

# Exploring Collective Intelligence in Online Brainstorming

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**Abstract** — How can we know what has happened within a work group? How can we visualize the non-visual? How can we evaluate forms of interaction in the context of group work? These are some of the questions we tried to answer with Qlim, using online brainstorming activities. To achieve this goal, we collected data related to users' activities, then we used several visualization techniques to show the evolution of the interactions: zoomable graphs to get more detailed information and synthetic graphs to allow an overall perception of the activity using colorization and fill.

**Keyword-Interactions; collaboration; emergence; monitoring; visualization.**

## I. INTRODUCTION

Collective intelligence emerges from interactions between individuals when a group is involved in a creative task or in solving a problem [1]. The singularity of such a phenomenon is that the effect of the group action is greater than the sum of that of all individuals. Collective interaction is complex, involving direct and indirect causes that are difficult to observe and to link together.

Most of the time, the only indicator of collective efficiency is the final global result of the collaboration. On a large scale, open sources software development or Wikipedia are some examples of crowd sourcing results. Outside observation of these effects, the inner mechanisms of the collective phenomena are theorized, but few are measured in real situations. For this purpose, we developed a platform dedicated to supporting collective intelligence with a full statistical and graphical monitoring environment. This allows us to observe various causes and effects of the collective action (consensus evolutions, influence, changes of opinion, etc.) from a structural and temporal perspective.

The Qlim (in French: Questionnaire en Ligne Interactif et Malléable - Interactive, Tailorable, Online Questionnaire) platform was designed to support online group interaction on the basis of a shared feedback mechanism as occurs in a brainstorming session. In short, the process starts with few questions and answer choices (QA). Participants are invited by e-mail to come to answer these questions, add new questions and add new answer choices. They are notified by e-mail of all additions made during the day. They can return to modify their answers at any time or to make new propositions for question or answer choices, and so on. This system was tested in a dozen asynchronous brainstorming experiments, each involving an average of 20 people.

This paper is organized as follows. First, we will present Qlim and its role in supporting collective intelligence. Then,

we will describe the monitoring environment, some examples of statistical and visualization results and an overview of the latest developments in the field of group dynamics monitoring. Finally, we will discuss these results and present our future work perspectives.

## II. COLLECTIVE PHENOMENA IN INTERACTIVE QUESTIONNAIRES

As a tool to support collective intelligence, Qlim is a web-application (see Figure 1) that relates to the brainstorming technique. It is made to build questionnaires, but like a brainstorming session, Qlim is useful for collecting data on opinions or new ideas. These questionnaires, very easy to use, are spread out in time, and it is up to the creator to decide when the questionnaire ends. Qlim presents some special functions. It is an interactive questionnaire, which means the participants are not just passive respondents. With Qlim, respondents can add some new answer choices, and some questions, which comes down to extending the questionnaire to suit their desires and their trends. A questionnaire can thus take the form of an open debate, which can stimulate creativity and bring a lot of new thinking. Qlim has also several other features. It supports the respondents by sending a summary in the evening in case of additions made during the day, to encourage them to further fuel the debate. Qlim also has color user guidance to highlight the news, ensuring the respondent will focus on the news, if he wishes.

“To solve a problem, much of the solution lies in the wording of the question” [2]. Qlim allows expression and creativity, it helps participants formalize their subjects of interest into a structured frame (unlike an online open debate forum). It is based on a question and radio buttons system, designed to encourage the participants to make a precise choice or to ask some new questions or to add new answer choices, to react, to criticize or to develop; it is designed to be creative and to give an open direction to the discussion unlike traditional questionnaires. The goal of Qlim is not specially to lead to a consensus, it is a creative space: the final question can be off-topic with regard to the first question.

Qlim captures what is exchanged in a group. The problem in common brainstorming systems is the lack of structure; a regular brainstorming session is not especially structured (it returns a raw list of ideas). However, the Qlim structure allows easy exploitation of the results of any interaction. Qlim uses the frame (textbox, radio buttons) so the participants have to identify and break down what they want to say, to be synthetic, so they structure their thoughts. This way, all interaction can be logged and these traces can be exploited to understand the behavior, developments and influences.

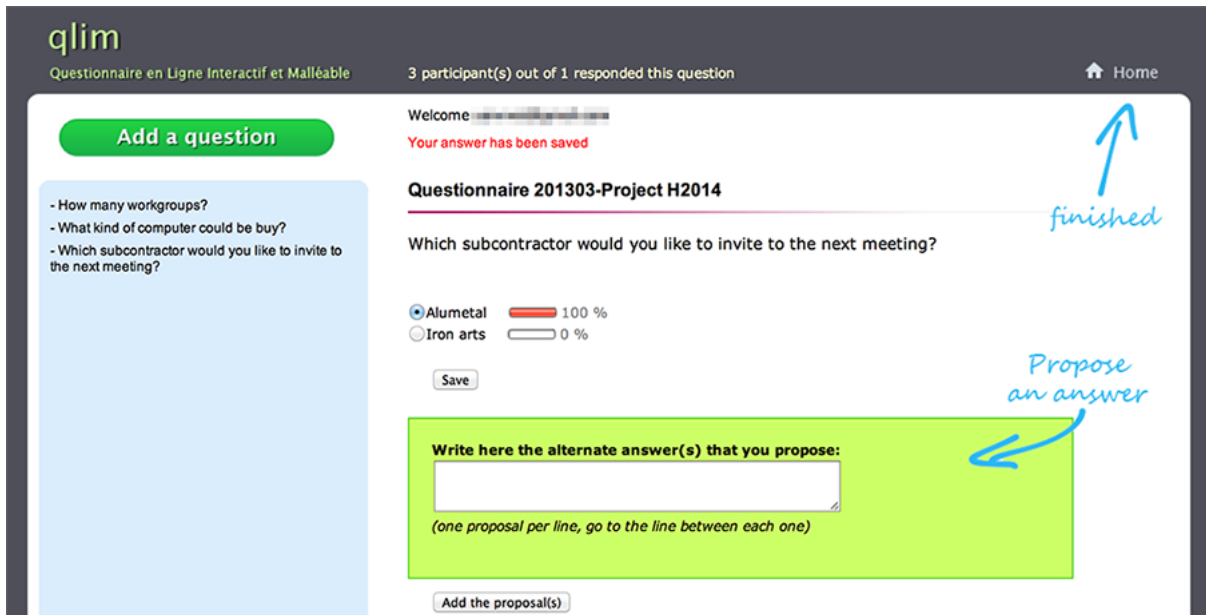


Figure 1. QLIM's page, to respond, add questions and answer choices, with guides.

Qlim's first aspect is the enhanced use of questionnaires, with two kinds of people, the creator who initiates the questionnaire and the participants. The second aspect is the use of the logged traces in order to monitor the interaction.

#### A. Qlim usage, from the creator's point of view

Figure 2 shows the user interface involved in this process. The "New questionnaire" button is available from the creator home menu. Creating a new questionnaire is simple. There are only four textboxes to fill, namely:

- the heading of the first question (for more questions, enter the questionnaire and press the "Add a question" button)
- some answer choices (if desired),
- the participants' e-mail addresses
- a name for the questionnaire



Figure 2. Creation principle

Before pressing the Save button, one important thing remains to be done: to choose "With" or "Without" the scores. Figure 3 shows the distinctive elements displayed when the creator chooses with the scores, namely, the number of participants who answered the question at the top of the page and a percentage at the end of the line for each answer choice (the "score"). It represents the success rate of each answer choice among the participants who answered the question. If present, these data may influence the participants because it becomes possible to know the trend of the group.

An Administration menu gives access to private functions to manage participants and questionnaires. The creator is able to list, to add or delete a participant to/from one of his questionnaires; he is also able to delete, to disable or enable his own questionnaires.

#### B. Qlim usage, from the participant's point of view

When a questionnaire is created, each participant receives an e-mail that is an invitation to participate in a Qlim questionnaire. Inside the message, a link directly leads to the web page with the first question. The participant makes a choice selecting a radio button and saves it by clicking the Save button. All the questions are listed in a column on the left side; the participant clicks the question he wants to answer (see Figure 1), in the order he wishes. If he changes his mind, he can go back to a question to modify his answer at any time, as many times as he wants. If the existing answers choices do not suit him, the participant can propose a new one simply by writing one or more answer choices in the textbox just below the question. It is also possible to add a

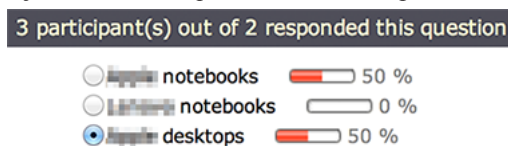


Figure 3. The distinctive elements of a question -with- scores

new question by a click on the big button “Add a question” (see Figure 1). This can happen if a participant wants to ask a question to know the opinion of the others, to fuel the debate, or if he finds “it’s not a good question!” or a relevant one, or if he wants to complete or to correct answers. He puts the heading and some answer choices if he wants, then clicks the Save button. It is also possible to add a question without any answer choices, in order to encourage questioning and to see the answers brought by the others. All new things, question and answer choices are available for all participants. Every evening, the new questions and the new answer choices are counted. If there were some creations, the summary of the day’s activity is sent by e-mail to every participant.

Participants are helped to rapidly identify changes through the user interface colored marks, a little bit like unread messages in a mailbox that are highlighted in a bold font (see Figure 4). A question that did not exist the last time the participant logged on appears in a red font and a question with new answer choices appears in an orange font. This is to draw attention to what’s new to encourage participation. The main menu gives access to the help function and enables every participant to know the results.

### III. MONITORING TOOL IN QLIM

Usually, traditional questionnaires provide statistics and graphs about their results. But the traditional questionnaires do not use the time or interactions links, so their results are like a snapshot. In comparison, Qlim brings new features that describe the complexity of the interaction more accurately. A questionnaire, like a brainstorming session, needs time. So the results cannot be just a mere snapshot, because it would be impossible to understand what happened without tracking the chronology of the interactions. A mere snapshot would be a great loss of valuable information. That’s why, in addition to the usual standard numerical results, Qlim supplies trends over time, which represent, in fact, the evolution of the interaction. By building Qlim, our intention was to try to understand collective phenomena inside a group. So, from the beginning, Qlim was designed to record each interaction. Every time an interaction occurs, it is recorded. We determined five features that are stored in relation to the user id through the questionnaire’s life duration: Visit a question, Answer a question, Add a new response choice, Add a new question, Modify an answer.

Used in Creative Problem Solving, the well-known 5 Ws (and one H) [3] (who, what, where, when, how, with what, and how), is an old formula used by police, journalists and researchers [4]. It inspired us, and in our database, the data structure that store the interactions matches the five Ws, and was even extended to store more parameters. The Who column stores the e-mail, the What column stores the type of interaction, the Where column stores the page name on which

- How many workgroups?
- What kind of computer could be buy?
- Which subcontractor would you like to invite to the next meeting?

Figure 4. Highlighting

the interaction occurred, the When column stores the date (and hour), and the others store values like the questionnaire index, the question index, etc. By consulting this table, we generate reports, tables of numbers and graphs.

Exploring and analyzing vast amounts of data can be very difficult [5], but the way we stored the data is very helpful (storing using this method has already been used [6]). This storage method simplifies the queries a lot and allows a large number of graphs. We made general graphs for the whole questionnaire (see Figure 5) with a graph for each action, to show their evolution, graphs (histograms and pie charts) of the activity of each participant, and graphs of the actions for each question. It becomes possible to study both individual behavior and collective phenomena.

The first set of graphs uses the time as the abscissa axis and the different actions as the ordinate axis. So, we can produce the evolution in time of the five actions (Visit, Answer, Add a new response choice, Add a new question, Modify). Technically, when the creator asks for graphs, a data set is created using several loops, then sent to a graphic library for display (JPGraph). We get histograms, grouped bar charts, accumulated bar charts showing the quantity of interaction in one time slot, or histogram and line combined showing each interaction plus accumulated visits, either for the whole questionnaire or for one question at a time, for all participants or one participant at a time.

“We showed that our eyes can quickly evaluate a situation of cause and effect, without the help of our cognitive system” said Patrick Cavanagh in January 2013 [7]. Thus, we have visually arranged all our graphs in vertical alignment (see Figure 6). The time scale is the same for all graphs, so it is possible to read in a set. This enables us to find parallels between the different actions at the same time (e.g., the effect caused by the arrival of a particular question). It makes it possible to see in one look the collective phenomena, cause and effect relationships, influences that could explain a turnaround, anything that cannot be observed with traditional questionnaires.

A second set of graphs has come from the use of another recent graphic library, “D3” (d3js.org), which is made of JavaScript and Ajax and allows some interaction once the graph is plotted. For example, the abscissa axis of the graph is “zoomable” using a cursor. It does not bring new data, the data remain the same, but it allows a larger view, which can be useful at times. Another feature causes a resampling of the data table on display, to get this time a more detailed view. To get a more detailed view is a shared concern, it seems [8].

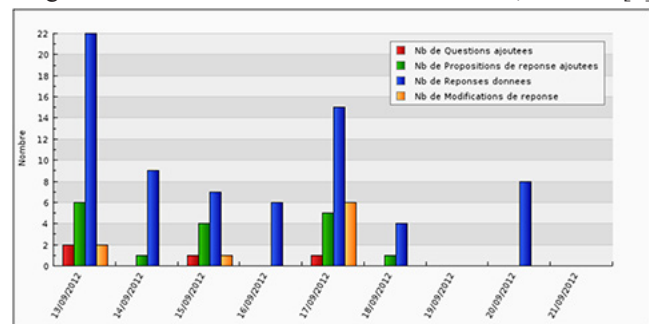


Figure 5. General graph for the whole questionnaire

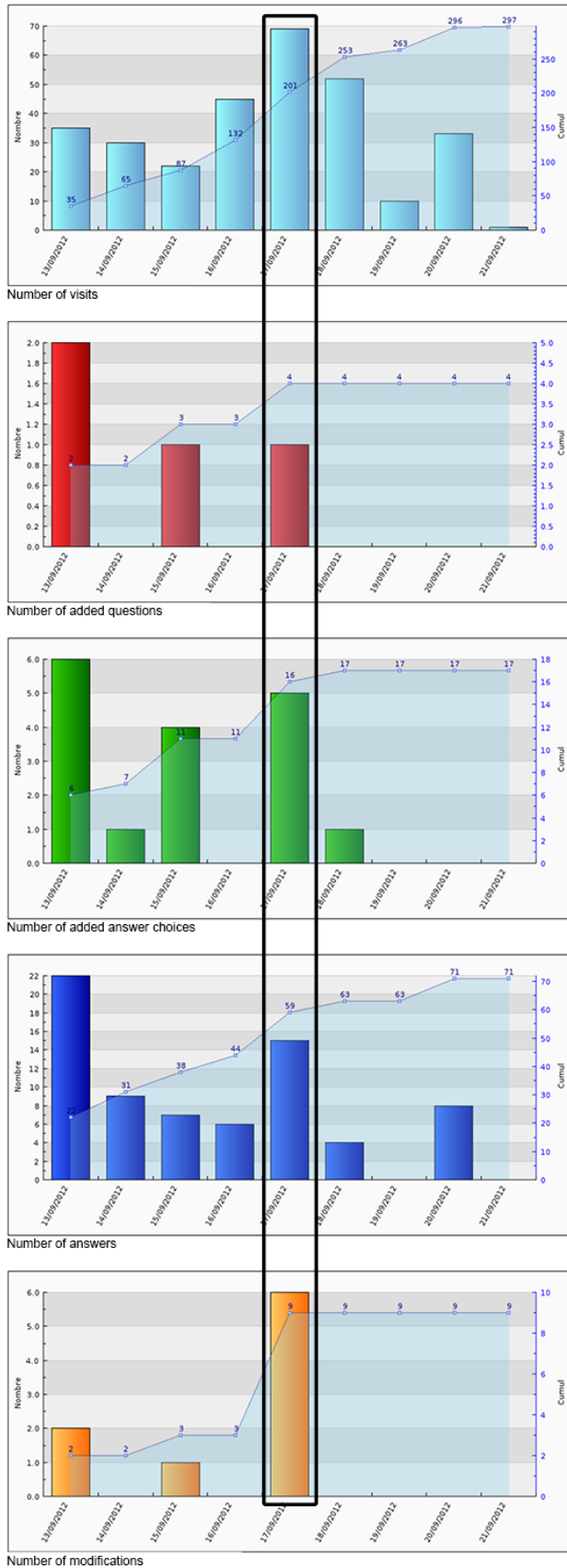


Figure 6. Each histogram represents an interaction

Besides the histograms, a third set of graphics is available. Collective intelligence stems from how well the group works together. Woolley [9] shows that a group where one person is dominant is less collectively intelligent and has poorer results (in solving problems - puzzles, games, etc.) than groups where conversational turns are more evenly distributed. The individual abilities of its members do not determine the performance of a group, and moreover a group whose members have higher social sensibility is more collectively intelligent. So, we made a view of the collective activity, of the distribution of the interaction and how many participants interacted. On a first graph (see Figure 7), we have drawn some donuts. The participant who made the highest number of interactions has a full donut, in proportion to his interactions. He is the maximum, the point of reference; all the others are calculated compared to him. We can see that even a lack of interaction has a specific meaning. We used the “Nothing” (transparent) interaction to fill the remainder of the donut to 100% when a participant made fewer interactions than the reference. There is one donut per participant on the graph and all the participants are on the graph, so this is another way to measure at a glance the collective activity, how it was distributed and how many participants have been interacting. A second graph represents a table (see Figure 8) with the time as the abscissa axis and the participants as the ordinate axis. In each cell, a matrix (2x2), contains four small color squares. Each one of the five interactions is represented by a color, for this participant, at this time. Calculated on the maximum number of interactions, the strength of the color (pale, medium, dark) shows how active the participant has been. This way, the group can take a dominant color or be a colored patchwork. The group colors make it possible to perceive at a glance the interactions that occurred. No red means that no questions were added, for example. A lot of orange squares means that the group changed its mind many times, etc. The more the group is monochrome, the less variety there has been in the interaction. On the contrary, a patchwork of colors means there have been many different interactions. This is a way to measure at a glance the collective activity, how it was distributed and how many participants have been interacting. We also included a wordcloud which is interesting to get a quick look at the most used words in a questionnaire. Data can be exported to a .csv file for further manipulation, for some graphics, this is a subject for our future work.

#### IV. STATE OF THE ART

Traditional questionnaires are very regulated, framed, constrained (check boxes, radio buttons, textboxes for open-ended questions, etc.), impossible to go back (later) to modify answers. They are static: no “ping-pong” game between the participants, no real interaction is possible. Nevertheless, it was observed that the respondents respond willingly when they are given the opportunity to do so, and the web mode also appears to be easier for this: open-ended questions by e-mail collect longer answers and more information than a paper survey [10, 11, 12]. That’s why an interactive questionnaire can be a place to collect lots of valuable information. We have noticed two other questionnaire-based collective intelligence tools: e-Brainstorming and Real-Time Delphi.

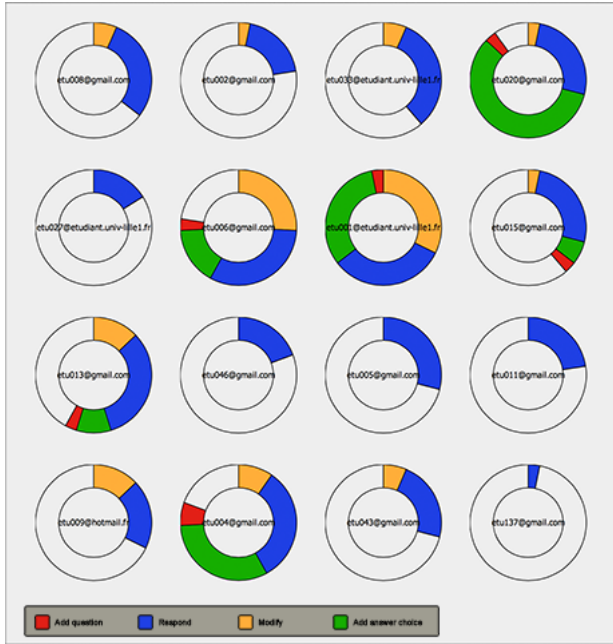


Figure 7. The collective activity by a donuts graph

### A. e-Brainstorming

The eBrainstorming is an initiative from the Orange Labs in Caen [2]. It is a computerized system of close-ended questions, a multiple choice questionnaire system (MCQ), intended to simplify and synthesize the opinions of a group. The system allows the respondents to add new questions and possible answers, and they can leave a comment in a free comments zone inside a question. It works without a moderator; the group has to be self-moderated. The questionnaire is scripted using simple and easy tagged language. It is written in one form, on a mobile phone application for example [14], then sent to a web server. The server generates the questionnaire, then a return mail is sent to the author with the URL of the web questionnaire, to be distributed to the chosen participants. The participants can access the synthesis (statistics, graphics). The system uses traces to evaluate the collective intelligence phenomena, and data can be exported.

Face-to-face brainstorming was an idea of A. Osborn [15] in the nineteen-forties, introduced to make his company more creative. In a Brainstorming session, there must be no criticism in order not to hinder creativity, so any idea can be a starting point for creative development from other participants. It gives a raw list of ideas in a short time.

### B. Delphi, Real-Time Delphi

The Delphi method is a structured communication technique, which tries to get opinions, judgments and justifications from the participants. It seeks a consensus (if possible), with a carefully prepared predefined set of questions, but here the creativity is controlled and contained. There are multiple rounds where questionnaires allow experts to provide their judgment, then to revise their answers (to be more accurate [16]). The process stops when a pre-defined criterion has been reached. The reasons and arguments collected can be highly valuable and useful. But Delphi takes

## Questionnaire : 897

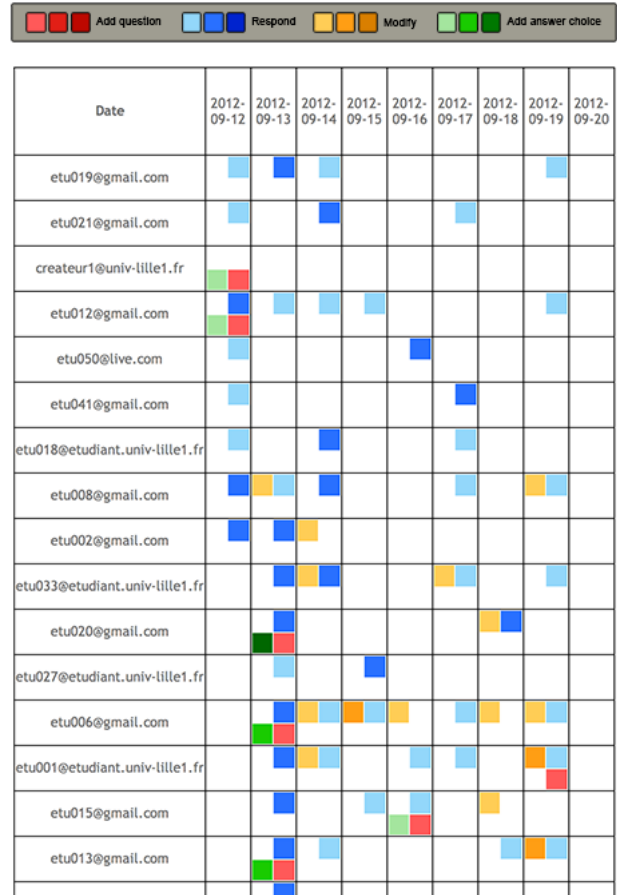


Figure 8. The collective activity by a table graph (anonymized)

time and requires good time management. It may be found long, expensive, tedious and requires a lot of effort [17].

Real-Time Delphi [13] is a computerization of the Delphi method, where Artificial Intelligence and Natural Language replace the human monitoring. It works “roundless”: every participant can come at anytime to update his input. Each question comes with some information (the average/median response of the group, the number of responses, the reasons).

### C. Visualization of interactions

Wanting to know what happens during group work, and to read the interaction is a current need, at the origin of a large number of very diverse projects. In 2006, Calvani et al. [18] wanted to visualize effective interaction in online collaborative groups. They found several methods in the literature: Quantitative methods for content analysis, the most used (De Wever et al. [19] and Van Keer [20] made a review). This method, they say, consists roughly of coding single messages and statistically analyzing them to read the frequency and identify the relationships. Social Network analysis is another method used to analyze interaction among the members of a community, about this latter method, Calvani et al. [18] cite Cho et al. [21]; De Laat et al. [22]; Garton et al. [23]; Reffay and Chanier [24], but they found that the tools (very roughly: an analysis of individual

messages between individuals) did not fit their situation. They considered quantitative methods based on Conversation Analysis [25, 26] to be time-consumers. Calvini et al. [18] were working on a forum inside Moodle (moodle.org), and they improved this module in order to monitor interaction. However, to observe interaction, a forum has one serious drawback, that is, the different actions are not quite distinct. Indeed, it is possible to add a post, for example, and we agree that this is an interaction which is possible to trace. However, one can do a large number of things in a single post, and it is difficult to analyze every interaction in that case. A forum does not seem to be the best tool to achieve that goal, because the actions are not distinct enough.

## V. CONCLUSION AND FUTURE WORK

As we have seen, this paper presents a tool that has two strengths in its combined features. First, the malleability (tailorability) of Qlim simplifies and enhances collaboration within groups. This helps the emergence of creative new ideas and solutions. Secondly, Qlim provides monitoring of non-visual aspects of the collective phenomena. In this regard, we can say that Qlim is more a laboratory tool than an operational one. There remain several possible improvements, for example to compare various experiments. Another kind of representation is needed, based on new indicators of collective collaboration with more descriptive graphics.

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