

# **A multicase study for the evaluation of a pattern-based visual design process for collaborative learning**

Davinia Hernández-Leo<sup>1</sup> (corresponding author), Ivan M. Jorrín-Abellán<sup>2</sup>,  
Eloy D. Villasclaras-Fernández<sup>2</sup>, Juan I. Asensio-Pérez<sup>2</sup>, Yannis Dimitriadis<sup>2</sup>

<sup>1</sup>Universitat Pompeu Fabra, <sup>2</sup>University of Valladolid

<sup>1</sup>Roc Boronat 138 08018 Barcelona, Spain, +34 93 542 1428

davinia.hernandez@upf.edu; {ivanjo@pdg; evilfer@ulises.tel;

juaase@tel; yannis@tel}.uva.es

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**Abstract:** Collage is a pattern-based visual design authoring tool for the creation of collaborative learning scripts computationally modelled with IMS Learning Design (LD). The pattern-based visual approach aims to provide teachers with design ideas that are based on broadly accepted practices. Besides, it seeks hiding the LD notation so that teachers can easily create their own designs. The use of visual representations supports both the understanding of the design ideas and the usability of the authoring tool. This paper presents a multicase study comprising three different cases that evaluate the approach from different perspectives. The first case includes workshops where teachers use Collage. A second case implies the design of a scenario proposed by a third-party using related approaches. The third case analyzes a situation where students follow a design created with Collage. The cross-case analysis provides a global understanding of the possibilities and limitations of the pattern-based visual design approach.

## **1 Introduction**

Learning technologies standards specifications, such as IMS Learning Design (LD) [1], enable instructional designers to computationally model their designs so that they can be enacted by compliant systems. However, these specifications provide technical-oriented, text-based notation systems that are not usable by teachers

and do not enforce design processes that support the creation of pedagogically sound designs. This paper presents the evaluation of the pattern-based visual design approach implemented in the Collage authoring tool [2] for the creation of collaborative learning designs computationally represented with LD. These designs are also called Computer-Supported Collaborative Learning (CSCL) scripts.

CSCL scripts structure sequences of activities, including the roles, groups, resources and tooling associated to each activity, in such a way that the activities can be delivered by runtime systems [3, 4]. In order to be potentially effective, these scripts should have been planned considering the CSCL critical elements that elicit the desired social interaction leading to learning benefits [3, 5]. Well-known generalizations of the pedagogical methods behind the scripts can be documented as design patterns to facilitate their recurrent application to many learning situations [6]. Design patterns describe a problem in a given context and its most common good solution, which is typically illustrated with diagrams or figures. Collage implements a visual design process based on Collaborative Learning Flow Patterns (CLFP). CLFPs formulate broadly accepted fruitful flows of (collaborative) learning activities. Collage uses the graphical representations of the pattern solutions to provide teachers with reusable CLFP-based templates that can be easily configured and refined by interacting with the visualizations of their elements (activities and roles/groups) for the creation of full-fledged LD scripts [7]. As a result of using visual templates instead of LD constructs and since the templates are based on patterns, we state that Collage facilitates non LD-expert teachers the creation of potentially effective designs. In other words, the main research question of this paper is: *Does the pattern-based visual design process*

*facilitate the high-level generation of contextualized scripts reusing CLFPs and focusing on CSCL critical elements?*

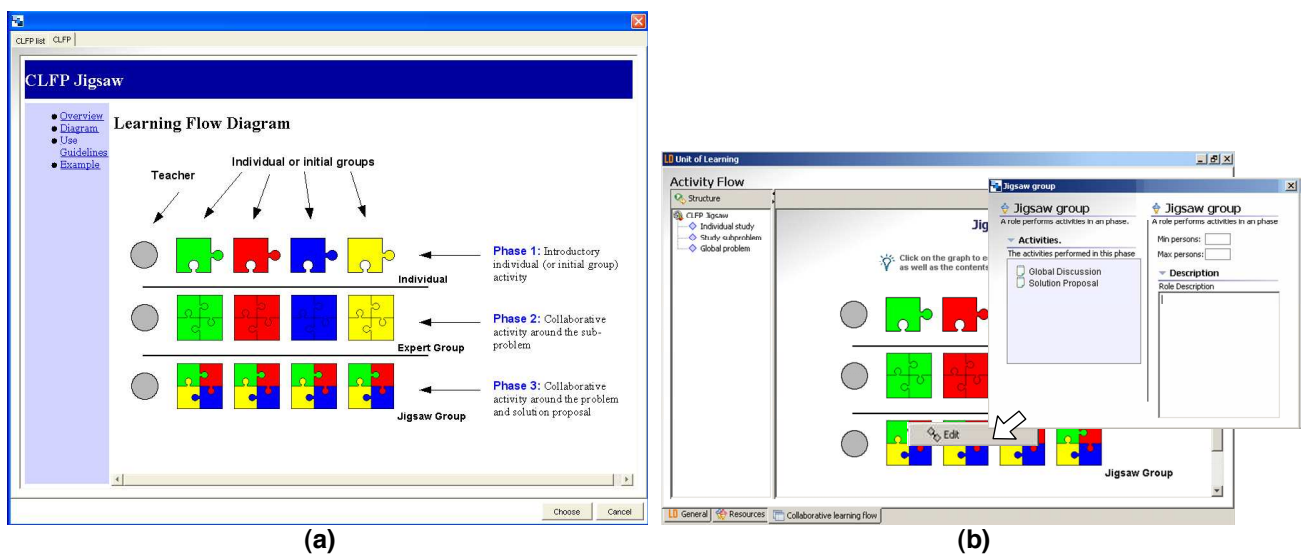
In order to answer this research question the whole lifecycle of implementing a script needs be considered. This lifecycle includes two main stages: design and enactment. Teachers should use Collage to design an LD script, but the script should be also actually run with students in a real learning situation. Therefore, more specific research questions can be formulated, namely: Can teachers easily use Collage to reuse CLFPs focusing on CSCL critical elements when creating a script? Is it possible to model an arbitrary design with Collage? What is the added value of Collage when compared with related approaches? Can a script created with Collage be implemented in real situations?

This paper presents the results of a set of complementary experiences that tackle these questions. After a description in Section 2 of the pattern-based visual design process implemented in Collage, Section 3 introduces the evaluation methodology adopted in the paper. Then, Section 4 presents the findings of the experiences separately, while Section 5 relates the experiences including a cross analysis with emphasis on the binding ideas regarding the global research question. Finally, section 6 concludes the paper summarizing the answers to the research questions and providing an outlook for future research.

## **2 The pattern-based visual design process in Collage**

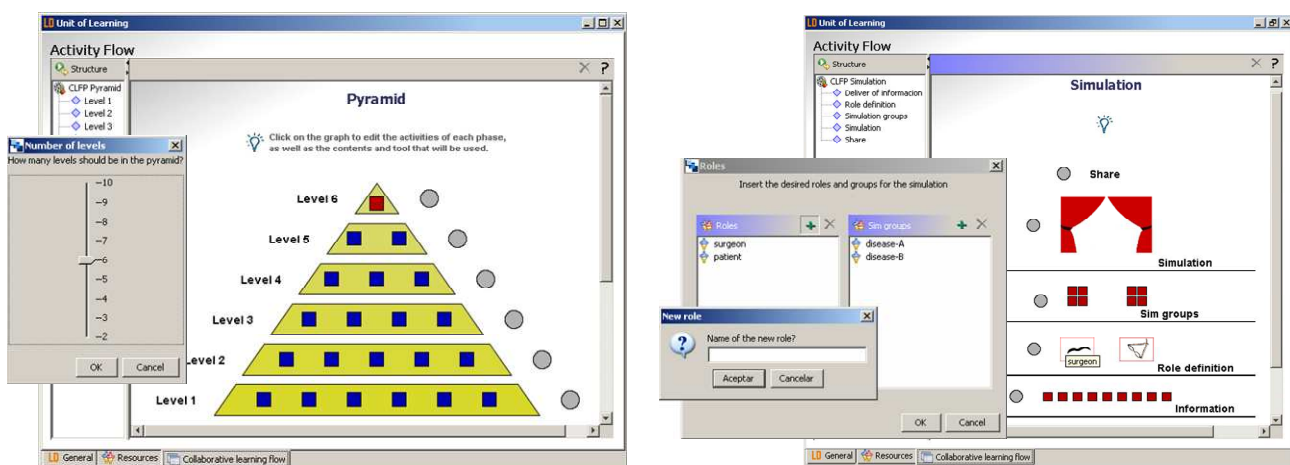
Collage implements a pattern-based visual design process which differentiates two main phases: the *selection* and the *authoring phase* [2]. In the *selection phase* teachers can choose the pattern (the CLFP) that is more suitable for the desired learning objectives or task type (open problem, divisible task, etc.). Moreover, they

have available help information describing each pattern, see Figure 1 a). This information includes a diagram illustrating the pattern solution. In the Figure the pattern shown is the Jigsaw CLFP, which proposes the following flow of activities: Each participant in a group studies a particular sub-problem (a piece of the puzzle). The participants of different groups that study the same sub-problem meet in an expert group for exchanging ideas and becoming experts in the section of the problem given to them. At last, participants of each jigsaw group (with a different piece of the puzzle) meet to contribute with its “expertise” in order to solve the whole problem (puzzle). Figure 1 b) shows how Collage presents the Jigsaw CLFP-based template in the *authoring phase*. Teachers can specify the sub-problems and the problem, the group composition, and the resources and tooling needed in each activity, by clicking on the graphical elements of the template.



**Figure 1. Pattern-based visual representations used as interactive templates to support the design of collaborative LD scripts a) Jigsaw CLFP as shown in the Selection phase implemented in Collage, b) Authoring the design interacting with the visual representation of the pattern**

Figure 2 shows two different examples of CLFP-based template visualizations. They correspond to the Pyramid CLFP, which proposes that increasingly larger groups discuss and generate new agreed proposals, and the Simulation CLFP which structures a role play scenario with activities including: students consulting information about their role, rehearsing simulations in small groups, and performing and reflecting on the simulation in large groups. Figure 2 a) presents how the visualization of the Pyramid template changes when the levels of the pyramid are determined by the user. Each level of the pyramid is an interactive element that leads to the form where teachers can describe the activities involved in that pyramid level. Figure 2 b) shows how teachers can add graphical elements representing roles when refining the Simulation template.



(a)

(b)

**Figure 2. Collage authoring tool a) Configuring the visual representation of the Pyramid (or Snowball) CLFP indicating the number of levels, b) Configuring the visual representation of the Simulation (or Role Play) CLFP defining the roles**

### 3 Methodology

The research questions derived from the pattern-based visual design approach implemented in Collage have been presented in the Introduction. The challenges

and nature of these questions lead us to follow a research methodology in which a number of experiences are organized as case studies.

### **3.1 *Why a multiple case study?***

According to Zelkowitz & Wallace there are three broad categories of software engineering technology validation models: observational, historical, and controlled [8]. Case studies belong to the so-called observational methods, which collect relevant data as an experience develops. Despite the weaknesses that are typically associated with this type of models (e.g. it is not always possible to generalize), this method is the most adequate to address the posed research questions. Historical methods such as literature research or surveys could not be used since there is not enough existing experience in the use of Collage yet. The need of involving human subjects to be able to answer the questions makes it difficult to use a controlled method, which requires multiple instances of an observation in order to provide statistical validity of the results. Because of the enormous cost or possibilities of replication, the controlled experiments are often limited to few replications, which increases the risk related to the validity of the results. Moreover, “authentic” experiences with real users cannot be rigorously replicated due to their non-trivial situational-dependence characteristics. Furthermore, we are more interested in the appropriateness of the pattern-based visual design process, evaluating the features that they provide in relation with the research questions, than in their measurable effects [9].

A case study can have an “instrumental” or an “intrinsic” purpose [10]. A case study is “intrinsic” when the main interest is in the case itself. In this paper the interest in the experiences is primarily “instrumental” since the central goal is to

answer the previously defined research questions. These questions demand the implementation of a set of experiences with different types of audiences (mainly teachers and students) and different types of scenarios (applying the design process to create scripts, running a script). Each of these scenarios focuses on a different manifestation (what is called “functioning”) of the main aspect under evaluation (what is called the “quintain”). The quintain is defined as the ultimate evaluation goal that is common to multiple experiences comprising a multicase study [10].

Hence, we use the multicase study method to systematize the evaluation of the different experiences required to analyse the posed questions, having as the quintain the pattern-based visual design process. The multicase study comprises three different case studies, each of which involves a different functioning. The final goal is to aggregate and comparatively analyze the case findings in order to conclude cross-case assertions about the quintain. The main action that enables the evaluation of the visual design process refers to the functioning of creating scripts using Collage. Therefore, we carry out four experiences with slightly different audiences (mainly teachers) that comprise the first case study. Most of the scripts created in these experiences are proposed by the authors. In this way, the functioning of the second case study is solving a scenario proposed by a third-party. This scenario is also tackled by other researchers proposing related approaches, what allows us to establish some comparisons. However, in order to test if the scripts created with Collage are meaningful, we also implement a script in an authentic situation with students. This functioning is the focus of the third case study.



It is necessary to say that the evaluation results of the cases are not presented according to the traditional style used in the case study methodology (e.g. with narratives, thick descriptions, etc.) Instead, the results are presented following a more analytical mode based on adaptations of a mixed evaluation method combining quantitative and qualitative data gathering techniques. This strategy is also aligned with the ideas supported by Stake [10], in that the case study reports should be adapted to the peculiarities of the audience to which the reports are targeted. The descriptions of the situations analyzed in the cases and the data collection instruments are largely explained in [11]. However, in this paper we have decided to use tables given its scope and potential audience.

After presenting the cases forming the multicase study, we explain the mixed evaluation method.

### **3.2 *Cases forming the multicase***

A case needs to be studied in its own context. On the other hand, in a multicase study, a single case is of interest because each case illuminates a different functioning in which the quintain operates [10]. The cases are selected considering the following criteria [10]: 1) the planning of the cases should be consistent with the research questions, 2) diversity across situations to examine different functioning (probably representing different audiences) in which the quintain is manifested, 3) good opportunities to learn: it may represent a trade-off between how typical and how accessible the cases are, i.e. representativeness vs. potential for learning, and 4) we need to reach an integrated, holistic qualitative comprehension of the cases that is embraceable. Considering these criteria, we structure the multicase with the

three cases shown Table 1. The experiences with the same functioning compose a case study.

**Table 1. Summary of the experiences involved in the multicase study**

Functions (Global activity accomplished in the experiences)	Name of the experience	Interviewees (type of audience)	CSCL designs created/ enacted		Deployment	Materials	Data gathering techniques / sources
			“Proposed” (previously tested in lab. experiments)	“Free” (ideated by the audience or a third-party)			
Visually creating CSCL scripts based on CLFPs using Collage  (CASE STUDY A: COLLAGE WORKSHOPS)	<b>GSIC/EMIC</b>	Five members of the GSIC/EMIC research group: CSCL practitioners without deep knowledge on LD	<b>NNTT<sup>1</sup></b>	<b>NM<sup>2</sup>, STA<sup>3</sup></b>	- Free deployment (with assistant)	Collage user manual and worksheet. Collage already installed	- Final questionnaire - Created scripts
	<b>UNFOLD</b>	Seven (official and invited) members of the UNFOLD project: educational technologists (some of them experts on LD)	<b>Paper-discussion<sup>4</sup></b> (NNTT <sup>1</sup> , show example)	-	-Familiarization (presentation), -guided creation of a CSCL script	Worksheet. CD containing Collage installers, user manual and the resources needed in the script	- Final questionnaire
	<b>UVA</b>	Five teachers of the University of Valladolid (Spain) with interest in ICT and CL and without knowledge on LD	<b>NM<sup>2</sup></b> (Job-interview <sup>5</sup> , show example)	(various, the audience had some time to create their own scripts)	-Familiarization (presentation with show example), -guided creation of a CSCL script - free deployment (optional, with assistants)	Collage user manual and worksheet. CD containing Collage installers and the resources needed in the script	- Initial (before familiarization) and final questionnaire - Observations - Discussion group
	<b>UCA</b>	14 teachers of the University of Cádiz (Spain) that use virtual campuses without deep knowledge on LD	<b>NM<sup>2</sup></b> (Job-interview <sup>5</sup> , show example)	(various, the audience had some time to create their own scripts)	- (Previous sessions about LD) -familiarization (presentation with show example), -guided creation of a CSCL script, - free deployment (optional)	Collage user manual and worksheet. Internet access to Collage installers and the resources needed in the script and further information	- Initial (before familiarization) and final questionnaire - Discussion group
Solving a third-party scenario (and comparing our proposal with other approaches)  (CASE STUDY B: PLANET GAME)	<b>ICALT</b>	Nine participants in a workshop and a panel at ICALT conference: researchers proposing related approaches	-	<b>L3-astronomy<sup>6</sup></b> (or Planet Game)	- We propose a solution for the scenario using our proposal beforehand. - Comparison of the different approaches: presentation and discussion	Description of the scenario provided by a third-party	- Achieved CSCL script with our proposal - Papers - Recorded discussion (video)
Putting into practice a CSCL script created with Collage in a real educational situation  (CASE STUDY C: NETWORK MANAGEMENT)	<b>NM</b>	12 university students and the teacher (engineering education)	<b>NM<sup>2</sup></b> (Paper-discussion <sup>4</sup> , show example)	-	-Familiarization (a session for presenting the script, the tools and training with another script: Paper-discussion) - Experiencing the script (a week)	Gridcole system integrating a chat, Synergeia and Quest and interpreting the script. A document explaining the roles students play in each moment	- Initial and final questionnaires - Observations - Discussion group - Log files - Students' outcomes

<sup>1</sup> A Pyramid and Jigsaw pattern based learning design on the use of ICT in Education; <sup>2</sup> A Jigsaw, Pyramid, Think-Pair-Share pattern based design to understand Network Management protocols; <sup>3</sup> A Jigsaw pattern based design to study Advanced Telematics Systems; <sup>4</sup> A Pyramid pattern based design to collaboratively discuss about a paper; <sup>5</sup> A Simulation pattern based design to develop skills to perform effective job interviews; <sup>6</sup> A Jigsaw pattern based game to learn Astronomy aspects.

Each case has an issue of special concern or importance. An issue has associated topics and more concrete information questions that shape the *conceptual structure* needed for designing and interpreting the study. The issue is related to research questions and to the functioning of the case, reflecting its main purpose. In this multicase we consider three different types of functioning and therefore three case studies with associated issues:

A) The main functioning that should be analyzed to evaluate the proposed approach is “**visually creating scripts based on CLFPs using *Collage***”. This is the main functioning since the associated case study (Case study A: *Collage* workshops) allows us to understand to a large extent a relevant issue concerning the quintain: *does the pattern-based visual design approach implemented in Collage facilitate the reuse of CLFPs in the creation of particularized LD-represented scripts, in a way that allows teachers to focus on CSCL critical elements?* Due to the relevance of this case study, it involves two different experiences with university teachers (from the University of Valladolid and from the University of Cádiz, both in Spain) consisting of four-hour workshops in which the participants create, as indicated in the visual design process implemented in *Collage*, concrete CSCL scripts (proposed by us, see Table 1). Both workshops were official teacher training courses of the two universities. Participation in the workshops was managed by the universities following their regular procedures and without the involvement of the researchers. This case study is enriched with two mini-cases accomplished as (shorter) workshops in which educational technologists (members of the UNFOLD project) and CSCL practitioners (members of the GSIC/EMIC group) participate. Some participants of the experiences forming this case study have



the opportunity to create their own scripts. However, this fact is not deeply analyzed in this case study.

B) A good chance to analyze the functioning “**solving a third party scenario**” entails the participation in a workshop integrated in the ICALT 2006 conference [12]. The organizers of the workshop propose a challenge consisting in implementing a collaborative learning scenario (a “Planet Game”) that they anticipate. The participants apply their related approaches to solve the scenario before the workshop. In this way, we create and execute a script reflecting the scenario. During the workshop the different solutions are presented and compared. Hence, the issue that this case study (Case study B: Planet game) illuminates is: *can we use Collage for visually creating a script representing a scenario proposed by a third party?*

C) The last but not least functioning is “**putting into practice a visually-created CSCL script**”. Studying this functioning is crucial in order to prove that the scripts created using the pattern-based visual design approach are meaningful and can be satisfactorily used in authentic situations, i.e. to study the issue: *can we use CSCL scripts visually created with Collage in real situations?* The experience analyzed in the case study devoted to this functioning (Case study C: Network Management) is a one-week blended learning situation part of an engineering education course at the University of Valladolid. The script is interpreted using the Gridcole system [4].

In conclusion, the selected cases are relevant to the quintain and provide opportunities to understand different functioning. The data required to examine the research questions has been collected according to the following mixed method.



### 3.3 *Mixed method*

Since we use a multicase study to structure the evaluation, the analysis process highlights a qualitative perspective [10]. That is to say, we aim at understanding each case taking into account its context. However, the method employed to collecting data is mixed in the sense that it integrates quantitative and qualitative data gathering techniques [13, 14]. Quantitative data allow detection of general trends, while data obtained through qualitative techniques allows the evaluators to understand these trends better by introducing contextual issues and considering participants' perspective. Table 1 show the techniques and data sources considered in each case: qualitative sources such as open questionnaires (useful for obtaining quotations), observations and discussion groups, and quantitative sources such as closed questions (to obtain measurement data) and automatically generated event log files. The quantitative data is aggregated and pre-processed using descriptive statistical analysis while the qualitative information is accumulated and structured into categories of analysis facilitating the interpretation of the arguments. The data sources used in the case studies differ due to the circumstances related to time or accessibility constraints. However, according to [10] this is not a problem since the cross-case analysis is qualitative and does not only compare quantitative measurable effects.

A critical concern when interpreting the data is related to the trustworthiness of the conclusions or findings. The mixed method relies on the process of gaining assurance of the interpretations by means of "triangulation", that is by comparatively analysing and critically reviewing evidence proceeding from different sources (and, when applicable, from several experiences with different participants) [15]. In this paper the quantitative analysis is performed by a team of researchers following the "member checking"



strategy, and each finding is sustained by several confirmations, supported by the data gathered and the context, indicating that key conclusions are not being overlooked or misinterpreted.

## **4 Findings of the separated cases**

The multicase study outcomes result from a cross-case comparative aggregation of the findings obtained in the case studies comprising the multicase. Therefore, each case should be studied independently. Last section introduced the description of each case study, including their context, setting, number of participants, designs created or enacted, deployment and materials used in each experience and evaluation data sources (Table 1). Each case was also determined by its own issue under study (main research question). Now we present the conceptual structure of each case study along with its findings. The conceptual structure includes the topics, derived from the issue, on which we focus the study and the particularization of the topics into more concrete information questions that guides the data analysis [10]. The findings result from applying the mixed method using the different data gathered in the experiences comprising each case study as indicated in Table 1. The findings are presented next in line with the conceptual structure of the case, i.e. sequentially answering the information questions.

### **4.1 Case study A: Collage Workshops**

Since the “*Collage workshops*” is the most critical case study involved in the multicase, it comprises four different experiences as shown in Table 1. Each of the first two experiences, namely GSIC/EMIC and UNFOLD form a mini-case study. In contrast, UVA (University of Valladolid) and UCA (University of Cádiz) experiences are the actual focus



of the “Collage workshops case study”. This organization is motivated by the following reason: the audience of the pattern-based visual design process implemented in Collage includes teachers (mostly at the university level) interested (but not necessarily experts) in collaborative learning and in applying ICT to support their educational practice.

Actually, the majority of the interviewees who participate in the UVA and UCA experiences are university teachers with a profile that conforms to the target audience. However, the interviewees of the GSIC and the UNFOLD experiences (mainly educational technologists and CSCL practitioners) are less representative in this sense, but can provide valuable information to illuminate some of the aspects of the case study. Further details about the workshops can be found in [16].

According to the issue of interest in this case study (see section 3.2) we propose the following topics that influence the issue and that guide its study:

1. We claim that our visual design process facilitate the reuse of patterns, which can be assembled and refined, when teachers create their own computer-interpretable scripts. Therefore, one of the centres of our approach is the ***pattern-based visual design process*** in which CLFPs are integrated in authoring tools as visual LD templates that can be selected and particularized according to the needs of a concrete situation.
2. Moreover, we state that the proposed design process enables that a conceptualization of the expected collaborative interactions is made explicit in advance. According to Strijbos such a process should ***focus on CSCL critical elements*** that affect interaction, namely: learning objectives, task type, level of pre-structuring, group size and computer support [5].





3. The visual design process under evaluation has been implemented in the Collage authoring tool. While utility is defined as the set of features incorporated by the tool, usability is concerned with the satisfaction with which users can accomplish the set of design tasks [17]. Furthermore, since the utility of the design process cannot be separated from the functionality and usability of the tool [18], we are interested in the *use of Collage*. Finally, the design process, and thus Collage, is intended for a specific audience: teachers interested (but not necessarily experts) in collaborative learning and the use of ICT. Therefore, an important topic of study refers also to *the characteristics of the audience*.

The data analysis and interpretation, accomplished in order to reach case findings, is done around the information questions that narrow down the following three topics.

Topic 1 has to do with the pattern-based visual design process, and comprises the information questions: I) Is the selection of the pattern-based LD visual templates and their representation useful and satisfactory? II) Does Collage achieve a satisfactory trade-off between the reuse of the CLFPs and the creation of scripts contextualized according to the situational needs? The findings related to this topic are collected in Table 2.

**Table 2. Findings Case A “Collage Workshops” Topic 1 - Pattern-based visual design process**

	Results	Selected supporting data
<b>Finding I:</b> on the selection and representation of pattern-based LD templates	The “selection phase” is critical and promotes the understanding of the patterns	- “... a minimum formation on patterns is necessary, for which Collage is helpful [discussion group UVA]” - “Collage systematizes the selection of patterns [questionnaire UCA]”
	Many arguments manifesting the significance of the CLFPs in which the visual templates provided by Collage are based. More strategies could be added, including those devoted to assessment	- Five (out of seven) interviewees select in a closed question of the [UNFOLD] questionnaire that “the CLFPs are significant, they are relevant examples of CL techniques” (the other two choose “I do not know any CL technique, but it seems to me that these are adequate”) - “... I miss a pattern that I employ in my classes, which is randomly selecting a member of a group to explain what the group has done [questionnaire UVA]”
	Interviewees’ ideas about the CLFPs coincide with what is visually presented in Collage	- CSCL experts participating in [GSIC/EMIC experience] agree - “I think that the patterns are perfectly transferred to the user workspace, reproducing the needed roles and activities for their execution [GSIC/EMIC]” - The graphical representations and their interactive possibilities are valued as especially useful [UVA, UCA, UNFOLD]

<b>Finding II:</b> on the trade-off between reuse of patterns and design options	The design process facilitates the reuse of CLFPs when structuring collaborative learning designs. The visually represented templates can be particularized according to the needs of concrete learning situations	<ul style="list-style-type: none"> <li>- 12 (out of 14) UCA interviewees and four (out of five) UVA interviewees agree on that Collage helps to reuse the CL strategies proposed in the CLFPs (the other interviewees selected N/A)</li> <li>- "I think that the tool imposes an elaboration process that impedes the non-reuse" states a UVA participant in [questionnaire UVA]"</li> <li>- "No (complete) example is directly transferable... I think that it is good to know an example in order to have something like a "demo"... but, at the end, each teacher has his circumstances and everything changes except for the structure [discussion UVA]."</li> <li>- "The same structure may be useful for different courses / environments, simply changing the resources, the definition of groups, objectives and activities [questionnaire UCA]"</li> </ul>
	The combination of patterns provides outstanding design flexibility	<ul style="list-style-type: none"> <li>- The utility of the combination of CLFPs is rated (in the range of 1 (it is not useful) to 5 (it is very useful)) with an average of 4.21 by the UCA participants and 4.20 by the UVA teachers.</li> <li>- "I think that the combination of patterns allows a better adaptation of the activity to the problems and methods that we want to develop, making the activity more complete... [questionnaire UCA]"</li> <li>- "... it would be nice if other patterns could be added! However, as patterns can be combined, these already offer quite a lot of flexibility [UNFOLD]"</li> </ul>
	The design process achieves a satisfactory trade-off between flexibility, keeping the essence captured in the CLFPs, hiding LD-specific technological details and providing a clear (but limited) set of design options	<ul style="list-style-type: none"> <li>- "... Collage is flexible and keeps the essence of the patterns. I think that the most important aspect of the tool is that it allows us to rationalize our labour without the need of much technological effort... [discussion UCA]"</li> <li>- "... it saves the teacher a lot of specification workload [questionnaire UVA]"</li> <li>- "I do not find the process too constrained since it enables the combination of patterns... and I think that it is easier for a novice to have an already structured model...[discussion UVA]"</li> </ul>

Topic 2 has to do with the focus on CSCL critical elements with the questions: III) Does the visual design process implemented in Collage help to determine the learning objectives, task-type and expected interaction that will be developed? IV) Does the design process help to understand and determine the structure regarding the flow of activities and the hierarchy of groups? V) Does the design process support also the definition of group-size, resource distribution, computer support and the structure within activities? The findings related to this topic are gathered in Table 3.

**Table 3. Findings Case A "Collage Workshops" Topic 2 – Focus on CSCL critical elements**

	Results	Selected supporting data
<b>Finding III:</b> focus on learning objectives and task type	The design process helps to determine the learning objectives related to collaborative learning that will be promoted and to select the task-type that will be solved by the students. The process also helps to determine the expected interaction (discussion, reasoning...)	<ul style="list-style-type: none"> <li>- The help provided (by the selection of CLFPs) to determine the learning objectives is rated (in the range of 1 (it does not help) to 5 (it helps a lot)) with an average of 3.86 by the UCA interviewees and of 3.40 by the UVA participants. Similarly, the help to determine the task type is rated with an average of 3.43 in the UCA workshop and of 3.20 in the UVA experience.</li> <li>- "in this way we are not just reflecting on what we are already doing in our practice... but also developing transversal competences... [discussion UVA]"</li> <li>"it helps to envisage how the interactions will develop... [questionnaire UCA]"</li> </ul>
<b>Finding IV:</b> focus on the structure regarding the	The data value as very satisfactory the support that the visual design process provides to determine the	<ul style="list-style-type: none"> <li>- UVA participants rate this aspect (4.40 in the range of 1 to 5, where 5 indicates that Collage helps a lot to determine the activity flow)</li> <li>- "I think that the most important aspect of Collage is that it helps to</li> </ul>

activity flow and group hierarchy	structure of the activity flow	structure and systematize the different types of activities... Collage has helped me to visually structure what I already do but I do not organize well [discussion UCA] - "it highlights the inter-relation among activities [questionnaire UCA]"
	The design process helps to understand and determine the structure regarding the hierarchy of groups	- "The visualization of the (learning) process helps to check the roles that each group plays in each moment [questionnaire UCA]" - "... thanks to the graphical representations, Collage helps to conceptualize the groups... [discussion UVA]"
<b>Finding V:</b> focus on group size and support within the activities	The design process helps to establish the group size. More support would be welcome	- "the information help provides clues and the interface of Collage allows the introduction of the desired group size limits [questionnaire UCA]" - "the determination of the group size limits can be improved, for instance, with automatic checkups as an interviewee mentions [questionnaire UCA]"
	The design process helps to determine the distribution of resources and tools among activities. But it does not provide suggestions of recommended content or tools	- "Since Collage guides the design process and the activities of each phase, we are obliged to reflect on each element that shapes the activity... [questionnaire UVA]" - "Collage pushes to specify resources and tools, though their characteristics should be known beforehand [questionnaire UVA]"

Topic 3 is focused on the use of Collage, the questions are: VI) Can the teachers use Collage successfully? VII) How can *Collage* be improved? VIII) Which are the characteristics and motivations of the potential audience of Collage? The findings related to this topic are collected in Table 4.

**Table 4. Findings Case A "Collage Workshops" Topic 3 Use of Collage**

	Results	Selected supporting data
<b>Finding VI:</b> Collage, easier-to-use CL-specific LD editor	Most of the participants find Collage user-friendly and intuitive.	- 12 (out of 19) UCA and UVA interviewees rate as "easy" (among the possibilities of "easy", "acceptable" and "difficult") the use of Collage, five assess it as "acceptable" and only two rate it as "difficult" - "I am satisfactorily astonished by the user-friendliness of the tool; I thought that it was going to be more difficult... [questionnaire UCA]" - "Collage is intuitive, user-friendly and does not provoke an "insecurity" feeling [questionnaire UVA]" - "... the participants create the design without difficulties... [observations UVA]" - The participants are able to create an almost completed example during the workshops, those having the time to complete have their scripts correctly validated by the runtime system.
	Easier to use, specific to collaborative learning, and it is the first editor providing pattern-based templates	"at last, patterns in practice!", "Collage seems to add some important features which will facilitate that teachers access LD authoring tools", "less complicated and more intuitive than Reload on its own...", "makes Reload much easier to use for specific purposes" [different UNFOLD participants]
<b>Finding VII:</b> improvements associated to selection of patterns, further design options and integration with complementary tools	It would be useful to have a "preliminary view" of the script as a "lesson plan"	- "I would suggest that the tool generates a plain document with the resulting design... [discussion UCA]" - "since the structure is clearly planned, it may also facilitate that the students know it well and can follow it easily... so that the workload of the teacher decreases...[discussion UCA]"
	Integration of Collage with complementary needed tools (production and delivery systems), which should support flexibility	- A tool that enables the instantiation of the scripts is required. This tool should guide the teacher in the population of group hierarchies with the actual participants. As said in [questionnaire UVA] "... in order to have the complete view the assignment of participants to roles is missing..." - "Before the fall semester we plan the objectives, activities and timing of the courses. However, the planning cannot be closed because many times external circumstances appear (e.g. holidays, illnesses) [questionnaire UVA]" "... if some students abandon the course in the third session, then I may need to re-structure... [UVA discussion]"
<b>Finding VIII:</b>	The audience of the design process	- "Collage is very well designed for collaborative learning and it seems

audience interested in CL and in the use of ICT	should be interested in designing CL processes to be used with an LMS in face-to-face, distance or blended situations or as lessons plans (without an LMS). The process provides design ideas and does not require the users to be experts on (LD) technologies	that we need to get used to it hereafter [questionnaire UCA]! - "I think that the tool can be of great utility in order to apply this kind of techniques, now that it seems one of the methods to apply in our classes ... [questionnaire UVA]" - "Patterns are quite adequate and for non-experts on CL (and LD) this is really and eye-opener!" [UNFOLD] - "for the novice teachers, a tool that guides users in the design process of units of learning is essential [questionnaire UVA]" - "the experience was quite dynamic and offered me new design ideas [GSIC/EMIC]"
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## 4.2 Case study B: Planet Game

In the "Planet game case study" the key added value is that we evaluate the pattern-based visual design process implemented in *Collage* with regard to the functioning "solving a third party scenario". This case study entails the participation in a workshop integrated in the ICALT conference [12]. The workshop is entitled "*Comparing educational modelling languages on a case study*" and its aim is to confront different learning design approaches and tooling through a common scenario. The scenario, approaches under comparison and detailed results are described in [19], we now introduce the conceptual structure of this case along with the main findings relevant to the multicase study and selected illustrating data. As indicated in Table 1, in this case the data under analysis include the script representing the scenario visually created with *Collage*, the papers presented in the workshop and the transcription of the recorded discussions.

Within the subjects tackled in the workshop the most important concerning our visual design process are: representation, design and re-use. However, other subjects related to the enactment are also relevant since they indicate whether the visually created script can be satisfactorily enacted. Therefore, the topics on which we focus the study are:

1. In the "Collage workshops case study" the scripts are proposed by the researchers. In this sense, it is interesting and necessary to test the application of



our pattern-based design process for the creation of LD scripts, as it is implemented in Collage, to an arbitrary scenario proposed by a third party.

2. Besides, this case study offers the opportunity to understand the pros and cons of our design process compared with the related representative approaches that participate in the workshop..

The concrete information questions that derive from these topics and the resulting findings are as follows.

Topic 1 is related to the application of Collage to a scenario proposed by a third-party, and includes the questions: I) To which extent is it possible to design a script proposed by a third party using Collage?, II) Can the script created with Collage be enacted by an actual LMS? The findings are collected in Table 5.

**Table 5. Findings Case B “Planet Game” Topic 1 Collage applied to a third-party scenario**

	Results	Selected supporting data
<b>Finding I:</b> the main aspects of the script can be designed with Collage	It is possible to apply our design process to design the script reflecting the third-party scenario	<ul style="list-style-type: none"> <li>- The LD script, and screenshots showing its visual creation using Collage are available at <a href="http://ulises.tel.uva.es/collage/l3astronomy">http://ulises.tel.uva.es/collage/l3astronomy</a></li> <li>- Though the script is not rigorously a jigsaw-based situation (students do not collaborate to jointly solve a problem but they “compete to propose individually the solution”), its learning flow structure is inspired in its essence: “The “Individual” phase of jigsaw is devoted to present the rules of the Planet Game and clue distribution depending on the team to which each student belongs. In this sense, it should be noticed that although the expert group phase of the jigsaw is not strictly considered in this scenario (not visible), the corresponding expert-group role must exist to differentiate between members of team A and team B. This is needed for providing the right expert interview (through a shared document repository) and the specific chat room in the discussion activity of the “Jigsaw Group” phase [19].” “There are only two details that cannot be rigorously authored with Collage. One of them is that It is not possible to specify that “the teacher decides when the exchanges are finished” because the IMS LD elements that enable its computational representation are not included in the Jigsaw-based template. However, it is possible to add the necessary IMS LD constructs to the script using other more general IMS LD compliant editor [19].”</li> </ul>
<b>Finding II:</b> the script created with Collage can be enacted using Gridcole system	An IMS LD runtime system such as Gridcole is capable of interpreting the UoL created using Collage	<ul style="list-style-type: none"> <li>- Screenshots showing the enactment of the created script are available at <a href="http://ulises.tel.uva.es/collage/l3astronomy">http://ulises.tel.uva.es/collage/l3astronomy</a></li> <li>- By interpreting the design Gridcole guides users through the flow of collaborative learning activities integrating the tools (different instances of the tools to each group) needed to support them [19]. The tools integrated to satisfy the third party scenario are chats, a shared repository and a web tool for questionnaires.</li> </ul>

Topic 2 has to do with the comparison of our proposal with related approaches. The information questions behind this topic are: III) What are the pros and cons of our design process implemented in Collage compared to other approaches regarding computational

representations? IV) What are the pros and cons of Collage compared to other approaches regarding design? V) What are the pros and cons of Collage compared to other approaches regarding enactment? VI) What are the pros and cons of Collage compared to other approaches regarding observation and trails aspects? VII) What are the pros and cons of our approach compared to other approaches regarding re-use/adaptation aspects? Table 6 gathers the findings around this topic.

**Table 6. Findings Case B “Planet Game” Topic 2 Comparison with related approaches**

	<b>Results</b>	<b>Selected supporting data</b>
<b>Finding III:</b> on the comparison regarding the representation	IMS LD supports the implementation of this script, with the interoperability advantages that it implies	<ul style="list-style-type: none"> <li>- [20, 21, 22] also use the IMS LD computational representation. However, it is worth mentioning that the way of modelling the script using IMS LD notation diverges. This shows the many possibilities of the specification which is flexible enough to describe scripts with the same core design but with different details open to author interpretations, intentions, authoring tool design constraints or features of the available runtime systems.</li> <li>- Only few details cannot be formally expressed using the LD notation itself, such as the automatic random allocation of participants to groups, which on the other hand it is not required by the scenario. In LAMS “the “Grouping” tool – set to divide students randomly into two groups [23]”</li> <li>- Other approaches presented in the workshop do not seem to be more expressive than our approach for representing the proposed script [19]</li> </ul>
<b>Finding IV:</b> on the comparison regarding design	<p>Our design process is pioneer in hiding the concepts of IMS LD by providing an approach that offers visual templates based on sound educational practice.</p> <p>Advanced LD constructs should be incorporated means of reusable elements that represent specific pedagogical-founded design solutions. Collage implements a design process that fosters the reuse of patterns capturing successful CL flow structures. However, other types of reusable elements, such as LAMS activity tools are possible.</p> <p>A possible direction towards a more easily extensible approach of our proposal could be researching the use of more general visual representations.</p>	<ul style="list-style-type: none"> <li>- “Reload and CopperCore are tools at the notation level [...] it is nice to see other approaches here ... that makes easier to use LD... [Video]”</li> <li>- “The building phase is not completely achieved yet in the current version our design language and infrastructure. Indeed, a user-friendly scenario editor destined to the teachers is required... [24].”</li> <li>- “We should keep improving on IMS-LD (standards are hard to impose) Important tasks are to: simplify the graphic languages; extend the EML with basic collaborative templates [21]”</li> <li>- To design the script with LAMS, “The teacher opens LAMS Authoring to create a linear sequence using, in order... (a set of activity tools) [23]”</li> <li>- “The Explor@Graph system is a tool where scenarios are designed as conceptual graphs [...] Designing the scenarios can easily be done top down, first describing the activities, adding description of resources and then adding links to them in the graphs. [...] Not all the needed functionalities are accessible, for example, the integration of evaluation coming from the teachers is not. But the system is certainly very easy to use to describe activities, concepts, to link resources and even integrate support [25] ”</li> </ul>
<b>Finding V:</b> on the comparison regarding enactment	There are diverse architectures to support the enactment of the designs. The differences in the enacted scripts of the different approaches are quite influenced by the available tools.	There are two different perspectives in the approaches participating in the workshop that include execution environments. Explor@Graph [25] and LAMS [23] are integrated systems for authoring and execution, while the approaches of [20, 22, 24] and we employ different systems for design and enactment (CopperCore, LDI and Gridcole). Besides, Gridcole and current developments around CopperCore advocate the integration of external tools according to service-oriented technologies
<b>Finding VI:</b> on the comparison regarding observation and traces	With regard to the current IMS LD tooling, observation and traces aspects are limited to the facilities provided by external tools integrated according to the UoL and by the use of the monitor service element.	<ul style="list-style-type: none"> <li>- [20] argues “observational facilities are provided by the use of IMS LD’s monitor service when linked to specific properties (e.g. responses to questions) for particular roles.</li> <li>- In our design each tool used to support the activities in the design collect log files for monitoring purposes</li> <li>- Other approaches participating in the workshop include their own monitoring facilities</li> </ul>

<p><b>Finding VII:</b> on the comparison regarding re-use/adaptation</p>	<p>Most of the approaches participating in the workshop declare that the resulting script can be easily re-used by changing the content associated to the activities. However we are already reusing a general structure (the Jigsaw pattern). As mentioned in Finding IV other levels of reuse are possible.</p>	<p>- “Though this UoL is planned for a study of the solar system, it can be reused for other subjects by changing document titles and associating different item locations [21]”  - “The pedagogical modelled situation can be re-used in other contexts: only the contents have to be changed [24]”  - The LD script, and screenshots showing its visual creation reusing the Jigsaw CLFP are available at <a href="http://ulises.tel.uva.es/collage/l3astronomy">http://ulises.tel.uva.es/collage/l3astronomy</a></p>
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### 4.3 Case study C: Network Management course

The “Network Management case study” provides an authentic non-trivial educational experience that puts into practice a CSCL script created following the pattern-based visual design process. The script enacted in this case study is originally proposed by one of the teachers implicated in the GSIC/EMIC mini-case study, which is embedded in the “Collage workshops case study”. The teacher represents in the script a learning situation that he has realized without computer support in his Network Management course for several years. In fact, the same teacher participates in the experience under analysis in this “Network Management case study”, putting into practice their own script. In contrast with the previous case studies, this case study considers students (and their teacher) as the interviewees. The experience is described in detail in [26]. Here we gather its main findings according the conceptual structure of the case so that they can be cross-analyzed later with the findings of the other two cases.

The following topics are proposed to guide the study of the issue behind this case:

1. When following the pattern-based visual design process, the teacher selects and combines the CLFPs that best serve the type of task to be solved and that best elicit the desired objectives related to collaborative learning. Then, the teacher particularizes the activities offered in the patterns according to the requirements of the learning situation. Therefore, an important topic refers to the **meaningfulness**



**of the script created with Collage.** That is to say, whether the script created with *Collage* actually reflects the teacher’s design intentions.

2. Accordingly, the **enactment of the CSCL script using Gridcole** is also of interest. This topic focuses the analysis on how the students follow the visually created script using Gridcole along the blended learning experience.
3. On the other hand, we are interested in seeking information regarding the implications of our approach for new research opportunities that affect education. Hence, the third topic considered in the conceptual structure of this case study analyzes in which sense it represents an **educational innovation with respect to previous students’ experiences.**

The information questions that originate from these topics and the resulting findings are the following. Topic 1 has to do with the meaningfulness of the CSCL script created with the visual design process, and includes the questions: I) Is the CSCL script contextualized to the actual learning situation? II) Does the CSCL script guide the learning process coordinating the students at the activity level according to the CLFPs on which is based? III) Does the CSCL script foster the desired objectives related to collaborative learning? The findings belonging to this topic are collected in Table 7.

**Table 7. Findings Case C “Network Management Course” Topic 1 Meaningfulness of the script created with Collage**

	Results	Selected supporting data
<b>Finding I:</b> the script is adequate for the task and objectives of the situation	Students and the teacher value as positive the structure of the experience regarding its utility to reach the objectives of the course and the type of task undertaken in the experience. Further work is necessary to provide more support regarding the preliminary stages of enacting this type of computer-supported experiences.	<ul style="list-style-type: none"> <li>- All students (12 out of 12) and the teacher value as positive (among the available possibilities: negative, acceptable or positive) the structure of the experience regarding its utility to reach the objectives directly related with the content of the course.</li> <li>- In the final questionnaire students say “... the structure is very positive to understand the different SNMP alternatives. I have acquired a good knowledge of SNMP without a great effort”, “... it is positive to break down the paper so that we have collaborated to extract the fundamental concepts of SNMP. Moreover, we have worked with a technical article, what we have never done before”</li> <li>- “The drawback of this type of experiences is the time required to prepare all the details. The tools should provide more support [Teacher questionnaire]”</li> </ul>
<b>Finding II:</b> the script guides the students according to the CLFPs	The script actually structures the teaching / learning process by coordinating the flow of activities according to the combined CLFPs. The experience proceeds to a	- The teacher considers that the development of the experience reflects exactly what he intended to design. However, because of time limitations the teacher decides to skip a phase of the script (it is not a problem of the design but of the actual circumstances that appears at runtime). This is noted in the observations, “The teacher skipped the



	large extent as it is designed in the script. Needs of flexibility emerged during the experience. As designed, the script helps resource distribution. The guidance in the sequence of activities, as indicated by the script, is effective and efficient.	“Pair” phase of the TPS (because of time limitations). He proceeded directly to the discussion...” - “We were distributed in groups and each member of the group read a part of the article [final questionnaire]” - “The use of a script facilitates an efficient achievement of the objectives. Besides it allows the teachers to follow the progress of students final questionnaire”
<b>Finding III:</b> the script promotes the objectives related to collaborative learning	The script truly promotes the expected positive interdependence and individual accountability, which encourage students to reflect on the concepts and to practice the desired competencies.	- The students rate (in a range of 1 (very negative) to 6 (very positive)) with an average of 5.17 (deviation of 0.37) the collaboration with their classmates. The log files generated by the tools and the student outcomes show that all students participate actively. “... it demands an active participation and responsibility, because we have to explain our part to the other members of the group... [discussion]” - “It has been necessary an effort of synthesis and explanation of the accomplished work to the other members of the group in the way of reaching consensus [final questionnaire]”

Topic 2 is related to the enactment of the CSCL script using Gridcole, and comprises the information questions: IV) Can the students follow successfully the CSCL script using the Gridcole system? V) How can the enactment of the CSCL script be improved? Topic 3 has to do with the educational innovation with respect to previous students' experiences, including the question: VI) Does the enactment of the CSCL script enhance students' previous experience in terms of structuring collaboration and use of supporting technology? Table 8 includes the findings around topics 2 and 3.

**Table 8. Findings Case C “Network Management Course” Topics 2, 3 Enactment and Educational innovation**

	Results	Selected supporting data
<b>Finding IV:</b> the students follow the script using Gridcole	Students follow the script successfully using the Gridcole system in the face-to-face as well as in the distant activities	- Log files show students follow the activities - “The tools worked correctly and the activities have been accomplished without problems” “... it is very helpful that the system indicates the objectives of each phase and provides direct access to the tools needed in each activity [Final questionnaire]” - Students rate (in the range of 1 (not useful) to 6 (very useful)) with an average of 5.75 (deviation of 0.43) the usefulness of the system to accomplish the task step by step - “Without the integrating system, the students would have needed to devote more attention to the tools [Teacher questionnaire].
<b>Finding V:</b> improvements associated to flexibility and awareness	Concerns include considering flexibility and incorporating awareness facilities	- See finding II - “I miss an activity index indicating which role should be selected in each moment ... [Final questionnaire]” - “The teacher reminds again that students should change the role [observations]”
<b>Finding VI:</b> new opportunities for structuring collaboration using ICT	Students value very positively the learning scenario in terms of structuring collaboration and use of supporting technology.  Students agree that this experience promotes the development of competencies useful for	- When students are asked to compare how different is this experience compared to their previous ones, nine of them answer that “they have found quite a lot of differences” and the other three indicate that “they have found a lot of differences” [Final questionnaire] - “... sometimes the lack of efficiency makes us to waste time and hate working in groups. The realization of guided (or partly guided) activities and the use of new systems like Gridcole increase the efficiency and our interest in the activities [Final questionnaire]” - “I have felt more guided because I knew what to do in each moment [Final questionnaire]” - “... we, as engineering students, are rather individualist, but in our

	students' future professional life.	professional future we will work collaboratively. Thus, this has been a good training experience and there should be more like this along our education [Final questionnaire]"
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## 5 Cross-case analysis

Previous sections emphasize the distinctive strength of each case, noting its particular context and its functioning. This section undertakes the cross-case analysis. Its purpose is not to revise the common relationships across cases, but to understand the commonality and differences across manifestations of the quintain [10]. The objective is to make assertions about the quintain and specifically to the derived research question:

1) *Does the proposed pattern-based visual design process facilitate the high-level generation of contextualized CSCL scripts reusing CLFPs and focusing on CSCL critical elements?* An additional question emerged as a result of the cross-case analysis. This question can be formulated as: 2) *What predictions can we make about future developments around the visual representations, LD and CSCL scripts?*

The assertions are understood better because of the particular activity of each case.

The evidence that leads to the assertions needs to be indicated through the case findings. Table 9, Table 10 and Table 11 illustrate the strategy adopted for formulating assertions, which emphasizes the various situations and findings of the cases. It consists of rating each case finding as to its importance for understanding the quintain through a particular question. As indicated in section 3.5 of [10], we use a three-point scale in which a high mark means that for a particular question, the case findings are of high importance (H = high importance; M = middling importance; L = low importance). When a finding is of significant relevance considering a particular question, the tables include a summary of the finding in the corresponding cell. The procedure accomplished



is moving from case A finding I to case C finding VI. For each finding, we describe its utility and prominence for its contribution to each question.

**Table 9. Partial matrix for generating question-based assertions from case findings, case A (adapted from the worksheet 5A of [9]) H = high importance; M = middling importance; L = low importance. A high mark means that for this question, the case findings are of high importance**

<b>Case A “Collage Workshops”</b>	<b>1) Does the proposed pattern-based visual design process facilitate the high-level generation of contextualized CSCL scripts reusing CLFPs and focusing on CSCL critical elements?</b>	<b>2) What predictions can we make about future developments around the visual representations, LD and CSCL scripts?</b>
<b>Finding I:</b> on the selection and representation of CLFP-based LD templates	<b>H</b> (The design process promotes the understanding of the patterns) (Practitioners’ ideas about the CL strategies collected in the CLFPs coincide with what is visually presented in Collage)	<b>H</b> (Other examples of well-known CL strategies; patterns for assessment)
<b>Finding II:</b> on the trade-off between reuse of patterns and design options	<b>H</b> (The design process facilitates the reuse of CLFPs when structuring collaborative learning designs; the combination of patterns provides outstanding design flexibility; particularized according to the needs of concrete learning situations; satisfactory trade-off between flexibility, keeping the essence captured in the CLFPs, hiding LD-specific technological details and providing a clear (but limited) set of design options)	<b>H</b> (Pattern-based templates are probably more useful in the process of customizing a new situation than ready-to-run scripts, but complete (or partly complete) examples are also helpful)
<b>Finding III:</b> focus on learning objectives and task type	<b>H</b> (The proposed process helps to determine the learning objectives related to collaborative learning that will be promoted and to select the task-type that will be solved by the students; the design process helps to determine the expected interaction)	<b>L</b>
<b>Finding IV:</b> focus on the structure regarding the activity flow and group hierarchy	<b>H</b> (The support that the visual design process provides to determine the structure of the activity flow is very satisfactory; it helps to understand and determine the structure regarding the hierarchy of groups)	<b>L</b>
<b>Finding V:</b> focus on group size and support within the activities	<b>H</b> (The design process helps to establish the group size; determine the distribution of resources among activities as well as to the computer support; the process helps to describe each activity and its eventual (textually-defined) structure according to the envisaged expected interaction)	<b>M</b> (The determination of the group size limits can be improved, for instance, with automatic checkups) <b>H</b> (Collage does not provide suggestions of recommended content or tools)
<b>Finding VI:</b> Collage, easier-to-use CL-specific LD editor	<b>H</b> (Most of the participants find Collage user-friendly and intuitive; the participants are able to create an almost completed example during the workshops; Collage is easier to use, specific to collaborative learning, and it is the first editor providing pattern-based templates)	<b>L</b>
<b>Finding VII:</b> improvements with additional design options and integration with complimentary tools	<b>L</b>	<b>H</b> (Integration of Collage with complementary needed tools, supporting flexibility; information reflected in the resulting scripts is also useful for the students)
<b>Finding VIII:</b> audience interested in CL and in the use of ICT	<b>H</b> (Audience interested in designing CL processes to be used with an LMS in face-to-face, distant or blended situations or as lesson plans; the design process provides ideas and fosters design creativity; it is not necessary to be expert (LD) technologists)	<b>L</b>

**Table 10. Partial matrix for generating question-based assertions from case findings, case B**

<b>Case B “Planet Game”</b>	<b>1) Does the proposed pattern-based visual design process facilitate the high-level generation of contextualized CSCL scripts reusing CLFPs and focusing on CSCL critical elements?</b>	<b>2) What predictions can we make about future developments around the visual representations, LD and CSCL scripts?</b>

<b>Finding I:</b> the main aspects of the script can be designed with Collage	<b>H</b> (The main aspects of the script can be visually modelled with Collage)	<b>H</b> (general way of specifying a group-service (not necessarily dedicated to conferences) is using the conference service element of IMS LD and an external binding document that indicates which groups need a different instance of the service)
<b>Finding II:</b> the script created with Collage can be enacted using Gridcole system	<b>M</b> (Gridcole system, which includes the CopperCore IMS LD engine, is capable of interpreting the UoL created using Collage)	<b>L</b>
<b>Finding III:</b> on the comparison regarding the computational representation	<b>M</b> (IMS LD supports the implementation of this script, with the interoperability advantages that it implies)	<b>H</b> (Group formation policy which could be instead supported by complementary specifications and administration tools; more (collaborative) tools and description of tools are needed in IMS LD)
<b>Finding IV:</b> on the comparison regarding design	<b>H</b> (Collage is pioneering in hiding the concepts of IMS LD by providing a design process that offers visually represented templates based on sound educational practice)	<b>H</b> (Incorporate advanced IMS LD constructs in Collage by means of reusable elements that represent specific pedagogical-founded design solutions), using more general representations, other types of reusable elements)
<b>Finding V:</b> on the comparison regarding enactment	<b>L</b>	<b>H</b> (Service integration can solve the problem of limited availability of tools; user-friendly administrative facilities needed when instantiating UoLs; mobile devices and tighter integration of design and enactment systems to increase flexibility at runtime)
<b>Finding VI:</b> on the comparison regarding observation and traces	<b>L</b>	<b>H</b> (Observation and traces aspects are limited to the facilities provided by external tools integrated according to the UoL and by the use of the monitor service element)
<b>Finding VII:</b> on the comparison regarding re-use/adaptation	<b>H</b> (We are already reusing a general structure – Jigsaw CLFP). Besides, since the Jigsaw template implemented in Collage specifies the groups in a general manner, the possibilities of re-using the script increases)	<b>M</b>

**Table 11. Partial matrix for generating question-based assertions from case findings, case C**

<b>Case C “Network Management Course”</b>	<b>1) Does the proposed pattern-based visual design process facilitate the high-level generation of contextualized CSCL scripts reusing CLFPs and focusing on CSCL critical elements?</b>	<b>2) What predictions can we make about future developments around the visual representations, LD and CSCL scripts?</b>
<b>Finding I:</b> the script is adequate for the task and objectives of the situation	<b>H</b> (Reach the objectives directly related with the content of the course; the structure of the experience is considered adequate for the type of task undertaken in the experience)	<b>H</b> (Provide more support regarding the preliminary stages of enacting this type of computer-supported experiences)
<b>Finding II:</b> the script guides the students according to the CLFPs	<b>H</b> (The experience proceeds it is designed in the script; the guidance in the sequence of activities is effective and efficient, as planned)	<b>L</b>
<b>Finding III:</b> the script promotes the objectives related to collaborative learning	<b>H</b> (The script fosters the desired objectives related to collaborative learning)	<b>L</b>
<b>Finding IV:</b> the students follow the script using Gridcole	<b>M</b> (Students follow the script successfully using the Gridcole system; students find the system very useful supporting collaboration and indicating what to do and which tools to use in each activity, and they consider that having access to the system from home provides flexibility)	<b>L</b>
<b>Finding V:</b> improvements associated to flexibility, awareness and authentication	<b>L</b>	<b>H</b> (Needs of flexibility - change the composition of groups; enhancing the intuitiveness of the interface and the addition of awareness and authentication utilities)
<b>Finding VI:</b> new opportunities for	<b>H</b> (Students value very positively the learning scenario in terms of structuring collaboration and use of supporting	<b>L</b>

structuring collaboration using ICT	technology; usefulness of the design process to increase the probability of reaching learning outcomes)	
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Next subsections gather the high-importance findings for each question, as suggested by the entries in Table 9, Table 10 and Table 11 and formulate assertions that can help to satisfactorily understand the benefits and predictions for improvement of the pattern-based visual design process. Figure 3 summarizes the assertions resulting from the cross-case analysis.

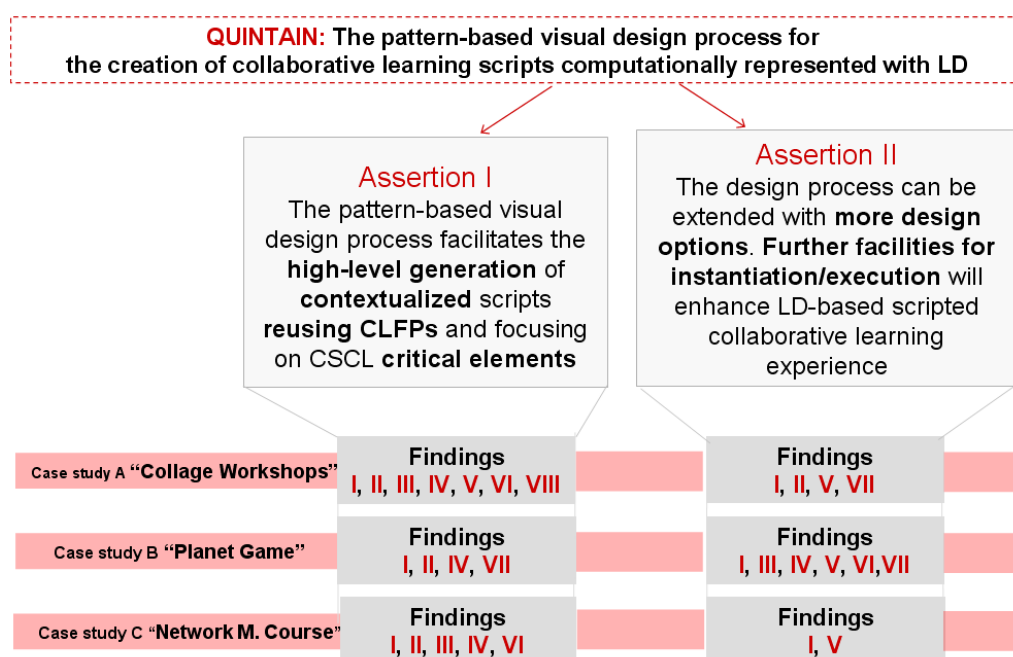


Figure 3. Analysis resulting from the cross-case analysis

### 5.1 Assertion 1

Question 1 appears significantly in case A (Collage Workshops), what indicates the relevance of this case for validating the pattern-based visual design process. This fact is also highlighted in the formulation of the multicase study, which anticipates that the main activity enabling the evaluation refers to the functioning of creating CSCL scripts by the target audience. On the other hand, the findings of case B (Planet Game) and case C

(Network Management Course) provide additional evidence that combined with case A's findings lead to the assertion: "the pattern-based visual design process facilitates the high-level generation of contextualized scripts reusing CLFPs and focusing on CSCL critical elements."

First of all, case B's findings I and IV (Table 10) indicate that the main aspects of a script proposed by a third-party can be modelled with Collage, which implements a pioneering approach: hiding concepts of LD by providing a design process that offers visual templates based on sound collaborative learning practices. These practices are formulated in terms of reusable patterns (CLFPs) that capture expertise regarding CL flow structures. The originality of Collage is also emphasized by case A's finding VI, which concludes that Collage is easier to use, specific to collaborative learning, and it is the first LD compliant editor providing pattern-based templates. As expected, the audience of the approach are teachers interested in collaborative learning and using ICT in their practice. They do not need to be collaborative learning experts (the design process provides ideas and fosters the design creativity of users) or experts in IMS specifications such as LD.

According to finding I of case A (Table 9), a critical phase of the design process is the selection of CLFPs, which promotes the understanding of the patterns. Besides, the analysis of the different experiences studied in case A shows that the steps of the authoring phase facilitate the reuse of the visually presented patterns in such a way that the resulting script is particularized according to the needs of a specific situation (finding II). Collage achieves a trade-off between flexibility (in which the combination of patterns plays an important role), keeping the essence captured in the patterns and hiding LD-specific technological details and providing a clear (but limited) visual set of design



options. Several findings of case C also imply that the generated script, which is experienced by the students, is contextualized according to their particular situation. For example, findings VI and I (cf. Table 11) indicate that students value very positively the scripted experience whose structure is considered adequate for the undertaken type of task and which facilitates reaching the objectives directly related to the concepts of the course.

The learning objectives and the type of task are in effect important CSCL critical elements according to which the design process enables the conceptualization of the expected interaction in advance. Case A's finding III and case C's finding III provide evidence in this line. Moreover, findings IV and V of case A reveal that the design process makes teachers focus on other critical elements. In this way, its support regarding the determination of the structure of the activity flow and the group hierarchy is very satisfactory. The design process also helps to establish the group size, the textual description of the (eventually micro-structured) activities, the distribution of resources and the computer support.

The fact that the script created within case B can be successfully enacted with a system indicates that the visually created scripts actually reflect the design intentions. A stronger statement in this sense occurs in case C's findings, especially in findings II and IV which testify that the experience with real students proceeds as it is designed in the script.



## 5.2 ***Assertion 2***

The combination of case findings regarding this question 2 originates the assertion: “the design process can be extended with more design options and further facilities for instantiation and execution will enhance LD-based scripted CSCL.”

Future work regarding the approach is pointed out in findings of case A (Collage Workshops) and case B (“Planet Game”). It includes incorporating other types of patterns, such as those related to assessment (case A’s finding I) which will require additional visualization aspects. This idea is in line with the possibility of integrating other types of reusable elements at other levels of granularity and completeness (case A’s finding II). Finding IV of case B discusses that the approach could incorporate advance LD constructs by means of reusable elements that represent specific pedagogical-founded design solutions. In this sense, a future research line is the study of the trade-offs between using more general graphical representations instead of the specific diagrams of the patterns’ solutions (among other things, to facilitate the integration of more reusable elements) vs. the intuitiveness.

Further facilities can be added to the implementation of the approach in authoring tools. For example, case A’s finding V suggests improving the support of the determination of the group size limits in group hierarchies with automatic checkups. It is also important to mention here the need of (generally) specifying group services within the environments supporting collaborative activities. This need appears in cases B (findings I and III) and C (“Network Management Course”).

Moreover, Case B’s finding V indicates that service integration into IMS LD environments can solve the problem of limited availability of tools in current LMSs, what constrains the design possibilities. A related problem is searching the (service-based)





tools that are adequate for supporting the script and which can be integrated by these systems. This need also appears in case A's finding V which points out that Collage does not provide suggestions of recommended content or tools.

The teacher interviewed in case C (finding I) manifests that enhanced support regarding the preliminary stages of enacting this type of computer-supported experiences is needed. It refers mainly to user-friendly administrative facilities needed when instantiating UoLs (e.g. creating the actual number of groups, associating users to groups). This is also a conclusion of case B's finding V.

On the other hand, observation and traces aspects are currently limited to the facilities provided by external tools integrated according to the UoL and by the use of the monitor service element (case B's finding VI). Further research and development is needed in this sense, on for example how the awareness of the students about their own and their group partners progress along the script can be supported (case A's finding VII).

Needs of flexibility are patent in CSCL scripted situations, LD tooling should consider flexibility facilities such as easily changing the composition of groups at runtime. This idea occurs for example in case C's finding V and is enforced in finding V of case B. It can be envisaged that tighter integration of design, instantiation and enactment systems will increase the flexibility.


## **6 Conclusions**

This paper has presented a multicase study that comprises three different cases which aim at assessing a pattern-based visual design process for the creation of collaborative learning scripts implemented in the Collage authoring tool. Each case evaluates the design process from different perspectives: teachers creating a script, the modelling of an arbitrary design (proposed by a third party), and applying a design created with



Collage in a real educational situation. The cross analysis of the findings resulting from each case has led us to answer affirmatively the main research question of this paper "Does the proposed pattern-based visual design approach facilitate the high-level generation of contextualized CSCL scripts reusing CLFPs and focusing on CSCL critical elements?" The study has also revealed us that more design options and further facilities for instantiation and execution will enhance the whole lifecycle in which the design process is framed.

Several reflections can be done after the analysis of the multicase. The quantitative data help to indicate tendencies around the issues of interest, but it is the comparative analysis of the qualitative data what lead to understand and explain the achievements of the visual design process as it is used in the several cases studied. In this way, the results presented in this paper imply a devoted work of data analysis and interpretation which is significantly demanding and whose outcomes cannot be easily generalized. However, the conclusions in form of case findings and multicase assertions show their value beyond the "simple" illustration of having reached the objectives of the approach and entail additional results which offer relevant founded clues for future work. Part of the future work identified are currently under accomplishment in the areas of extending the design options with assessment aspects [27], supporting the instantiation of the designs created according to the approach [28] and enabling the search of supporting tools [29]. Surprisingly, multicase studies are not typically used with instrumental evaluation purposes in the domain of Educational Technology, including visual instructional design languages and applications. This paper also represents a methodological show case illustrating how the study of different cases involving diverse



functionings, perspectives or manifestations of a proposed approach provides complementary findings that lead to global cross-case conclusions.

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