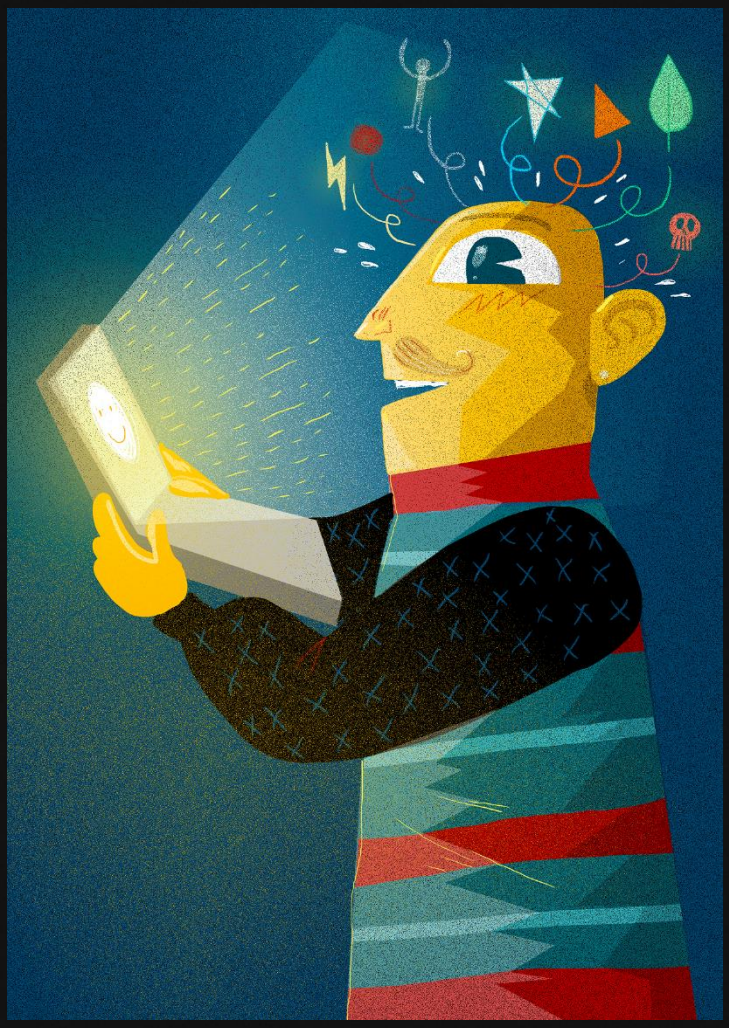
Game Environments



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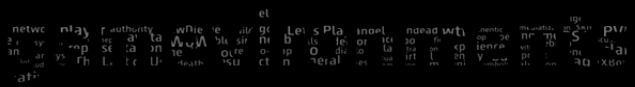

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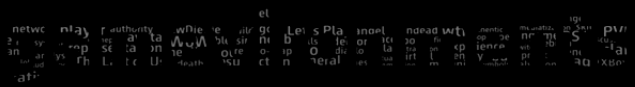

Peer-reviewed Article

Towards an E-class Stimulating Social Interactivity based on Digitized and Gamified Brainstorming[i]

Stéphane Gobron, Corentin Barman, Artan Sadiku, Xavier Lince and Isabelle Capron-Puozzo[ii]

Abstract
How do we strengthen the social bond in the case of a situation where we have to conduct a distance-learning course? Since we can no longer do without digital tools, this article proposes to use of digital media where young audiences may wish to actively participate. The idea is to set up an e-class where everyone can contribute and be stimulated. In this context, we propose to set up digital brainstorming, based on the best products on the market and adding gamification attributes. Being careful not to make it a serious game, we developed a gamified online application that allows working out issues creatively and collectively. To study positive or negative impacts of gamification, we organised multiple user-tests comparing professional tools and our proposal. This led to a thinking on the type of gamification assets and when to use them within the creative process.

Keywords: Brainstorming, Remitting teaching, Brainstorming, Social interaction, Gamification, Digitization, Virtual environment, E-classroom, gamevironments

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For a teacher, especially with little experience, it is not always easy to stimulate students or pupils. The advent of game consoles and, more generally, of digital world – professional or recreational – increasingly requiring working at a distance, worsens the situation. The young teacher is certainly familiar with these technologies but does

not often have the pedagogical perspective to stimulate his audience; the older professor certainly has this human experience but, with now ultra-connected audience, there is a strong risk of losing the communication thread. In addition to this growing societal gap, digital tools increase health situation linked to COVID-19 (Mercier et al. 2021), to an explosion of depression, even human distress.

The unprecedented crisis we are experiencing with the COVID-19 pandemic has had disastrous effects on student mental balance, and dropouts are legion (e.g., some Swiss universities: 30% instead of the usual 5% before the end of the first semester). One particularly big issue is that students rely heavily on interactions between peers for their mental construction. The lack of social ties and interaction between them seems to be one of the major causes. The problem is not easy and is unfortunately likely to persist: how to enable more interaction when both teachers and students stand in front of a screen at distance? A solution can be the use of group activities where the focus is on a subject, not participant: e.g., brainstorming. Brainstorming consists of three principles and phases: the generation ideas by participants under the lead of a moderator, visual categorization of ideas (for example, on a white board), and creating a hierarchy of idea themes and patterns. This process does not necessarily require people to be physically close to each other.

Furthermore, it stimulates interactivity through a creative process: each one brings his/her own building block, constructing innovative solutions together to answer the subject at the centre of teaching. In this project, we have developed an online gamified brainstorming software to demonstrate the effects of a study course built via idea generation (Craft 2016, Zobrist and Brandes 2017). With gamification – not to be mixed with serious games development (Gobron 2021, Berg Marklund 2015, Wenk

and Gobron 2017) – our second goal is to show that we can stimulate the social bond through sharing and exchanging, all by becoming an actor in the learning process.

During the brainstorming sessions, students were encouraged to:

1. Stimulate their creative process, divergent and convergent thinking, analogue or comparative combinatorial thinking, serendipity or flexibility (Beckman and Barry 2007, Capron-Puozzo 2016, Lubart et al. 2015);
2. Interact with their peers to defend their ideas and co-construct families of ideas to bring out the concepts related to the subject.

One of the indirect study's objectives is to assess the impact of gamification. This project fully focuses brainstorming in the context of education: (1) paves the way for gamification of brainstorming in education, (2) gives the possibility of analysing the creative process from a research perspective and (3), enhances social bonds within the learning session.

Contextualization and Aims

Creativity

Amongst the most commonly cited soft skills, creativity is a recurring term. It has been identified with social intelligence as a key skill to get a job by 2030 (Zobrist and Brandes 2017, 56). In related studies, creativity is defined as "the ability to produce work that is both novel and appropriate" (Sternberg and Lubart 1999, 3), i.e., useful, adaptive, flexible with demanding tasks (Anderson et al. 2004, Lubart and Lautrey 1998, Lubart et al. 2015, Runco and Jaeger 2012). Individuals with higher levels of openness are both curious about their internal and external worlds and their lives, are richer in experiences, implying that open people are more creative. Furthermore, these people are also more willing to welcome new ideas and adopt unconventional

values (Costa and McCrae 2008). Mednick's associative model of creativity postulates that creativity is the ability to bring together several elements by forming new combinations to respond to the constraints of another context (Mednick 1962). The further apart these elements are, the more creative the combination created. In terms of more qualitative approaches resulting from the generation of ideas, Lubart et al. (2015) and Barbot et al. (2015) refer to brainstorming as described by Osborn (1965), or the creative problem-solving process as described by Parnes et al. (1962).

Brainstorming

The Brainstorming technique was introduced by Osborn (1953) almost four decades ago, with the aim of providing a structure to improve group problem solving. Numerous studies have since proven the effectiveness of this method (Dennis and Valacich,1993, Lamm and Trommsdorff 1973, Nunamaker et al. 1996). Osborn introduced the following rules:

1. No criticism of given ideas: Criticism should be put *on hold*. Instead, participants should focus on extending or adding ideas. The criticism is reserved for a later stage in the process;
2. Go for large quantity of ideas: The assumption is that greater the number of ideas, bigger is the chance of producing a radical and effective solution;
3. Build on each other's ideas: It is believed that idea generation can be stimulated by a process of association;
4. Encourage wild and exaggerated ideas: To get a wide set of suggestions, wild ideas are encouraged as they can present a new perspective on the problem and help reach a better solution.

Brainstorming Issues

Multiple studies demonstrate that a smaller number of individuals can be more productive (Diehl and Stroebe 1987, Lamm and Trommsdorff 1973, Mullen et al. 1991, Paulus et al. 1995, Taylor et al. 1958) than an entire group in a brainstorming session. Different issues have been identified as the cause of this difference. First, members cannot contribute their ideas when they emerge because another member might be speaking. They are then forced to keep their ideas to themselves for some time. This phenomenon is called *Production Blocking*. This delay in speaking has been identified as a major cause of the differences in effectiveness between brainstorming in groups or alone (Dennis and Valacich 1993, Dennis and Wixom 2002, Diehl and Stroebe 1987). Then, distraction is another significant issue. In group brainstorming, a participant may say unrelated comments to the current session and distract the others (Aiken et al. 1997, Murthy 2009, Pinsonneault et al. 1999). Some users may decide to not involve themselves in the discussion. This is known as social loafing, or free riding (Murthy 2009).

Another mentioned factor is the cognitive blow to keep one's ideas in mind and interact with other people's ideas while clearing out distractions: it is known as concentration blocking (Diehl and Stroebe 1987, Gallupe et al. 1992). Productivity in a collaborative work is directly influenced by the involved cognitive load (Antunes and Ferreira 2011, Kolfschoten 2011). Finally, one of the most recognised issues is social inhibition, where participants avoid giving ideas because of the possibility of others disapproving of their feelings or expressions (Camacho and Paulus 1995, Collaros and Anderson 1969, Dennis and Valacich 1993). Reciprocally, the social influence model (Paulus and Dzindolet 1993) suggests that *very* productive participants can improve the group performances (Paulus et al. 1995, Shepherd et al. 1995).

Electronic Brainstorming (EBS)

To solve the mentioned problems, researchers have been implementing a variant to the traditional brainstorming method, the Electronic Brainstorming (EBS). Which makes use of computers allowing members to interact and exchange ideas. The ideas that are generated using Electronic Brainstorming are anonymous and, thus, tend to be expressed more freely and in greater quantity. Electronic Brainstorming's efficiency has been shown in multiple studies (Al-Samarraie and Hurmuzan 2017, Dennis and Valacich 1993, Dennis and Wixom 2002). Anonymity during a brainstorming session has been demonstrated to compensate social inhibition (Connolly et al. 1990, Dennis and Valacich 1993, Dennis and Wixom 2002). Production blocking can also be mitigated as electronic brainstorming allows participants to give their ideas simultaneously (Dennis and Wixom 2002, Gallupe et al. 1992, Valacich et al. 1994). Nevertheless, an identified limitation of Electronic Brainstorming is the attention paid to other ideas (Michinov et al. 2015), which is considered an important factor in the group's creative performance. Michinov et al. (2015) demonstrated that depending on the digital interface at disposal, participants are not always motivated to do so.

Nominal Group Technique

The Nominal Group Technique (NGT) is a group process involving problem identification, solution generation, and decision making (Delbecq and Van de Ven 1971, Delbecq, van de Ven and Gustafson 1975). A group is usually formed by one moderator and six to nine participants (Delbecq and van de Ven 1971). The Nominal Group Technique usually involves five stages:

1. Introduction and explanation: The moderator meeting welcome the participants and explains how the session will be conducted;

2. Ideas generation: Participants will now silently write down all the ideas that comes to mind related to the question. Participants cannot communicate with each other during this stage. This usually last for ten minutes;
3. Ideas sharing: Each participant will then share his individually-noted items with the others. No criticism is yet given at this point, instead participants should focus on writing new ideas that build upon others' ideas. This typically lasts 15-30 minutes;
4. Group discussion: Participants are now encouraged to discuss ideas and asked for specifications. The moderator needs to keep this procedure as neutral as possible, and no idea should be eliminated. The group combines different ideas in categories. This stage can last
5. 30 to 45 minutes;
6. Voting and ranking: Finally, when all the ideas are given and shared, participants rank or vote on the ideas by selecting the ones that answered the initial question at best. After this process, the results are directly given to the group and the session ends – hopefully – having reached a specific outcome.

Proposed Deployment in an E-classroom

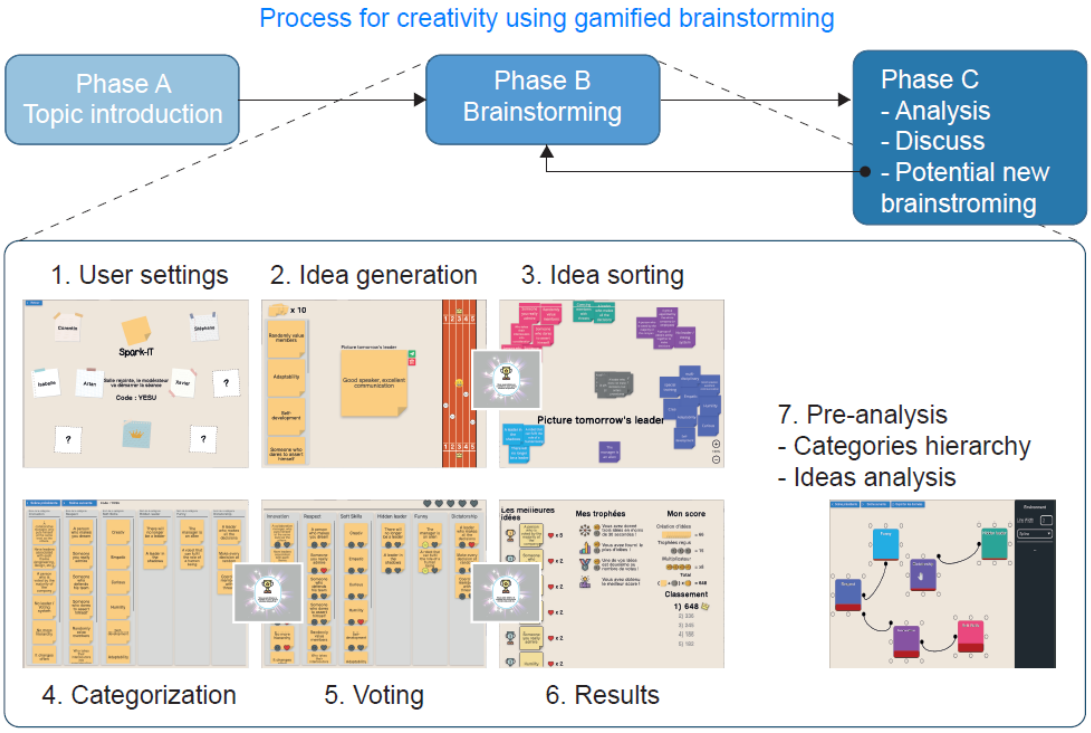

Figure 1. Three main phases – A. general introduction; B. brainstorming, composed of seven steps (1 - 7); C. conclusion phase.

As shown in figure 1, we consider a hypothetical basic 3-phase teaching approach (upper part shown in blue). *Phase A:* Welcoming participants; presenting the general steps of the procedure; proposing a specific methodology; defining the framework, timing, rules to follow; detailing objective and purpose of the work; stating the subject to be studied precisely; asking if there are questions (but not related to the studied object). *Phase B:* Gamified e-brainstorming to stimulate interactivity – detailed in this article. *Phase C:* recognition of the accomplished work; questions or remarks about the process; present the rest of the work, such as the work in subgroups of each category; find a new subject to debate to fuel a new cycle of brainstorming.

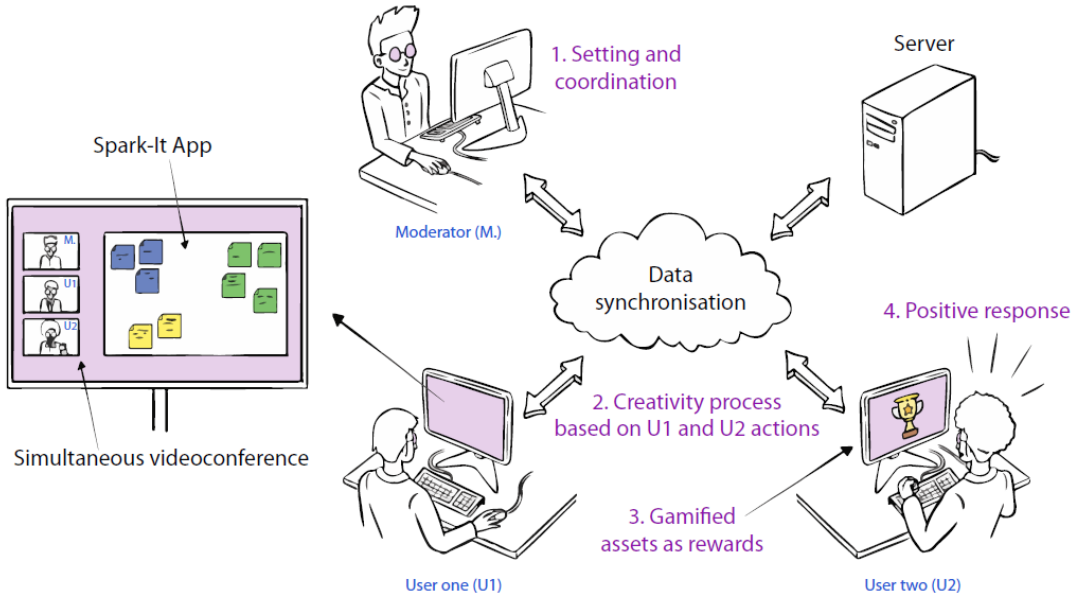

Figure 2. Illustration of how the creative process and social links can be enhanced using a gamified online brainstorming: the *Spark-IT* project.

To carry out our project *towards interactive e-classroom based on digitized and gamified brainstorming* (see figure 2), we had to make methodological choices that respected as much as possible the definition of the above Nominal Group Technique model. In this context, we want – despite the physical distance that separates participants – to recreate a social bond, a presence at the human scale that transcends the digital medium. The brainstorming tool allows us to set in motion a collective intelligence based on imagination, listening, sharing, debating, taking a position, and converging points of view into a mutual idea. Supported by imagination, this approach provokes at the same time a personal highlight, a shock of ideas and social communion opening even more the field of possibilities. In this context, we support the thesis that adding a playful dimension – through the deployment of gamification – can only promote the social relationship between pupils or students.

Targeted Issues

Software Selection Criteria

The previously-named criteria were then evaluated by three members of the *Spark-IT* project for the three applications. The applications were tested in order to (1), identify possible problems that might arise with end-users in our educational context and (2), examine the functionality – strengths and weaknesses of the interfaces, options, methodologies – provided by corresponding software. Table 1 shows an overview and comparison of the different types of features each application include, which was used as a framework for the evaluation process.

Criteria	Application M	application K	Application L
General			
Video conference	Yes	Yes	Integration available
Moderator role	Editor / Visitor	Moderator / Participant	Editor / Visitor
User experience			
Connection			
Ease of connection	Can join from an email invitation	Can join from a link	Invitation linked to the account
Account	Account required	Connection with a pseudonym	Account required
Idea generation			
Users actions	No restriction possible	Can control the user available actions	No restriction possible
Session theme	Can manually put text	Shown by default	Can manually put text
User inputs	Sticky notes, drawings, texts	Sticky notes, drawing only for moderator	Sticky notes, drawings, texts
Categorisation			
View synchronisation	Yes	Yes	Yes
Categories / List view	No	Yes	No
Voting			
Cast votes	Fully-integrated voting system	Need to "like" a sticky note trough a menu	Voting available
Timer	Yes	No	Yes
Results			
Data export	Export to PNG, CSV, PDF...	Export to CSV, PDF	Export to PNG, CSV, PDF, Visio
Results view	Shown at the end of the voting phase	Need to do it manually	Shown at the end of the voting phase

Table 1. Criteria to compare the brainstorming applications.

After further testing the tools, only the criteria that were significantly different and critical for the project were selected and weighted to find the best brainstorming program for our use-case. Three members of the project (A, B, C in table 2) rated each criterion on a scale from one to five. A score was then calculated for each of them.

Criteria	Application M			Application K			Application L			Weight
	A	B	C	A	B	C	A	B	C	
Connection process	4	3	4	5	5	5	5	3	3	1
User experience	2	3	4	4	4	4	4	2	2	2
Control over idea generation	1	1	2	5	4	5	1	1	2	2
Voting phase	5	5	5	1	2	2	5	5	4	2
Results view	5	5	3	2	2	3	5	5	4	1
Mean score in %	66%			70%			64%			

Table 2. Weighted criteria for the brainstorming software comparison.

The application *K* was selected despite the small advantage. What it lacks in its voting capabilities is made up by its ease of connection and better controls for the moderator.

Proposed Solution

Gamification

The project's gamification objective is to measure its influence on the quantity and quality of produced ideas. Different elements have been implemented, ranging from trophies, a leaderboard, *funny* votes to a race during idea generation. They will be described in greater details in the next section, but here is an overview of all the implemented elements, and the purpose they serve.

The gamified idea generation process is presented in the form of a race: writing down an idea moves the participants along their track. The leading user is temporarily awarded a crown which is taken as a trophy by the final winner. As described later, trophies are awards given at different stages of the application's journey.

Race, stress, and creativity – a race can be categorised in terms of gamification elements such as a real-time leaderboard while also allowing for the display of one's score as one progresses through the race. We were hesitant to implement this type of gamification element. Indeed, the principle of the race causes stress; on the one hand, stress can be a positive source of innovation and therefore of creativity. But in large doses the opposite effect can occur. We have decided to go ahead and consider these aspects important and complex enough to be the subject of a future study. An animation is played every time a trophy is received, showing the icon and a description. Trophies are used as an incentive to perform better and reward such positive behaviour. During the voting phase, since the number of votes is limited and to prevent users to vote for ideas they find funny, but that are not relevant to the session, *funny* votes can be used. Special trophies are given to the participants who receive this kind of votes. At the end of a session, the individual scores are calculated from the number of ideas written and the trophies received. All the scores are shown inside of a leaderboard providing a comparison between each participant. To avoid direct judgement by participants, the scores are displayed anonymously.

Gamification Deployment

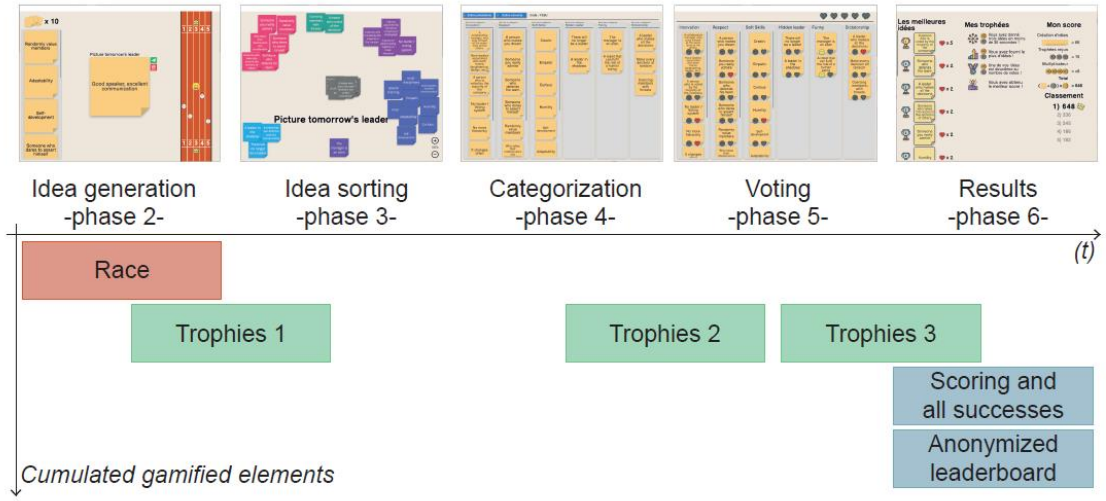

Figure 3. Illustration of the gamified aspects in three categories: in red, a competitive race of ideas; in green, rewards related to the quantity and quality of the shared ideas; and in blue, the final scoring.

Figure 3 shows the gamification deployment in the *Spark-IT* application: in red, a competitive challenge based on a race of ideas; in green, a set of rewards related to the quantity of ideas (trophies 1) and then the quality of ideas (trophies 2 and 3); and, finally scoring and rewards where winners are enhanced and losers anonymized. In all cases, the application is parametrized not getting at least a trophy. As it will be presented in details in the analysis of the user-test, the idea generation step (i.e., phase B2) was crucial for the following social interaction. It was risky to make an actual race since bringing competition to the creativity process is a double-edged sword. Fortunately, the participants received it fairly well: no negative nor positive reaction. Even if it was not point out as an issue, we believe that further investigation should be carried out. Once the gamification process was completed, the participants were overwhelmingly enthusiastic to start again.

Software Specifications

The main objective of the development stage was to create a product that is easy to use and understand for normal users. Gamification elements, design, user inputs, portability and networking had to be easily integrated or implemented in the software. Following these different requirements, it was decided to use the Unity game engine as main development tool. Although the main goal of Unity is centred around the development of video games, it provides multiple tools to facilitate the UIs (User Interfaces) construction, such as enabling the visual manipulation of UI elements trough the built-in editor. In addition to the provided development tools, packages or assets can be downloaded and added to the editor, using the Unity Asset store. *Photon PUN* is a free networking solution that is well-known in the Unity community. It is maintained regularly and provides easy-to-use tools to setup network communication quickly between multiple devices. The basic networking solution provided by Unity (UNET) is deprecated (House 2020), which is why *Photon PUN* was chosen as the networking solution.

Project Outcomes and Results

Comparing *Spark-IT* with the List of Criteria

When the market analysis was performed, a list of criteria was selected to choose the most fitting online brainstorming tool. These points will be listed here again, explaining what was implemented in the project to achieve them. Most of these elements were specially taken care of, to ensure a similar or better brainstorming experience as the reference software.

- *Pricing:* Costs can be assessed in several dimensions. The costs of using an already available tool against developing our own solution is certainly not very advantageous. The development cost can be approximated to two

engineers and three consultants during five months. If instead we want to compare the usage costs, the results are simpler. The website can be deployed on any static web content delivery service, which range from free to 100$ per year, depending on the hosting platform. The *Photon* server used to create rooms and share content during the experiment is free for up to 20 concurrent users. To scale to a hundred concurrent users, the license would then cost 95$ per year (Photon n.d.);

- *Video conference:* Implementing a custom video conference tool was not needed to the project, as simply interfacing with other existing solutions was possible. In the project, *Microsoft Teams* (2017) was used as the HES-SO already owns a license to create professional sessions;
- *Moderator role:* The moderator and participant roles were entirely respected, giving different controls to each. When launching the application, anybody can create a session and take on this role, inviting other users as participants;
- *Ease of connection:* Three different solutions were considered for this project: either join via a link to the session, or via a code inside the application or join the only existing session. The third solution was used as a prototype, where only one session could exist simultaneously since it was supposed to be used by participants physically present in a room, using tablets and touchscreens. To accommodate the migration to a website, it was decided that multiple rooms would be possible, and would be protected to prevent unwanted participants from joining and disrupting an ongoing brainstorming session. Creating link invites was then the most user-friendly solution, as they would directly join the session without having to navigate inside the main menu. However, we opted for the solution inside the application with a four-letter code, to make it easier to give the code verbally. This solution will be more practical when *Spark-IT* is deployed on tablets;

- *Account:* Accounts are not required for this application. Instead, users will enter their name or a pseudonym. This name is only displayed in the lobby when joining the application, so that users can see they have successfully connected to the session. However, the name is saved, when exporting the data, to be able to link the survey results to the given ideas;
- *User actions:* Since the application follows the desired steps of the classical brainstorming, all the implemented actions for the users are independent from the moderator. They can each do very different things, and the moderator has full control over the application;
- *Session topic:* The session topic is displayed throughout the application. Over the sticky note when writing ideas at the start and in the middle of the screen when sorting ideas later. It is always visible when needed;
- *User input:* As we decided to study only text ideas in the application, this is the only implemented option. A drawing feature could be implemented in the future, if the need arises;
- *View synchronisation:* During the sorting phase, the other systems allow to synchronise the participants' view to what is seen by the moderator. This is necessary as the whiteboard is an infinite plane where participants can zoom in and out until nothing is visible anymore. In the *Spark-IT* application, these controls are also available to the users, but the range is very limited and the centre of the whiteboard is always visible. In this case, the synchronisation is not needed;
- *Categories and List view:* Both have been implemented. Creating categories is simple in *Spark-IT* with the edge detection and the conversion to the list view. This functionality has been implemented to be as straightforward as possible;
- *Casting votes:* The voting phase is an important phase of the application, and was made as simple as possible to enable users to vote directly by pressing

different icons on the sticky notes. The same presentation in categories has been kept to locate the ideas;

- *Timer:* No timer has been integrated in the application (as it was decided not to show it to the participants). Only the moderator runs an external timer, and gives verbal information at different intervals (i.e., five minutes left, one minute left);
- *Data export:* At the end of a session, the moderator can click a button to download directly the formatted data as a CVS file. The data contains timestamps, author names, ideas content, categories and number of votes;
- *Results view:* A results view is shown at the end, listing the best ideas. This view is enhanced with different gamification elements, showing the earned trophies, the score and leaderboard.

Evaluation with Participants

Business school students were asked to participate in the evaluation of online brainstorming applications: application *K* and our solution *Spark-IT*. Every student performs two sessions: one per software. Two brainstorming topics were selected, making sure the participants were familiar with the concepts as to collect meaningful ideas. The subjects are: Imagine tomorrow's leader/manager; How to innovate in tomorrow's companies. Two principal biases were then identified in the project, the order of the applications use, and which topic was taken. To reduce these elements influence, we decided to conduct a blinded experiment, by splitting who will use which application first. Ten groups of five participants were formed; however, out of the 50-expected students, only 31 attended both experiments and filled entirely the surveys. The distribution of the blinded experiment is described in figure 4. With this organisation, each software has been used first by a different group, and each topic has been used individually in each software.

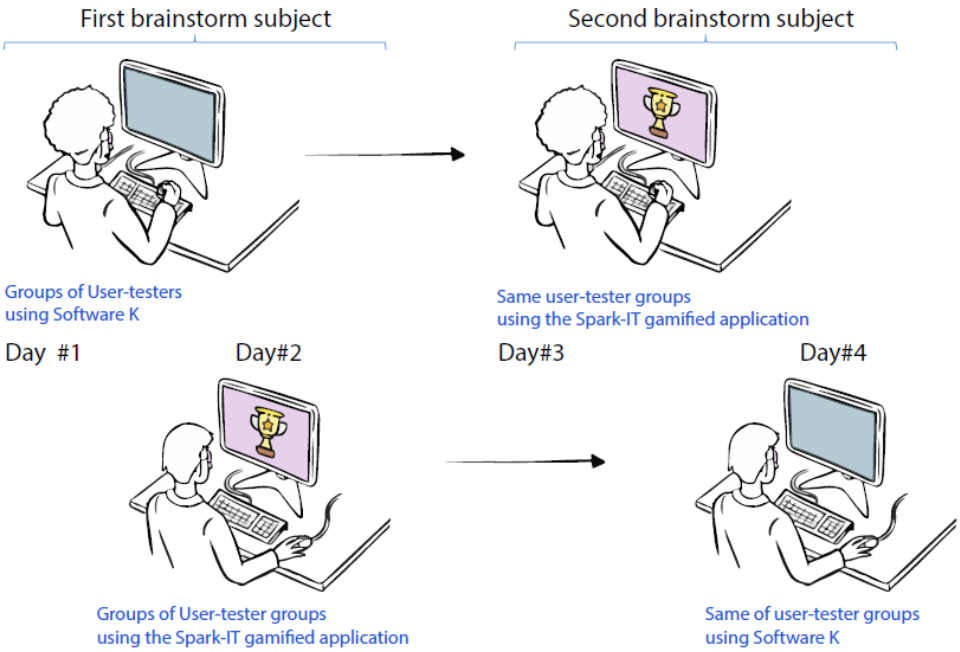

Figure 4. Illustration of the double-blind user-test process.

Participants had to fill a survey after each session, answering subjective questions about each experiment, and UI or UX-related (Bollini 2017) questions to see which software they preferred. The eleven-point Likert scale is used to answer the questions, and the user can also add a comment. Some subjective questions were optional. The survey questions are presented in figures 5, 6, 7, and 8. The survey questions aimed to answer a few core questions: what was the participant's experiences using the application itself (figure 5); were they previously familiar with these types of gamified applications (figure 6); and, finally, their thoughts on how the gamified elements in particular changed (or didn't change) their ideation processes (figures 7 and 8). This provided us both with an evaluation of the application itself, as well as the application as compared to other types of solutions.

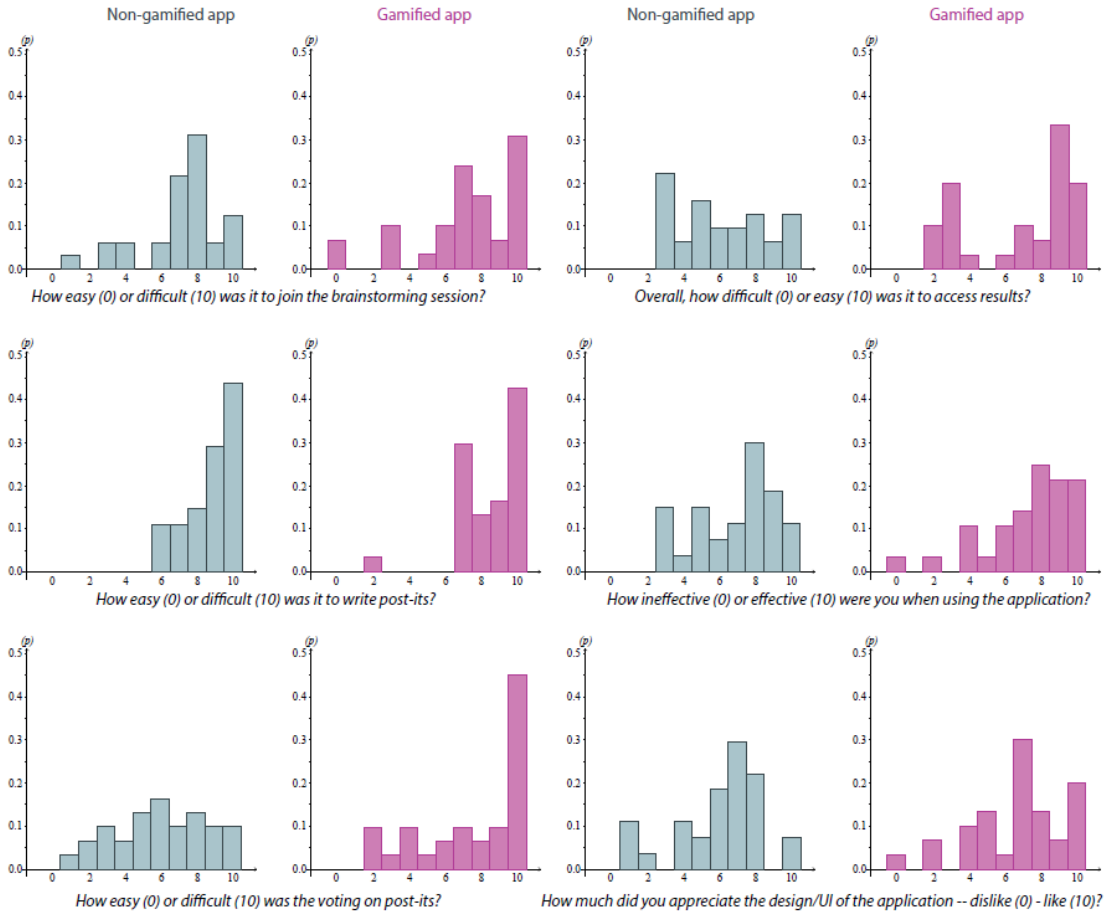

Figure 5. Resulting histograms relatively to the ease of use.

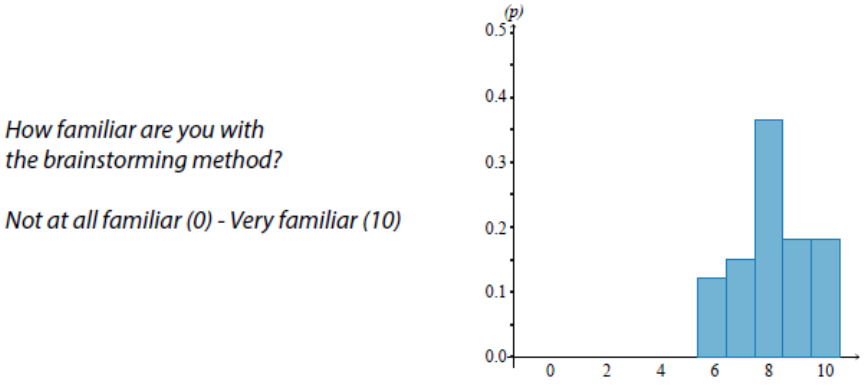

Figure 6. Each user-tester was at least moderately familiar with the brainstorming method.

UX Survey Results

Each of the in figure 6 listed questions are illustrated as histograms in figure 8, showing the distribution of the votes. The received comments will be discussed for each question in the following paragraphs.

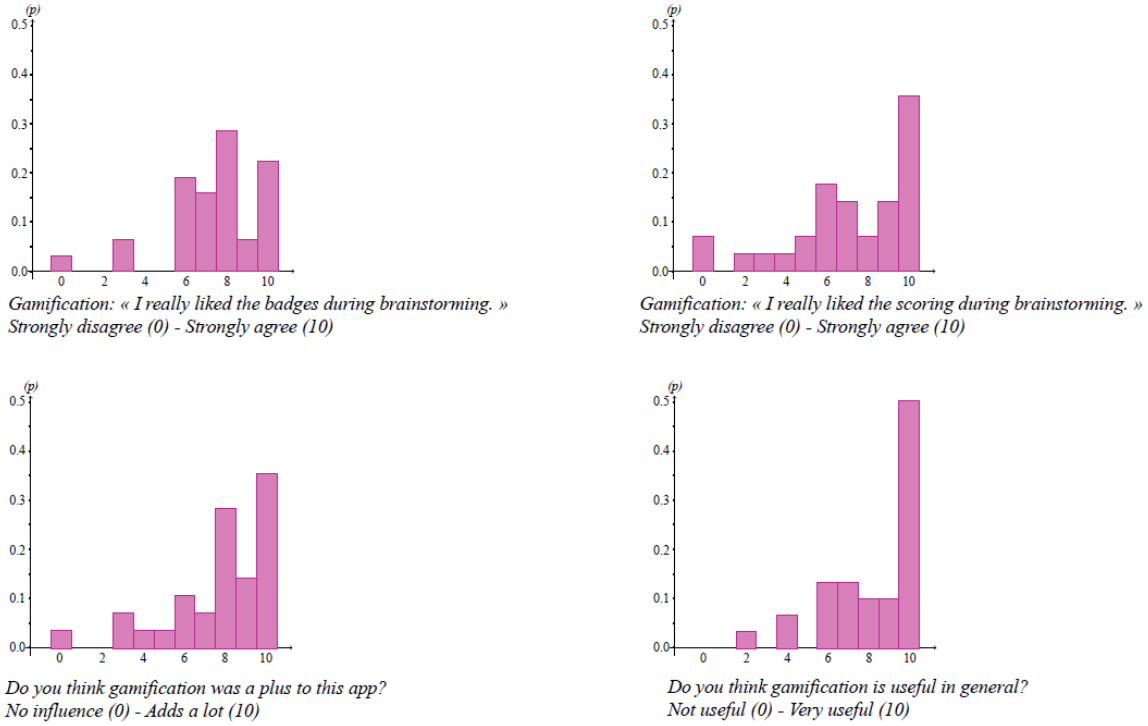

Figure 7. Resulting histograms relative to the impact of gamification.

Are you familiar with the brainstorming method? The business school students were all familiar with the brainstorming methodology, having participated in sessions previously. The chosen participants were suitable for the experiment, as it was not required to explain too much about the course of a session. They will be able to have a better critical judgement on the application as well.

How easy was it to join the brainstorming session? Sessions with both applications went relatively well in the connection process. Two participants could not log in at all

in the *Spark-IT* application, due to a technical error that was detected and fixed during the tests. Both applications performed similarly here, joining with a link and a code was adapted for the audience.

How easy was it to write the post-its? The design of the writing area was similar for both applications, so they unsurprisingly performed similarly in the survey. Overall, the design works well and should be maintained.

How easy was the voting on the post-its? This is where the first big difference arises between the two applications. We knew from the start that application *K* was not adapted for this voting methodology. The implementation in *Spark-IT* is successful, as most users were very satisfied with it. The negative reviews are due to an UI issue when exporting to *WebGL*, where it was difficult to scroll down the lists of ideas as it would go relatively slowly.

Overall, how easy or difficult was it to view the results? Most users were dissatisfied with the results view in the application *K*, where it was only visible after users had sorted the list of ideas. During the sorting phase, they found it also difficult to navigate on the infinite whiteboard. The *Spark-IT* design was preferred by some, but a significant minority did not like the design they found too convoluted: The presentation in this last view could be revisited. Some also noted that they would like to see the funniest ideas displayed.

Do you think you were effective or ineffective in using the application? Participants seemed as effective using either application, and no significant difference can be noted here between both software.

What do you think of the application design? This question was also subjective and the answers are more spread out. Most of the participants noted that it was simple, but effective.

The results for *Spark-IT* can be raised by improving the fluidity and fixing a few UI issues.

Do you think this application is missing any functionality (important or not)? For *Spark-IT*, users suggested these functionalities:

- Add a visible timer during idea generation;
- Add new brainstorming types – e.g., brainshaking, braindumb, SCAMPER;
- The possibility to centre on the same idea when sorting them, so that everyone will be focused;
- A way to ask questions inside the application, so that they will be seen by everyone;
- A way to see other participants' sticky notes when writing, as to iterate on them;
- Optimise the application;
- Better score visualisation;
- A way to delete ideas.

Some of these ideas were actually present in the application, like the way to delete ideas. Most complaints are about the performance of the application and new functionalities for other types of brainstorming. The rest of ideas are worth looking into.

If you had a magic wand, what part of the program would you change? For *Spark-IT*, users suggested the following parts:

- A way to name ideas when sorting them;
- Change the interface style;
- Fix the application slowness;
- Better leaderboard at the end, make a global rank using all the different sessions;
- Remove the race aspect as it is not the objective of a brainstorming;
- Better voting interface.

A few users were not satisfied with some of the interfaces, the overall slowness and the few bugs that occurred. They suggested to improve a few of the interfaces, mostly the results screen. Some suggestions are noteworthy, like the ability to name categories when making groupings.

I really liked the badges given during the brainstorming session. Three participants did not like any of the gamification implementation in the *Spark-IT* application. Fortunately, most users found the usage of trophies added a significant value to the experience, as they felt more motivated.

I really liked the scores given during the brainstorming session. The scoring was a bit more divisive, as it was only shown at the end and the presentation was a bit confusing. Most participants liked its addition.

Do you think gamification added anything to this app? And do you think gamification is useful (in general)? These two questions should be analysed together. Most users think that gamification is a useful tool that can be leveraged. Similarly, a majority

thinks that it was effective in this project, but a few improvements could be added. A small minority thinks that the context of the race is not appropriate for creativity and brainstorming.

Finally, do you have any suggestions and/or comment to improve the application? The same suggestions cited previously appear here: most people liked the application but wanted it to be optimised to run smoothly on their laptops. A few user interfaces improvements are also cited. For *Spark-IT*, users suggested these improvements:

- Develop other brainstorming methods;
- Change the interface style and improve it;
- Less gamification in the application;
- Improve some user interface, as sometime it was difficult to understand what was going on;
- Integrate a video conference inside the application, to see each other;
- Improve the application performance.

If you had to choose between both applications, which one would you choose? Here we can distinguish three different groups of people. First, a third slightly preferred using application *K*, and another third slightly preferred using *Spark-IT*. The final third overly preferred using the gamified experience with *Spark-IT*: the participants enjoyed the application playfulness,

Quantity of Produced Ideas

All the ideas produced during the application *K* and *Spark-IT* sessions were exported and anonymized to analyse them for quality and creativity. This part is not covered in this report, but will be the subject of a paper made by the HEP-VS, where they will

also analyse the statistical meaning of the data. The quantity of ideas is known and can be used as a simple metric of the results.

In total, 33 people participated in both sessions, and generated 844 ideas using both software. Among these, 465 were written in *Spark-IT* and 379 in the application K. However, 28 of the ideas used with the gamified application were actually empty sticky notes – probably due to attempts to cheat in the race by certain participants. Still, an increase of 15% ideas were produced using the gamified application. To evaluate the participants' experiences of using the application, we asked them to compare it to non-gamified applications they've previously been using. Figure 8 shows the results of this comparison.

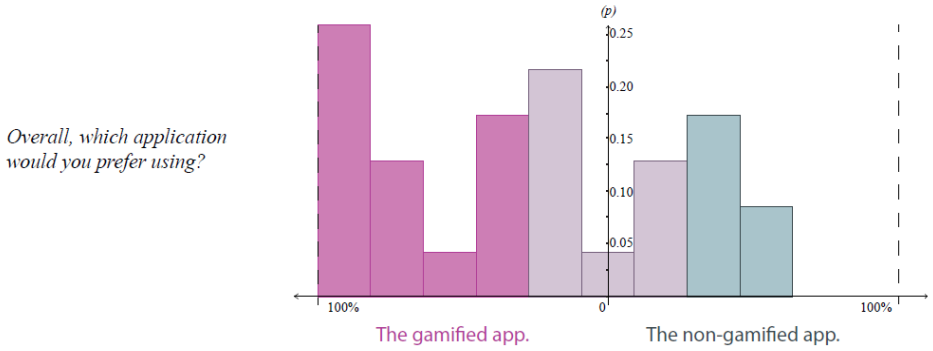

Figure 8. Final user-test question, which application would you rather use: a fifth of those surveyed would prefer a solution without gamification.

Social Bonding and Gamification

Based on the best brainstorming products on the market, we were able to develop a tool to compare the impact of a range of different gamification aspects. Our goal was to put the user at the centre of this project and to see how the social bond could be enhanced with this tool. Through the analysis of user tests, we have shown that something as nuanced as social connection clearly challenges our views on the use of

gamification. Indeed, the challenges of creating and interacting in an environment of social bonding form a real design challenge through the optimum use of gamification.

Discussion

In this article we tried to examine thought processes and challenges beyond the use of gamification in the process of electronic brainstorming. One main design issue was the use of competition (i.e., the race) and whether using the process recursively would have a positive impact. Our project focused on the question of user creativity and how gamification could stimulate their social interaction. By analysing only the quantity of produced ideas and the results of the survey we can already extract some interesting information. In retrospect, the number of participants (N=33 for sessions and N=31 for the surveys) was not sufficient to ensure the reliability of the data. An initial participant count of 50 was prepared, and other sessions were to have up to 100 unique users. Unfortunately, due to the current events and restrictions of the global pandemic it was difficult to coordinate it. That being said, here is the most significant information we gleaned from our study:

- Brainstorming performance: The number of ideas with the *Spark-IT* application is slightly higher, with up to 20% more ideas. Three users cited the integration of the race as a positive motivation, and two thought it as too stressful.
- Favourite: 78% of the participants thought the integration of the gamification was a positive addition to the brainstorming session. Out of the 31, only two thought that made it worse. The rest had mixed feelings. When asked which application they preferred, a third overly preferred

Spark-IT, a third slightly preferred *Spark-IT* and the last third slightly preferred the application K.

- User Experience: *Spark-IT* performed similar or better than the application *K* to perform the individual tasks during brainstorming: Connecting, Writing ideas, Categorising and voting. A few performance issues impacted some users' enjoyment.

The increased performance can be explained by multiple influences. First, it might just be a statistical error, as only eight sessions were performed with each application, generating around 50 ideas each time. Since the number of participants per session also varied, it is difficult to estimate the consistency. By just taking the raw data, the standard deviation is of 20 ideas, showing that more sessions are required to base a clear conclusion. The second explanation is the impact of gamification in the application. This can be disproved, since at the point of idea generation, no trophy or score has been shown to the user, as seen in the figure 3. Only the race had an influence at this point, and it would require repeated usage of the *Spark-IT* application to see the other gamified elements' effects.

With current user-test settings, we cannot show significant impact detected on the performance of this aspect of brainstorming. New conclusions could be reached if more users were sampled to participate in the experiment. At this point, it might be interesting to find new gamified elements to incorporate before or during the idea generation, to stimulate even more its effect. Another possibility is, as mentioned earlier, to perform repeated sessions with the same users as they will become familiar with the trophies and scoring system.

The fact that the *Spark-IT* project is preferred over the application *K* is reassuring. It proves that the proposed implementation is successful and has a great potential for

further developments. This success can be linked to both the user experience and the gamified aspect. We can explain the preference of *Spark-It* by the fact that it was developed specifically for the use-case of this project. As the application *K* was re-purposed to fit the desired brainstorming methodology, it was expected that the voting capabilities would be better in *Spark-IT*. It is still notable that where the application *K* performed the best (idea generation and sorting), it could be matched with the implementation done in *Spark-IT*. Even if the gamification did not impact idea generation so much, it certainly was well received by the participants, increasing their interest in the software. The use of gamification has then reached another objective: deliver a more enjoyable experience.

Perspectives and Needs

First of all, different ideas have been suggested by the participants during the survey; here is a list of the most recurrent ones:

- Provide new brainstorming types (brain shaking, brain writing, rapid ideation, starbursting, stepladder...). This could serve as groundwork to investigate the efficacy of the different techniques, while checking other gamification elements;
- Improve user interfaces to review results. The user interface (and more specifically its UX) had been done too quickly and some users were lost. The results of the *funny* votes should also be shown;
- Improve the application performance, as it is slow on older user laptops;
- A way to name ideas when sorting the ideas on the board;
- Integrate a video conference inside the application, so that the users can see each other when they brainstorm;
- Add collaborative tools for users to send questions.

Otherwise, since it has been shown that the impact of gamification as currently set did not influence idea generation (in phase B.2), we now plan to perform repeated studies with identical groups of participants to determine its recursive impact. Indeed, considering that end-users will be aware of gamification in phases B.3 to B.6 – trophies and scoring given at the end – we expect a recursive impact at the number on ideas written or the quality.

Another major perspective for this project would be the implementation of the solution we initially wanted to put in place (which could not be tested due to Covid): the use of tablets and touch screens. Therefore, we could consider a comparative study between (1), the use of this digital material versus the paper-based approach and (2), its use in class vs. online. We believe that such research could help us to better understand the strengths and weaknesses of digital technology in supporting social connection when teaching is to be done at a distance.

To go further, design thinking is currently receiving a lot of attention as there are many approaches to formulate and solve problems: agile, lean start-up, scientific method, Six Sigma, critical thinking and systems thinking. As suggested by Beckman (2020), it would be interesting to examine how all these techniques can be related to each other. Indeed, in the long run, we believe that the results of this analysis would greatly contribute to the improvement of both e-brainstorming and its gamification.

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