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Exploring Teachers' Perceptions on Modeling Effort Demanded by CSCL Designs with Explicit Artifact Flow Support

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Abstract: Artifact flow represents an important aspect of teaching/learning processes, especially in CSCL situations in which complex relationships may be found. However, explicit modeling of CSCL processes with artifact flow may increase the cognitive load and associated effort of the teachers-designers and therefore decrease the efficiency of the design process. The empirical study, reported in this paper and grounded on mixed methods, provides evidence of the effort overload when teachers are involved in designing CSCL situations in a controlled environment. The results of the study illustrate the problem through the subjective perception of the participating teachers, complemented with objective parameters, such as time consumed, errors committed, uncertainty and objective complexity metrics.

Keywords: CSCL, Learning design, artifact flow, effort subjective measurement
Categories: H.3.1, H.3.2, H.3.3, H.3.7, H.5.1

1 Introduction

The explicit artifact flow definition has been found to be important in the field of Learning Design and especially in collaborative learning processes. This coordination mechanism helps managing the dependencies (e.g. time, documents, etc.) among the individual or group activities in particular CSCL scenarios. For instance, in a basic PEER REVIEW activity the task of criticizing should start once two conditions are fulfilled: the specific task of reporting is completed and delivered reports (e.g. documents or other products types) are available for specific group or individual tasks [Derntl et al. 2012]. Satisfying these dependencies in design-time may lead to an efficient implementation of best practices but at the same time, such definition process may be highly demanding and error-prone even for typical situations. Additionally, in run-time, misunderstandings or omissions on processing artifacts created individually or in group may jeopardize the completion of the whole activity [Palomino et al. 2013] and teachers or facilitators need to be aware about how the learning process should be or is conducted [Rodríguez-Triana et al. 2013].

The information associated with incorporating the artifact flow definition adds complexity to the CSCL designs, as well as the proneness of committing mistakes during the design process. Complexity measures based on standards (ISO 9126) identify as the most influencing factors the number of design variables involved. The teacher-designer may neither consider these variables at design time, nor the effect of their interaction on the learning process performance. Some examples of these variables refer to the manner the artifacts are provided, how the learners are regrouped along the process, or functional features of the learning tools in use. Reuse-based approaches [Palomino et al. 2013] may save time and effort but there has been no consensus in the CSCL community about the formalization of such reusable models based on effectiveness criteria [Alvino et al. 2009].

Available authoring and deployment tools do not provide sufficient support to assist teachers on designing, reusing and particularizing CSCL scenarios with explicit definition of artifact flow. For instance, using WebCollage the teacher-designer is responsible to manually set the dependencies one-by-one, and therefore they do not have enough time and support in order to carry out an efficient design process or reflect on artifact flow from pedagogical and management perspectives [Karakostas et al. 2012]. Despite the exploratory studies conducted through the analysis of complexity based on objective metrics or the characterization of current authoring tools, it deems necessary to develop a realistic study enrolling teachers to evaluate their subjective perception on modeling effort when the artifact flow mechanism is introduced. Thus our research question is formulated as follows: [RQ] How do teachers-designers perceive the effort required by modeling CSCL scenarios with explicit definition of artifact flow?

To explore this question, we have conducted a study with university teachers from different disciplines with different level of experience on Computer Supported Collaborative Learning (CSCL), given their participation in professional development workshops or in research experiences in this field. The goal of the ArtFlowDER study (Artifact Flow Design-Effort-Redesign) described in this paper was to assess the effort perceived by real teachers on designing realistic and functional CSCL scenarios in two different design situations. Firstly, they customized a CSCL scenario, in which constraints were imposed by the use of specific collaboration strategies. Secondly, the teachers reused their previous ideas and the initial learning design to set a new scenario with a different class size. The effort perceived is estimated by combining the teacher's subjective assessment, the measurement of time consumed, the number of errors committed or breakdowns, and the complexity of the designs, as well as findings derived from observations. Thus, to reach some conclusions, through this study we gather and analyze data about the effort devoted by the participating teachers and aim to suggest factors that may explain the phenomenon. Note that, as compared to [Bordiés and Dimitriadis, 2014], the ArtFlowDER study aims to measuring perceived effort, when teachers-designers work with a real-world complex scenario, which includes multiple types of activities.

The structure of the paper is as follows: in the next section works related with the modeling effort measurements and model complexity metrics are presented and analyzed, including those related with CSCL modeling. Section 3 describes the ArtFlowDER study, i.e. its context, the methodology adopted, the interventions that were made and the associated data gathering techniques. In the following section, the results of the study are presented and discussed, while the section 5 summarizes the conclusions and provides pointers for future work.

2 Effort estimation in CSCL design processes

The Learning Design approach and tools attracted the interest of the research community during the last decade, since their benefits in supporting teacher-designers during the design process of learning activities [Conole, 2012]. Collaborative learning is especially challenging in terms of learning design, since the incorporation of social interaction for group knowledge building is made at expense of making learning designs necessarily more complex. Despite of such benefits, the adoption of the learning design approach in CSCL by the teacher community is still low [Prieto et al. 2014]. Several studies assessed the teacher perception regarding available learning design approaches and multiple authoring tools; nevertheless the design effort perception is an issue that has not been sufficiently studied as a way of explaining the low adoption issue.

Teachers are frequently involved in learning design processes as designers [Casey et al. 2008]. In most higher education institutions teachers are called to act as designers and deployers of learning scenarios allowing communicate their own pedagogical decisions [Derntl et al. 2012]. From the technical-professional perspective they may build ready-to-use learning activities design from scratch, redesign their own products doing cosmetic adaptations, redesign products created by other stakeholders and also cooperating with other colleagues. Teachers also learn through the process of designing but typically they lack time to develop their instructional design expertise and the available authoring tools present usability issues [McKenney et al. 2015]. For instance, a study of the WebCollage tool [Karakostas et al. 2012] shows its limitations with respect to the management of the artifact flow dependency among the activities during the particularization process. Other authoring tools do not even contemplate the possibility of efficiently modeling the flow of artifacts. Therefore, it deems necessary to evaluate the effort perceived by teacher when they are designing CSCL scenarios with explicit artifact flow definition considering the limitations of the authoring tools and the inherent complexity of plausible CSCL scenarios, and provide evidences regarding the importance of the artifact flow definition in this perception.

This paper pays attention to advanced designs, which complement the definition of learning activity flows with explicit artifact flow definition. This coordination mechanism aims to satisfy the dependencies among group or individual activities involved in the teaching and learning process [Miao et al. 2007] [Palomino et al. 2013]. Such interactions are complex and deeply grounded in context [Malone and Crowston, 1994]; and according to objective measures applied on a tiny group of synthetic PEER REVIEW designs the demand rises to 3 times more of information content, and may generate about 2 times of uncertainty, as compared to learning designs without artifact flow definition [Bordiés and Dimitriadis, 2014]. Parameters such as the access mode, the number of artifacts involved, and the number of peer groups resulting as the most influencing factors in terms of complexity.

The measurement of effort in the field of workflow process modeling has been addressed mainly through the proposal of objective complexity metrics [Braha and Maimon, 1998] [Mendling, 2008] [Wu et al. 2010]. Currently most of these metrics are not empirically validated [Muketha et al. 2010] [Sánchez González et al. 2010] and there is not enough evidence that they can serve as predictors of assessing the effort perceived by human designers, when such perception is affected by several factors in a modeling scenario. For instance, in the field of process modeling the correlation between control flow complexity and perceived complexity have been validated [Cardoso, 2006], as well as with the proneness of error situations occurred at a runtime process with its model complexity [Mendling, 2008]. However, in the field of CSCL design, there is still need for studies in which the perception on modeling effort should be determined and complemented with objective metrics.

3 The ArtFlowDER study

The rest of this section will describe the study context, the methodology adopted, as well as the interventions that were carried out. Such information is necessary in order to interpret appropriately the study results, which are shown in the following section.

3.1 Context

The ArtFlowDER study was conducted within a laboratory research context in working sessions that took place between December 2014 and October 2015. Each session took approximately 2 hours of work. A total of 15 university teachers from different teaching areas (Computer and Telecommunication engineering, Medicine, Nursing, Education, Philosophy and Geography) and profiles were enrolled in these sessions. Eight of them are teachers who had participated in previous professional development workshops on collaboration strategies and CSCL design. The other seven teachers have experience researching on CSCL design and ICT. Each face-to-face session was composed of two main tasks in which the participating teachers were invited to customize [DESIGN] a generic CSCL scenario (named MOSAIC) provided in a document. They followed the orientations incorporated therein related with contextual characteristic, such as the class size and the available educative ICT tools. During the second task, they reused the initial design to adapt it to a different class size [REDESIGN].

The MOSAIC scenario is a real word scenario employed also in [Palomino et al. 2013], and it is composed of 6 phases involving several collaboration strategies (PUZZLE, SNOWBALL, PEER REVIEW and GROUP FORMATION) [Hernández-Leo et al. 2006] [Karakostas and Demetriadis, 2011]. As depicted in Table 1, the SNOWBALL is composed of 3 levels; the first level integrates a PUZZLE structure whose phases are interwoven with PEER REVIEW situations. The MOSAIC description also incorporated four artifact flow dependency constructs or variability facets [Bordiés et al. 2014] (in bold and tagged as [VF1, 2, 3 & 4]), where two or more activities are involved. In these constructs the relationships among the activities are expressed as constraints or rules in terms of the coordination components (Goal, Activity, Actors and Dependencies) [Malone and Crowston, 1994], thus allowing to choose a particular configuration within the resulting set of valuable settings.

In the first task (DESIGN) of the sessions the teachers are encouraged to customize the CSCL scenario described in the document and follow the orientations provided to them a few days before. This way the teachers came to participate with some previous knowledge of what to do, thus saving time and avoiding a "cold start" effect at the beginning of the sessions, just as they would do in real situations. To achieve the first task participating teachers are also provided with a worksheet which consists in a dot matrix, where the Y-axis represents the phases sequence and the colored dots on X-axis represent the organization of individuals or groups in each phase (Figure 1 shows a participant together with the worksheet).

No	MOSAIC phase description
P1	Initial subphase of PUZZLE: students create an initial version of a concept map. To do so individuals or groups involved in the first phase study 3 supporting documents (one on each "dimension" of the problem in question). At the end, each individual/group should review the concept maps generated by peers who have studied the same initial documents [VF1] (PEER REVIEW).
P2	Expert subphase of PUZZLE: students-experts, who have studied the same "dimension" problem, group together in order to discuss and generate a new version of the concept map. Again, students review the concept maps created by other expert groups and provide appropriate feedback [VF2] (PEER REVIEW).
P3	Final subphase of PUZZLE: student-experts of different "dimensions" of the problem are incorporated in puzzle groups to generate a new conceptual map. Once generated, the students individually reflect on the maps generated by other puzzle groups [VF3] (PEER REVIEW). Complementarily, the teachers supporting the activity read and analyze the maps created by the various puzzle groups [VF4]. This support task allows teachers to decide on the most suitable combination of groups of the second phase of the SNOWBALL.
P4	Phase 2 of SNOWBALL: students are grouped according to the decision made by the teaching staff (GROUP FORMATION). The new groups now produce a fourth reconciled version of the concept map.
P5	Phase 3 of SNOWBALL: Students, as a whole class, generate the final version of the concept map based on the maps of the previous phase.

Table 1: MOSAIC pattern-based scenario description

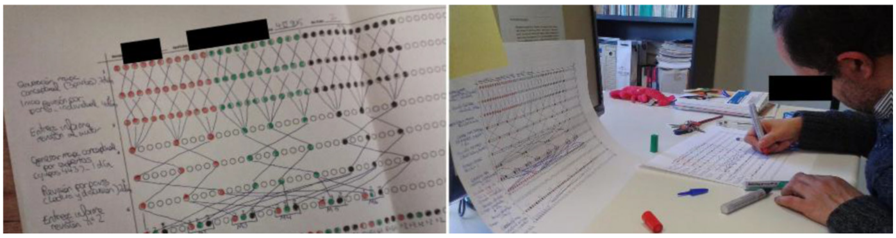


Figure 1: Participant teacher working with the worksheet provided

The worksheet approach was adopted as instrumental tool instead of working with more demanding LD authoring tools, such as WebCollage/GLUE!-PS [Karakostas et al. 2012], edit2 [Sobreira and Tchounikine, 2012], or directly using the target virtual learning environments, such as Moodle. We opted not to use specific authoring tools and learning environments, in order to keep low the duration of the experiment, and at the same time allow for ICT-independent findings. The artifact flow sequencing is represented by interconnecting clustered or single dots of different phases with colored lines or arrows. With regards to the second task [REDESIGN], the participating teachers are invited to rethink their initial design, considering a new requirement, i.e. that the class size has been reduced by approximately a 30% (from 48 to 34 learners). The fact that both DESIGN and REDESIGN tasks were performed in the same session allowed participants to reflect and perceive better the differences between the requirements and the proposals that they made.

3.2 Methodology

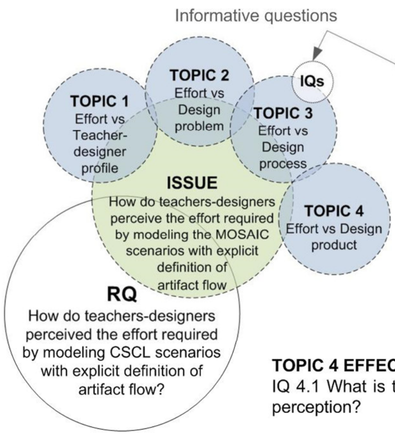
To explore the research question about the teachers' perceptions of effort demanded by the design CSCL scenarios with explicit artifact flow support, we performed a mixed methods study [Creswell, 2013]. Mixed methods are considered as the most adequate to explore complex phenomena in the field of CSCL involving multiple perspectives [Suthers, 2006] [Stribos and Fischer, 2007]. Specifically, we analyze qualitative and quantitative evidence simultaneously, using qualitative data to explore in-depth the phenomena and identify emergent issues, while the quantitative data is used complementarily to show trends. We interpret the data without pursuing the generalization of results but providing an in-depth analysis of the phenomenon under study, i.e. the artifact flow modeling in CSCL design and redesign [Guba, 1981].

The analysis of our qualitative and quantitative evidence is structured using a "data reduction" method [Miles and Huberman, 1994] along the evaluation process [see Fig. 2] though Issue, Topics and Informative Questions (IQs). The Issue is the concept around which the evaluation process is organized. Our Issue, the effort perceived by the participant teachers in creating the MOSAIC scenario is explored according to the complexity components as main categories or topics (see Figure 2). The Topics refer respectively to the relation between Effort and Teacher-designer Profile [TOPIC 1], the Design Problem [TOPIC 2], the Design Process [TOPIC 3] and the Design Product [TOPIC 4] [Summers and Shah, 2010]. Then, these categories and their metrics are complemented with specific informative questions adopted from the framework for empirical evaluation of conceptual modeling techniques proposed in [Gemino and Wand, 2004]. These informative questions aim to explain the relationship between affected factors (e.g. the effort perceived on reusing designs), and influencing factors (e.g. task performed: design, redesign) and assess the conceptual modeling techniques in use such as the CL pattern language or best practices adopted from the community (e.g. on group formation, artifact sequencing).

Our study used a variety of data gathering techniques (see figure 3 for a detailed graphical description, which uses the codes explained here): web-based questionnaires with Likert-scale and open questions, observation notes, video recordings of the face-to-face sessions, and participant-generated artifacts (worksheets) coming from the work sessions. Qualitative data is gathered during the DESIGN (x=1) and REDESIGN (x=2) tasks, through observation notes [Obs x] and video recordings [Rec x], and from the answers to the open questions of the initial questionnaire [Quest0], regarding participants' profile, and from the answers of the final questionnaire [Quest 3], regarding participant's assessment of the activities. The quantitative data is gathered from the 5-point Likert-scale profile and assessment questionnaire [Quest 0, Quest 3], features observed [Obs x, Rec x], and from metrics [Metric 3] of models represented in worksheets [Worksheet x]. Based on the aforementioned raw quantitative data we measure the correlation among the profile [Quest 0], PROBLEM, PROCESS, PRODUCT parameters [Obs x, Rec x], and the effort assessment values as well as the differences between DESIGN and REDESIGN tasks.

TOPIC_1: EFFECT OF THE TEACHER-DESIGNER PROFILE ON EFFORT PERCEPTION
IQ 1.1- Does the uncertainty generated by the lack of knowledge of CL technoques affect effort perception?
IQ 1.2 Does the uncertainty related to the lack of experience of configuring CL scenarios affect effort perception?
IQ 1.3 What is the correlation of the explicit expressions on the dichotomy experience/inexperience and the effecort perception?.

TOPIC 2 EFFECT OF THE DESIGN PROBLEM ON EFFORT PERCEPTION
IQ 2.1- Does the plausibility of the proposed design solution and the design task influence the effort perception?
IQ 2.2 Does the proposal of pedagogically effective solutions to CL situations with artifact flow requires a significant effort?
IQ 2.3 Do the conceptual errors get wors when CL situations with artifiact flows get worse?
IQ 2.4 What is the effect of the redesign task to effort perception?



TOPIC 3 EFFECT OF THE DESIGN PROCESS ON EFFORT PERCEPTION
IQ 3.1 Do teachers perceive that the process (sequence of steps to follow) of designing CL scenarios with artifact flow demands a lot of effort?
IQ 3.2 Does making mapping mistakes (representation of the solution at the worksheet) contribute to an increased effort perception?
IQ 3.3. Does the task of modeling CL scenarios with artifact flow is prone to generate situations of overwhelm and breakdown?
IQ 3.4 Does the uncertainty related to the design process contribute to the perception of additional effort?

TOPIC 4 EFFECT OF THE DESIGN PRODUCT ON EFFORT PERCEPTION
IQ 4.1 What is the effect of the complexity of the designed solution to the effort perception?

Figure 2: Data reduction schema showing the Research Question (RQ), the corresponding Issue (I), the four TOPICs and the Informative Questions (IQs) that are associated to each topic (in both graphical and textual representations).

3.3 Description of the interventions

The mixed method evaluation flow employs various data gathering techniques and data sources employed prior to, during and after the DESIGN and REDESIGN tasks, (see Fig. 3, for a graphical representation where labels are defined, so that they can be referenced throughout the text). Initially, participants of the ArtFlowDER sessions fill a profile questionnaire [Quest 0] (see Appendix), while the DESIGN and REDESIGN tasks are carried out with as fewer interventions as possible by the researcher. As explained before, the participants were invited to customize the MOSAIC scenario considering both intrinsic and extrinsic restrictions [Dillenbourg and Tchounikine, 2007]. The former are related with characteristics of the collaborative strategies involved. The latter are inferred from parameters such as the size of the class (initially 48 students) and the ICT tools available (BSCW or Google Documents) and the fulfillment of a functional setting as requirement. Nevertheless, when initiating the face-to-face sessions, the participants were informed by the researcher about the degrees of freedom available to modify the sequences of activities, incorporate different alternatives, etc. The activity was completed once all groups have been formed for each phase of the scenario, tools and delivery times have been assigned, and dependencies among individual or group activities have been satisfied [Worksheet x]. During the process the researcher observes [Obs x], measures time consumed for reflection [REFLEX x] and mapping [MAPP x] each task x (1 or 2, for DESIGN and REDESIGN, respectively) and the setting options considered by the teacher [OOBS x], takes notes about the happenings, clarifies the doubts posed by the participants, intervenes to know which are the setting options that have been considered in the process, and finally remarks the need of representing all the particular dependencies in the same way, as participants would do when using authoring tools they are eventually familiar with.

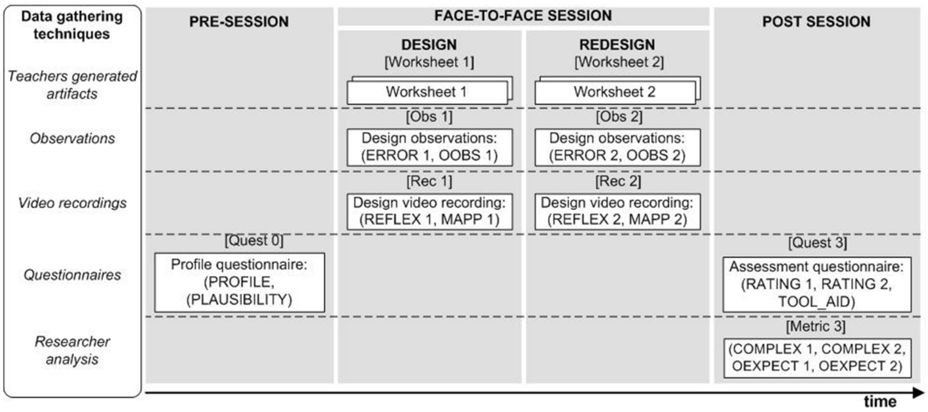


Figure 3: Data gathering and analysis techniques used during the mixed methods study. The techniques were carried out before (PRE-SESSION), during (FACE-TO-FACE SESSION: DESIGN and REDESIGN tasks) and after the session (POST-SESSION). Data source labels (between brackets) and parameters (between parentheses) are also shown.

In the end of the session, participants fill an assessment questionnaire [Quest 3] (see Appendix, where codes for parameters and features are shown in bold). On the other hand, the researcher processes the design and redesigns worksheets [Worksheet 1&2] using process model metrics [Metric 3] and performs the corresponding quantitative and qualitative analysis.

4 Results and discussion

This section summarizes the main results and findings obtained in the ArtFlowDER study. Overall, participating teachers perceive the effort differently, depending on their profiles as designers, the particularities of the task or the inherent characteristics of the modeling. The following subsections describe the main findings in the study, which are structured according to the TOPICs and Informative Questions (IQs), defined in the data reduction process (see Fig. 2). A selection of the qualitative and quantitative evidence that support these findings is presented, while a summary of processed numerical results (values of parameters and total numbers of features occurrences) is shown in Tables 2 and 3 respectively.

				PROFILE			PROBLEM	PROCESS											PRODUCT	
PARMETERS	RATING_1	RATING_2	TOOL_AID	ARTFLOW	PROFILE	ICT_CL	PLAUSIBILITY	ERROR_1	ERROR_2	OOBS_1	OOBS_2	OEXPECT_1	OEXPECT_2	REFLEX_1	REFLEX_2	MAPP_1	MAPP_2	COMPLEX_1	COMPLEX_2
HI-R	4.6	2.9	3.9	3.7	16.7	3.9	3.9	1.6	1.2	6.3	4.1	27.3	16	43	9	25	16	161	148
LO-R	2.4	2.1	3.5	3.6	15	3.8	4.1	0.9	0.8	6.1	4.1	26.5	11	33	8	22	9	160	150
HI-P	3.1	2.6	3.9	4.8	18.8	4.6	4.0	0.9	0.9	5.8	4	26.5	15	34	6	23	10	143	133
LO-P	3.8	2.3	3.5	2.2	11.8	2.7	4.0	1.3	1.3	6.7	4.3	27	13	43	11	24	17	184	171

Table 2: Summary of parameters associated to TOPICs. The first row denotes the four topics; the second row includes the parameters that correspond to each topic (codes are explained in sections 3.1, 3.3 and in Appendix). The last four rows show the values of the parameters, disaggregated by the teachers who provided high and low ratings (HI-R and LO-R) and showed high and values of profile (HI-P and LO-P).

		PROFILE			PROBLEM									PROCESS				PRODUCT
FEATURES	*tool aid*	*expert/novel*	*management issue*	*info uncertainty*	*plausibility*	*studio setting*	*class size*	*basic ideas*	*effective solutions*	*redesign/design*	*design/redesign*	*problem_effort*	*conceptual mistakes*	*uncert_entropy*	*mapping_errors*	*process_effort*	*overwhelm/breakdown*	*product_effort*
HI-R	4	2	0	8	1	4	8	5	8	5	2	5	3	6	5	6	4	4
LO-R	2	8	5	2	3	0	7	5	6	5	3	5	0	5	6	7	3	4
HI-P	3	9	3	3	4	4	8	4	8	4	3	8	1	8	6	6	3	4
LO-P	2	1	1	7	0	0	6	6	5	4	2	2	2	3	5	6	4	4

Table 3: Summary of a selection of TOPIC features occurrences (to be read similarly to Table 2).

4.1 Relation between modeling effort and Teacher-designer profile (TOPIC 1)

Thirty-one out of 169 occurrences were categorized as "teacher-designer profile" (from now on: PROFILE) features showing how teachers face modeling of CSCL scenarios and how they perceive the effort. As expected, high-profile (HI-P) teachers spent less mapping and reflection time, committed fewer mapping errors, but interestingly, they created less complex designs and considered fewer setting options [OOBS 1] at the DESIGN task (Corr. Coef= -0.6, P-value= 0.026). Regardless expertise, during the REDESIGN task the teachers reused partially or completely the setting options adopted from the DESIGN phase, thus reducing the uncertainty.

About 50% of PROFILE topic aspects pointed out to the **effect of the uncertainty in the modeling process**. Such uncertainty is explained on one hand by the lack of information about the collaborative learning techniques such as the collaborative learning patterns [IQ 1.1] (Evid 1 *"doubts concerning the performance of the patterns, or the jigsaw groups [experts] configuration",* [RATING_1=4; PROFILE=18] [Obs 1]). On the other hand, the uncertainty was derived by the fact that some of them did not have enough experience in configuring "effective" CSCL scenarios (Evid 2 [Rec 1]: "*I do not know whether it will prove it to be successful", "after the second snowball phase, should we do more peer reviews or is this sufficient?... All together? Do you think there are too many?"* [RATING_1=5; PROFILE=12]; *"I hope that by using this scheme (artifact assignment) it works"* [RATING_1=4; PROFILE=17]). Finally, it was found that those inexperienced teachers, as well as those who considered that the DESIGN task effort demanding, were the ones who expressed such uncertainty.

The other half of the PROFILE topic occurrences points out explicitly to the **expert/model dichotomy** feature, which in turn is related with how teachers can address real-world scenario issues [IQ 1.2]. As Table 3 shows, these features were mostly associated with HI-P teachers or teachers who considered that DESIGN and REDESIGN did not demand significant effort. Explicit expressions employed by the teachers-designers provide evidence that the aforementioned experience greatly influences the perception of effort and the way modeling is performed: (Evid 3 *"-eventually when you catch it loose it's easier",* [RATING_1=5; PROFILE=12] [Rec 2], *"After doing this several times, now it is not so difficult",* [RATING_1=5; PROFILE=20] [Rec 1]). Additionally, all profile teachers considered the experience as a supporting means for effectively modeling CSCL scenarios with artifact flow definition. The experience on modeling artifact flows for CSCL scenarios [ARTFLOW] is correlated with the mapping time [MAPP 1] (Corr. Coef. = -0.59, P-value <0.05). Therefore, as expected, the [PROFILE] and [ICT_CL] parameters show a negative correlation with the number of setting options considered by the teacher during the DESIGN task [OOBS 1] (P-value < 0.05) [Metric 3]. Moreover, it is significant that the higher the [PROFILE], the fewer setting options [OOBS] were considered by the participating teachers. This happened when more configurations were theoretically available [OEXPECT] regarding the MOSAIC characteristics and the decisions made by the teacher until the specific decision-making point. This aspect will be deeper analyzed in further subsections.

Other evidence shows the contrast between experienced and novel teachers with respect to their skills regarding the management of the collaborative learning scenarios and the design process itself [IQ 1.3]. (Evid 4 [Rec 1]: *"Our groups should be large, you can lose quality but it is more viable for the teacher",* [RATING_1=3; PROFILE=16], *"if they do it wrong or good, how will they fix it after ...?",* [RATING_1=2; PROFILE=18], *"You have to reach a compromise between workload as a teacher and the number of students per class",* [RATING_1=2; PROFILE=20]). An interesting case refers to an experienced teacher who followed a different procedure to address the DESIGN task, as compared to the rest of participants in the study. She firstly identified the learning activities whose group formation, artifact assignment or pattern constraints might be mostly risky with respect to fulfillment of the "effectiveness" requirement. Once these phases were identified, she configured them according to a reduced set of feasible and complying settings. (Evid 5 *" It is true that this way I have managed to get back to fit everything in the design, but if the* *number was different and they had not given me a number of group, multiple of 4 or 8, there would have been more problems for the phases of the pyramid",* [RATING_1=2; PROFILE=18] [Rec 1]). We should remark that the DESIGN task was considered to demand a low effort for this experienced teacher and proposed most of **"valuable" pedagogical solutions**.

4.2 Modeling effort versus Design Problem complexity (TOPIC 2)

This topic has been explored by formulating specific informative questions regarding the way the following factors affected the perception of required effort: assessing the plausibility of the provided scenario and the assigned DESIGN task (difficulty to adapt their courses to the MOSAIC schema), proposing "effective" design solutions, committing mapping errors, or performing the REDESIGN task. The overall reuse is also analyzed based on these factors.

Eleven out of 15 participating teachers considered the MOSAIC and the initial DESIGN task as **plausible** (rated 4 or 5 in a 5-point Likert-scale) given the similarities with designs developed in their everyday practice or in the context of the workshops they participated [IQ 2.1]. However, some of them pointed out the complexity of the scenario, the difficulty to map theirs courses to the MOSAIC workflow schema and the lack of specification of the learning objectives, as negatives aspects. (Evid 6 "- *It is plausible, although it seems a very complex design"* [RATING_1=5; PROFILE=16] [Quest 3], *"The scenario is, in fact, similar to some that I proposed in my classes [...] but reach a consensus on a conceptual map is not as solid and may result in a process too laborious or fail. on the other side, I've missed a definition of learning objectives and the specific topic of the activity* [RATING_1=2; PROFILE=18] [Rec 1]).

Additional evidence shows that the **artifact flow modeling** was explicitly **referenced in terms of effort demand**. (Evid 7 *"[when assigning artifacts to activities] Now you have made it more complicated",* [RATING_1=4; PROFILE=17] [Obs 1, Rec 1], *" once you have solved this dilemma, the rest of the design is simple, except for the definition of persons to* review, *which by now is more complicated",* [RATING_2=4; PROFILE=17] [Rec 2], *"how do I map out my idea to the meta-model? It is very tight",* [RATING_1=4; PROFILE=18] [Rec 1], *" In general I am used to model flows [...] However, the way that they have suggested the design of the expert group phase (with generation of a product with the same characteristics as the respondent, later than the jigsaw groups) was slightly novel for me and it was costly for me to use this idea",* [RATING_1=2; PROFILE=18] [Quest 3], *"the finished design does not require much effort, but the total effort might be larger, given that some tasks have not been yet specified (or some of their attributes need to be refined)",* [RATING_1=2; PROFILE=11] [Quest 3], *"It can be challenging when you do not have help, but if you do, then not",* [RATING_1=5; PROFILE=14] [Quest 3]. It should be noted that, even though the HI-P teachers use mostly these expressions, low and high effort ratings are equally distributed.

The study also analyzed the effect of proposing **"pedagogical effective" solutions** on the ratings provided [IQ 2.3]. Evidences of effective pedagogical solutions were found in 9 out of the 15 participants, mostly in HI-P teachers or those who rated as high the effort demanded. However, there are no significant differences compared to LO-P teachers, or these who rated as low the effort demanded. (Evid 8 *"I* *can't group these four [students] who have worked with crossed documents", "All of them come from jigsaw groups but they can see other points of view."…"Yes there are differences, we can group those that have reviewed similar documents",* [RATING_1=5; PROFILE=12] [Obs 1, Rec 1], *"In the expert phase is where you must perform the peer review, and not before",* [RATING_1=4; PROFILE=20] [Rec 1]). Making **conceptual mistakes** was identified as an important aspect, since some participating teachers adopted a particular solution, which later they considered that such solution did not comply with the effectiveness design requirement [IQ 2.4]. These conceptual mistakes were mostly found related with LO-P teacher who rated as high the effort demanded (Evid 9 *"- It is observed that an option is discarded for being considered non-effective"* [RATING_1=4; PROFILE=18] [Obs 1], *"You can't use it [an adopted configuration] because one of the groups is left without a presentation" (- Then the groups must be remade),* [RATING_1=5; PROFILE=14] [Obs 1, Rec 1]).

The application of the Wilcoxon test does indicate that there is a statistically significant **difference between DESIGN and REDESIGN tasks**, except for the mapping errors [ERROR] which manifested similarly in either of the two tasks (Z= -0.420, P-value>>0.05) [IQ 2.2] [Metric 3]. The reduction of 30% of the class-size explains the reduction in the complexity of the refactored designs [COMPLEX 2], the time consumed in reflection [REFLEX 2] or mapping actions [MAPP 2] as well as the number of setting options theoretically expected [OEXPECT 2]. In the REDESIGN task, the setting options considered by the teachers [OOBS 2] were also affected, since mostly they were either fully reused from the DESIGN phase, or suitably changed by another solution which better met the new requirement. In general, almost all participants, independently of their profile, perceived that the reuse of already defined strategies and settings may save time and effort. (Evid 10 *"Is it necessary to repeat it? It's because it is the same design!"; "[jigsaw] I would not make so many groups, but I would change the configuration". [VF3] "It's easy [the redesign], it is the same thinking [as the design]",* [RATING=2; PROFILE=11] [Obs 1, Rec 1]). In particular cases (mostly LO-P teachers), participants considered that the reuse effort was significant, especially when the previous grouping and artifact settings did not match well with the new class-size, suggested at the REDESIGN task. (Evid 11 *"¿34? What a number",* [RATING_change: from 4 to 4; PROFILE=17] [Rec 2], *"However, we must devote extra effort to adjust the design to the new characteristics of the group size. In this case, the new group size means that the configuration is more complex than the DESIGN scenario",* [RATING_change: from 5 to 4; PROFILE=12] [Quest 3], *"I was able to take advantage of almost all of the hard work done in the DESIGN scenario , and the modifications made have been very simple (size and number of groups)",*[RATING_change: from 5 to 2; PROFILE=16] [Quest 3], *"It requires investing time that can only be compensated for if you can reuse what you have done.", "When I have done it, I have seen it useful especially for high numbers or users, but the change of class, now no longer compensates me",* [RATING_2=3; PROFILE=20] [Rec 2]).

4.3 Modeling effort versus Design Process complexity (TOPIC 3)

The effect of the PROCESS component on the perception of required effort is estimated through the analysis of several features, such as the setting options considered by the teacher [OOBS] and those theoretically expected [OEXPECT] [Obs 1&2, Metric 3], the overwhelm and breakdown situations, as well as the errors committed when the solution is mapped to the worksheet representations.

Evidence points out the **design process issues** as factors that influence the global effort rating [IQ 3.1]. As depicted in Table 3, several occurrences of explicit expressions and observations related to this feature were observed mostly found in LO-P teachers as well as those who rated the effort demanded as non-significant. (Evid 12 *"[the teacher] do it Agile"* [Obs 1], *"The effort in my opinion is 'worthwhile' but not negligible",* [RATING_1=3; PROFILE=7] [Quest 3], *"It can be challenging when you do not have help, but if you do, then not",* [RATING_1=5; PROFILE=14] [Rec 1], *"damn, this is complicated, eh??", "- concentration is required to complete the representation",* [RATING_1=4; PROFILE=18] [Obs 1]). The **lack of sufficient time available** for the modeling tasks and the limitations of the authoring tools (e.g. worksheet in use, edit2, GLUE!-PS) to support an effective reuse of designs, were also detected. (Evid 13 *"- the teacher refused to complete the REDESIGN model", "- He would have apply the same (grouping and artifact assignment strategies) with fewer learners",* [RATING_change: from 3-2; PROFILE=16] [Obs 2], *"After doing this several times it is not already that difficult, but requires investing some time",*[RATING_change:5-3; PROFILE=20] [Rec 1]. *"I would love more time to propose some activities that would have been more effective",* [RATING_1=2; PROFILE=11] [Rec 1]). Moreover, the analysis of the gathered data indicates that the higher the complexity of the design-product [COMPLEX], the longer is the times spent in reflection [REFLEX] or mapping [MAPP] actions. Noticeably, the greater the time spent in reflection [REFLEX 1] (Coef. Corr. = -0.60, P-value = 0.017) and mapping [MAPP 1] (P-value > 0.05) at the [DESIGN] phase, the lower are rated the authoring and deployment tools [TOOL_AID] as supporting means for artifact flow definition and particularization [Metric 3]. While several teachers considered that tools such as the GLUE! suite are useful (e.g. *"[Using GLUE!-suite], everyone has access to what is really needed and that's fine",* [RATING_1=3; PROFILE=11] [Obs 1, Rec 1]), some of them criticized the limitations of these tools to support an effective CSCL design process, especially when the artifact flow is incorporated. (e.g. *"- Does not understand the logic of WebCollage+GLUE!-PS",* [RATING_1=3; PROFILE=16] [Obs 1], *"Moodle does it at random" [the assignment of artifacts] but does not give control to the teacher, does not allow local peer-review",* [RATING=4; PROFILE=17] [Quest 1&3]). Thus, some of them considered that important improvements should be made so that the authoring tools could be support more effectively the design process (Evid 14 "- *What they should implement are some kind of artifact flow templates that save effort, minimize situations of the design prone to error, reduce time mapping",* [RATING_1=2; PROFILE=20] [Obs 1], "*GLUE!-PS could incorporate a function assigning the patterns in the formation of students",* [RATING_1=5; PROFILE=20] [Quest 3], *"- To simplify the definition of a pattern of flow artifact that allows greater reuse from one course to another (with different numbers of students and groups),* [RATING_1=3; PROFILE=11] [Quest 3], "*Guidance and support elements to guide the teacher in the process, perhaps in the form of questions, to facilitate the completion of the activity and to think about everything that must be taken into account",*[RATING_1=2; PROFILE=18] [Quest 3]).

As shown in Table 2, eleven out of the fifteen participating teachers were involved in **mapping error [ERROR] situations** during the sessions [IQ 3.2]. Low-profile teachers and teachers, who did rate as high the effort perceived, were mostly affected, but no significant correlation was found between the mapping errors [ERROR] and the effort perceived [RATING]. (Evid 15 *"I have not followed the pattern of the allocation of artifacts for the review", (Teacher 5)* [RATING_2=4; PROFILE=17] [Rec 2]).

Overwhelm and ***breakdown*** situations were present when repetitive editing actions were realized during sessions, mappings errors committed or important design decisions were up to be made [IQ 3.4]. They represent the 20% of the elements identified and they are clearly related with the design PROCESS. In average, the LO-P teachers who rated as high the effort perceived were mostly involved in such situations (Evid 16 [Rec 2]: *"I have no idea how I would do it",* [RATING_2=4; PROFILE=12], "*uff! I always get confused with this",* [RATING_2=3; PROFILE=14], *"I am lost",* [RATING_2=4; PROFILE=18]).

The different phases of the CSCL are characterized by **certain degree of uncertainty**. This uncertainty is manifested for several reasons: poor understanding of the design problem, lacking on domain knowledge (epistemic), and decision making when several options are available (entropic variability) [IQ 3.3]. All the participant teachers comprehend the tasks and objectives, and epistemic uncertainty was analyzed in previous subsections. The theoretically expected setting options which define the design wingspan [Sen et al. 2010] as well as the extend at which the abstract artifact flow situations (VF1, 2, 3 & 4) are particularized, depend on the constraints of the collaboration patterns enrolled (i.e. PYRAMID, PEER REVIEW, JIGSAW), and the cascading effect of the decisions the teacher made along the process. Based on the aforementioned hypothesis, the theoretically expected options [OEXPECT] set were calculated, through the analysis and processing of each design created [Metric 3, Worksheet], as well as the video recordings [Rec], and finally applying documented collaboration setting guidelines. The observed options [OOBS] are those which were considered and expressed by teachers as the set of candidates to be adopted in their designs. (Evid 17 *"I've never worked with 16 in a classroom ... I do not know whether it is feasible for 16 to share, or use a unique group with all sources",* [RATING_1=3; PROFILE=7] [Rec 1], *"- Professor shuffles several options, another option could be to make a full Peer Review with rotation and a 2nd sub-phase to generate a complete situation for 4 students",*[RATING_1=4; PROFILE=20] [Rec 1]). Noticeably, the number of the considered options was found to be 3 to 8 times less than the number of expected options [Metric 3], resulting in a reduction of the perceived uncertainty. This gap is higher for HI-P teachers, while it is reduced in the REDESIGN task. However, a sound correlation is observed between the theoretically expected setting options [OEXPECT 1] and the number of mapping errors committed [ERROR 1] at the DESIGN task (Corr. Coef. =0.5) [Metric 3]. The literature prescribes a validated relationship between error proneness and process complexity [Mendling, 2008]. The larger the number of expected options, the more complex is the making decision process, and therefore the effort demanded.

4.4 Modeling effort versus Design Product complexity (TOPIC4)

The processing of the gathered data indicates that the effort rating [RATING] bears no direct relation with the **complexity of the design product** [COMPLEX], either for DESIGN or REDESIGN task [IQ 4.1]. Designs with similar complexities [Worksheet 1&2, Metric 3] were differently rated with respect to each profile as teacher-designer, time consumed on reflection, and mapping among other parameters.

Particularly, 5 teachers made explicit reference to the design complexity as significant affecting factor, and 4 of them finally rated as high the effort demanded (Evid 18 *"In this case, the new group size indicates that the configuration is more complex than the DESIGN scenario",* [RATING_2=4; PROFILE=12] [Quest 3], *"[jigsaw grouping] It is difficult to represent",* [RATING_1=3; PROFILE=11] [Obs 1, Rec 1]). Moreover, other 4 evidences have shown that the design model complexity is perceived and evaluated from the point of view of the learners and the viability of the activity (Evid 19 *"This is being super-complex, but is effective for the students and the process",* [RATING_1=5; PROFILE=14] [Rec 2], *"Something short is better than doing something more complex… if they [the students] get tired of 'beating around the bush' of repeating too much",* [RATING_1=2; PROFILE=20] [Rec 1]).

Note that, although there is no statistically significant correlation between the complexity of design product and the effort rating. However, the accomplishment of certain pedagogical objectives requires complex design-products, which indeed may imply an additional workload.

4.5 Discussion

The study results show that, participating teachers perceive the effort to varying degrees attending to various factors, i.e. the profile of the teacher as a CSCL designer, the complexity of the design task, the effect of redesign, the design process and the characteristics of the product model in order to fulfill the effectiveness requirements. The MOSAIC scenario, which was used in the study, was considered to be plausible by most participants [IQ 2.1]. Also, teachers-designers considered the artifact flow as an interesting aspect to include in their courses, even if the modeling complexity is increased, or the risk to fail in proposing pedagogically effective settings [IQ 2.3]. Explicit expressions were observed regarding the design process as profitable but not negligible in time and effort terms [IQ 3.1].

As expected, findings point out experience on the modeling methods and on the application domain as paramount to achieve an efficient and effective modeling of CSCL scenarios with artifact flow [IQ 1.2 & 1.3]. Also the occurrence of conceptual and mapping mistakes can be mitigated from experience but additional support is required on assisting the design process, reducing time and effort spent. For instance, participant teachers may benefit form the introduction of a kind of artifact flow templates, which once formalized may support the automatic creation of complete CSCL situations with artifact flow definition. Such templates would also support the abstract artifact flow constructs reducing the configuration variability to few setting options as well as the process complexity, and increasing the probabilities that more setting options been considered or observed. Moreover, it deems necessary to help teachers on the early detection of conflicting phases on the learning process that should be firstly considered in order to prevent possible configuration mismatches among phases. Globally, the redesign task is less demanding in terms of perceived effort as compared to the design task. Artifact assignment logics and grouping strategies are properly reused, as much as possible [IQ 2.2]. However, mismatches between the available designs and the new requirements may jeopardize the effectiveness of the process and more effort would be demanded. Finally, evidence shows that, redesign is valued as less demanding by all types of teachers regardless their prior experience as designers. The complexity of the designs (design & redesign) was considered mostly in terms of effectiveness [IQ 4.1]. Explicit evidence has shown that complexity is perceived and evaluated from the point of view of the learners, time available for each task, etc. The complexity of the design product was mostly considered as a secondary parameter.

Findings show a demand for new features of the authoring and deployment tools for assisting teachers in creating effectively and efficiently CSCL designs in which artifact flow is explicitly defined, especially for inexperienced teacher-designers. Regarding the Design Problem complexity, the authoring tools should provide conceptual assistance for sequencing and assignment of artifacts based on best practices. The Design Process complexity should be reduced by detecting the most conflicting phases to avoid mismatches in configuration, as well as calculating the most effective strategies for uncertainty reduction. Finally, teachers should be assisted to deal with the complexity of the Design Product through the automatic or semiautomatic creation of complete artifact flow situations for CSCL scenarios. In this regard, WebCollage brings support the creation of the learning activity flows as well as group formation following best practices in the form of collaborative patterns [Karakostas et al. 2012]. ILDE (Integrated Learning Design Environment) [Hernández-Leo et al. 2014] could be used as the software environment to be enhanced, since it integrates most existing Learning Design tools, and most concretely, the WebCollage authoring tool and the associated GLUE!-PS deployment tool, since they have shown to be successful, while they support a pattern-based learning design process, which is aligned with our approach. For instance, WebCollage and GLUE!-PS need to include support of the artifact flow definition at early phases of the design process, thus enabling effective reflection over the interaction between the learning flow and the artifact flow.

5 Conclusions and Future Work

In this paper we have explored the research question [RQ]: How do teachers-designers perceive the effort required by modeling CSCL scenarios with explicit definition of artifact flow? Subjective measures were analyzed in the ArtFlowDER study, reported in this paper, as a complement to previous objective measures of the design process complexity. During this study, based on mixed evaluation methods, fifteen participants were invited to customize (DESIGN) an authentic collaborative scenario with explicit artifact flow (MOSAIC) and then reuse the proposed solution in order to adapt (REDESIGN) it to a different class size. The study was structured according to a data reduction method, analyzing several topics (the effect of teacher profile, and design problem, process and product on the perceived effort), which fit to an established framework for empirical evaluation of conceptual modeling techniques, through several informative questions.

Results show that subjective measures on perceived effort reveal more complex relations, as compared with objectives measures, while uncertainty and teacher-designer profile are the factors that mostly influence the perceived effort. Findings suggest that further research and development work should be carried out with the objective to adapt and enhance existing authoring tools in order to reduce the perceived effort, when artifact flow is defined. Adapting the tools to the teacher profiles, reducing the existing uncertainty and taking advantage of the added value of redesign (and reuse) can constitute the guiding lines for future work towards adoption of a learning design process using explicit artifact flow definition, which has been otherwise positively valued by the teachers.

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Appendix. Questionnaires [Quest 0, Quest 3]

[Quest 0]. Profile Questionnaire

1. Years of teaching experience *
2. Course type(s) you currently teach : *[] Grade [] Master/PhD [] Others:_________*
3. Before this experience you have had contact with collaborative learning? *Yes/No*
4. Before the study you ever had contact with the WebCollage/GLUE!–PS suite? *Yes/No*

USE OF ICT IN TEACHING

5. I use regularly **[ICT]**s in my teaching *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*

USING COLLABORATIVE LEARNING TECHNIQUES

6. I use regularly collaborative learning techniques **[CL]** in my teaching *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*
7. I often use ICT to support collaborative work **[ICT_CL]**? *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*

MOSAIC SCENARIO (read carefully and answer the following questions)

8. Is the provided scenario (MOSAIC) plausible? **[PLAUSIBILITY]** *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*

If the MOSAIC was not considered as plausible, please explain why. You can rely on the experience of your everyday practice.

[Quest 3]. Assessment of perceived effort regarding the design/redesign of scenarios with artifact flow

1. I have modeled before the artifact flow in my designs **[ARTFLOW]**: *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*. Justify your answer *

DESIGN EFFORT ASSESSMENT

2. The artifact flow modeling of the DESIGN scenario has demanded a significant effort? **[RATING_1]**? (Understanding the "effort" as expression of the workload demanded by the task). *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5)* Totally agree. Justify your answer *_________
3. Which factors have influenced the configuration of the DESIGN scenario? You can choose several of the suggested options. You can add new factors, if you think so. *[] Individual or group profiles, []number of individual or group participants, [] Functional characteristics of educational tools in use, [] Logistics and staff, [] Characteristics of the patterns involved, []Others:_________*
4. The step sequence followed to set the DESIGN scenario? *:_________

REDESIGN EFFORT ASSESSMENT

5. The modeling of the REDESIGN scenario based on the DESIGN scenario has demanded a significant effort? **[RATING_2]**? *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*. Justify your answer *:_________
6. Which factors have influenced the configuration of the REDESIGN scenario? You can choose several of the suggested options. You can add new factors, if you think so. *[] Individual or group profiles, [] number of individual or group participants, [] Functional characteristics of educational tools in use, [] Logistics and staff, [] Characteristics of the patterns involved, [] DESIGN scenario configuration, []Others:_________*
7. Which was the step sequence followed to set the DESIGN scenario? *:_________

AUTHORING TOOLS ASSESSMENT

8. The WebCollage+GLUE!-PS or other authoring tools facilitate the effective design of CSCL situations with artifact flow **[TOOL_AID]**? *(1) Strongly disagree (2) Disagree (3) Neither agree nor disagree (4) Agree (5) Totally agree*

What elements must be present in the tools supporting the realization of this task?