A Model-Based Coding Scheme to Analyze Students' Organization

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Abstract: In this article we present how we use Bardram's model of collective work dynamics [1] to elaborate a conceptual tool for coding and analyzing the self-organization of students involved in a mediated (computer-based) pedagogic collective challenge.

1 Introduction

We define a pedagogic collective challenge as a CSCL learning situation where: (1) the problem set is designed to make learners practice target domain-related and/or meta-cognitive competencies; (2) a group of learners is involved, as a team, in the solving of the problem; (3) the solving requires the learners to join their forces; (4) the problem and the setting are designed to create a positive tension that motivates learners. Such challenges aim at enhancing learners' motivation in involving themselves in the collective solving and, within this process, in knowledge generative interactions such as conflict resolution, explanation or mutual regulation [2].

Challenges, as CSCL scripts, correspond to particular cases of collective work situation: learners are mutually dependent in their work [3]. This requires the overhead activity of articulating their respective activities [3, 4]. When learners only communicate via a computer-based system, taking these organizational dimensions into account is a core issue as they (1) impact the overall process and (2) conduct learners to be involved in knowledge-generative interactions. Our research aims at understanding these issues and how to help students in organizing themselves. For this purpose, we have engaged in the design of a computer-based system that (1) supports learners in organizing themselves and (2) supports human tutors in monitoring and supporting the learners' process. The design principles of our prototype [2] are inspired by Bardram's theoretical model of collective work dynamics [1]). In order to attempt understanding students' activity in its relation to this model, we have elaborated an analysis grid based on this model. The results presented in this article are (1) this analysis approach and (2) the lessons learned from an exploratory use of this analysis approach on two groups.

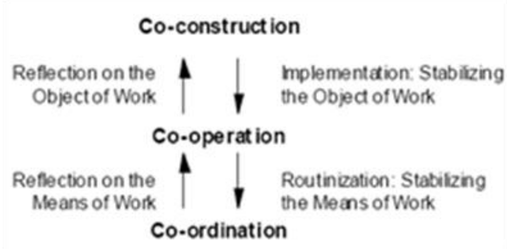

Figure 1. Bardram's model [1]

Bardram's model (cf. Fig. 1) focuses on collective work dynamics. It stresses the fact that perceiving breakdowns appearing during collaboration is an important dimension of the understanding of the collaboration dynamics, and the importance of supporting the dynamic transitions that may occur from one level to another during the activity (these levels corresponding to analytic distinctions: an activity takes place simultaneously at all levels.). At the co-ordination level, actors concentrate on the task they have been assigned to. Their work is related to a common goal, but their individual actions are only externally related to each other. They realize the global task from the point of view of their individual activity. Co-operation is an intermediate level where actors are active in considering the shared objective. This enables them to relate to each other, and make corrective adjustments to their own and others' actions according to the overall collective objective. Co-construction is the level where actors focus on re-conceptualizing their own organization and interaction in relation to their shared objects. Bottom-up transitions are related to an analysis of the object or the means of the work, which can occur in relation to a breakdown or an explicit shift of focus. Top-down transitions are related to the solving of problems and contradictions, and lead to a stabilization of the object and means of the work.

As a case study, we use a mathematical problem based on a car race simulation. The challenge (see [2] for details) has 3 phases: (1) preparing data (measuring data related to the cars' behavior such as speed or dynamics), (2) achieving different calculus in order to define a given set of values that will allow obtaining a target state and (3) launching the simulation to check the results. In order to succeed at phase 3, students must organize themselves, i.e., decide what to do, who will do it, and how. With respect to the co-construction level (cf. [2] for details), the prototype proposes a shared interface: the simulation, a collective "data description" editor, and communication tools (a chat and voting tools) to discuss, add or suppress a line in the data description table. The data description editor allows students (and suggests) collectively defining the data they will need to solve the problem: the level of priority of the actions to be processed (e.g., "high"); the involved notion (e.g., "cars that stop"), the name that is adopted by the group to denote the data (e.g., "duration of the stop"), a textual description of the data and the action to be realized in relation with this data (e.g., "measure"). The result (a list of lines) is a kind of general problem solving plan. With respect to the co-operation and co-ordination levels, students are then presented with a shared planning definition/execution editor. For every couple data/action (e.g., “all cars” / “define race duration”), it is suggested that students declare who will achieve each action (e.g., “measure” or “check”). Students can decide to delegate each action to just one student, or to two or three of them. They can come back on their declaration at any time. A chat allows synchronous interaction, and the students have to vote to skip to the next phase. With respect to the model, we are here at both the co-construction and co-operation levels. The key idea is that the array denotes the (emerging) adopted organization. Finally, the co-ordination level is the level where each learner is confronted with his tasks: measuring distance or time, calculating speed, applying mathematical procedures, etc. Tasks, rules or roles have been fixed at the preceding level (and learners can come back to this upper-level by a bottom-up transition). At this level, each learner’s work is separated (but coordinated) with that of other learners. In the prototype, the execution level (i.e., enacting the plan) corresponds to a similar interface as when defining and distributing the tasks, but the cells are now editable, i.e., students can edit the calculated values. The interface is still common, allowing everyone to know what he is supposed to do and what the others are doing. The evolution of the solving is dynamically denoted by the fact the content of the chosen cells in organization mode are gradually replaced by effective values with respect to the students’ choices.

2. A coding scheme to capture organizational issues

The coding scheme (cf. Table 1) elaborated to analyze group-organization (using or not using our prototype) is designed to make salient the dynamic aspects of the organization (changes of levels and breakdown). It is based on the theoretical background (Bardram’s model), our research objectives (understanding organizational issues), and lessons learned from exploratory experiments. For each of the Bardam’s model levels, it proposes 3 items that correspond to some given characteristics of the given level. These 9 criteria are more precisely defined via 2 to 5 indicators (or sub-criteria) each. For example, at the level “co-operation”, the criterion “2.2 Decision-making about the organization” is characterized by four indicators (“allocation of tasks”, etc.).

Level	Actions	Sub-criteria / indicators
1 Co-construction	**1.1 Understanding of the problem**	**1.1.1** Working out or improving a common representation **1.1.2** Working out or improving a common language
	1.2 Elaborating or revising a general organization of the resolution	**1.2.1** General planning of tasks **1.2.2** Elaborating/fixing a division of labour **1.2.3** Defining roles **1.2.4** Taking time into account
	1.3 Installing a co-operative structure	**1.3.**1 (Re) Defining general rules of interactions **1.3.2** (Re) Defining resources-sharing and interactions means **1.3.3** (Re) Defining how to use the interaction means
2 Co-operation	**2.1 (Re) Proposing, negotiating a precise planning**	**2.1.1** (Re) Breaking up the plan into tasks and sub-tasks **2.1.2** (Re) Defining the division of labour **2.1.3** Managing results **2.1.4** Managing tasks articulation **2.1.5** Managing tasks schedule
	2.2 Decision-making about the organization	**2.2.1** (Re) allocating tasks **2.2.2** (Re) adopting a division of labour **2.2.3** Making organization explicit **2.2.4** Solving conflicts
	2.3 Agreeing about how to work together	**2.3.1** Deciding on how to evaluate and mutually adjust each one’s work **2.3.2** Being aware of others students’ planned work **2.3.3** Specifying the rules / communication of the results **2.3.4** Specifying the rules / usage of the proposed tools
3 Co-ordination	**3.1 Adjusting the adopted organization**	**3.1.1** Taking collective advancement into account **3.1.2** Articulating tasks **3.1.3** Synchronizing tasks **3.1.4** Requesting organization modifications (votes)
	3.2 Applying the adopted organization	**3.2.1** Applying the adopted tasks allocation **3.2.2** Applying the adopted division of labour **3.2.3** Applying the adopted rules / communication of the results **3.2.4** Applying the adopted management of time **3.2.5** Being aware of one’s tasks
	3.3 Manner of working together	**3.3.1** Being aware of the others’ actions **3.3.2** Evaluating and mutually adjusting one’s work **3.3.3** Complying with the communication rules **3.3.4** Complying with the rules / usage of proposed tools

Table 1. The coding grid

We define a breakdown as a difficulty or a contradiction related to the organization activity which could break the dynamics of collective solving problem if it seemed likely to remain for some time. Breakdowns must be regarded as natural and important events, which should (if the actors are aware of them) challenge the group, and cause a reflexion on the means or the object of the work, i.e., a bottom-up transition. A breakdown is solved by a stabilization of the object or means of work, and should end-up by a top-down transition. The general structure of the coding grid is thus also useful to detect breakdowns. Our definition of a breakdown is too general to be used as a detection criterion. The coding tool can however be used by considering the negation of the criteria and sub-criteria, reformulated as necessary. For example, the criterion “understanding of the problem” on the co-construction level breaks up into two indicators (or sub-criteria): “to work-out or improve a common representation” and “to work-out or improve a common language”. The corresponding breakdown criterion is “problem not collectively understood” and the two sub-criteria are “common representation not clearly established” and “common language not clearly elaborated/acknowledged.” Such sub-criteria are not absolute indicators of breakdowns, but should rather be regarded as “symptoms” that may conduct to diagnose a breakdown. Indeed, when considering breakdowns, time is an important issue. When a breakdown is detected, data can be further analyzed to understand if it has been solved and how, or not solved and why.

3. Exploratory testing of the coding scheme

In order to check if our coding scheme allows interpreting a session in the terms of the model, we have used it to analyze two groups, one using our prototype and the other just using the non-specific means (shared simulation and chat). Every computer was equipped with software (Camstasia) to record the learners’ screens in the form of a video file. The chat’s and the different tools’ logs were also recorded in a XML format. A numerical tape recorder was used to capture possible learners’ oral comments if any. Learners’ chat messages were copied into an Excel file. Then, by simultaneously analyzing the videos of each student (i.e., 3 videos by group), the different learners’ actions, as captured at the computer interface, were coded and inserted in the Excel file. The coding denotes: the timing; the name of the learner; the tool that is used; the type of action (e.g., “measure”); complementary data such as the data value or the tool’s mode (organization, execution). The result is a chronological reconstruction of the collective session as a 3 column table displaying the messages and actions of the three learners of a group. Table 2 provides a visual representation of part of the overall coding.

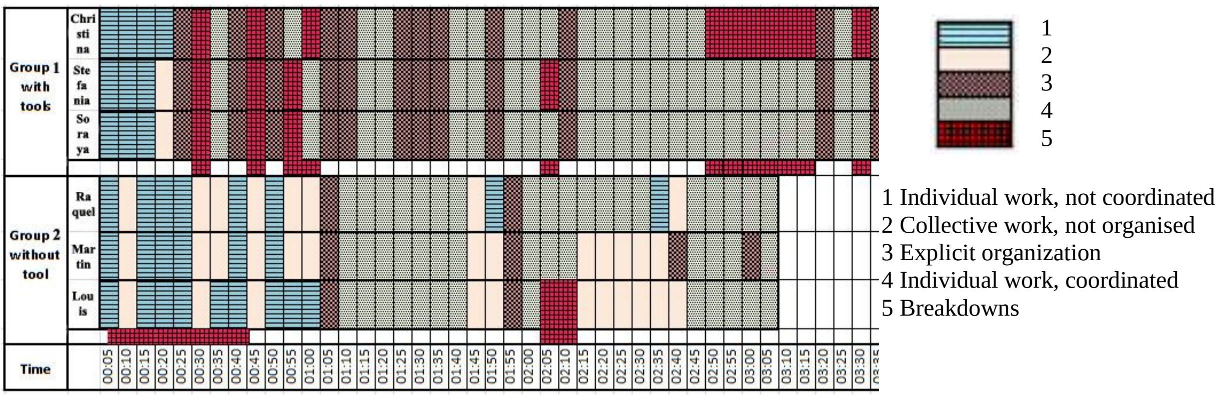

Table 2. The overall result of the coding

<u>Pieces of analysis for Group1 (using the prototype)</u>

After the introduction phase, the “data description” shared editor suggests students to list the data to be acquired for the challenge. This collective phase corresponds explicitly to the co-construction level of the model. Group 1 produced a list of 10 lines. This is an example of collective production as a result of a common representation (sub-criterion 1.1.1; numbers refer to Table1) and development of a common language (1.1.2). The meaningful order of the lines is an example of the elaboration of a general planning of the tasks and subtasks (1.2.1) indicating the beginning of a general organization of the resolution (1.2). Consequently we can clearly qualify this episode (which lasted 1 hour) as corresponding to the co-construction level of the model. This was confirmed by the chat messages analysis (not exemplified here due to space limitation).

After having listed the data to collect and the associated actions, the students skipped to the planning definition/execution editor (indication of the co-operation level), exchanged messages corresponding to an allocation of the tasks (2.2.1) and adopted a division of labor (2.2.2) based on the different lines defined at the previous stage. In this phase appear messages such as: Soraya: “Cristina, you manage 1234”; Soraya: “yes?”; Soraya: “Stefania line 567”; Soraya: “Soraya line 8910”. They use the editor to declare that they will manage some lines and/or cells (2.2.1, 2.2.2), making the adopted organization visible (2.2.3). The indicators clearly denote that the students skipped from the co-construction level to the co-operation level. The fact students considered their organization to be sufficient and that they were going to skip to the execution mode was both denoted by messages (e.g., Stefania: "execution?" -co-ordination level indicator- or messages filled automatically by the voting tool like "Student[x] wants to change the mode, do you agree?") and the use of the voting tool to accept the change (indication of transition). The data then denotes the "execution" of the adopted organization. As an example of an interesting sequence that appears at this stage, the students filled 10 selected cells of the table (3.2.1, 3.2.2, 3.2.3) and then adjusted their results (3.3.2) by discussing and finally agreeing on the speed unit to be used: Cristina: "we do it in cm/s? or in m/s?"; Stefania: "Yes"; Soraya: "for what" ; Cristina: "for speed"; Soraya: "m/s"; Cristina: "it is easier in cm/s"; Cristina: "ok? " ; Soraya: "ok". This denotes a move from the co-operation level to the co-ordination level. The students can skip from the "organization" mode to the "execution" mode of the editor and *vice versa*. The data presents six uses of the tool in "organization" mode (total=45 minutes) and six uses of the tool in "execution" mode (total=2h08minutes), this latter being located primarily at the co-ordination level. Moves from the "organization" to the "execution" mode clearly denote top-down transitions (co-operation to co-ordination), and moves opposite to bottom-up transitions (co-ordination to co-operation).

<u>Pieces of analysis for Group 2 (not using the prototype)</u>

Group 2, not having a tool that suggests acting at the co-construction level at first, adopted a different approach. Individual uses of the simulation tools show students began by attempting to solve the problem individually for about 40 minutes. The absence of any organization is (according to our indicators) a symptom of a possible breakdown. The breakdown is confirmed when the data shows that one student decides to share his data with the others, and realizes that there are discrepancies. The students suddenly realize that two of them did not understand the problem: Martin: "there is something I don't understand…" (1.1.1); Louis: "me too." (1.1.1). The breakdown is solved by Raquel's explanations (1.1.1). This breakdown corresponds to the co-construction level, and is solved at the same level. After this breakdown is solved, messages related to the resolution strategy (1.2.1) appear, and then on the division of labor (2.2.2), and then the allocation of tasks (2.2.1), for example: Louis: "to better organize ourselves I make the cars 7 8 9, you share the others it will be quicker" (1.2.1, 1.2.2 and 2.1.2), Martin: "Louis 4 5 6 and me the 1 2 3" (2.1 and 2.2). These messages denote a top-down transition to the co-operation level. The discussion continues at this level, Martin: "each one has to find when they stop, the time length of the various stops ok??"; "Raquel 456"; "ok??"; Raquel: "ok"; Louis: "ok" (2.2). Next, learners start to gather the data and transmit the results when ready. This meets the different 3.2 sub-criteria (application of the adopted organization). It can however be noted that, during these 39 minutes, each learner solves the entire problem and communicates his results in his own language. This corresponds to the co-ordination level, but is rather a set of simultaneous individual activities.

<u>Breakdowns (Groups 1&2)</u>

A first example is related to a conflict in the use of the "data description" shared editor (Group 1). In this case, although the editor is meant for the co-construction level, their use of the shared editor is situated at the co-ordination level. A problem appears when they simultaneously modify the same line: Soraya: "so you are going to complete all the table?"; Stefania: "not all". To solve the conflict they carry out a bottom-up transition towards the co-construction level: they agree on the use of the shared tool (1.3.2, 1.3.3), which had not been agreed on yet: Soraya: "only one fills the table"; "and the others correct and add". They then move to the co-operation level to specify how to share the editor (2.3.4): Soraya: "I fill", and then they return on the co-ordination level and continue their work (filling/correcting lines).

We also categorize as breakdowns ignored requests for organization. For instance, in Group 1, at the co-operation level: Stefania: "I finished column 6"; "What should I do?"; "What line?" (no answer). This breakdown is due to a bad synchronization of the tasks, and was solved when the two other students completed their work (6 minutes later). In Group 2 we identified 5 ignored requests for organization, for example: Martin: "everyone must choose 1 car or everyone must choose 3???"; Martin: "I've also nearly finished calculating the final results after so what can you do?; Raquel: "and now what should we do??? ".

An example of a serious breakdown (which impacted the final result) implying the three levels of the model (Group 1) begins at the co-ordination level with the success of a student in testing some values. This brings the group to modify the adopted organization and to redefine the general strategy (co-construction) by a revision of the tasks allocation (co-operation): Soraya: "Cristina you test, we fill the table". Then each one carries out the new organization, two learners filling out the table (co-ordination) while the third tests the values (co-ordination). At a given moment, this latter transmits a message to warn the group (indicator of breakdown 3.2.5): "I'm sorry, I'm unsuccessful"; "I tried but some calculations are wrong I think because I succeed with some cars and not with others". The task allocated to this third student is stopped, while the two others continue their calculus. As the warnings remained ignored, the breakdown lasted for 1 hour, the group not realizing they were facing a serious problem. This led them to fail. It can be noted that, in this case, the students did not make this change of strategy explicit by modifying the current plan description. However, interestingly, the grid helped us understand that, in some other cases, during the plan execution (i.e., in context), students did request to skip back to the organization interface and modify the plan. As an example, one of the students discovered some discrepancies in the measures. She used the chat to suggest there was a problem: Stefania: "Take a close look to the duration of car #1, we have 1 second of variation!!!"; "It's because of … (the reference point they use for the measure)"; she changed the value, and then they moved to the organization mode; Cristina: "Stefania we take as starting line the white line… or another?"; Stefania: "Or the end?"; Stefania: "The line or before the line"; Soraya:"All the line"; Stefania then proposed to modify the plan (it was one student per line): "We make two per line to compare the variations" and Cristina: "Soraya Cristina line 1" ; Cristina: "Stefania Cristina line 2"; Stefania: "ok"; Cristina: "Stefania Soraya line 3".

4. Discussion: some lessons learned

When using the grid, it appears that some messages or actions may correspond to several sub-criteria; in this case they are coded by the corresponding criterion. It also appears a group of actions and/or messages are to be coded as a single episode in the terms of the model. Finally, unexpected uses of the technology must also be taken into account.

Applying our coding tool to the data collected for the group using the prototype if of course much easier. The prototype and the coding tools being based on the same model, the use of the different functionalities (editors, vote, etc.) provide very precise information with respect to the students' organisation-level and the transitions, information which is confirmed in most cases by analyzes of the messages and actions. The fact the general structure is very clear (co-construction and then alternated episodes of co-operation and co-ordination) eases the coding and the understanding. For instance, the editor that allows deciding what data is to be collected leads to actions and messages corresponding to the co-construction level. Indeed, elaborating a list of actions via a shared editor leads to working out a common language (1.1.2) and to establishing a mutual understanding of the problem (1.1.1). Addressing the order of the lines is a premise for a general planning of tasks (1.2.1). The fact that the students use the "organization-mode" or "execution-mode" of the planning editor provides an explicit indication of the level to be considered (co-operation, co-ordination), which can be checked using the coding indicators. Skipping from one tool to another, changing mode (organization/execution) or using the voting tool are reliable indicators of transitions, which can be confirmed by the precise actions and messages processed at the same time. For the group without the prototype, the coding is made more difficult as things (actions, messages, levels) are much more intertwined. Coding and understanding what is happening requires locating the messages that can unambiguously be interpreted (e.g., allocation of tasks or division of labour), and to use them to further analyze the rest. For instance, in Group 2, each learner was at the same time solving all the problem and sharing his resolution with the other members. The activity of organization primarily consisted in sharing and checking the individual results. This was based on an implicit organization, which was not directly visible. Many of our sub-criteria did not apply, and were inducing us in error (level-confusions; detection of false breakdowns). We were only able to use our coding tool properly (but, then, with the same effectiveness as for Group 1) after we understood the underlying implicit operating-mode of the students, which was made possible by analyzing longer sequences and by using the coding-scheme criteria rather than the sub-criteria.

Although the prototype has a structuring effect, we discovered transitions which did not correspond to changes of the tool's usage mode. For example, the students have modified their organization twice (Co-operation) in "execution" mode, in one case without clarifying it in the tool. They also made some measurements (Co-ordination) in "organization" mode. As said previously, Bardram's levels correspond to analytic distinctions: an activity takes place simultaneously at all levels. However, it would be interesting to go deeply into the question of why the students did not use the tool-facilities. We evaluate to approximately 80% the conclusions from the prototype-usage confirmed by message and action analyses, and to 20% the ones that were contradicted.

The exploratory test also provided some hints related to the structuring impact of the prototype (differences between the groups), which are not described here due to space limitation. Independently from this impact, the fact the prototype eases the analysis and makes it manageable by a tutor (we believe it does not need a coding specialist if pertinently supported by dedicated tools) is, given our objectives, an interesting result.

5. References

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