The 4Ts Game to Develop Teachers' Competences for the Design of Collaborative Learning

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Abstract. This work describes a serious game aimed at supporting teachers in the development of competences in the conceptualization phase of Learning Design. The game builds on the 4Ts model, which addresses four main dimensions of collaborative learning activities: the **task** learners will carry out, the **team** structure of working groups, the **time** schedule and the **technology** adopted. Participants play the game by laying down cards on a board; cards represent instances of the above-mentioned dimensions, while the board structures their aggregation and allocation in time. Scaffolding is available to novice designers, who can start the design from an existing pattern by using **technique** cards. The application that implements the game performs various consistency checks on the status of the board; provides on-demand feedback; supports multiple sessions both locally and at a distance; allows for further reuse and deployment of the designed activity. The article displays various examples of the application usage, highlights the system architecture, and describes some possible directions of evolution for this game.

Keywords: Serious games · Learning design · Teacher training

1 Learning Design

Collaboration is a key aspect of learning: learners engaged in collaborative activities are involved in a process of co-construction of knowledge based on meaning negotiation, sharing and reinforcement. Online Collaborative Learning, in particular, is believed to hold the promise to implement socio-constructivist learning processes based on active learning, collaborative knowledge building, reflection triggered by multiple perspectives. However, effective design of collaborative learning activities is not an easy task, especially for teachers and instructors who are not familiar with Learning Design (LD). In this context, a variety of tools, both conceptual and technological, has been proposed in literature [1–5]; these tools provide support to some specific design tasks, ranging from the planning of student activities to their delivery of learning resources and instructions.

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Unfortunately, very few tools support the creative process of conceptualizing collaborative tasks, although many teachers and designers, even experienced ones, face significant problems when addressing this task. The reason for this lack of support can be found in the level of creativity required by the conceptualization process, and in its intrinsic complexity, thus making it hard to reduce the design activity to a sequence of predetermined steps. Consequently, existing LD tools seldom have a significant impact on teachers' practice and therefore encounter limited adoption [6–8].

For these reasons, [9] proposed a collaborative board game aimed at supporting the design of game-based learning scenarios. Not only did teachers enjoyed using it, but also their collaborative attitude and creativity improved by playing with the cards: interacting with tangible elements allowed for more flexibility and usability than usual digital environments devoted to LD development. One drawback of such a paper-only approach is in the lack of saving and retrieving facilities, as it is difficult for participants to continue working on their collaborative design at a distance, or in a later session. Above all, the result of the design effort cannot be easily exported to an LMS platform to be deployed in a learning environment [9].

We have therefore developed three versions of a serious game, all based on the 4Ts Model [10], to support groups of teachers in the design of collaborative learning activities. We have been exploring various combinations of tangible and digital mix-ins: initially the game was fully tangible; we subsequently developed an "augmented", half-tangible-half-digital, version of the game [4]. In its most recent implementation, the game is completely digital, and allows for the direct manipulation of software representations of cards on a board through a gaming interface. In the following, we will present the 4Ts Model, and describe the digital version of the game.

2 The 4Ts Model

The 4Ts model was developed in 2011 and then validated during a workshop conducted at the Alpine Rendez-Vous of the STELLAR Network of Excellence [11, 12], which was attended by a number of researchers active in the field of learning design and online collaborative learning.

The model addresses four main dimensions of the design of collaborative learning activities [10]:

- The **Task** learners should carry out (e.g., writing a report, solving a problem etc.)
- The **Team**(s) that learners should be grouped into to carry out the Task and the corresponding interaction mode(s): pairs, small groups, plenary class etc.
- The **Time** schedule learners should adopt
- The **Technology** needed to carry out the Task (e.g., forum, wiki etc.)

During the design process of a collaborative learning activity, designers make decisions about these four dimensions, on the basis of the following boundary conditions (see Fig. 1):

- the expected learning outcomes, i.e. the learning objectives pursued by the activity;
- the content domain addressed in the learning activity;

- various contextual constraints, such as: the number of students who will take part in the activity, their age, previous competences, special needs; timeline restrictions; particular characteristics of the working or operative environment, etc.

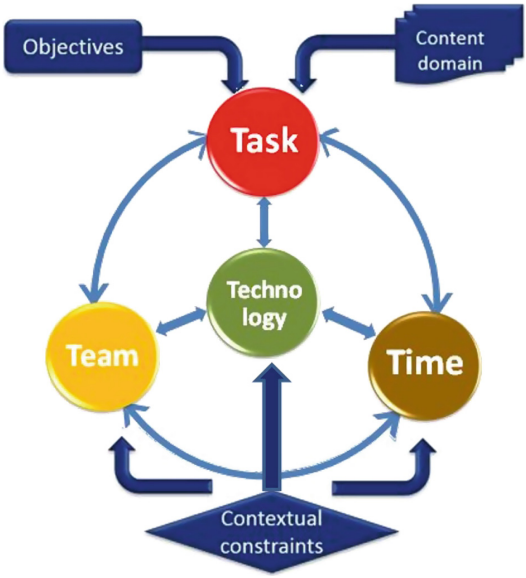

Fig. 1. The four dimensions of the model

The four dimensions of the model are not mutually independent: rather, they are tightly intertwined: a decision regarding any of them inevitably influences all the others. To support teacher and designers in the decision making process involved in LD, these dependencies should be made explicit. To this end, the game based on the 4Ts Model aims to support players in the exploration of these four dimensions.

As we shall see in the following, we have also identified a well-defined pattern language, in order to allow novice teachers to build their design on pre-defined structures rather than from scratch.

3 The Game

The game is hosted on a board that represents Time on four columns, each corresponding to a week (see Fig. 2). Each column has slots to accommodate cards from five different decks [13]:

- The **Task deck** (red cards): possible assignments for the students
- The **Team deck** (yellow cards): possible group structures
- The **Technology deck** (green cards): possible kinds of device, either hardware of software, to support the learners activity. Currently, the game only allows for a

maximum of two technology boxes per task; in the future, we might explore the possibility to specify more than two technologies for each task.

- The **Technique deck** (blue cards): possible collaborative patterns.

Each column can contain one Technique card, and one or two activity specifications; each activity consists of one Task card, one Team card and one or two Technology cards.

Regardless the deck they belong to, all cards share the same structure: they contain a short definition of the element they represent, and highlight suitable associations with other cards. For instance, the Forum card (belonging to the Technology deck) suggests compatible team and task arrangements that learners can effectively perform using a discussion forum.

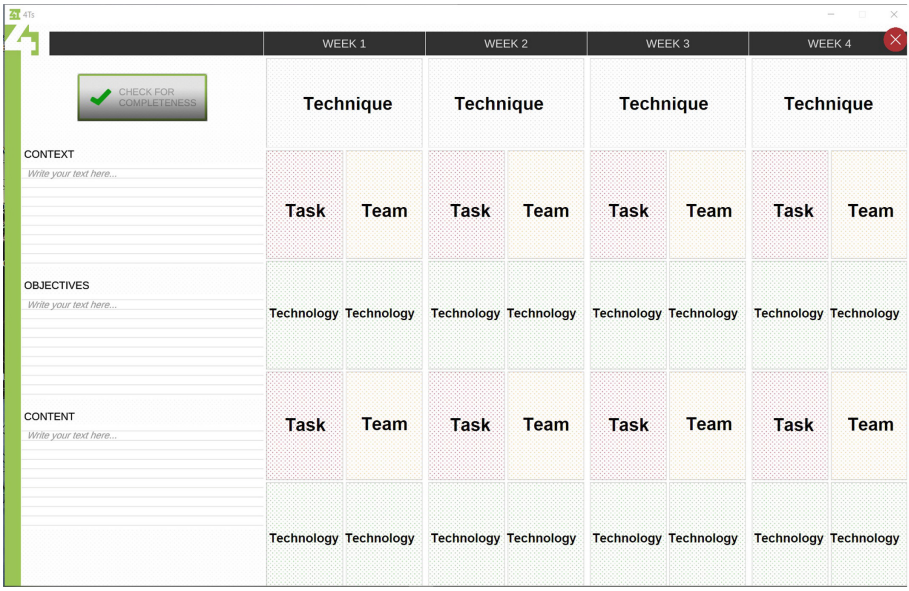

Fig. 2. The Board structure

Please note that the board allocates some space (on the left side of Fig. 2) to text fields that designers should fill in with information about the context, the objectives and the content domain associated to the activity under design. As already stated (see Fig. 1), these boundary conditions heavily affect most design decisions, and should therefore remain visible to designers throughout the conceptualization phase.

3.1 The Card Decks

Figure 3 shows an example of for each type of card, namely a "Writing a report" task, a "Small Groups" team, and a "Forum" technology card. Tables 1, 2, and 3 describe the sets of Task, Team, and Technology cards, respectively.

Fig. 3. Examples of Task, Team and Technology cards

Table 1. The set of task (red) cards.

Writing a report	Writing a short text following a set of instructions The report can range from a simple for-and-against list on a particular topic, to a full narrative description
Studying	Reading and studying assigned materials - text, audio or video recording, reference material, etc.
Finding materials	Conducting a search (free or guided) in any source of materials to locate information and documents on a given topic. This task, and the strategies for performing it effectively, are considered to have intrinsic educational value
Preparing a list of questions	Producing a list of questions, items, etc. on a given topic. The value of the task lays in the preparation, rather than in the final outcome/list. In the case of the list of questions, these might be posed, for example, during an "Interview with an expert"
Commenting on someone else's work	Providing feedback about the work of others, with suggestions about how that work might be improved This is usually preceded by a task that involves producing something, e.g. "Writing a report", "Producing an artefact", "Preparing a Presentation". The Task concludes when the feedback is shared with the author(s) of the work
Preparing a presentation	Preparing a presentation that will inform others about a given topic under examination. This usually leads to the task "Giving a presentation"
Carrying out an assignment	Completing one or more exercises or similar that have been set by the teacher
Giving a presentation	Presenting work to others. This is usually preceded by a preparation task like "Preparing a presentation", "Writing a report" or "Producing an artefact"
Solving a problem	Solving one or more problems that the teacher has set

(*continued*)

Table 1. (*continued*)

Interviewing an expert	Posing questions to an expert in order to obtain further information and enhance understanding of a given topic. This is usually preceded by the task "Preparing a list of questions"
Assuming roles	Deciding who is to assume the different roles within a fictional situation enacted as part of a role-play activity. Examples of roles/characters may include team coordinator, rapporteur, defeatist, optimist, bureaucrat, efficientist, technophile, technophobe, etc. Once learners have assumed roles, in the following phases of work, they have to play them
Producing an artefact	Producing an artefact of any kind: a model, a map, a drawing, a video, a piece of software, etc. The artefact may be an original produced from scratch or perhaps a revised/reworked version of an existing work generated either by the same author/s or by someone else. The activity concludes when the artefact is handed in to the teacher and/or shared with others
Debating	Holding an organised discussion that examines a particular question or issue, often with the aim of reaching a shared conclusion, or to highlight various aspects

Table 2. The set of team (yellow) cards.

Individual learners	Individuals working separately
Small groups	Groups of learners numbering three to eight people
Pairs	Learners working in twos
Medium-sized groups	Groups of learners numbering nine to nineteen people
Large groups	Learner groups numbering twenty members or more
Plenary	The entire learner population addressed, be it a single class or a whole cohort of students

Table 3. The set of technology (green) cards.

Forum	A tool for asynchronous many-to-many communication, usually text-based
Presentation software	Applications like PowerPoint or Prezi for creating slide presentations to be shown to a live or online audience
Interactive whiteboard	A large digital display unit with an interactive surface that allows you to display content (text, images, videos, etc.) from a connected computer but also to manipulate these and add notes and drawings
Wiki software	A system for people to create and edit web pages in a collaborative manner using a web browser

(*continued*)

Table 3. (*continued*)

Video-conferencing system	A system that allows a group of people to hold a synchronous meeting online, thus avoiding the need to gather physically
Selected study materials	Reference materials on a given topic that the teacher has sourced and then presents for study - may include articles, papers, books, lecture notes, website links, audio-visual materials, etc.
Source of materials for learning	Any general information source, like the Internet or a library, that learners access to search for data, documents and the like
Text editor	An application like Word or Google Docs for creating and editing documents either offline or online - when used in a group, it allows members to work together on the same document, either by adding contributions or commenting on what others have written
Projector	A device for projecting the video signal from a computer onto a screen, so that it can be seen by a potentially large audience
No technology	In face-to-face situations, non-mediated interaction may be considered an alternative to forums or videoconferences
Materials and tools for practice	Any tool or material the teacher makes available to learners for practical activities. These include things like maker kits, educational software, apps, simulators, etc.

3.2 How Participants Play the Game

A group of designers play the game with the goal of designing one or more collaborative learning activities: after having defined learning objectives, contents and constraints of the activity, designers read and analyse the available cards, discuss, negotiate among the group the proper design decisions, and select appropriate cards to lay down on the board. Card after card, a coherent description of the learning activity emerges from the board.

The design resulting from a session of the 4Ts paper game consists in the state of the board, with all the technique, task, and technology cards properly positioned in the board slots.

Figure 4 shows an example of the status of the game board during a design session. Participants have planned for the first week a task consisting in a web search students will carry out in small groups over a set of referenced web sites. During the second week, larger groups will be preparing slide presentations to deliver to the whole class.

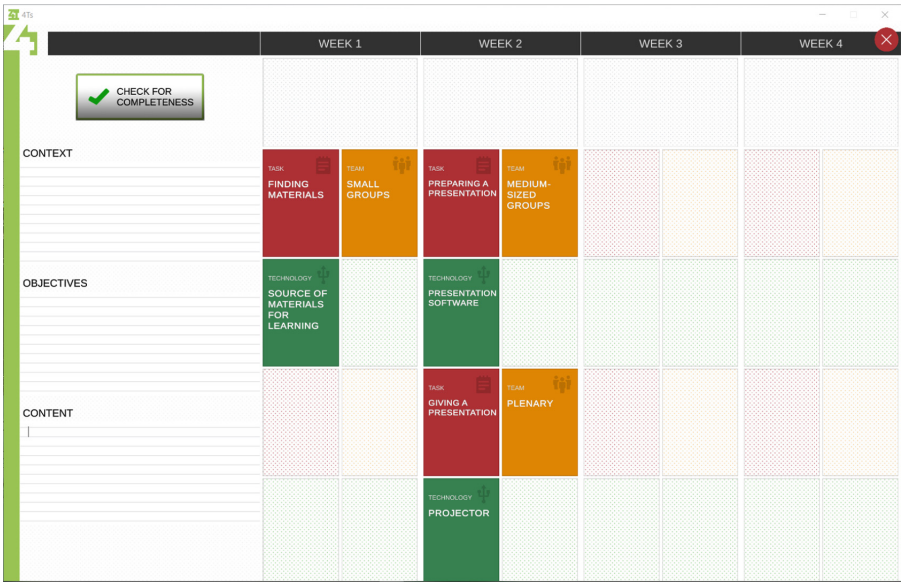

Fig. 4. The status of the board during a design session

3.3 Scaffolding for Novice Designers

A fourth type of cards, namely the Technique cards, is particularly useful to provide some scaffolding for participants who are novice in the CSCL field, because these cards allow starting the design from an existing pattern, rather than from scratch.

Techniques allow the organization, structuring, and scaffolding of activities, so that students who will take part in the activity being designed, will be able to collaborate effectively in order to achieve the expected learning outcomes. Techniques cards provide the elements for the pattern language we have mentioned in a previous section: each Technique card (blue colored) represents and suggests a notable collaborative pedagogical design patterns. The Technique card deck includes the following elements, but this set is open to future extensions and integrations:

- JIGSAW
- PEER REVIEW
- CASE STUDY
- PYRAMID
  - FOR LIST PREPARATION
  - FOR PROBLEM SOLVING
- DISCUSSION
  - TOWARDS ASSIGNMENT
  - TOWARDS ARTEFACT
  - TOWARDS REPORT
- ROLE PLAY

3.4 An Example of Technique Card: Jigsaw

As an example of a Technique [14], let us consider the Jigsaw pattern, a research-based cooperative learning technique invented and developed in the early 1970s by Elliot Aronson and his students at the University of Texas and the University of California [15, 16].

A Jigsaw activity comprises two phases:

- In phase 1 a complex issue is subdivided into 4-5 *segments;* learners form small groups, each group addressing one segment so that each member of the group becomes "expert" in that segment.
- In phase 2 groups are broken and reshaped, so that in each new group there is at least one "expert" for each segment of the previous phase: each group includes all the knowledge to solve the whole original issue.

The Jigsaw organization can be depicted as in Fig. 5:

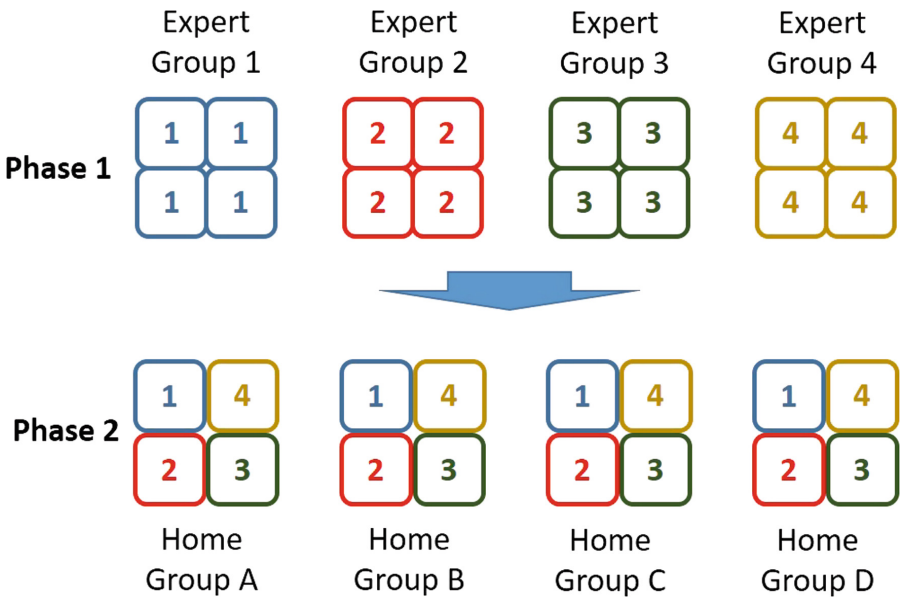

Fig. 5. Group articulation in the Jigsaw classroom.

Table 4 below shows how a Jigsaw activity can be represented within the 4Ts Model.

Table 4. The Jigsaw in 4Ts perspective.

Time	Phase 1–1st week	Phase 2–2nd week
Task	Individual study of learning material Collaborative development of a shared artefact (e.g., report, presentation etc.)	Problem solving activity to carry out collaboratively exploiting what has been learned in previous phase Plenary discussion
Team	"expert" groups	"home" or "jigsaw" groups
Technology	Discussion forum	Discussion forum

Figure 6 below shows the Technique card representing the first phase of the Jigsaw pattern. Note that, beside a short description of the technique, the card suggests proper task, team, technology, and time options. These are just hints, as several different combinations of 4T cards may suitably implement the technique.

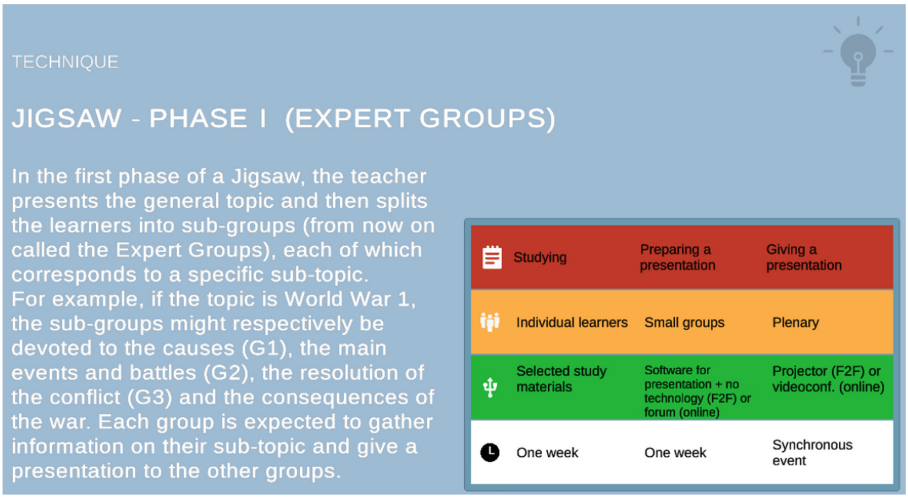

Fig. 6. A *Jigsaw – Phase 1* Technique card.

Figure 7 shows the status of the board after that participants have fully defined a Jigsaw activity.

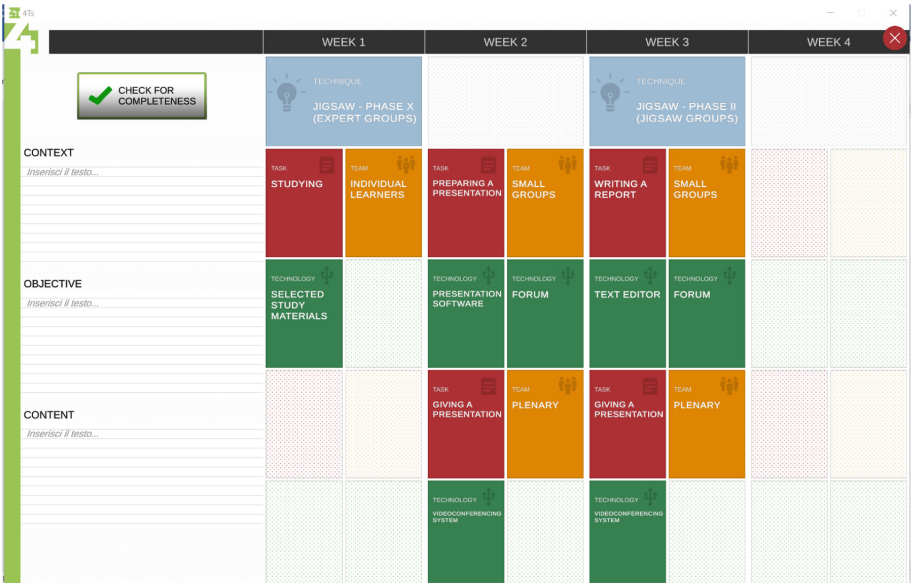

Fig. 7. The board for Jigsaw

4 System Functionality

As outlined before, the digital implementation of the game offers some valuable advantages over the initial, cardboard-only version. The software system that implements the game can perform a number of checks on players' moves, provide on-demand feedback, support multiple sessions and playing at a distance, and allow for subsequent deployment of the designed activity.

Whenever participants place a new card on the board, the system checks the board status to assess its consistency. Some combinations of cards are not allowed because do not make sense (e.g., an individual learner using a videoconferencing system, or because a task card that is incompatible with the technique card specified for the same week). In these cases, the system points out the incompatibility, as shown in the example of Fig. 8.

If technique cards have been used, participants can also ask the system to check if the technique has been fully specified.

If participants are stuck and do not know how to proceed, they can ask the system for suggestions: given the current status of the board, what card could be laid in a given slot?

The system produces a persistent, computational representation of the design. It is therefore possible to record and re-build easily the contents of the board at any given time, to allow for session break and resume.

Being the result of the conceptualization phase, the board final state should be easily reusable as the input to tools that support the design process; with this respect,

Fig. 8. The system highlights an incompatible combination of cards: the first phase of the Pyramid technique cannot be carried out in small groups.

the computational representation of the board allows for the integration of the 4Ts Game with other LD tools, in order to cover the whole design lifecycle [17].

5 System Architecture

The architecture of the augmented 4Ts Game encompasses three layers. The layer at the top represents the user interface: board and cards. The middle layer is in charge of the business logic: system initialization, persistency management, syntax checks, output formatting etc. Finally, the knowledge base at the bottom is responsible for representing the rules of the game (as outlined in the cards) and performing the semantic checks.

Queries to the knowledge base perform the following:

1. Correctness check: does the board currently contain a correct combination of cards?
2. Completeness check: does the board currently contain a complete combination of cards?
3. Card(s) suggestion

The user interface layer is implemented in Unity™ [18]. The middle layer is implemented in C#, whereas queries and responses returned to the business logic are expressed in XML syntax. The knowledge base is implemented in Prolog; thanks to the decoupling offered by an HTTP-based interface, the knowledge base sub-system can be located in a separate network node (e.g., a server in the cloud). This also allows for the collection of experimental data to validate the usability of the system and its pedagogical effectiveness.

The implementation of the digital game is in its final stages, with prototypes undergoing extensive testing.

6 Conclusions and Future Developments

The 4Ts game aims to scaffold the design of collaborative learning in Technology Enhanced Learning environments by making explicit, through the Technique, Task, Team and Technology cards and the board representing Time, the (mostly tacit) knowledge that expert designers have developed through experience. As a consequence, the game is particularly suited to the training of designers with little experience in the design of CSCL activities. In this context, one of the limitations of the game (the limited flexibility of its knowledge base) is also an asset, because it provides guidance based on clear-cut rules and consolidated design patterns. For experienced designers, however, this lack of flexibility could become too restrictive of their creativity in the design of innovative teaching approaches.

Future research directions include validation experiments of the game in authentic situations; usability evaluation of the interface with both real users and experts; comparison of the digital game with previous paper-only and mixed-tangible versions.

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