Self-regulation in cooperative student work at university

PASCALE ROCA & MANUEL BÄCHTOLD

Laboratoire Interdisciplinaire de Recherche
en Didactique, Éducation et Formation (LIRDEF)
Université de Montpellier & Université Paul Valéry Montpellier 3
France
pascale.roca@umontpellier.fr
manuel.bachtold@umontpellier.fr

ABSTRACT
This case study focuses on the functioning of a group of first-year university students in the context of a science epistemology course. It proposes an analysis of their interactions by considering the phases of self-regulation, with the aim of identifying the conditions that favor cooperative work. More precisely, it tests the combination of the two analysis grids in terms of cognitive and socio-emotional interactions, anticipation, performance and reflection phases, and meta-self, meta-group and topic-talk interventions. The results of the analysis show that the combined grid allows a fine understanding of the functioning of a group. Several limitations and possible improvements of this grid are discussed.

KEYWORDS
Cooperative learning, self-regulation, complex problem, epistemology of science

RÉSUMÉ
Cette étude de cas porte sur le fonctionnement d'un groupe d'étudiants en première année d'université dans le cadre d'un enseignement d'épistémologie des sciences. Elle propose une analyse de leurs interactions en considérant les phases d'autorégulation, avec pour objectif d'identifier des conditions qui favorisent le travail coopératif. Plus précisément, elle teste la combinaison des deux grilles d'analyse en termes d'interactions cognitives et socio-émotionnelles, de phases d'anticipation, de performance et de réflexion, et d'interventions de type méta-soi, méta-groupe et discours sur le sujet. Les résultats de l'analyse montrent que la grille combinée permet une compréhension fine du fonctionnement d'un groupe. Plusieurs limites et améliorations possibles de cette grille sont discutées.

MOTS-CLÉS
Apprentissage coopératif, autorégulation, tâche complexe, épistémologie des sciences

THEORETICAL FRAMEWORK

Cooperative learning leads overall to better learning performance than settings based on individual work, especially at the university (Johnson & Johnson, 2002), fosters the development of social relationships (Tolmie et al., 2010) and of high-level cognitive skills, such as argumentative skills and critical thinking (Schwarz & Baker, 2017). However, according to several meta-analyses, positive effects are only obtained in a fraction of the comparative studies, raising the question of the conditions for effectiveness (Buchs et al., 2016). A body of quantitative research has identified several conditions for effectiveness, such as goal interdependence (Johnson, Johnson & Stanne, 1990). However, some qualitative studies show that by giving the same goal to several groups of students, they can adopt very different functionings that lead to contrasting performances (Oliveira & Sadler, 2008). Self-regulation processes and socio-emotional interactions emerge as key elements in understanding these differences (Järvelä et al., 2016). The study presented in this paper focuses on the group functioning of first-year university students in the context of teaching epistemology of science. It investigates in depth the activities of these students, considering the self-regulation phases during cognitive and socio-emotional interactions. The objective is to better understand the functioning of groups and to identify possible conditions that favor fruitful cooperative work with regard to the targeted learning.

Cooperative learning and conditions for effectiveness

"Cooperative learning" can be minimally defined by the following two elements: teachers provide a task to students that they must complete together in small groups; they hold them accountable for their own learning and for helping each other (Buchs et al., 2016, p. 957). In order for such cooperative learning to be effective, two conditions have been clearly identified by research: "goal interdependence" (i.e., students perceive that they can only achieve their goal if others also achieve their own goal) and "resource interdependence" (i.e., students can only achieve their goal if others provide them with the necessary resources) (Johnson et al., 1990, p. 622). To ensure goal interdependence, students should be given the task of solving a "complex" problem (i.e., one composed of many interacting elements) (Kirschner, Paas, & Kirschner, 2011, p. 615), or even an "ill-structured" problem (i.e., one for which there are different possible hypotheses, evidence, opinions, and thus solutions) (Kitchener, 1983, p. 223). But these are only necessary conditions, as they do not guarantee a co-construction by the group when dealing with the problems, as they can be solved by a strong division of labor with minimal interactions (Cohen, 1994, p. 12). To promote more cooperative group functioning, a successful strategy is for the teacher to provide advance preparation on the group work and its goals (Cohen, 1994, p. 26), which may be very short (Buchs et al., 2016). It also appears that group work is most effective if students have prior experience with group work and have internalized "patterns" of group functioning (Zambrano et al., 2019).

Self-regulation processes and socio-emotional interactions

The studies mentioned above follow quantitative approaches based on the comparison of a large number of groups with data from tests or questionnaires administered to the students. They have the limitation of not being able to take into account all the complexity of the interactions in each group. However, by conducting a fine-grained qualitative analysis of the verbatim of the oral exchanges of three groups of students, who had the same task consisting in exploring a complex problem in science, Oliveira and Sadler (2008) highlighted very different interaction patterns. In

particular, this study shows that two groups performed less well, in one case because of poor control of group learning, and in the other case because of a combative social context. These two explanations each refer to two important aspects of group functioning in the face of a complex problem studied by Järvelä et al. (2016): self-regulation and social-emotional interactions.

Self-regulated learning can be defined as "the degree to which students are metacognitively, motivationally, and behaviorally active participants in their own learning processes" (Zimmerman, 2013, p. 137). This is a complex construct that includes a set of regulatory processes, which can be distinguished according to 3 phases of learning: an "anticipation" phase that includes analyzing the task before performing it, a "performance" phase that includes monitoring the completion of the task, and a "reflective" phase that includes evaluating what was achieved and how it was achieved (Zimmerman, 2013, pp. 142-144). Järvelä et al. (2016) investigated the relative proportion of these three phases in group functioning in the context of two types of interactions, namely "cognitive interactions" related to the task to be performed by the group and "socio-emotional interactions" that refer to the emotions and forms of motivation expressed by the group members regarding its functioning in relation to the task. It appears from this study that the (partially or totally) socio-emotional interactions are not negligible and represent 17% of the group interactions. It also appears that the performance phases are present mainly during cognitive interactions, whereas the anticipation phases are present mainly during socio-emotional interactions - the reflexive phases being more marginal.

In a recent study, Kuhn, Capon and Lai (2020) compared the proportion of metacognitive self-regulatory processes in oral group exchanges as a function of their performance on a complex task. They distinguished between three types of interventions: metacognitive interventions focused on the individual ("meta-self") or on the group ("meta-group"), and argumentative interventions on the topic of the task ("topic-talk") (Kuhn et al., 2020, p. 185). The results of the study show that higher performing groups are distinguished by a greater proportion of meta-group interventions. These results point to the importance of self-regulation that addresses group functioning to better coordinate the actions of students in the group when performing a complex task.

Research question

In the study presented here, which is exploratory, the objective is to extend this investigation of the group's functioning in the face of a complex problem in the context of a first-year university science epistemology course. Our approach consists in using the two analysis grids proposed respectively by Järvelä et al. (2016) and Kuhn et al. (2020) and testing their operativeness in this specific context. The research question can be formulated as follows: to what extent can these two grids be combined to study the functioning of a group in the context of teaching epistemology of science at the university?

METHOD

Participants

The students taking part in this research are in the first year of a multidisciplinary degree of pre-professionalization for primary school teachers. As part of their training, they are regularly put in the situation of working in groups to solve complex tasks. The case study presented in this article concerns the functioning of a group of 7 students during a session that took place in the second

part of the year, after 8 months of training. The group under study is composed of 6 girls and 1 boy, aged between 17 and 20 years old.

The teaching device

The session studied is part of a teaching whose objective is to introduce students to the epistemology of science. The session focused on the notion of scientific concept. In order to study this notion, students had to work in groups and were put in the situation of solving a complex task, which consisted in exploring the notion of scientific concept and producing a poster proposing a definition of this notion (the poster produced is provided in Appendix I).

The teaching strategy was based on both collaborative learning and problem-based pedagogy. A paper document containing the instructions was given to the group. To solve the task, the students were asked to recall elements of epistemology that had been discussed in previous sessions. In addition, a file on the notion of scientific concept was made available to them on a digital space (including a mind map of a website for teachers, definitions from wikipedia, a list of examples of scientific concepts from wikipedia, and a chapter of researchers in science education on this topic). The teacher provided support to engage the group in cooperative work. In particular, she did not answer the students' questions directly but encouraged them to discuss the questions together and to co-construct their answers.

Data collection

In order to study the cognitive and socio-emotional interactions between the students in the group during the session, a video and audio recording was made using two fixed cameras and an additional microphone placed on the table among the students. Their verbal exchanges (with times of silence in between) were transcribed, as were their movements and gestures. As the session was conducted during the COVID pandemic, the mandatory wearing of masks did not allow us to fully capture their expressions.

Data analysis

The aim of this study being to study the operativeness and the complementarity of the analysis grids of Järvelä et al. (2016) and Kuhn et al. (2020) in the context of a teaching of epistemology in the first year of university, we remobilized these two grids and tried to combine them. Note that the grain of analysis of these two grids is not exactly the same: Järvelä et al.'s (2016) grid takes as a unit of analysis a set of several verbal interventions constituting a cognitive and/or socio-emotional interaction, while Kuhn et al.'s (2020) grid considers each intervention individually to categorize it in terms of meta-self, meta-group or topic-talk.

Järvelä et al.'s (2016) analytical grid is actually twofold. A first grid distinguishes between the two types of interaction (see Table 1), while a second distinguishes between three phases each characterized by different self-regulatory processes (see Table 2). The way in which the two grids are combined is specified in Table 3. The examples given are taken from their study, the context of which should be specified: the study was carried out with 44 second-year teacher training students in a mathematics education course; the students had to work in groups of 3-4; the objective of the training was to develop collaborative skills.

TABLE 1

Types of interaction (from Järvelä et al., 2016)

Types of interaction	Description	Examples
Cognitive interaction (Cogn)	Interaction between two or more group members who are sharing ideas and developing them together, working together towards a shared goal or jointly solving tasks. An utterance or expression always has to be followed up by at least one other group member's reaction.	Solving, calculating, or discussing a task together. Sharing and developing ideas. Discussing how to begin. Discussing how to proceed. Agreeing on a new strategy. Discussing what the group has learned.
Socioemotional interaction (Socioemo)	Interaction including two or more group members about emotions, motivation, or having the purpose of increasing or decreasing group cohesion and/or inducing laughter. An utterance or expression always has to be followed up by at least one other group member's reaction.	Discussing feelings of motivation. Sharing positive or negative feelings towards the collaboration or the task. Discussing beliefs about the ability to complete a task. Expressing a good team spirit. Praising the group. Encouraging another group member. Joking or laughing together

TABLE 2

Types of self-regulation phases (from Järvelä et al., 2016)

Types of phase	Description	Examples
Forethought phase (For)	The students activate beliefs and processes in preparation for the learning itself. There are two categories of forethought: task analysis, which includes goal setting and strategic planning; and self-motivational beliefs, which include self-efficacy beliefs, outcome expectations, intrinsic interest, and goal orientation (Zimmerman, 2000).	Discussing what the group needs to do during the session or at home. Discussing instructions. Sharing feelings of motivation regarding the upcoming task. Discussing the group's capabilities, strengths, or challenges. Dividing work.
Performance phase (Perf)	Performance or volitional control phase includes processes that occur during learning efforts. The performance phase includes two processes: self-control and self-observation. Self-control processes help pupils focus on the task and use the most efficient strategies to achieve their goals. The second type of process, self-observation, involves monitoring specific aspects of performance through, for example, self-recording or self-experimentation (Zimmerman, 2000).	Solving, calculating, or discussing a task. Writing together. Praising an idea, a solution, or the group's progress. Asking or receiving help from the teacher. Discussing if a task-related strategy should be changed. Commenting on time.
Reflection phase (Refl)	During the self-reflection phase, learners self-evaluate the information they gathered by monitoring their behavior against the goals they set during the forethought phase and make causal attributions for the outcomes (Zimmerman, 2000).	Discussing if the group has reached its goals. Discussing how the group solved a task. Discussing what the group learned. Praising the group for a good session. Discussing what kinds of feelings the task aroused. Discussing challenges in the group's performance.

TABLE 3

Combination of the types of interaction and self-regulation phases

Types of interaction	Cogn			Socioemo			Both cogn & socioemot			Irrelevant (i.e., not related to the task) / no interaction
Types of phases	For	Perf	Refl	For	Perf	Refl	For	Perf	Refl	Not applicable

The analysis grid of Kuhn et al. (2020) is given in Table 4. This grid distinguishes two types of metacognitive intervention. It also distinguishes a set of types of argumentative interventions. Here again, let us specify the context of the study from which the examples reproduced in the tables are drawn: the study concerns 35 students in a business school who are enrolled in a market strategy course; the groups are made up of 3-4 students who have never worked together before, and engaged over a period of 8 sessions to simulate decision-making within a company.

TABLE 4

Types of metacognitive and argumentative intervention (from Kuhn et al., 2020)

Types of intervention	**Description**	**Examples**
Meta-Self	An utterance that relates to self, rather than the subject matter of the discussion	"I am very concerned what the R&D portfolio is." "It just does not make sense to me." "Okay so basically I come to compare our brand awareness by consumer segment."
Meta-Group	An utterance that relates to the group's discussion itself, rather than the subject matter of the discussion	"So then if we go back to R&D." "And we see, the feasibility and the R&D." "Because the question we need to answer for the research part."
Topic-Talk	Utterances being part of the argumentative discourse related to performance of the task	An utterance that asserts something {claim}; an addition to preceding utterance {add}; a question asking whether other will accept or agree with a claim {agree?}; a request for the other to clarify a proximal utterance {clarify?}, etc.

To test the operativeness of these grids, we looked in our verbatim for occurrences of interaction or isolated intervention that could correspond to each of the categories. To study the complementarity of the grids, we combined them according to an ordered ramification: types of interaction / types of self-regulation processes / types of metacognitive or argumentative interventions. We then considered the smallest unit of analysis, namely interventions, and looked for occurrences in our verbatim that could correspond to each of the branches of the combined and branched grid.

RESULTS

In Table 5, we present the verbatim excerpts analyzed according to the combined and branched grid. These verbatim excerpts correspond to the smallest units of our three-step analysis, namely student interventions (or even parts of student interventions). To understand what type of self-

regulation and interaction these interventions refer to, it is necessary to consider the whole passage from which they are taken (see Appendix II).

TABLE 5

Excerpts from our study analyzed by means of the combined and ramified analysis grid

Types of interaction	**Types of self-regulation phase**	**Types of intervention**	**Examples**
Cognitive interaction	Forethought	Meta-self	E3: I sent you the drive. G9: No, I wanted to put the different categories, you know: notions, sub-notions?
		Meta-group	D8: I think so, because we have time, we have an hour and a half, so...
		Topic-talk	E5: What's on before? {question} E6: Nothing important. {clarify}
	Performance	Meta-self	B3: No, I think it's the one at the bottom, illustration. G3(b): What color should I use? G12: I can't write straight, though.
		Meta-group	G3(a): What color should we use? G8(b): Do we have any counter examples? G13(b): Well, go ahead, I'm going to write, if you want I'll write straight.
		Topic-talk	B8: Situation. With an s. {clarify*} F1: So a scientific concept is an intellectual tool. {claim} F7: Well, yes, it has an aim, right? {clarify}
	Reflection	Meta-self	H10: I think that's it. I4(a): I think we should reword it.
		Meta-group	A2(a): We had already done that, we had already put it in the drive. H4: We don't know. I4(b): If we copy and paste in the end we don't understand.
		Topic-talk	A2(b): Roughly speaking, this is the definition of the complex task. {clarify} A4: With an open question that requires research. {add} B2(a): Yes, there's the scientific concept. {add*} H1: In fact, it's an analysis of the problem for the moment. {claim*}
Socioemotional interaction	Forethought	Meta-self	C1: Why am I called Anonymous Pumpkin [in the drive]? C5- But noooo [means: "I don't believe it"].
		Meta-group	Not found
		Topic-talk	C2: It's like that... and then there's hedgehog and squirrel too. {clarify}
	Performance	Meta-self	Not found
		Meta-group	Not found
		Topic-talk	Not found
	Reflection	Meta-self	Not found
		Meta-group	Not found
		Topic-talk	Not found

Both cognitive and socioemotional interaction	Forethought	Meta-self	H6: Label it must be a mode of... uh... I don't know... I don't know how to say it [student searches for simpler terms to make his classmates understand and testifies to his powerlessness to do so].
		Meta-group	D7: Do we all read together or not?
		Topic-talk	Not found
	Performance	Meta-self	G5: Uhhh pffffouh... I don't know [means: "I don't know what color to choose that will be relevant" and "I want the color chosen to be appropriate to satisfy the group"].
		Meta-group	D4: There is one... the scientific concept... well... the scientific concept is a mind map [silence; the student looks at the others in an inciting way] do you have it in front of you or not? D9: Then the second document has four pages but they are not very long. G1: So we start writing, huh? We'll be nice ["nice" means "we'll be good students"].
		Topic-talk	F2: Well... already ["already" is expressed in an encouraging tone] it is an intellectual tool. {clarify}
	Reflection	Meta-self	Not found
		Meta-group	I1: Does the definition fit you? I6: So then... it has been marked ["it has been marked" is expressed in an underlined way to attract everyone's attention]... the scientific concept is first of all an intellectual tool which aims to be objectified and which establishes between phenomena a sufficiently general and invariant relation to authorize the prediction of results or of facts.
		Topic-talk	H8(b): Your name is Esther. It's a label. It's assigned to you. {add}

In the analyzed verbatim, we found occurrences that correspond to 18 out of the 27 items of the combined and branched grid: 9/9 of the cognitive interaction items; 7/9 of the socioemotional interaction items; and 2/9 of the both cognitive and socioemotional interaction items. Several observations should be noted: the forethought phases of self-regulation corresponding to planning are all short-term; the reflection phases of self-regulation do not reflect a global analysis by the students of the task they performed; some interventions (noted * in Table 5) coded as topic-talk seem to favor the coordination of the group's actions for the performance of the task, rather than being part of an argumentative discussion; the interventions that are clearly of the topic-talk type show how the group is co-constructing the notions of epistemology, and how the group is making these notions its own.

DISCUSSION

The analysis conducted in this case study shows that the grids of Järvelä et al. (2016) and Kuhn et al. (2020) can be combined and provide a fine-grained understanding of how a group is functioning when facing a complex task in the field of epistemology of science at the university. The fact that the units of analysis of the grids are different makes this combination possible. They appear to be complementary in the sense that the types of interactions and self-regulation phases allow to contextualize and give meaning to interventions interpreted in terms of meta-self, meta-group or topic-talk. The distinction between meta-self and meta-group seems to be relevant to

distinguish two forms of group functioning which are related respectively to a division of the task into individual works (i.e., weak form of cooperation) and to co-construction (i.e., strong form of cooperation). The observations made suggest several new distinctions that could enrich the analysis: short-term/long-term planning; reflection on micro-tasks/on the whole task; argumentative interventions/interventions allowing to coordinate actions for the achievement of a task. Moreover, taking into account non-verbal behaviors helps analyze the interactions according to the categories of the grid and therefore appear important to integrate.

To confirm the relevance of the combined and branched grid and to test the distinctions mentioned above, the analyses should be conducted with a larger corpus integrating the verbatim of other groups in the same training. Once stabilized, this grid should make it possible to quantify the interventions that fall into each of the categories with regard to the group's performance. It will also enable to study possible changes in group functioning over the three years of the training.

REFERENCES

Buchs, C., Gilles, I., Antonietti, J.-P., & Butera, F. (2016). Why students need to be prepared to cooperate: A cooperative nudge in statistics learning at university. *Educational Psychology, 36*(5), 956-974.

Cohen, E. G. (1994). Restructuring the classroom: Conditions for productive small groups. *Review of Educational Research, 64*, 1-35.

Järvelä, S., Järvenoja, H., Malmberg, J., Isohätälä, J., & Sobocinski, M. (2016). How do types of interaction and phases of self-regulated learning set a stage for collaborative engagement? *Learning and Instruction, 43*, 39-51.

Johnson, D. W., & Johnson, R. T. (2002). Social interdependence theory and university instruction: Theory into practice. *Swiss Journal of Psychology, 61*, 119-129.

Johnson, D., Johnson, R., & Stanne, M. (1990). Impact of goal and resource interdependence on problem-solving success. *Journal of Social Psychology, 129*, 507-516.

Kirschner, F., Paas, F., & Kirschner, P. (2011). Task complexity as a driver for collaborative learning efficiency: The collective working-memory effect. *Applied Cognitive Psychology, 25*, 615-624.

Kitchener, K. S. (1983). Cognition, metacognition, and epistemic cognition: A three-level model of cognitive processing. *Human Development, 26*(4), 222-232.

Kuhn, D., Capon, N., & Lai, H. (2020). Talking about group (but not individual) process aids group performance. *International Journal of Computer-Supported Collaborative Learning, 15*, 179-192.

Oliveira, A., & Sadler, T. (2008). Interactive patterns and conceptual convergence during student collaborations in science. *Journal of Research in Science Education, 45*(5), 634-658.

Schwarz, B., & Baker, M. (2017). *Dialogue, argumentation and education: history, theory and practice*. New York: Cambridge University Press.

Tolmie, A., Topping, K., Christie, D., Donaldson, C., Howe, C., Jessiman, E.,…, & Thurston, A. (2010). Social effects of collaborative learning in primary schools. *Learning and Instruction, 20*, 177-191.

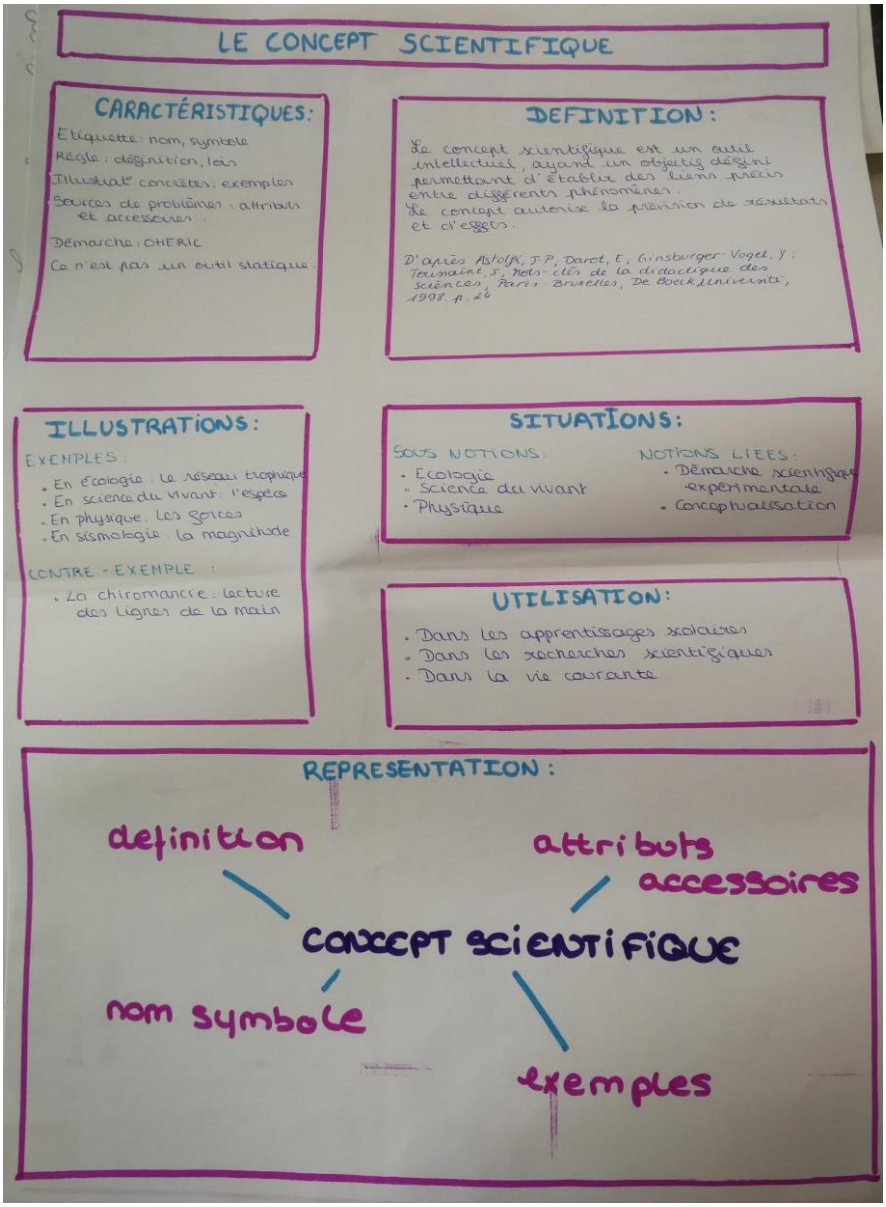
Zambrano, J., Kirschner, F., Sweller, J., & Kirschner, P. (2019). Effects of group experience and information distribution on collaborative learning. *Instructional Science, 47*, 531-550.

Zimmerman, B. (2013). From cognitive modeling to self-regulation: A social cognitive career path. *Educational Psychologist, 4*8(3), 135-147.

APPENDIX I

FIGURE A1

Poster produced by the group under study



APPENDIX II

TABLE A1

Excerpts from our study with different kinds of interactions

Types of interaction	Examples
Cognitive interaction	**Excerpt A** **Context:** students read the document provided by the teacher; one of them reads the document, the others make comments **Analysis:** students are sharing ideas and developing them together **Verbatim:** A1: What are the specifics of the tasks you were asked to do in this course? What did they have in common?... well, that's not a definition... A2: We had already done that, we had already put it in the drive in the drive... Roughly speaking, this is the definition of the complex task. A3: Yes...and that... what they had in common was a group work with uh research uh data A4: With an open question that requires research. **Excerpt B** **Context:** students are preparing the structure of the poster **Analysis:** students are working together towards a shared goal **Verbatim:** B1: So next we can make a definition with the... the first thing there... the first document B2: Yes, there's the scientific concept; so this is an illustration? B3: No, I think it's the one at the bottom, illustration. B4: Illustration, yes. You just mark illustration. B5: Ok, situation, and use. B6: With an "s"? Illustration? B7: Uh yeah. B8: Situation. With an s.
Socioemotional interaction	**Excerpt C** **Context:** a student wonders about the pseudonyms used in the drive **Analysis:** students are intended to arouse emotion, laughter **Verbatim:** C1: Why am I called Anonymous Pumpkin [in the drive]? C2: It's like that...and then there's hedgehog and squirrel too. [laughs] C3: It's Google drive. It's not you who got them... C4: Oh no, no. C5: But noooo. C6: Yes, you do. C7: But I want to [unintelligible]. [laughs] **Excerpt D** **Context:** students discover the documents set up by the teacher on the digital workspace to perform the task **Analysis:** students conduct short-term self-regulation by analyzing documents; one of them has the purpose of increasing group cohesion **Verbatim:** D1: How many pieces are there? D2: Four. D3: Oh yeah.

	D4: There are four pieces. There is one... the scientific concept... well... the scientific concept is a mind map... do you have it in front of you or not? D5: Yes. D6: It's a mental map in fact. D7: Uhhh... Do we all read together or not? D8: I think so, because we have time, we have an hour and a half, so... D9: Then the second document has four pages but they are not very long. D10: Then, it's different concepts. D11: How many leaves? D12: Three. D13: Three. D14: And then we have a definition, but we'll... D15: Well, this is the one we share. D16: Yes.

TABLE A2

Excerpts from our study with different kinds of self-regulations phases

Types of self-regulation phase	**Examples**
Forethought phase	**<u>Excerpt E</u>** **Context:** students are regrouped and a document called "slide presentation" has been distributed in a single copy to the group. This group is used to work with Google drive and will use it to share the documents available to solve the task **Analysis:** students are engaged in goal setting and strategic planning on a micro task; there is a request for information that does not refer to information that was there before **Verbatim:** E1: So, we read the slide? E2: Let's read the slide. E3: I sent you the drive. E4: Ok, thank you. E5: What's on before? E6: Nothing important. E7: I sent you the drive, I don't know if you got it? E8: Yes... yes. **<u>Excerpt D</u>** **Context:** already mentioned above in the socioemotional part (see TABLE A1) **Analysis:** students are engaged in goal setting and strategic planning on a medium-term task **Verbatim:** D1: How many pieces are there? D2: Four. D3: Oh yeah. D4: There are 4 pieces. There is one... the scientific concept... well... the scientific concept is a mind map... do you have it in front of you or not? D5: Yes. D6: It's a mental map in fact. D7: Uhhh... Do we all read together or not? D8: I think so, because we have time, we have an hour and a half, so... D9: Then the second document has four pages but they are not very long. D10: Then, it's different concepts D11: How many leaves? D12: Three.

	D13: Three. D14: And then we have a definition, but we'll... D15: Well, this is the one we share. D16: Yes.
Performance phase	**Excerpt F** **Context:** one student reads documents aloud to the group; they make comments at the same time **Analysis:** students are solving the task; one student expresses the validation of the understanding of what has been just read (reflective process), another one corrects him (regulation); they are interpreting the meaning of the document together in a collective cognitive process **Verbatim:** F1: So a scientific concept is an intellectual tool that wants to be... objectified and that establishes between phenomena a sufficiently general and invariant relation to authorize the prediction of results or facts....or facts. Ok. F2: Well... already it is an intellectual tool. F3: The con...yeah the scientific concept is first...is an intellectual tool that wants to...that wants to be objectivity. F4: Objectified. F5: Oh yes, I hadn't seen, objectified. F6: So his aim, no, it's not...no, it has nothing to do with it. F7: Well, yes, it has an aim, right? F8: Yes, yes. **Excerpt G** **Context:** students begin to lay out the final poster they are asked to produce **Analysis:** students are writing together, with self-control **Verbatim:** G1: So we start writing, huh? We'll be nice. G2: We'll never have time to make the mind map. G3: What color should we use? What color should I use? G4: Any one you want [of markers]. G5: Uhhh pffffouh...I don't know. G6: Uh...is it...so...before... G7: The dark one, yeah. G8: We'll take the three [markers]...Do we have any counter examples? G9: No, I wanted to put the different categories, you know; notions, sub-notions. G10: We'll see later. G11: Yeah, start the definition, in the meantime. G12: I can't write straight, though. [student begins to write on an A3 sheet the definition: "The scientific concept is an intellectual tool with a defined objective allowing to establish precise links between different phenomena"] G13: Is it good as a definition? Well, go ahead, I'm going to write, if you want I'll write straight.
Reflection phase	**Excerpt H** **Context:** students analyze the documents in relation to the expected production (the poster) **Analysis:** there is a reflection process during an intermediary phase; learners self-evaluate the information they gathered **Verbatim:** H1: In fact, it's an analysis of the problem for the moment. H2: So the scientific concept: names and symbols... H3: What is the label? H4: We don't know. H5: Rule... source of problem... concrete illustration.

H6: Label must be a mode of... uh... I don't know... I don't know how to say... kind... uh
H7: Basically, there is a scientific concept that has a name and symbols.
H8: Uh like a general truth. Your name is Esther. It's a label. It's attributed to you.
H9: Yeah, that's it.
H10: I think that's it.
H11: Ok.
H12: Not sure huh.

Excerpt I

Context: students are considering what content to put in the poster to be produced
Analysis: learners self-evaluate the information they gathered; they are discussing what the group learned
Verbatim:
[students have the following text in front of them: "...the fact that the scientific concept is first of all an intellectual tool which is intended to be objective and which establishes between phenomena a sufficiently general and invariant relation, to authorize the prediction of results or effects"]
I1: Does the definition fit you? We can take the same definition as is.
I2: We are going to copy and paste.
I3: Well, on the one hand we take a scientific definition. Right. Because then we don't have the source of the book.
I4: I think we should reword it. If we copy and paste in the end we don't understand. We just have, um...
I5: Yeah, that's it.
I6: So then... it has been marked ["it has been marked" is expressed in an underlined way to attract everyone's attention]... the scientific concept is first of all an intellectual tool which aims to be objectified and which establishes between phenomena a sufficiently general and invariant relation to authorize the prediction of results or of facts.
I7: So...
I8: To start with, it's an intellectual tool.
I9: Yeah, that can't be rephrased....
I10: Which has an objective...
I11: With an objective...uh what else does it say?
I12: It's over.

Excerpt A

Context: already mentioned above in the cognitive interaction part (see TABLE A1)
Analysis: students discover the paper document and remobilize their knowledge on the notion of complex task
Verbatim:
A1: What are the specifics of the tasks you were asked to do in this course? What did they have in common?... well, that's not a definition...
A2: We had already done that in the drive...basically it's the definition of the complex task
A3: Yes...and that... what they had in common was a group work with uh research uh data
A4: With an open question that requires research.