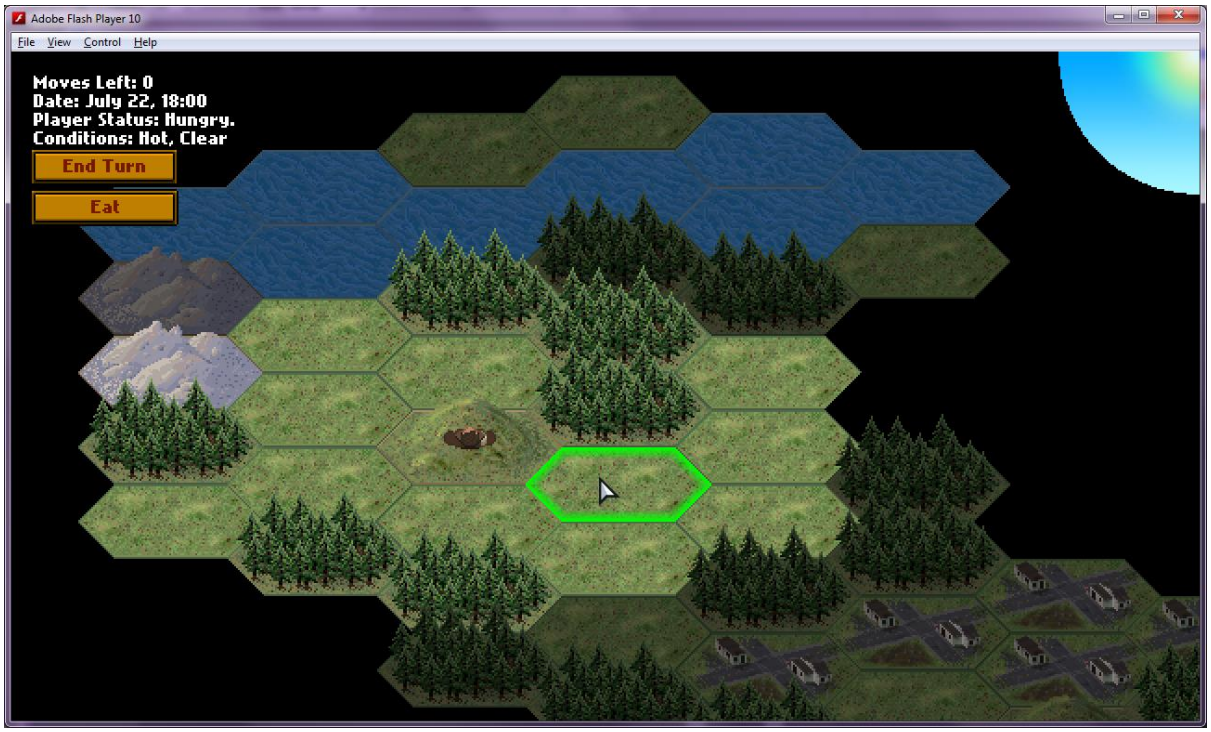

Figure 22: Example isometric view of hex-field (ignore content of the hexagons)

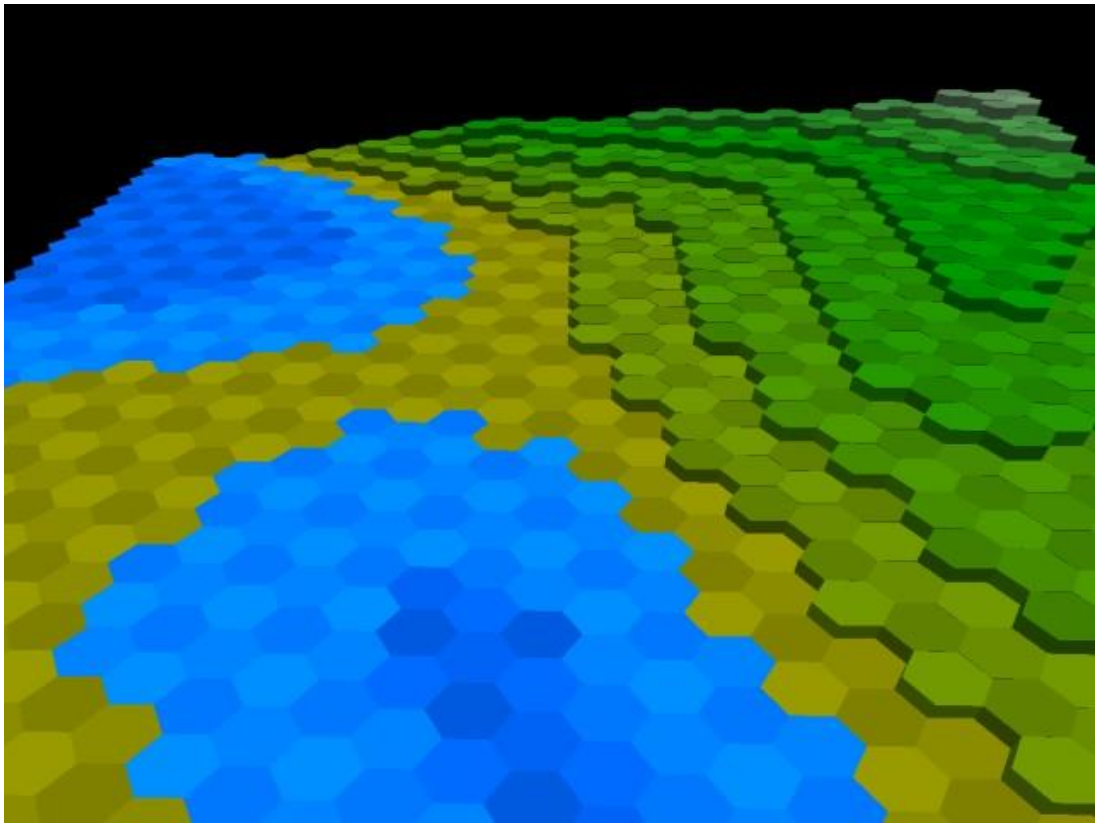

Figure 23: Example isometric view of hex-field (ignore elevation feature)

A possibility space session begins at the centre of the knowledge space with a single word or concept. The hexagons around the starting position can be seen (not necessarily the contents) but the player is uncertain how far the landscape extends in any direction. Unseen areas may be hidden behind a 'fog-of-war' effect, or simply 'off screen'.

Figure 24: Classic fog-of-war effect - the player cannot see the grey areas and their content remains completely unknown

Exploration of the space should be simple, intuitive, and rewarding:

- Single finger drags a new hexagon to the centre position by panning the map
- ´Single tap on a central hexagon 'pops up' the content field, displaying an image, word, or concept
- Two finger rotate landscape (may not be required)
- Two finger pinch zooms in/out (may not be required)

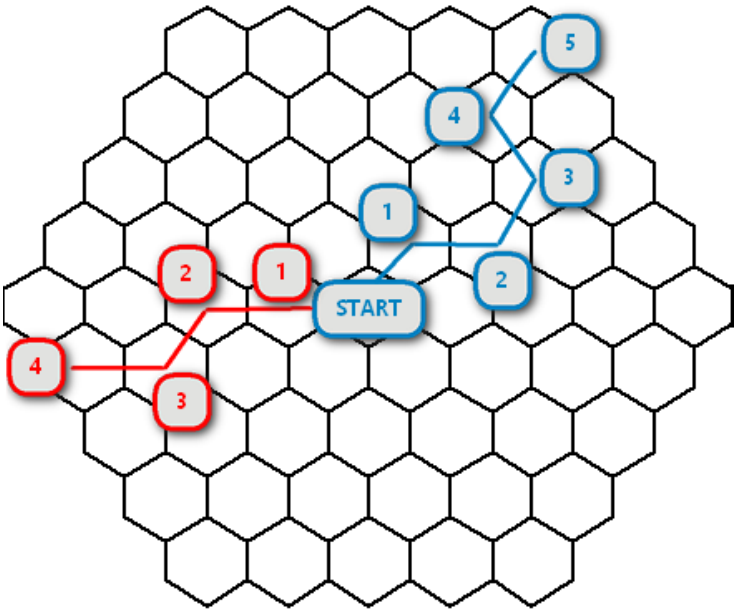

Figure 25: Examples of paths traced through the possibility space

Some or all of the hexagons in the map space contain content generated by the various NCSR-D webservices.

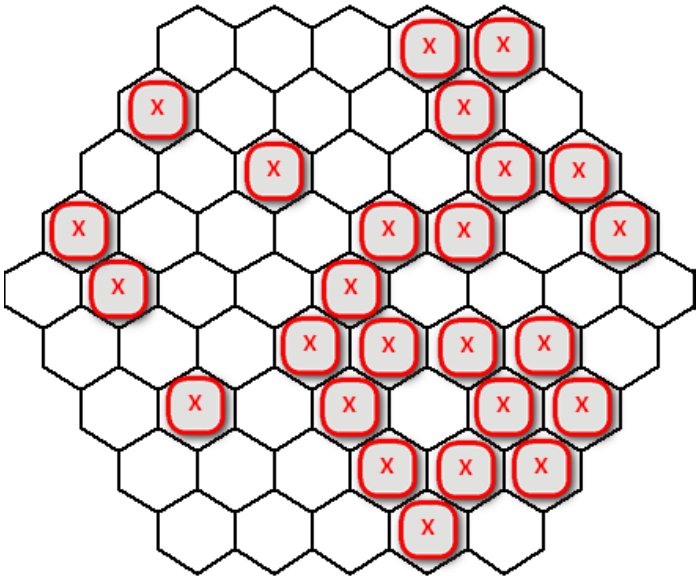

Figure 26: Partially populated hex-map (sparse on the left, denser on the right)

How is the space populated?

Each hexagon in the map space is surrounded by exactly six other hexagons.

Population is controlled according to parameters set by the player or contained within the challenge if launched from C2Space (not decided yet). The player will choose which kind of game based on the integration of webservices. It is presumed that the specific webservice(s) will be selected at the session start and the type of content available will follow from that decision (see following examples).

Example: exploring an ontology

When exploring an ontology the ring around any given hexagon contains content selected from the next level of the hierarchy contained in the knowledge base. It is possible to explore the possibility space 'down' from high level concepts, or 'up' from very specifically detailed starting concepts. The session can be played with words, images, or a combination of the two. Different relationship categories might be explorable based on some in-game choice, e.g. direction, distance…

Concerns with this approach include that the map may be too small for meaningful exploration based on the small available levels in the hierarchy. Also, I'm not exactly sure how much the knowledge base needs human created input to grow, and therefore this one-way exploration might be too trivial/offer nothing to evolve the ontology content.

Example: exploring semantic space

In this case the ring around any given hexagon contains content which is semantically closely related to the centre point (i.e. similar by a known value). Only by exploring further afield can the player discover less closely related conceptual content. In this case the precise semantic distance between concentric rings can be adjusted up or down. Exploring at a distance is presumed to increase the chance of encountering something unexpected.

Concerns with this approach include how long it takes to generate content for a large abstract space, thereby determining how much of the space can be displayed at any given moment on the screen.

From these initial population concepts it may be possible to build in more relationships, e.g. moving up in the space favours longer words, or more images. Colours or terrain might be used to indicate some property of the space, etc.

Possible modes of play

- Free explore (move around in any direction on a large or unbounded map)
- Time restricted (discover content in maximum of two minutes)
- Word search (try to find a specific word in the space)
- Semantic vs Ontology exploration (as above)
- Just words, just images, words and images
- Restricted paths (some hexagons are un-selectable)

Ending a possibility space session

The end of a possibility space session can be triggered by

- Time expires
- The player voluntarily ends the play session

At the end of the session a record is kept of

- The start condition
- The final content discovered
- The path that was followed through the space

These data points can be stored and viewed in C2Space.