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Chapter # - will be assigned by editors

EVALUATING THE TRANSPOSITION OF A LEARNING ANALYTICS DASHBOARD CO- DESIGN TANGIBLE TOOL TO A DIGITAL TOOL

Katia Oliver-Queennec – Sorbonne Université, CNRS, LIP6, F-75005 Paris, France and Univ. Lille, DAPI, GIVRE, France

François Bouchet – Sorbonne Université, CNRS, LIP6, F-75005 Paris, France

Thibault Carron – Sorbonne Université, CNRS, LIP6, F-75005 Paris, France

Claire Pinçon – Univ. Lille, CHU Lille, ULR 2694, METRICS: Évaluation des Technologies de Santé et des Pratiques Médicales, F-59000 Lille, France

Abstract: In-person sessions of participative design are commonly used in the field of Learning Analytics, but to reach students not always available on-site (e.g. during a pandemic), they have to be adapted to online-only context. Card-based tools are a common co-design method to collect users' needs, but this tangible format limits data collection and usage. We propose here two steps: first to adapt an existing co-design card deck-based method for an online use, then to leverage the benefits of the digital format to trace data with a research focus to study the dynamics of collaboration. We also assess whether the previously adapted digital tool has the same impacts as the face-to-face original method. Beyond the case described here, this chapter aims at identifying key factors and points of attention identified in adapting a card-based co-design method into a digital version for designing learning dashboards, and which elements can be traced in order to study collaboration and propose future improvement to the method. This digital adaptation was tested by university students in different contexts (n=177). All groups have successfully designed a dashboard, and using the original evaluation scales, users have evaluated our digital tool as almost as suitable as the original method. Then, we compared the use of the digital adaptation online with this use in face-to-face sessions which were less successful. We conclude by showing how the added traces open new perspectives to understand collaboration through links between speech acts and collaboration profiles or defining adapted dashboard for students.

Key words: Learning analytics dashboard, co-design, participatory design, cards.

1. INTRODUCTION

Faced with the massification of higher education, traditional teaching is not always suitable for training an increasingly larger and more heterogeneous student audience. One of the solutions to answer this development is the use of digital technology for (1) training and (2) personalization of training based on the collection of learning data and on their analysis (learning analytics). The dashboard, a classic decision-making aid tool, can support learning and is developing constantly in the field of Technology Enhanced Learning (TEL), mainly for teachers and students (Bodily & Verbert, 2017). The problem remains to be able to provide appropriate Learning Analytics Dashboard (LAD) to this heterogeneous public, meeting their needs.

In the field of human computer interface, but also more broadly, user-centered design is a design philosophy which aims at really satisfying users' self-expressed needs (Sanders, 2002). Concerning the conception of LAD, several research studies have shown the importance of explaining clearly the pedagogical objectives (Ifenthaler & Seel, 2005) and of choosing a relevant method (Jivet et al., 2017). To build LADs, participatory design (Ruiz et al., 2018) is a relevant method which has already been often used in the design of TEL tools. However, according to Prieto Alvarez et al. (2020) students are usually not involved in the participatory design of TEL, which could explain why some LADs are not always adapted to the learning target. Our first goal was thus to rely on such an existing co-design method for a higher education student context.

Moreover, co-design sessions usually involve an in-person session with participants sitting around a table, which is challenging when social distancing is mandatory, or simply when it is hard to schedule a moment for all stakeholders to be available in a given location. There are reasons to question whether an online version with remote participants would be as efficient, as virtual collaboration can act as a brake on the success of the collaboration by limiting exchanges through text and voice, without facial expressions or body language. McNair et al. (2010) identified the importance for participants to establish a sense of trust, which can be challenging in an online context. Therefore, our second goal is to verify whether an online co-design approach of dashboard for and by students can lead to successful results by adapting an existing method to an online context.

Scheduling co-design sessions can be difficult, and even impossible in a global pandemic context. Moreover, even when in-person sessions can

happen, it is harder to collect traces of activity when tangible objects are manipulated. If it can complicate human collaboration, the use of online tools facilitates another important aspect in studying interactions which is tracing participants' activity. Although recording and annotating video and audio of participants' interactions is possible, a digital tool can considerably help in tracking some of these. In a co-design context, the traces that can be collected are made of (1) observational data of how the method is being used, which analysis can help in proposing evolutions to the method (e.g. reformulating instructions, adding human assistance in some critical steps), (2) intermediate data to be able to understand the conditions of effective collaboration (e.g. contributions from each participant and intermediate choices sometimes not retained by the group at the end), and (3) production results (the learning dashboards). We will present here the data collected and the results of several experiments showing that this approach might indeed be an efficient replacement for face-to-face sessions. We also explore the new possibilities that the traces offer in order to assess the quality of the interactions and outcomes.

Deriving from these observations, we can formulate two research questions that will guide us in this chapter:

- (RQ1) Can the transposition of a tangible tool to design LAD using participatory design into a digital tool be evaluated at least as well as the original tool? Which can be split into 2 sub-questions:
 - (RQ1.1): Is the adaptation of a tangible co-design tool used in face-to-face to a digital tool used online as effective?
 - (RQ1.2): Is a digital co-design tool perceived in the same way in face-to-face and online?
- (RQ2) How can the digital transposition of a tangible participatory design tool be used to provide better insight into its usage in order to improve the method?

The remainder of this chapter is organized as follows. In the next section, we start by presenting previous works on participatory design leading to the conception of LAD. Then in section 3 we provide a first answer to RQ1.1 by proposing the transposition of a tangible tool to a digital tool, by presenting the face-to-face method we used, called PADDLE (PARTicipative Design of Dashboard for Learning in Education), the properties to transpose, and our proposal for a digital version, before describing the experiments carried out, the data collected, our results with a discussion the pros and cons of this digital transposition. Throughout this section, we also show how to enrich the digital transposition in order to answer to RQ2. In section 4, we present material and method of a second experiment using the same digital tool in

face-to-face sessions to answer RQ1.2, our results with a discussion to try to understand differences in perception. Finally, we conclude by presenting the perspectives opened by this work.

2. PREVIOUS WORKS

2.1 Participatory design

Work by Schneider et al. (2011) has shown that the use of tangible objects (such as cards) can facilitate collaboration and could explain the recurrent use of this format for co-design. However, other works focused on collaboration have also shown that the use of digital technology engages participants in productive processes and in a co-construction framework (Jeong & Hmelo-Silver, 2016). It is therefore unclear *a priori* how a digital adaptation of an existing tangible co-design approach will be perceived. On the one hand, the tool can compel users to guide them and help them stay focused on their main task, but on the other hand, it can also limit creativity if it is too direct. Thus, there is a need to find the right balance in its design.

With participatory design, “the user becomes a critical component of the process” (Sanders, 2002), and they can be involved using the appropriate tools, such as card decks (Roy & Warren, 2019). For learning analytics applications, some card decks-based approaches such as LA-DECK (Prieto Alvarez et al., 2020) have led to successful outcomes in terms of design: “the cards succeeded in playing very similar roles to those documented in the literature on successful card-based design tools”. But LA-DECK focuses more on establishing a dialogue between designers, data scientists and users than purely on letting users express their needs.

A literature review of 155 card-based design tools (Roy & Warren, 2019) shows that this format is widely used: their tangible form combines several ideas, with a limited amount of information, thus providing a good intermediary between structureless tools (post-it) and complete tools (instruction manual). However, this review also points out that only “some of the tools are [...] also available as apps or online.” Moreover, the existence of a digital version does not guarantee that traces are recorded, as most methods are more interested in final production than in an analysis of the processes used to obtain them. Finally, when the information was explicitly provided by the authors, it appears that none of these tools was used with remote participants: participants were always in a face-to-face context around a table. These sessions are often accompanied by a facilitator who introduces the session, presents the cards, answers any questions and concludes the session (Prieto Alvarez et al., 2020). Some studies about co-

design (Goldman et al., 2019) uses both online activities and face-to-face time, and recent studies have analyzed the transposition of tangible tools into digital tools in other contexts (Jost & Divitini, 2021).

2.2 Learning Analytics Dashboard

Although the research field around learning analytics dashboards (LAD) is quite young (Schwendimann et al., 2017), several reviews of the literature on the LADs have already been written (Verbert et al., 2014). LADs allow the learners to be aware of their progress, to create meaning and to take decisions that will impact their learning. But Jivet et al. (2017) explains that LADs are not always developed in line with clear educational objectives, and that making people aware of their journey is not enough to improve learning. In addition, LADs can also cause negative effects (Tan et al., 2017; Teasley, 2017) in particular when they provide comparisons with peers for certain student profiles. It is therefore necessary to create LADs adapted to the learning contexts and according to the students' needs. Some works show students' expectations for personalization and the importance of having an adaptable LAD (Roberts et al., 2017; Teasley, 2017). There are also early works on the design of adaptive LADs, such as those of Dabbebi et al. (2019) on the design and the dynamic generation of contextual LADs for teachers. All these studies highlight the interest of adaptive LADs, but such LADs have not been developed for the learners themselves.

As seen before and in the previous works (Lucero et al., 2016; Roy & Warren, 2019; Ruiz et al., 2018), this approach is generally implemented using cards. The participatory design kit developed by Dabbebi et al. (2019) offers a complete method for designing LADs, the first uses of which were carried out with secondary school teachers. Therefore, it appeared to be the closest to our goals, and we chose to adapt this method to students in the context of higher education.

3. RQ1.1 – TRANSPOSITION OF A TANGIBLE TOOL TO A DIGITAL TOOL

3.1 Material

3.1.1 THE PADDLE METHOD

To design Learning Analytics Dashboards (LAD), Dabbebi et al. (2019) developed a participatory-based design tool using card decks which was positively rated by its users. Our adaptation of this method to the context of higher education and focused on co-design by students is called PADDLE. We used an iterative approach to test and propose adaptations of the design kit for our student target. First of all, we practiced with the existing tool by working with its intended audience (teachers) over two sessions, but in a higher education context. This appropriation time validated (1) the relevance of the method in a university context, (2) its suitability to easily collect users' needs, and (3) the positive rating it received from participants. We were thus able to define a first variant of the initial method. This variant for a higher education context required changes in vocabulary, length of time for the student target and the addition of questions for participants. Vocabulary related to secondary education such as "pupil, class, school, department, academy" has been changed to "student, promotion, institution, regional, national". A second set of changes was necessary to adapt the tool to different stakeholders, i.e., students. In order to more easily fit in time slots usually available to them between two classes, we reduced the duration of a session from 150 minutes to 90 minutes, which led to adopting a question-based approach to better guide them and thus save time. For example, the card entitled "Monitoring" initially described by a definition, has been replaced by "How do you keep track of your work? What do you need to track your work?". The participants take turns answering the questions and thus identify their possible needs. Naturally, these adaptations do not prevent from using PADDLE with the initial targets (teachers) as well.

Table 1. PADDLE phases

Phase	Description	Cards
Phase 1	Introduction of the session with icebreaker activity	
Phase 2	Choice of the LAD goal between monitoring, planning, communication, evaluation, evolution and remediation	6 objectives cards
Phase 3	Definition of the context by answering the questions: who, where, what, how, for when, when	7 questions cards
Phase 4	Definition of the data to track, the	Data (open cards) and

	indicators to compute and the associated visualizations to display them	visualizations cards (25 proposed visualizations and cards to personalized)
Phase 5	Drawing of the LAD to show how all the visualizations can be associated together in an integrated dashboard	

PADDLE allows to co-design LADs in small groups of two to four people. The sessions last from 90 minutes (for students) to 120 minutes (for teachers) and consist of five phases presented in table 1. The session is supervised by a facilitator who supports debates and helps participants in formalizing their ideas. Nonetheless, the facilitator intervenes only on request or when he/she detects a group is struggling, in order to give participants autonomy. In particular they refrain from giving examples of indicators in a learning context or to express judgment on participants' proposals, in order not to inhibit nor direct the students' discussions. To facilitate transport, pooling and animation, the board has been transformed into convenient cards: PADDLE comes in the form of laminated cards to be able to reuse them and magnetic cards to manipulate them on a whiteboard (cf. Figure 1). Participants must set a goal and then complete a board to describe their context before identifying the relevant data and their graphic representations. Finally, they assemble these elements to design their LAD.

Traces of the sessions are collected using audio recordings of the groups, photos of intermediate stage results, photos of the LAD produced and a paper-based or online evaluation questionnaire.

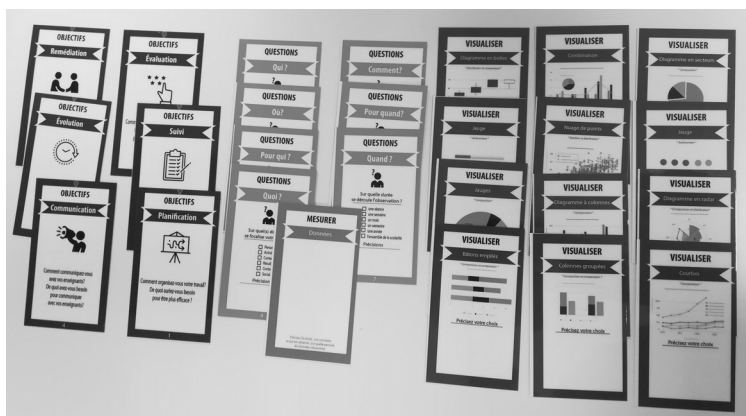


Figure 1. PADDLE cards presented in table 1

3.1.2 Transposition of relevant properties of PADDLE

We identified 8 properties in the PADDLE method (cf. table 2) and considered their possible digital transpositions to improve trace collection. These 8 properties were chosen to be generic enough to assume that they would also be relevant for any other adaptation of a card-based co-design method into an online remote version, as none are intrinsically related to mechanics exclusive to PADDLE. We believe however that the way we chose to translate them are not unique, and it is possible that for other methods, other translations would be more relevant than the ones chosen here.

More precisely, here are the justifications of our choices; we tried not to lose their primary functionality. The first three properties are only associated to one of the five phases:

- Initial explanations (phase 1): the use of a video makes it easier to collect traces (time spent listening to the video, number of views), but the absence of a human to initiate the activity could be detrimental to the motivation of the group. So, we chose to keep a human briefing.
- Graphic production (phase 5): using digital tools can have potentially more readable results than a handwritten production. In the case of online software use, the link to the productions is saved.
- Evaluation of the method and the results obtained (phase 5): the evaluation method initially developed by questionnaire is adapted to the digital format to facilitate the analysis.

The five following properties are more global and associate to the method overall:

- Collaboration between participants: one option considered consisted in adding RFID chips to identify manipulated cards, to keep the tangible aspect of PADDLE, but it limits the possibility of remote sessions. So, we preferred to force each member of a group to give their opinion by proposing individual fields for some questions. This approach requires all members of the group to participate, reinforcing the commitment in the production process and allowing to collect each participants' traces.
- Scripting collaboration: scripting the digital device reproduces the order of the cards originally proposed and blocks the possibility of inadvertently mixing the cards. The digital format allows collecting information on the time spent on each card, thus allowing to identify for instance the most discussed cards.
- Answers to participants' questions: a chatbot could be considered in order to deal with simple questions, to more easily trace recurring problems as well as guarantee that the provided responses are standardized. However,

chatbots can tend to distract participants (who can spend time gaming the system instead of accomplishing the task at hand (Bouchet, 2009)), lead to distrust in the whole approach if the answers are not appropriate, or may over-guide participants in the method. For these reasons, we chose for now to force participants to call the facilitator, even if it may slow down the process.

- Regulation of the session: time regulation is possible to force the transition from one phase to another but may limit rich exchanges, and it is recommended that participants be involved in the regulation of their collaborative activities (McNair et al., 2010). The digital format allows to trace the time spent in each phase.

Visibility of previous decisions: posting a summary of each phase allows the group to check their choices and change their minds. Access to this screen can be traced to estimate the coordination of decisions with past choices.

3.1.3 The ePADDLE method

We proposed to transform the PADDLE method and cards deck into the application ePADDLE (cf. Figure 2); a digital format of PADDLE improving traces collection. Based on the 8 properties presented in the previous section, table 2 list each digital transposition we chose to collect.

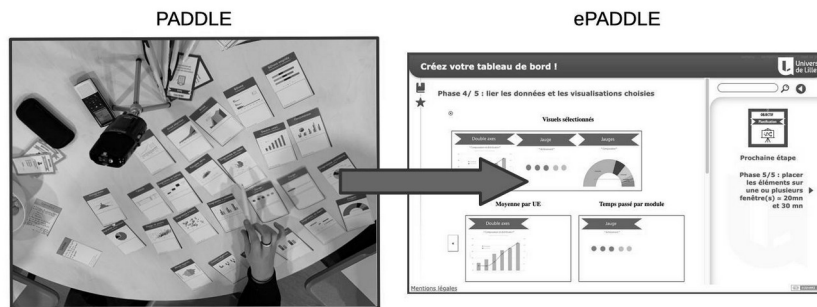


Figure 2. From PADDLE with tangible cards to ePADDLE for remote online co-design sessions.

To elaborate the digital transposition of PADDLE, at first, we looked for an adapted tool which can quickly prototype and collect traces. We chose an open-source tool called Scenari Topaze¹ which can generate conditioned path

¹ <https://download.scenari.software/Topaze/>

in a simple format (web html pages and javascript). Then we developed ePADDLE with several iterative phases with several types of users to test and evaluate it before using it with student groups. All this work has been done remotely during the first French lockdown in response to the Covid-19 pandemic.

The ePADDLE application keeps PADDLE's key elements: (1) its original 5 phases (presentation, decision choice, context, data and visualization choice and LAD design), (2) the number of participants (2 to 4 in each group), (3) the facilitator whose role is mostly to introduce the goals of the workshop at first, and then to answer to both technical questions and methodological questions. Among the new elements we had to adapt or introduce to organize a remote online session, we can mention: (1) the fact that groups are asked to work together with a web conferencing tool where they can chat, talk by voice and share their screens, (2) two additional specific roles to take into account that it is harder for the session facilitator to keep track of the progression of each group compared with a session where all groups are in the same room: the scribe (whose role is to connect to the ePADDLE app, share their screen and take note of answers from the group), and the time keeper (whose role is to ensure some groups do not spend too much time on some phases), (3) the fact that activities are tracked using the LMS Moodle, commonly used in higher education, as the ePADDLE module is open source and can be embedded into Moodle².

Table 2. Translating the different properties of PADDLE into ePADDLE

Properties	PADDLE	ePADDLE	Additional traces
Initial explanations	Slideshow presented by the facilitator	Slideshow presented by the facilitator	-
Collaboration between participants	Card selection and card annotations by participants	Participating with scribe role and fields to be filled either individually or collectively	Individual and group responses from participants
Scripting collaboration	Ordered cards and regular interventions by the facilitator	Online interface for scripted collaboration	Time spent by phase
Answers to questions	Session facilitator role	Group facilitator or facilitator for the session	Trace questions in the chat
Time regulation of the session	Session facilitator role	Participating with time master role and follow-up of the session facilitator	-
Visibility of previous	Magnetic cards on the whiteboard	Summary of the choices made between each phase	Summary of previous choices

² <https://padlad.github.io/productions>

decisions	and annotation of participants	and via the menu of the digital device	and number of times the summary was viewed
Graphical production of the result	Stationery/Office materials (paper, pencil, scotch, ...)	Tool of choice: paper, participant-controlled software or online editing software	Link if online production
Method for results assessment	Questionnaire	Questionnaire with link in the digital device	-

3.1.4 Additional data collected with ePADDLE to evaluation collaboration

To answer RQ2, to provide better insight into ePADDLE usage in order to improve the method, it is important to consider several dimensions as:

- the different types of roles adopted and the preferences of each (Belbin, 2010) (e. g. coordinator, completer-finisher or teamworker),
- oral collaboration management (Burkhardt et al., 2009) (e.g. fluidity of collaboration, sustaining mutual understanding,...), which can be analyzed through the participants' speech acts (McNair et al., 2010) (e.g. Question - Answer - Acknowledgement of contribution or Command – Announcement or again Correct – Accountability),
- trust level between participants (Holton, 2001) through the analysis of potential pre-existing interpersonal links between the participants,
- the quality of the collaboration as perceived by the participants in the task themselves,
- the quality of the product of the collaboration as assessed by the group and by others.

We tried to list how to trace additional data we need to evaluate collaboration in table 3.

Table 3. Additional trace data to evaluate collaboration

Dimension	Solutions adopted in ePADDLE
Collaborative roles	Belbin profile test for collaboration evaluation
Acts of dialogue	Audio or screen record to allow manual coding in speech acts. We considered offering participants a simple interface with a few smileys to indicate their intentions when they spoke. We did not choose this solution for fear of distracting the participants from the main objective of the co-design session.
Trust level	New questions inside the original questionnaire to rate how well they

	knew the other participants in their groups
Perception of the quality of the collaboration	Original questionnaire from PADDLE
Perception of the quality of the collective production	Original questionnaire from PADDLE and a poll to the participants allowing them to vote for the best LAD. We have reproduced each LAD designed by students results with a common look (same colors, same pictograms) and asked all students to divide 10 points between their favorite LADs

3.2 Method & data collected

3.2.1 Conditions and methodology of the experiment with PADDLE

We carried out with volunteer students three recorded PADDLE sessions followed by a qualitative analysis: (1) two of them with two pairs of 1st year language students enrolled in a training formation dedicated to mastering the university environment, and (2) one with three 5th year pharmacy students in the context of a course using a serious game based on professional simulation. For each session, we recorded the interactions between students, we listed the cards selected, the data they chose to display on their LAD, the final display of the LAD they defined and we asked participants to complete the original evaluation questionnaire (Dabbebi et al., 2019). This evaluation consists in 7 statements to rate using 5-point Likert scale to evaluate their satisfaction both with the process and its outcome (the dashboard they designed). This data collection was led after declaring it to the university data protection officer (DPO).

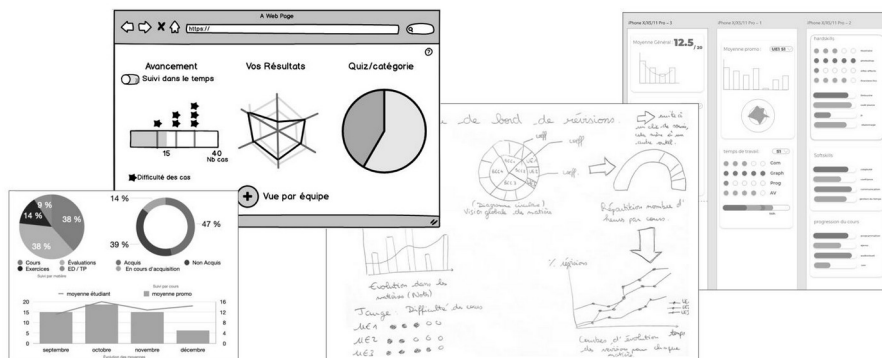
3.2.2 Conditions and methodology of the experiment with ePADDLE

To validate the claim that ePADDLE supports LAD co-design, 8 sessions using ePADDLE were organized, involving overall n=177 students, composed of first year university students in multimedia design (n=58) and second year university students in pharmacy (n=119), randomly assigned to 52 groups of 2 to 4 students. The experiment was carried out in 2020 in two different universities. With students in multimedia design, we organized four sessions of fifteen students with their teacher. The students were from 18 to 21 years old and familiar with computer use. In the groups, there was a distribution between male and female of 40/58. With students in pharmacy, the experiment was carried with four sessions of approximately thirty students with a PhD student. The students were predominantly female and in an initial study program without specific computer use for their studies.

The audio interactions of each group were recorded. Each participant was asked to fill the same post-session questionnaire used with PADDLE.

For each property of the PADDLE method, data are described as median [interquartile range] since their distribution is asymmetric. Means were compared with Mann-Whitney-Wilcoxon tests or Student's t-tests as appropriate, depending on the normality of the variable as tested by a Shapiro-Wilk test. No adjustment was done for multiple comparisons. The two-sided type I error rate was set at $\alpha=0.05$.

Each PADDLE property implementation has either been retained as they originally were or transposed through an implementation that allows for better tracing. The ePADDLE sessions made it possible to successfully design 52 LADs (one per group - cf. Figure 3), as no group failed to propose a dashboard at the end of the session. Moreover, it allowed to easily collect the data captured during the session, in addition to the traces usually collected with PADDLE. The follow-up of the questions was successfully managed with only one facilitator per session. The regulation can be considered adapted because the duration of the workshops remained mostly in the expected time (from 81 to 147 min, M - 108 min, SD - 18 min). Finally, the visibility of previous decisions and graphic production can be



validated by the productions made, which are in line with the choices of the participants.

Figure 3. Examples of LAD designed with PADDLE and ePADDLE

By reusing the original evaluation questionnaire (Dabbebi et al., 2019), according to users' evaluation (see table 4), ePADDLE was rated a bit lower than PADDLE used in in-person sessions, significantly so regarding help to specify needs and creativity.

Table 4. Translating the different properties of PADDLE into ePADDLE

Properties	Statements to rate using 5-point Likert scale	PADDLE (n=8)	ePADDLE (n=177)	p*
Collaboration	The tool helped you to have a good group dynamic.	M=5 [4;5]	M=5 [4;5]	0.60
	The tool helped you to converge towards a solution.	M=4 [4;5]	M=4 [4;5]	0.95
Scripting	The tool is easy to handle.	M=5 [4.5;5]	M=4 [4;5]	0.11
	Cards are easily understandable.	M=4.5 [3.5;5]	M=4 [3;4]	0.08
	The tool has enabled you to better specify your needs.	M=5 [4;5]	M=4 [3;4]	0.005
	The tool has enabled you to find original solutions.	M=5 [4.5;5]	M=4 [3;4]	0.002
	And this solution seems relevant to you.	M=5 [4;5]	M=4 [4;5]	0.10

* The degree of significance of the Mann-Whitney test after Bonferroni correction

Then, we worked on the comparison of the results obtained with pharmacy students and multimedia design students, results are presented in table 5. There are significant differences in the perception of the group dynamics and the relevance of the solution:

- group dynamic: mean difference of 0.4 point CI95% [0.12;0.68], p=0.005
- relevance of the solution: mean difference of 0.3 points CI95% [0.02;0.59], p=0.04

Table 5. Evaluation of ePADDLE properties used in remote sessions by pharmacy students and multimedia design students

Properties	Statements to rate using 5-point Likert scale	MMI (n=58)	Pharma 2A (n=119)	p
Collaboration	The tool helped you to have a good group dynamic.	M=4 [4;5]	M=5 [4;5]	0.005
	The tool helped you to converge towards a solution.	M=4 [4;5]	M=4 [4;5]	0.27
Scripting	The tool is easy to handle.	M=4 [4;5]	M=4 [4;5]	0.69

Cards are easily understandable.	M=3.5 [3;4]	M=4 [3;4]	0.13
The tool has enabled you to better specify your needs.	M=4 [3;4]	M=4 [3;4]	0.72
The tool has enabled you to find original solutions.	M=4 [3;4]	M=4 [3;4]	0.79
And this solution seems relevant to you.	M=4 [4;5]	M=4 [4;5]	0.04

3.4 Discussion

Our transposition of the tangible co-design tool into a digital version has achieved its primary objectives: to allow remote co-design sessions, to define LADs and to collect useful traces for our research work. The evaluation of this new tool by the users shows some limits. On the creativity aspect, the tool could not compete with a real paper whiteboard. On the aspect of needs definition, it is possible that the scripting of the digital version guides the participants too much and limits their expression of needs compared to the tangible version. There was one facilitator per group for the PADDLE sessions compared to one facilitator for several groups for the majority of ePADDLE sessions. It may have an important role in developing the expression of needs.

When we look deeper evaluation of users with different profiles: multimedia design and pharmacy. Indeed, the study contexts of the cohorts are very different and can bring an important bias. Due to the nature of their studies, multimedia design students are probably more comfortable with digital tools, and they are probably used to collaboration. Second year of pharmacy students come out of a competition from a very individual first year during which there are no group activities. These differences could explain the differences in perception, the pharmacy students felt that the tool helped them to have a good group dynamic and were more satisfied with their result.

Naturally, these results will have to be confirmed with larger samples but also with other contexts.

4. RQ1.2: DIGITAL TOOL USED IN FACE-TO-FACE

The digital transposition of our tool seems to be less adapted when used online, we can ask ourselves how this digital transposition is perceived in face-to-face. The digital version would retain its trace collection capabilities and could be as effective as the tangible version.

4.1 Material and method

In addition to the experiment presented in part 3, we kept the same approach and we organized 3 sessions using ePADDLE in face-to-face, involving n=78 second year pharmacy students, randomly assigned to 23 groups of 2 to 4 students.

We collected the same data as those collected in the online experiment:

- data to evaluate the tool: each participant was asked to fill the same post-session questionnaire used previously
- data for our future work: the audio interactions of each group were recorded and the Belbin team roles questionnaire.

For each property of the PADDLE method, data are described as median [interquartile range] since their distribution is asymmetric. Means were compared with Student's t-tests. No adjustment was done for multiple comparisons. The two-sided type I error rate was set at $\alpha=0.05$.

4.2 Results

During the ePADDLE sessions in face-to-face, students designed 23 LADs of which 20 groups used paper and pencil for phase 5 drawing. During the online sessions, they produced 34 LADs of which 7 designed with paper and pencil. Students made similar choices of tools, although the face-to-face session made it easier to use pencil and paper for collaboration.

The comparison of the perception of ePADDLE properties between online and face-to-face sessions of the same cohort are presented in table 6.

Table 6. Evaluation of ePADDLE properties by second year pharmacy students in face-to-face sessions and online sessions

Properties	Statements to rate using 5-point Likert scale	Face-to-face (n=78)	Online (n=119)	p
Collaboration	The tool helped you to have a good group dynamic.	M=4 [4;5]	M=5 [4;5]	0.0003
	The tool helped you to converge towards a solution.	M=4 [3;5]	M=4 [4;5]	0.0003
Scripting	The tool is easy to handle.	M=4 [3;5]	M=4 [4;5]	0.001
	Cards are easily understandable.	M=3 [3;4]	M=4 [3;4]	0.09
	The tool has enabled you to better specify your needs.	M=3 [3;4]	M=4 [3;4]	0.02
	The tool has enabled you to find original solutions.	M=4 [3;4]	M=4 [3;4]	0.26
	And this solution seems relevant to you.	M=4 [3;4]	M=4 [4;5]	0.00008

Significant differences were found for some properties, for which remote users are more satisfied:

- Group dynamics: mean difference of 0.5 points CI95% [0.2;0.7], $p=0.0003$
- Convergence towards a solution: mean difference of 0.5 point CI95% [0.2;0.7], $p=0.0003$
- Easy-to-handle card: mean difference of 0.5 point IC95% [0.2;0.8], $p=0.001$
- Requirements specification: mean difference of 0.4 point CI95% [0.01;0.6], $p=0.02$
- Relevant solution: mean difference of 0.5 point CI95% [0.2;0.7], $p=0.0008$

4.3 Discussion

Against all expectations, ePADDLE receives better evaluations for the online sessions. We would have thought that the face-to-face sessions would be better perceived by the participants (especially on the creativity part) or at least evaluated in an equivalent way. We can imagine several reasons for this result. Management by a face-to-face scribe may be less conducive to collaboration because he or she is the only one who interacts with the tool. Indeed, the screens used during the face-to-face sessions were small (tablet or student computer) and may not have allowed all participants to see the scribe's screen well. The arrangement of the tables may be an additional barrier to collaborating with a single screen. Offering the broadcast on a larger screen might have had a different result or using adapted furniture as learning labs can offer. We can therefore ask ourselves if the collection of traces during a face-to-face co-design session with a digital tool remains as interesting if we lose the quality of the tool. For face-to-face sessions, digital tables would be an interesting way to study, as they can combine the advantages of the different methods, such as making all the participant actors, while collecting digital traces easily.

5. CONCLUSION AND PERSPECTIVES

Our results with students are encouraging and show the possibility of developing online co-design sessions to achieve our main goal consisting in co-designing LADs. Indeed, if the main advantage of this digital transposition is to obtain pre-formatted data that allows a rapid processing of

these, we can see other benefits, such as allowing remote use. Moreover, this transposition has led to enrichment to the initial method, such as the definition of multiple roles originally all under the responsibility of the session facilitator.

However, there are still limits with this transposition which leave room for potential future improvements. One particular limit is the lack of traces during the final dashboard design phase. Adding an embedded graphic production tool would not only facilitate this activity for participants and standardize the dashboard produced by different groups, but also help in collecting traces still poor for this phase (only the final dashboard is collected but not the design process of this dashboard). Another limit is revealed by the second experiment, namely the fact that the digital transposition seems only partially adapted for face-to-face sessions. Potential improvements could involve testing digital co-design tools in adapted spaces such as the Learning Lab where collaboration using digital tool is more optimal. Another limit relies on the validity of the properties in another context: although we made an effort to identify property that appear to be generic, only transpositions of the same properties in other contexts would confirm it. This initial work should be further developed by testing ePADDLE in other contexts (using different target groups, considering the impact of how participants are recruited) and by comparing with adaptations of other co-design methods. These additional studies will help to determine rules to follow for such transpositions to be successful.

Through this study, and in particular with the additional traces, we open perspectives such as improving the quality of group dynamics, an important point to enable remote collaborative work and fully validate this tool. We also have been able to focus on using post-session questionnaires to understand group dynamics and identify potential favourable conditions for successful collaboration through (1) an analysis of speech acts based on (McNair et al., 2010), and (2) finding links with Belbin's collaboration profile (Oliver-Queennec et al., 2022). Such analyses could help in enhancing initial group formation or during a session to identify clues indicating a less productive collaboration. In parallel, we contribute to a collaborative work to develop a new version called PaDLAD V2³. Future work will focus on defining adaptative LADs for students by identifying indicators and visualizations expected by students depending on their objectives and learning contexts

³ <https://padlad.github.io/productions>

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