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Co-creating a web-based visual representation model for authoring blended learning designs

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Abstract. This paper reports the co-creation process carried out during the development of a web-based visual representation model for authoring blended learning designs. The results of several participatory design workshops with high school teachers of two school communities have allowed to advance the development process through iterative cycles of refinement and improvement. The authoring tool resulting from the co-creation process supports teachers in the planning and visualization of complex blended learning scenarios (including hybrid massive online courses, flipped classroom and problem-based learning designs). Our experience contributes to the research community with a case study on using co-creation in technology-enhanced learning, where we discuss the challenges and opportunities found during the implementation process of this collaborative and participatory approach.

Keywords: Co-creation, learning design, authoring tools, blended learning

1 Introduction

Innovation in education is time-consuming and it is challenging to develop it in an effective way [1]. Innovative approaches and best practices are usually presented in a way that is difficult to understand by the large mass of educators [2]. In this context, the Learning Design (LD) field has emerged as a paradigm which aims to provide a general descriptive framework for representing educational practices in a way that can be shared effectively [3]–[5]. This approach has been found to be useful for several stakeholders related with educational institutions (faculty and instructional designers) to document their (best) practices and interpret the practices of others [4]. But despite its potentialities regarding teaching and learning innovations, there is a gap on the adoption of the LD approach by the practitioners [6]. Whereas some initiatives of participatory design have been identified in order to include users' insights on LD solutions for reducing its adoption gap [6], [7], more work is needed to explore the use of co-creation during the development process of specific LD tools.

Co-creation refers to any act of collective creativity which can be used at all points along the product development, from the idea generation but also at all key moments of decision throughout the design process [8]. The practices of co-creation in design (co-design or participatory design) date back to the 70s starting with the user-centred design approach. But nowadays, we are moving from simply designing products for users (user-centred) to designing for the future experiences or purposes of people (co-designing), integrating society in the innovation process [8]. Therefore, it is necessary to reconsider the role of designers to achieve user participation in design [9].

In this paper, we report the co-creation process carried out during the development of a web-based visual representation model for authoring blended learning designs. Our case study aims to contribute to the research community with an experience on using co-creation in technology-enhanced learning, discussing the challenges and opportunities found during the implementation process of this collaborative and participatory approach.

2 Design Authoring Tools for Blended Learning

For some time now, several authoring tools have been conceived to support teachers in the process of documenting their teaching practices, making their learning design ideas explicit and shareable. [10], [11] present and compare a variety of tools that have been developed to guide the decision-making process in LD. In this line, [3] groups the LD tools in two different types: "pedagogical planners" and "tools for visualizing designs". The author argues that whereas pedagogical planners can guide and support practitioners in making informed design decisions (while they are planning their teaching practices), tools for visualizing designs can be used to visualize and represent learning designs.

Planning and visualization support are especially relevant when implementing innovative pedagogy models as problem-based learning (PBL), flipped classroom (FC) or hybrid Massive Open Online Courses (hybrid MOOCs). Yet, those cases are considered by several authors as complex blended scenarios [12], [13].

On the one hand, previous research has established that activities or learning sequences are essentially time-based and require a plan [14]. Specially in blended scenarios, when learning is facilitated by the effective combination of different modes of delivery, models of teaching and preferences for learning, and founded on transparent communication amongst all parties involved with a course [15]. In these cases, it is highly recommended to elaborate a plan which provide an effective orchestration of the individual components in advance [12]. Moreover, teachers need to be well prepared and organized as well as prepare students for it [16]. Likewise, it has been found that students in their blended learning experiences appreciate especially the detailed study plan, the pacing guide, as well as having access to material well organized and easy to find, with all different parts being segmented into short, discrete sections [17].

On the other hand, some authors [12] point out that there is a significant move towards a more seamlessly blended experience of multiple media within a single course (or even inside a single learning activity). But, at the same time, practitioners are not well supported in the reflective practice of teaching (from which the innovative teaching ideas can come from) that would require these complex blended scenarios [1]. Thus, in front of educational practices that present some difficulty for being understood and shared (due to the diversity and the complex articulation of the elements that compose them) more intuitive visual representations of learning designs are needed [4], [18].

As explained earlier, in blended learning is necessary to carefully consider how to best incorporate each online element into their overall pedagogical strategy including how interaction with those elements will be incentivized [19]. [20] defends that "from both the staff and student point of view, it is most important that the students make valuable use of their time when present at the University". The same author stated that, if well designed, this time can enhance the opportunities for both social construction [21] and conversational learning [22]. But, among a large amount of models, frameworks and tools raised from the field, the LD_lite approach to LD is one of the few that focuses specifically on supporting teachers in the design of

blended e-learning [12]. In the same vein, we have conceptualized a visual model for blended learning which addresses the specific case of hybrid MOOCs [13]. But more research is necessary in order to explore whether the existing LD solutions can support practitioners who attempt to implement the complex blended pedagogical models listed above (FC and PBL among others). Moreover, despite the available options and the potentialities regarding teaching and learning innovations that the LD field can bring to the education landscape, there is a gap on the adoption of the existing LD tools by the real practitioners [6], [23], [24]. To address this issue, we argue that initiatives of participatory design which include users' insights [7] may contribute on reducing this gap. In this line, more work is needed to explore how the use of co-creation during the development of specific LD tools can foster the adoption of LD aims.

3 A Visual Model for Representing Blended Learning Designs

Figure 1 shows the blended learning visual representation model [13] on which we based the study presented in this paper. The model is composed by activity and resources-medium layers and a timeline. The activities can be placed on the 'in-class' or in the 'out-of-class' activity layers depending on where and when occur. Whereas the resources, which are aligned with the activities where they are used, can be placed in the different resources-medium layers. A resource medium indicates how the resource will be available for the users (teachers and/or students). For instance, a book (resource) would be placed in a physical resource-medium layer (as other physical resources as paper sheets, laboratory material, etc.), whereas a MOOC medium layer could contain a video, an online test or a web-text resources among others [13]. The resources layers duration depends on the period where they are available or 'open' for the students. Activities and resources can be mandatory or optional. The blended learning visual model also defines how to represent the activities, mainly using the following four descriptors:

1. *Teacher's presence* (available face-to-face, online or not present).
2. *Students' type of work* (individual, in groups or the whole class).
3. *Type of task* (remembering, understanding, applying, analysing, evaluating and creating)
4. *Grading mode* (graded task, not graded or task for auto-evaluation)

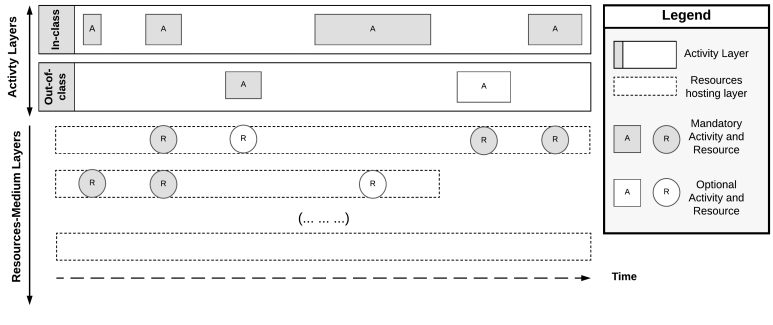

Fig. 1.. Blended learning visual model. Extracted from [13].

During the conceptualization of the blended learning visual model, we identified the need of going beyond a theoretical paper-based representation to a more practical and interactive visualization. Thus, we decided to develop a web-based version of the model in order to provide practitioners the opportunity of using it interactively and online. The main result of the development process has been a design authoring tool named *edCrumble* [25], whose development has been carried out following a design-based research approach, with the whole cycles described generally in [26]. The tool aims to support the visualization and planning of complex blended learning practices bringing together the advantages of both types of tools "pedagogical planners" and "tools for visualizing learning designs". The final interface of the tool's editor is described in the following figure (figure 2).

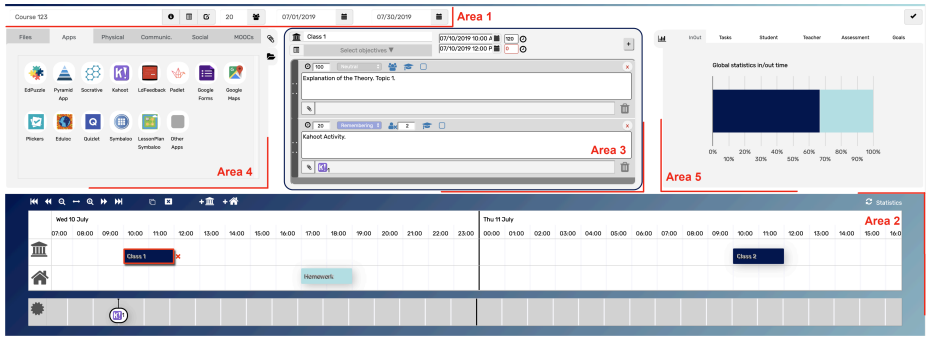

Fig. 2. Authoring tool interface areas.

The top area (figure 2, area 1) allows users to provide general information about the design context. The area 2 is an online version of the visual blended model (figure 1) with the in-class/out-of-class main layers and the resources-medium layers (in the example of figure 2, it can be seen a timeline with two activities and a medium layer 'web' with a *Kahoot* resource on the first in class activity). On the centre (area 3), it appears the activity selected from the timeline that user may want to edit or explore. Once an activity is selected, the user can set up the corresponding learning objectives and add the tasks that compose it. Indicating and editing for each task: the time allocated, the corresponding four descriptors from the blended model, a description of the task, and the associated learning resources. The design of the activity representation interface (area 3) is based on the activity's interface used by the Learning Designer authoring tool [5]. Moreover, on the left, there is the resources' area (area 4), which is divided on several resources' categories (files, apps, physical, communication, social and MOOCs). The user can drag and drop a resource to the task of an activity and edit its characteristics: title, description, target (teacher or student resource), medium layer (miscellanea, Learning Management System, MOOC platform, web, physical artefact or cloud storage) and medium name. After adding a resource in an activity, a visualization of an icon associated to this resource appears automatically in the timeline, placed in a new layer depending on the resource-medium type [25]. Finally, the analytics area (area 5) provides users analytics (visualizations) extracted from the meta-data of the produced design.

Hence, the main objective of this study is to report the iterative co-creation process followed from the paper-based version to the web-based model (authoring tool). Within this aim, the co-creation process reported in this paper addresses the following research questions regarding the development process for advancing on the visual representation for blended learning designs:

- (RQ1) To what extend the visual representation model for hybrid MOOCs can be used by and/or adapted to other complex blended scenarios such as PBL and FC?
- (RQ2) To what extend the visual model can serve as the baseline of a web-based authoring tool for the visualization and planning of blended learning designs?

4 Methodology

This research uses mixed methods design [27] since we believe that both quantitative and qualitative data together will provide a better understanding of our research problem than either type by itself. Specifically, we use an iterative co-creation process with high school teachers (participatory design workshops) following a design-based research approach [28].

4.1 Participants and sample

Participants were 24 high school teachers from two school communities which had different organizational cultures (see table 1 in the appendix). Whereas the school #1 (whose teachers will be identified in this paper with the code U1-*teacherID*) is an urban school with a top-down management, the school #2 (teachers will be identified using the code U2-*teacherID)* is a rural school with a cooperative organizational form. We assumed that teacher norms and practices could differ between different educational institutions and thus can enrich our analysis [29]. Participants had between 4 and 38 years of teaching experience, but the average number vary depending on the school, being 12.6 years in the school #1 and 20.4 years in the school #2. Table 1 in the appendix shows the participants' demographics in detail. Participants from both schools participated voluntarily to the project.

Researchers state that the data collection and analysis have followed ethical considerations avoiding harm to participants, respecting confidentiality (anonymizing the data collected) and ensuring that their participation was voluntarily (they could withdraw at any time without need to justify their decision, as well as they had the right to omit answers to any question). At the beginning of the project, researchers explained the context of the study and seek informed consent from the participants who were willing to participate.

4.2 Procedure

Several participatory design workshops were carried out (between October 2017 and February 2018) for serving in the advancing on the development of a web-based prototype of edCrumble using participants' insights and reflections [26]. The aim of the participatory design workshops was prototyping and assessing the preliminary versions of the authoring tool together with the participants of two school communities. The same workshops structure was followed for each school community despite the context was different in order to address the first research question: in the first school the workshops were about PBL and in the second school they were about FC. During the co-creation process, participants worked with different versions of the online prototype and participated on different activities which included focus groups, sharing and discussing activities, questionnaires and interviews (see figure 3).

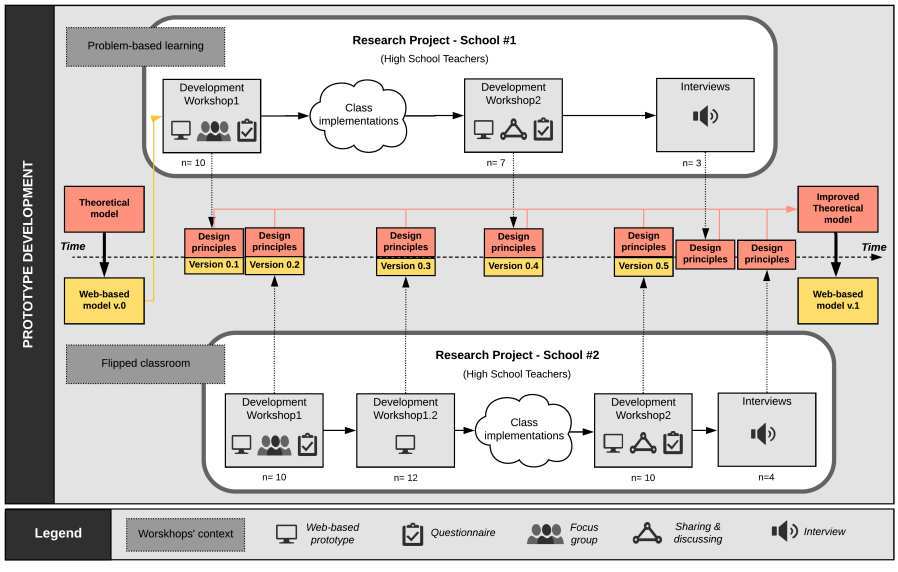

Fig. 3. Co-creation process during the development cycles: procedure and instrumentation.

Researchers prepared a first online prototype based on the visual blended learning model [13]: the first version of the authoring tool (see web-based model v.0 box in figure 3). From this starting point, the following steps were carried out in each school community:

- **Development workshop 1.** In which teachers had to design a learning design using the online prototype, with the help of the researchers (participants were asked to come to the workshop with a concrete design idea). It was a 2h workshop with the following steps: (1) Introduction to the tool; (2) Work with the tool designing a learning design for being implemented within their classrooms (a PBL or a FC design depending on the school); (3) Focus group where researchers asked questions about the experience that participants had with the use of the tool, discussing their strengths and weaknesses. (4) Last, participants were asked to answer a research questionnaire individually.
- **Development workshop 1.2.** In the case of the School #2, they had another 2h workshop because they needed more time for designing the interventions using the tool and be prepared for implementing their designs in their classrooms. In this case, researchers took observation notes of teachers' using the tool for usability improvements.
- **Class implementations.** Teachers implemented their designs in class. During this step, which took between 4 and 9 weeks, researchers were available online for solving teachers' doubts regarding the use of technology selected for using in their class.
- **Development workshop 2.** In this workshop, which took 1-2h depending on the school, teachers followed three steps: (1) Working with the tool for documenting the designs implemented at class, adding the design changes suffered by the real implementations; (2) Sharing their implementation experiences and a joint reflection about the possible redesign of their original

designs considering the lessons learned; (3) Last, participants were asked to answer a research questionnaire individually.

- **Interviews.** We carried out seven semi-structured f2f interviews (three teachers from School#1 and four from School#2) of about 45 minutes each. Due time and resources constraints we could not interview all 24 teachers.

4.3 Instrumentation, data collection and analysis

The current study used several instruments to gather data from the field work: two questionnaires, focus groups, interviews and observation notes. The first questionnaire was designed to collect information regarding the use of the first versions of the web-based tool, with the aim of identifying the strengths and weaknesses as well as the difficulties encountered during its use. Thus, allowing to be able to identify the most necessary improvements to be done in the next versions. It was composed of the following four open questions:

- (Q1-1) What difficulties did you find during the design process using the online tool?
- (Q1-2) What do you think are the main strengths of the online tool?
- (Q1-3) What do you think are the main weaknesses of the online tool?
- (Q1-4) What suggestions would you recommend to improve the online tool?

Moreover, in the case of the first questionnaire delivered in the school #2 two more questions were added regarding the visualization of design analytics provided by the prototype:

- (Q1-5) Have you ever looked at the graphics (on the right side of the tool) while you were editing?
- (Q1-6) If you have looked at the graphics, did you find difficulties in understanding them? What difficulties?

The focus groups carried out during the first workshops had the same research objective of the first questionnaire. This instrument permitted to get group discussions and views, complementing the individual insights from the participants expressed in the questionnaires and allowed us to get a more accurate interpretation of their text-based responses. The second questionnaire (delivered during the development workshops 2), primarily assessed the tool regarding its potentialities for documenting designs, learn from others' learning designs and reflect during the design process. Following, the questions are listed (all questions were open-ended except the third one which was a five-level Likert scale, 1: strongly disagree, 5: strongly agree):

- (Q2-1) Indicate in what percentage you have been able to document your implementation with the tool:
- (Q2-2) If you answered a number less than 100% to the previous question, explain why.
- (Q2-3) Indicate your level of agreement for each of the following phrases in relation to the design tool:
  - It helped me to document my implementation.
  - It helped me to understand the implementations of other peers.
  - The documentation of my implementation using the tool helped me to reflect on my own design.
  - The documentation of other implementations using the tool has helped me reflect on implementations of other peers.

  - The analytics provided by the tool helped me to reflect on my own implementations.
  - The analytics provided by the tool helped me to reflect on implementations of other peers.
- (Q2-4) Do you think that the design tool allows you to document and visualize a complete learning design?
- (Q2-5) Have you missed some functionality of the design tool that would have helped you to better document your design?
- (Q2-6) Did you miss any design tool functionality that would have helped you better understand the designs of other colleagues?

Finally, the interviews consisted of a series of open-ended questions (see details in [31]) that invited participants to share their perspectives regarding (1) how they used to design and document their educational practices before knowing our tool and (2) how was the design process they followed during the workshops using the tool. The resulting qualitative data from the questionnaires, focus groups and interviews were coded with inductive thematic analysis driven by the research questions of each phase and were cross-referenced to justify interpretations. The main topics were then categorized in order of dominance and triangulated with the different instruments results in a more in-depth analysis for corroborating the overall consistency of the findings.

5 Results and Discussion

5.1 Results from the development workshops 1

The first question from the questionnaire (Q1-1), delivered during the development workshops 1) aimed to identify the main difficulties which participants found during the use of the first edCrumble's versions (0 and 0.1). The main topics from the qualitative analysis are listed in the appendix (Table 2) with the frequencies depending on the school community as well as the corresponding participants' answers excerpts. Specifically, five answers from the participants expressed difficulties regarding the slow edition process using the tool (the 33% of the difficulties gathered from the question Q1-1). Thus, the biggest drawback during the use of the tool was regarding the slow edition related with the activities and tasks. Specially, functionalities which can facilitate avoiding repetitive work were missing (like copy, paste, repeat, etc.). The next topics with most frequencies (13% of the answers each), were related with the timeline management, the tool inputs and outputs limitations as well as the need for a major activity types visualization awareness.

The questions Q1-2 and Q1-3 contributed to identify the main strengths and weaknesses of the first online prototype versions *0* and *0.1*. Results from the qualitative analysis identified four main topics regarding the main strengths highlighted by the participants (topics' frequencies and participants' excerpts are detailed on the table 3 of the appendix):

- *Visual representation* (VR) – present in the 35% of the answers: participants stood out that the visualization provided by the tool allows to see the whole design sequence at glance, controlling how all the elements of a learning design are related with each other in a visual way.

- *Organization and planning* (O/P) – 35%: opinions from the participants expressed that the tool allows to structure a learning design in a systematic way, enabling to plan the different activities along the time of a learning sequence (showing all the necessary information regarding the organization process).
- *Reflection and awareness* (R/A) – 17%: participants highlighted that the tool allows to reflect on the design process and enables the awareness of the different elements and decisions made on the learning designs expressed within it.
- *Support and guidance* (S/G) – 13%: according to the teachers who participated in the study, the tool help and guide during the design process. It supports users in taking design decisions in the generation of teaching-learning activities as well as in the choosing of the possible resources available to use.

The strengths provided by the participants about the web-based tool are aligned with those resulting from the evaluation of the paper-based prototype in [13]. Thus, the strengths found regarding the paper-based model are reinforced by the those found in the web-based model, pointing to a high level of consistency between the two versions and verifying the work done in the co-creation development process. Moreover, the strengths identified are in line with the objectives that the tool aimed to fulfil in the second research question (RQ2): supporting the visualization and planning of blended learning.

Whereas, five main topics were identified regarding the main weaknesses of the web-based tool, listed as follows in order of most frequency obtained (answers' frequencies and participants' excerpts are detailed on the table 4 in the appendix):

- *Tool's development limitations* (TdL) – present in the 55% of the answers: this weakness refers to usability issues and new features which still need to be developed in the tool. Mainly, they are related with the difficulties found and the future improvements already detected and addressed on the previous discussion. This result was already expected since this is an evaluation of a very early version of the tool.
- *High time investment* (HtI) – 27%: three participants highlighted the high amount of time needed to be able to plan or document a complete learning design using the tool. This weakness is related with one of the difficulties identified in the previous discussion which needs improvement: the slow edition of the design in general.
- *Need of support* (NoS) – 9%: one participant stood out the need of having support for learning how to use the tool. Despite the low ratio of participants who expressed this need, researchers considered to address this weakness and developed several video tutorials as well as pop-up tips and messages (see *Imp23* in table 6 on the appendix) embedded in the editor in the last version (v.1). This solution was developed as soon as possible since it must be noticed that the tool is intended to be used autonomously by teachers, beyond workshops led by experts (where participants can receive direct support). Thus, the tool ought (and aims to) be very easy to use.
- *Educational polices* (Ep) – 9%: a teacher expressed the fear to the risk that the design process would be bureaucratized through the use of the tool. For example, leaders of organizations could ask teachers to plan and systematically document their learning designs mandatorily in order to control their work, instead of promoting the use of the tool for fostering the exchange of teaching practices (within and among the communities of teaching) and learn from the experiences of other teachers.

Interestingly, most of the weaknesses identified from the paper-based model [13] have been overcome with the online version. However, it is still necessary to reduce the need of support for understanding and using the tool and to revise some of the activity types descriptors (e.g. the type of collaborative activity; see the proposed *Imp10* in table 6 of the appendix).

Once identified the main strengths and weaknesses of the tool, the next question of the research questionnaire (Q1-4) aimed to directly collect suggestions from the participants to improve the tool. Table 5 in the appendix presents the list of proposed improvements by the teachers grouped by five topics: platform configuration; tool inputs and outputs; timeline management; interoperability of the tool; and the slow edition. Most of the suggestions have already been related with a limitation described in the above results.

In the case of the first questionnaire delivered in the school #2, two more questions were added regarding the visualization of design analytics provided by the prototype. The first question (Q1-5) asked participants whether they had ever looked at the graphics while they were editing. Five out of six participants answered positively. But when researchers asked whether they had found difficulties for understanding the graphs (Q1-6), three out of the five participants expressed issues to understand the graphs (e.g. U2-6 expressed 'I do not know if the graphs made reference to the total or to each activity') and another one argued that she did not paid much attention to them. Only one participant stated that she did not find difficulties for understanding the graphs, but she concerned about the need of having to fill out all the design data to be able to extract conclusions from them. These findings were in line with the discussion raised during the focus group activity in the school #1. In which they also stated that they had understood easily the colour code used in the graphs which was related with the tasks' descriptors colours. Notwithstanding, the visualization of the analytics provided with the graphs was not a priority in the development workshops 1, as researchers prefer to evaluate the timeline and activities' representation. Thus, these two questions were merely exploratory to get insights for small improvements (see appendix, *Imp22* in table 6) to be able to discuss the analytics in the second group of workshops.

Finally, the focus groups were useful for understanding some of the above discussed issues. Some teachers from the first school, asked to have more features to gain agility in the edition: configure pre-settings states when creating a new activity (duration, etc.) and a new task (see appendix, *Imp2* in table 6); they would like that the task could be ordered once created (*Imp 20*); they would like to see the whole design together in one view on the timeline, e.g. hiding the time between the activities (*Imp18*); they want to see the titles of the activities in the timeline's activities (*Imp25*). Moreover, they think that is necessary to have a summary of the design as a printable document, e.g. to bring it to the class as a guideline (*Imp6*). As well as, they really asked to have an 'student' mode visualization, for sharing the interactive timeline generated by the tool with their students -e.g. for projecting it to the class and discuss the plan all together- (*Imp16*). Lastly, some teachers discussed their visualization preferences regarding the timeline comparing with the visualization options provided by Google on its calendar application (day, week, month…).

Moving to the teachers of the second school, they started the focus group expressing that they liked the tool. Specially they liked its flexibility, as they think that it allows to go into detail and write the design in deep, or to be less detailed and describe the design in general terms (depending on each person). Then, researchers introduced the topic regarding the possibility of sharing the visualization with the students, need which raised in the previous focus group with the other school. Despite they also agreed that it is a good idea, they added some interesting reflections about it. They pointed out that it is important to balance which portion of the design must be shown to the students, because showing all the course work (that you expect from

them to do) at a glance, may overwhelm them (especially in the course level when they need to prepare the exams to access university, as they are under more pressure). The tool can help them get organized but also can become a focus of tension and stress. Moreover, a teacher commented that if students know in advance what they will do in class, the 'creativity' factor may be lost as students can move forward to what teacher wants to do in class. They think that, sometimes, can be interesting that students do not know what will be done in class, to surprise them (this encourages learning and creativity; moreover, if they do not know what will be done in class, they are more attentive). One possible solution that teachers proposed would be to limit the time frame that students can see on the timeline (e.g. only showing one week before the class day with the objective that it ends up being an organization tool for students also).

At the last part of the focus group, teachers commented that the editor displays too much information at the beginning, which can overload the user (as the editor shows all its sections at the same time). Participants suggested to only show the 'content and general settings' menu (see figure 2, area 1) when a user creates a design, hiding the 'timeline' (displaying it when the user introduce the start and end dates) as well as the 'resources' and 'analytics' sections (displaying a button to expand them under request of the user); also, making bigger the 'selected activity details' section – see appendix, *Imp26* in table 6. Regarding the analytics provided by the tool, teachers think that it would be very interesting and necessary to be able to visualize the workload outside the classroom at the group level (e.g. out-of-class workload of several subjects that take place at the same time). They comment that at the individual level of the course (analytics of a single design) it is easy to control the workload outside the classroom, but the challenge is how to know if, at the same time, students have more work from other subjects which are running in parallel. In this line, edCrumble could facilitate a possible solution to this problem, allowing to generate aggregated analytics from several designs (community analytics, see *Imp24*). Teachers expressed and highlighted that it would be great for them having this feature, which would allow them to have a joint agenda for controlling the out-of-class workload of the several subjects within a course (they would also like to export it to a Google calendar, in line with the *Imp4*). Moreover, they commented that if they would have this information at the school level, it would allow them to redesign their courses depending on the overall workload of the students outside the classroom (e.g. sometimes putting work they had proposed to do outside the classroom, inside the class time). Interestingly, in the case of the schools of this study (high schools), teachers mentioned that they do not have stipulated the number of hours students have to do outside of the classroom. But at university level, professors do need to define how many hours (credits) students must do in total per subject (inside and outside of class), thus, we think that this feature may be very convenient for them as well. Furthermore, in the interviews, this discussion continued. Mainly, the reflection raised was regarding the potentialities of community analytics in order to avoid repetition of methods among teachers of the different subjects of the same course. For instance, if every teacher uses FC (e.g. asking students watch videos out of class), the positive effect of the pedagogical method can be reduced as students may be overloaded of watching a lot of videos at home. Community analytics could be helpful to offer awareness of these situations and allow teachers to redesign considering also the others' designs, improving the quality of a complete course.

5.2 Results from the development workshops 2

The second questionnaire delivered in the development workshops 2 (after teachers implemented in their classes the learning designs planned with the tool) allowed to

evaluate the online prototype versions *0.3* and *0.4*. Despite 13 participants from both school communities answered the questionnaire (out of the 17 participants who attended the workshops 2), three of them expressed that they could not implement their designs in class, neither document their design ideas using the tool. Thus, only ten participants were considered in the analysis of the second questionnaire's results. Out these ten, only two were able to document the 80% of their designs using the tool. Three participants documented between 50 and 75% of their designs whereas five participants only were able to document less than 20% (results from the Q2-1). The main reason they mentioned for not being able to complete the 100% of the documentation was the lack of time (Q2-2), results consistent with the literature. As prior studies have noticed [6], time/workload factors can influence the use of a tool due to the teachers' lack of time for designing and documenting their teaching practices. In the case of the school #1, one participant (U1-9) highlighted that in her case, the implemented PBL design changed considerably respect to the initial design documented in the workshop 1 using the tool. Thus, she had not enough time to update the changes into the tool for the second workshop. In this line, participant U1-1 argued that her PBL design was very long (13 class sessions) and for this reason she had no time to document the completed design into the tool. Surprisingly, participants did not mention any difficulty related with the pedagogical method used (PBL or FC), apart from stating that the long duration of the PBL designs was the reason of not having time to document them completely (in some cases). Hence, the findings reported here appear to support the assumption that the blended model [13] can be used beyond the MOOC-based approach, being able to represent complex blended designs as those using PBL and FC methodologies (answering the RQ1). Nevertheless, considerably more work will need to be done to reduce the time needed for documenting designs using the tool in the different steps of the teaching-learning cycle (some improvements discussed above have a direct relation with this issue). Moreover, in the case of the school #2, two participants (U2-4 and U2-6) indicated that they had problems for saving her work during the edition and they lost part of her design already introduced on the tool. Notice that, during the workshops, the school #2 were using laptops connected to Internet by Wi-Fi (which sometimes presented slow connection speed) whereas the school #1 used desk computers with Internet cable connection. In order to address this issue, in the last version (v.1), the tool incorporated an automatic saving to avoid unwanted loss of information (every time user does an action, the tool evaluate whether it is necessary to save the work done automatically). Since in the previous versions to v.1 users needed to save their work manually (see appendix, *Imp13* in the table 6).

Figure 4 shows the results regarding the participants level of agreement for each of the formulated sentences in the question Q2-3. The sentence with a highest level of agreement was the c (40% of participants agree with and 50% strongly agree), related with the potentialities of the tool about enacting teachers' reflection on their own designs. This finding is consistent with the evaluation obtained during the first workshops, as one of the identified strengths of the tool was related with the promotion of reflection and awareness among teachers. The second most agreed sentence was firstly the *e*, which also relates to the reflection process but specifically which is promoted by the analytics provided by the tool. And secondly the *b*, which refers to the potentialities of the tool design representation in facilitating the understanding of others' work (70% of agreement/strongly agreement in both cases). Result aligned with one of the strengths of the model identified in the conceptualization phase [13] which is its potential for communicating the work to others. Regarding whether the analytics provided helped teachers to reflect on the others' implementations, 40% agreed with and 20% strongly agree. Whereas only 50% agreed or strongly agreed regarding the tool helpfulness in documenting the designs. These results are likely to be related to the main weakness of the tool

identified above which is the tool development limitations (as the results are contextualized within in an ongoing evaluation during the co-creation process, instead of an evaluation of a final version). Moreover, they can also be due to the main difficulty found by the teachers regarding the slow edition (which could be perceived as a frustration and it can be conditioned these results). The low rate of teachers who documented more than the 80% of their designs, as well as the limited time on the workshops for the sharing part, could also affect the percentages obtained by the sentence *d* (only 30% of agreement with it) as teachers could not reflect on the others' implementations in the best conditions.

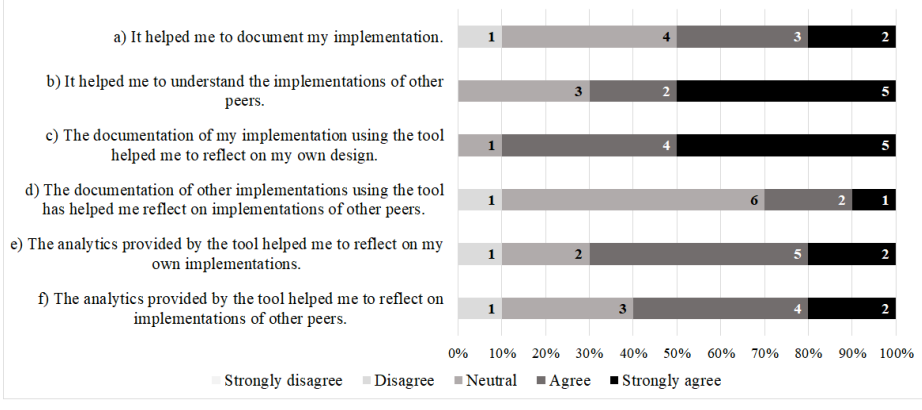

Fig. 4. Documentation and analytics evaluation (tool's versions 0.3 and 0.4). Results from the questionnaire delivered during the development workshops 2.

Interestingly, and regarding the question Q2-4 of the questionnaire, a common view amongst participants was that the design tool allows to document and visualize a complete learning design (positively supporting the RQ2) – as a teacher said, 'I think it is very useful for documenting and for giving you a more global idea of what you want to design' (U2-4). This result is aligned with the findings from the paper-based model [13]. Despite all participants answered positively, some of them also pointed out to some of the limitations already discussed above. For instance, one of them (U2-1) highlighted that the agility to introduce the data on to the system needs to be improved. Also, two of them mentioned that it requires time: 'Yes, it can help, but it takes time. Once done, it can be very useful' (U1-4) or 'Yes, but the first time you do it you need a lot of time' (U1-5). Moreover, a last participant mentioned 'Yes, but I lack a lot of practice. I find it a bit repetitive and long work, and I get lost often' (U1-1). In the final part of the questionnaire, participants were asked to report missing functionalities in the tool which would help them to better document their designs and which functionalities were missing in order to better understand the designs of other colleagues (Q2-5 and 6). One participant (U2-3) answered the Q2-6 reporting the need of knowing the overall work students must do out of class (according to the teacher's design) and grouping this information from the different subjects (several teachers' designs) which are running in parallel to better plan the out of class work for the students and not overload them. This result was already reported during the focus group of the school #2 which has resulted in the improvement 24 implemented in the version 1.0 of the tool (see appendix, table 6).

The next section of the survey was concerned with offering them an open space for comments. Participant U2-3 said 'I really like to control what part of the work is done

at home and what part is done in class' (reinforcing the in-class/out-of-class dimensions of the model.) and U2-4 thinks that is a great tool. The first result is in line with some of the interview answers, which indicated that being able to control the time of workload planned to be done out-of-class allows teacher to be prepared and informed to deal with student complaints about homework. Whereas U2-1 offered an interesting reflection about the potentialities of the tool in facilitating the reflection process but also arguing that it is still not 'practical' enough to be used during the day-to-day teachers' practices:

> 'I see it impractical, since it is about documenting and planning a lot, which takes a long time, but perhaps has little impact in practice. If you do it or do not do it, it does not show in the classroom. It has long-term advantages, the next course, by another teacher... but it requires a lot of time to implement and later, so you can do your service, you also have to dedicate time. It has helped me to reflect and improve, but I doubt that in the future I will use it for day to day.' (U2-1)

It can therefore be assumed that further work needs to be done to reduce the time to plan or document a design using the tool (in line of several proposed improvements about making the tool more agile and connect it with the existing systems users already used, to easily migrate their work from one side to another automatically – especially for those teachers who have been teaching a subject during long time and do not have the need of designing the course for the first time). In the case of the experienced teachers, most of the times they redesign the course based on the last course results, thus they need more flexibility in the timeline to change the initial design (result obtained from the interviews, asking e.g. to be able to eliminate an activity and automatically reorder the others on the classes times, see *Imp27* of table 6 in the appendix). However, at the end, it is a matter of reducing drawbacks and trying to increase the benefits, and future studies will show whether some advantages that the tool can bring to the teachers, which may solve some of their day-to-day challenges (e.g. the community analytics feature discussion) will be enough to 'seduce' them to use and adopt the LD approach that the tool offers whereas we try to reduce the drawbacks.

5.3 Revision of the blended learning visual model

During the co-creation process, we identified that users had a challenge for representing the activities out of class using the tool due to the out-of-class activities often are flexible in time: teachers can estimate their duration as well as define the period when students can do the activity (usually, from the day that the teachers publish the instructions till the delivery date). But, at the end, students are who decide in which moment of this period they do the activity. Thus, the model has been updated with the possibility of representing flexible activities over the time (see figure 5 and *Imp28* in table 6 of the appendix).

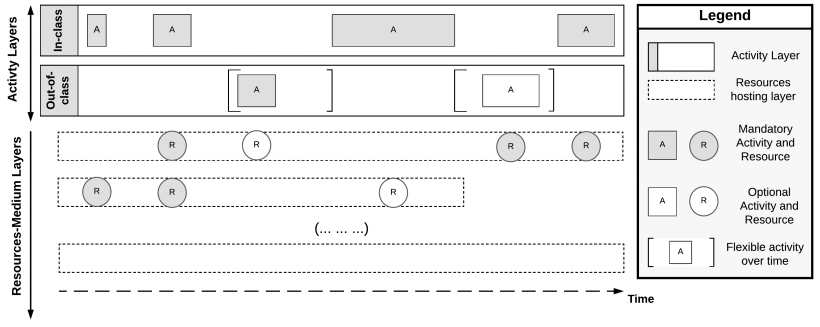

Fig. 5. Revised Blended learning visual model.

This new element add complexity in exploring how to visualize synchronicity within the model, discussion which already raised during the conceptualization phase of the model [13]. As Norberg, Dziuban, & Moskal (2011) argue, the synchronicity can be determined by type of resource used in the activity (e.g. a book, a forum… are asynchronous; whereas a webinar, a classroom… are synchronous). But we argue that, in some cases, the same resource (e.g. a book), can be used synchronously (e.g. at class, when teacher gives 20 minutes to students for reading a chapter of a book individually, and the whole class is doing the same activity at the same time) or asynchronously (when teacher ask students to read a chapter of a book as a homework for the next week). Hence, synchronicity also depends on the type of collaborative work related with the activity and also whether this activity have been defined to be done exactly on a specific date/time or, on the contrary, students can decide within a period when they want to do the activity, etc. Thus, we think that the model provides, together with the type of resource and its medium, all the contextual elements necessary from which synchronicity can be deducted.

Finally, from the results of the evaluation, it has been decided to update the categories of one tasks' descriptor: the students' type of work. Apart from the current descriptor's options 'individual', 'in groups' or 'the whole class' (as it is used on the orchestration graphs by Dillenbourg, 2015), results indicate that it is necessary to add a new category, which we named 'dynamic groups', in line with the research done by [36]. This new category (see appendix, *Imp10* in table 6) would allow users to represent group activities where the number of members per group can change dynamically (e.g. when groups are grouped, instead of individuals, in several steps of the activity).

5.4 Reflections on the implemented co-creation process

Participatory design workshops provided effective scenarios to develop the tool together with the final users which allowed us to advance in cycles of improvements depending on the users' insights and needs. Results from the continue evaluation trough the different co-creation workshops gave rise to a series of design principles collected in [30] and facilitated the development of the tool through different prototype versions reported in this case study. Despite that co-creation had a positive impact in the decision-making process of our research, it also presented two important challenges: (1) the prioritization of feedback diversity; and (2) the management of workshops' time and participants' expectations.

First, researchers analysed the results after each workshop to be able to identify the software improvements arose from the participatory design activities. Then, they prioritized those improvements to be developed for the next workshop and let the rest as future work. This prioritizing process (following cycles of improvements) has been the most challenging part of the development phase. The prioritization process was always a balance between considering the feasible points to be developed in the time we had until the next workshop, and that a direct proposal from the participants would always be included to motivate them to continue in the process (since during the use of the first versions it was quite frustrating for them to use a system that was not yet very mature and, thus, usable). Having new versions of the prototype in each workshop allowed us to advance considering participants' insights and engaging them in the co-creation process. Table 6 in the appendix shows the list of the improvements (each of them with its corresponding ID), their short descriptions, the source (the instrument/s from which the need for this improvement has been identified), the development state (implemented or still not implemented) as well as in which version the improvement has been published (in case it has been developed). Out of the 28 improvements listed in the previous table, 15 have been implemented (54%) within the cycles of improvements trough the several tool's versions of the development process. However, there are still 13 (46%) pending implementations to be considered and to be developed in future versions.

Second, due to our context, the workshops had to offer some benefit to the participants beyond participating in a co-creation process: we taught them how to design applying FC and PBL methodologies. This was good for motivating participants, but it was challenging in terms of managing the limited time and expectations. While we were training the participants, we had to collect data and fit the corresponding co-creation activity using the tool. The hardest point was managing participants' expectations, finding a balance between their collaboration in our research and our contribution to them in terms of learning about educational design through the activities.

Apart from the difficulties detected in using the tool, participants also mentioned other challenges concerning the workshop structure and organization. Firstly, two participants mentioned the difficulties for finding the ideas for the design itself beyond the use of the tool. U1-6 expressed that the main difficulty was 'Have the overall vision of the design that I am developing', whereas U1-1 stated that 'It's harder to think what you need to do than to use the tool itself. The tool is pretty intuitive'. Secondly, the lack of time for using the tool for the first time in the workshops also introduced some challenges, as U1-10 stated 'The lack of time to place the activity (also the lack of familiarity with the tool) slows down the entire process'. Thirdly, the short duration of the workshops and the language spoken by the researchers (part of the workshop was in a different mother language of those from the teachers) had a negative impact on the participants as it introduced somehow stress and frustrations, as one participant commented such difficulties as 'Follow-up of the explanations in English, having to make decisions quickly' (U1-5). And lastly, having access to multiple features and authoring tools in the ILDE platform [32] as well as the use of other platforms during the workshop (e.g. a *Moodle* virtual learning environment, for explaining the PBL and FC theory) introduced more difficulties and frustrations to participants: '...insecurity in the use of the ILDE' (U1-5); or difficulties expressed by the same user related with 'the access to the tool, I just did not locate the resources well: in *Moodle* of PBL, ILDE, to my designs…'. To minimize the usability issues which might come from having access to other editors and design types within the same platform, researchers proposed to develop in a future a separate instance of the LdShake platform [33] which only would contain the edCrumble's_editor (see *Imp15* in table 6 of the appendix) to carry out a more focused usability analysis in further evaluations.

6 Conclusions

Researchers have developed the learning design authoring tool edCrumble following a co-creation process. The tool provides an innovative visual representation of the designs that facilitates the planning, visualization, understanding and reuse of complex designs. The results show that the tool can not only be used within the hybrid MOOCs blended learning cases, but also for representing other complex blended learning designs as FC or PBL. This study has shown that the main strengths of the first versions of the tool are in line with those from the paper-prototype version of the blended learning model in which the tool is based, which are: its visual representation, that facilitates the organization and planning, promotes reflection and awareness; as well as that it provides support and guidance during the design process. However, the tool has presented some limitations which include: the tool's missing features due to that the evaluation has been done during the development process; the high time investment needed for documenting a design; the need of support and some issues related with educational polices.

The co-creation process carried out has had a positive impact during the development of the tool allowing to identify the cycles of improvements needed as well as to revise the initial blended learning model. However, co-creation also has presented challenges related with the prioritization of feedback diversity and the management of workshops' time and participants' expectations. Despite half of the improvements identified with the teachers have been already implemented during the co-creation process, further work is required for continuing developing the tool and minimizing its limitations considering the research results. Specially, authoring strategies need to be ideated to reduce the time needed for documenting designs using the tool. Moreover, an evaluation of a final version of the tool as well as more research exploring the potentialities of the design analytics embedded in the tool is needed.

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