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The final publication is available at:

<https://doi.org/10.1016/j.tsc.2018.06.004>

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Accepted Manuscript

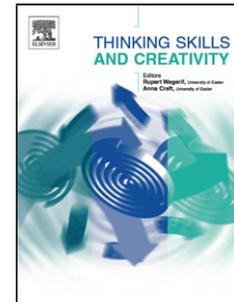
Title: Characterizing and unpacking learning to learn together skills in a wiki project in primary education

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PII: S1871-1871(17)30207-9
DOI: <https://doi.org/10.1016/j.tsc.2018.06.004>
Reference: TSC 515

To appear in: *Thinking Skills and Creativity*

Received date: 3-8-2017
Revised date: 6-6-2018
Accepted date: 12-6-2018



Please cite this article as: Pifarré M, Li L, Characterizing and unpacking learning to learn together skills in a wiki project in primary education, *Thinking Skills and Creativity* (2018), <https://doi.org/10.1016/j.tsc.2018.06.004>

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Characterizing and unpacking learning to learn together skills in a wiki project in primary education

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Highlights

- Identification and definition of key features of 4 learning to learn together skills
- Distributed leadership, Mutual engagement, Group reflection, Group Assessment skills
- Wiki affordances promote learning to learn together skills
- Technology and pedagogy are equally important to promote learn to learn together skills
- Effective technology-enhanced pedagogy has to include the promotion of L2L2 skills

Abstract

Learning to learn together (L2L2) skills are widely acknowledged as some of the most important 21st century skills that enable learners to participate in a digital and global society. This paper examines how L2L2 skills emerged in a small-group wiki-based collaborative project and in the context of face-to-face real-classroom practice, in order to conceptualise L2L2 and identify the key features of the skills involved. To this end, our paper reports on an empirical study with primary school students who worked

in two different modes of interaction, namely face-to-face in-pair discussion and on-line wiki-based between-pair discussion. The study identified and defined key features of four L2L2 skills, namely distributed leadership, mutual engagement, group reflection and group assessment, all of which emerged to a similar extent during the wiki project. It was found that a few distinctive features of L2L2 skills are related to different stages of task resolution, wiki affordances and different modes of collaboration. Therefore, this empirical study argues that technology and pedagogy are equally important and required to promote L2L2 skills in primary school classrooms and also it discusses some educational implications for the design of more effective technology-enhanced pedagogy.

Key Words

Learning to learn skills, Collaboration, wiki, computer-supported collaborative learning.

1. Introduction

Learning to learn together (henceforth L2L2) has been defined as a complex competence that emerges in a group or collectivity with the goal of learning how to be an effective facilitator of group learning (Yang, Wegerif, & Pifarré, 2013). L2L2 skills will equip citizens for life in the knowledge society in today's global age, in which distributed teams working together to solve problems and inquiring into issues are increasingly common. Nevertheless, teaching how to learn collectively and how to develop skills that allow individuals to learn to learn with others is one of the greatest educative challenges (Mercer, 2013; Wegerif, 2015).

In the context of web-mediated learning, researchers argue that learning is also about how to learn together in an online community. Research in the area of computer-supported collaborative learning (henceforth CSCL) has resulted in an extensive account of how communication technologies can provide scaffolds to facilitate and support collaboration and learning (Jeong & Hmelo-Silver, 2016). Likewise, from an L2L2 perspective, technology can also be seen as an essential facilitator of collective thinking and actions because technology provides external representations of group

work, enables multimodal interaction along with talk and can support rich new forms of dialogue that highlight differences between perspectives, and make ideas and reasoning processes more explicit (Hennessy, 2011; Mercer, Hennessy, & Warwick, 2017).

Thus, the relevance of learning to learn with others using technology is critical in preparing children to adapt and become flexible in these fast-changing times. Apart from some preliminary work (e.g. the Metafora Project, <http://www.metafora-project.org/>), little research has been conducted in this area (Schwarz, de Groot, Mavrikis, & Dragon, 2015) and little is known about what L2L2 skills are, what distinguishing features L2L2 skills have, how they emerge in action and how they are used for solving collaborative challenges, how they unfold during a collaborative project, or how L2L2 skills are linked to specific technological features.

Our study lies within this line of research and our paper pursues a two-fold goal. First, our research attempts to provide evidence-based understanding of L2L2 skills by outlining features of these skills emerged from small-group wiki-supported collaborative work. Second, we intend to find out how these L2L2 skills are employed by learners in group work and the difference and relations of these skills between in-pairs face-to-face interaction and in between-pairs wiki-written interaction.

In addition, we hope to contribute to the discussion about pedagogical tools to be considered for directing technology-mediated peer interaction in order to support the development of L2L2 skills. To this end, the paper focuses on studying how the wiki facilitates L2L2 skills in two modes of collaboration: in-pairs face-to-face interaction and between-pairs wiki-written interaction.

2. Learning to Learn Together

There is extensive educational research arguing that the benefits of promoting learning to learn (henceforth L2L) skills are a set of capacities and meta-strategies that help the individual learner face new challenges. L2L skills have been emphasised to develop flexible and adaptable thinking (e.g. Resnick, 1987; Claxton, 2004; Fredriksson & Hoskins, 2007). However, the consolidation of a global networked knowledge society in which collaboration is a central tenet leads to the necessity to incorporate the role of the “others” as a key variable in promoting learning. In the same vein, Van der Linden & Renshaw (2004) conclude that, in order to understand how children learn

collaboratively, researchers have to reduce the gap between cognitive aspects involved in collaborative learning in contexts where learning goals are relatively fixed, and collaboration in socio-cultural contexts with relatively open learning goals. Using this approach, and in the context of mathematics, Dekker, Elshout-Mohr and Wood (2006) state that the challenge in promoting collaborative learning is to direct peer interaction towards four characteristics that include cognitive and social aspects, namely “talk about the concepts to be learned”, “elaborative contributions from the participants”, “a continuous attempt and regulation to achieve a shared understanding of concepts” and “making productive use of the mediation-means (tools) that are available”

Additionally, Rupert Wegerif has extended these arguments by coining the concept of learning to learn together (L2L2) skills as a key concept to prepare students for the knowledge age (Wegerif, 2015; Wegerif, 2013; Wegerif & De Laat, 2010). Wegerif and collaborators argue that L2L2 skills can be seen as an extension of the individual approach of L2L that incorporates a social conception of learning which combines the dimension of task management (how to organise complex inquiries with multiple stages and strands) with the dimension of social relationships (working with different personalities, expectations and identities in order to participate constructively in learning as a collective accomplishment).

These researchers also lay claim to the importance of designing pedagogy capable of promoting L2L2 in education. Wegerif and collaborators’ educational proposals are based on four theoretical axes: a) dialogic theory as an inclusive theoretical framework for describing, designing and evaluating collaborative learning; b) shaping and widening interaction dialogues through “thinking together” talk; c) the central role of technology in promoting inside thinking and L2L2 skills. Technology enables collective thinking because technology makes it possible for a dialogue to take an external form that allows one person or a collectivity to reflect on ideas; in this context, collective thinking combines the external visible technological moment of thinking with the internal, invisible and uniquely moment of reflection (Wegerif, 2015:437); and d) the promotion of cultural change by teaching skills and competences to groups. This cultural change involves people and tools, including, mainly, communication technology.

These theoretical and pedagogical principles served as working hypotheses in the R&D EC project entitled ‘Learning to learn together: a visual language of the social orchestration of educational activities – Metafora’. This project focuses on the design of a technological platform for supporting L2L2 in solving problems in Science and Mathematics, and served as a starting point in clarifying the unarticulated L2L2 concept (Schwarz et al., 2015). Based on literature review, Yang, Wegerif and Jones (2012) identified four key aspects of L2L2:

a) **Distributed leadership** was characterised as a social and situational process that can emerge through different forms of participation. Five different leadership strategies were highlighted: namely, turn management, argument development, planning and organizing, topic control and acknowledgement.

b) **Mutual engagement** can be realised through and around shared objects. Learners are mutually engaged through critical discussions, creative design and manipulation. Therefore, shared objects are key referential anchors for mutual engagement and understanding.

c) **Peer-group assessment** is about the evaluation of individual and group learning. Individual assessment focuses on judgment of peers’ feedback and experience and expressing personal emotions in line with the general atmosphere. On the other hand, group learning assessment refers to evaluating the work and directing it towards useful group outcomes, distribution of labour and expertise aimed at group goals and developing togetherness and trust in the group in order to lead to deeper discussion.

d) **Group learning processes** dynamically proceed and evolve in relation to the group’s shared mental models. To make these knowledge procedures explicit to the group, three distinct temporal opportunities for group reflection around an online discussion map were identified: i) Beginning: planning group task resolution, reflecting on individual preferences, collective responsibility and intended level of participation; ii) Middle: ongoing reflection on group functioning, regulation and managing task resolution, emerging roles, norms and gaps between individual and collective outcomes, and, iii) End: reflecting on the original and emergent interpersonal structure and group learning, intended individual learning outcomes and achieved outcomes.

Identification of these four aspects of L2L2 served as a framework for the design of

technological scaffolds to promote L2L2 skills in the Metafora Project. Although the project provided some empirical evidence about promoting L2L2 skills with technology in real classroom settings, little development has been made on establishing a clear definition of the different L2L2 skills with their distinctive features. Our study aims to bridge this gap by providing data-based definitions of L2L2 skills, their distinct features and how they look like in action. In our view, this knowledge about what the L2L2 skills consist in would be valuable for stakeholders, educators and teachers to design better educational projects in real classroom contexts to develop L2L2 skills, and would provide them with lenses through which to examine the process and the product of collaborative learning.

Based on previous research, Schwarz et al. (2015) identified collective reflection, mutual engagement and peer assessment as possible directions for desirable L2L2 practices in promoting inquiry and argumentation. These authors envisaged **collective reflection** as an on-going collective reflection while planning and monitoring work together. They used the Metafora platform on the basis of technology capable of facilitating collective reflection since inquiry/problem-solving actions can be visualized and shared. **Mutual engagement** was characterised by help-seeking, help-giving and leadership-sharing. This work highlighted the difficulties in translating leadership sharing into definite practices. Furthermore, interactive **peer group assessment** emphasises the benefits than can be gained from peer feedback for both those assessing and those assessed. Although this study stressed the role of CSCL tools in supporting the promotion of L2L2 as well as inquiry and argumentation, it did not provide further elaboration on the definition of the distinct features of L2L2 skills when using technology that could be transferable to other educative situations.

The research to date on L2L2 skills is still exploratory and remains at a theoretical level. More specifically, existing research has remained inconsistent in establishing what L2L2 skills are, and there is insufficient empirical evidence to illustrate what distinctive features each skill consists in and how L2L2 skills are used in action. Our study aims to address these issues.

3. Wiki technology to promote L2L2 skills

Wiki environments are hypertext systems that allow users to create webpages in

which a community of users can consult, add and link multimedia information (Leuf & Cunningham, 2001). The wiki-based technological facilities for multiuser edition, content development tracking or asynchronous written communication have been pointed out as intrinsic affordances to support collaborative learning processes and student-generated content (Lau, Lui & Chu, 2017; Pifarré & Kleine Staarman, 2011; Ruth & Houghton, 2009; Wheeler, 2010).

Despite the wiki affordances for supporting collaboration, several studies also highlight pedagogical challenges. One of them is the extensive use of wikis in traditional learning and their focus on the outcomes of using them, that is, the accumulation of knowledge built upon by successive generations of users (Elgort, Smith, & Toland, 2008). Another challenge could be the fact that wiki is unable to change students' tendency to divide tasks among themselves and work separately rather than collaborate and solve the task collectively (Hadjerrouit, 2012).

In our view, these pedagogical challenges for a successful classroom use of wikis to foster collaborative learning processes hinge upon the alignment of pedagogy and technology in designing classroom practices. This paper argues for the pedagogical use of wiki technology from a dialogic perspective in which technology is seen as a tool for creating, opening, widening and deepening dialogic spaces to encourage students to think and learn together (Wegerif, 2015; Mercer et al., 2017). Based on the dialogic perspective of learning, we have analysed the wiki affordances to promote L2L2 learn skills and subsequently design pedagogical activities based on using wikis.

3.1. Distributed leadership and empowering all participants in wikis

Sharing of leadership is central to a wiki (Ruth & Houghton, 2009). All users have the same rights and facilities to participate in the creation of shared documents, whose content and structure evolve through the contributions of all members and shared community goals. Users' contributions are easy to make and multimedia information can be introduced; in this way, diverse styles of learning are encouraged, which lead to knowledge construction.

In addition, wiki concentrates all users' contributions and the different versions of the common document into one specific location; this serves as a transparent environment in which users can easily consult all participants' contributions, be aware

of the collaborative task, and take the lead to move the collaborative task forward (Lundin, 2008).

3.2. Mutual engagement among all participants in wikis

Learning in a wiki is based on the social construction of knowledge, in which all users can be engaged in writing a text together (Ruth & Houghton, 2009). Users can easily add new information, share ideas, widen the topics under conversation, discuss and build on others' ideas, and give feed-back to each contribution.

The inherent affordances of wiki to encourage all users to be mutually engaged in the task support the development of an intersubjective orientation towards other participants' perspectives and the creation of a dialogic space to co-construct new understanding and produce a truly shared digital artefact as the result of their collaboration (Pifarré & Kleine Staarman, 2011).

3.3. Group reflection and group assessment in the wiki

Wikis save all changes and previous versions in the history function. All users can easily track content development and this gives the users a valuable mirror for group reflection and assessment: they can visualize group learning skills that promote the co-construction of new content understanding; they can also evaluate key users' contributions, and, in the process, they may reject inconsistent ideas. The fact that users interact in the wiki environment asynchronously may stimulate group reflection processes because users have time to consult other resources and to analyse other users' contributions (Hadjerrouit, 2012).

4. The wiki project

This empirical study was conducted in a Spanish primary school within a 6th grade science curriculum classroom. Twenty-four, 9-10 year-old primary education students and one teacher participated in this study. The teacher had assigned the students to work in pairs in the classroom during the project, and every pair worked together sharing one computer. The wiki environment was used to write a joint argumentative text on a scientific topic, together with 2 other pairs.

Mercer et al. (2017) claimed that technology must be used with a dialogic intention for supporting classroom dialogue and thinking over time. It is therefore pedagogy that is paramount not technology. In our study, the researchers and the teacher jointly

designed a pedagogical framework, as described below, in order to shape a technology-enhanced peer interaction capable of promoting the development of L2L2 skills in a primary school context.

The students took part in a science project, spanning 13 one-hour lessons, which were divided into three different phases with distinctive learning objectives.

1) The first phase had the objective of developing talk capable of promoting L2L2 skills. It consisted of three one-hour face-to-face sessions. These sessions were based on dialogic theory (Wegerif, 2013) and on the *Thinking Together* approach (Dawes & Sams, 2004; Mercer & Littleton, 2007), and students were encouraged to set up and reflect upon ground-rules for effective communication of ideas in a collaborative situation. In addition, sentence openers were provided as a tool to enhance L2L2 talk. Students worked on the use of three kinds of openers: a) *Mutual engagement*: giving information (eg. 'In my opinion'); asking for someone else's point of view (e.g. 'What do you think about...') and giving reasons; b) *Taking leadership moves and responsibility*: (e.g. 'I would suggest we do....'); summarising the discussions (e.g. 'to synthesize'; 'we think'); c) *Group reflection and evaluation*: expressing disagreement (e.g. 'I do not agree with.... because') and expressing agreement.

2) In the second phase and during the following three classes, the students worked in pairs on web-based inquiry activity about a scientific topic on planet Mars. At the end of this phase, each pair wrote an initial propositional text in which they had to present their ideas about the possibility of setting up a colony on Mars and the potential difficulties faced by such endeavour.

3) In the third phase, three pairs of students were grouped together in the wiki environment in order to write a collaborative text about Mars. For the following seven class sessions, we monitored the participation of students in the collaborative writing task in two aspects: a) *when* students were to participate in the wiki: pairs took turns to work in the wiki for periods of about 10-15 minutes; b) *how* students were to interact: students collaborated in two modes: in-pair face-to-face (henceforth F2F) interaction and on-line interaction between the three pairs through the wiki environment. These two collaboration modes are shown in Figure 1 below. The vertex of the triangle represents collaborative mode 1, in which each pair worked F2F together in order to write collaboratively their contribution in the wiki. The middle of the triangle represents the

collaborative mode 2, in which the three pairs collaborated together on-line in the wiki; in this second collaborative mode, students could interact in the two wiki spaces: the negotiation space and the group text space. We call this space an *intermental zone* to stress the function of wiki in providing opportunities for pairs to engage in critical discussion to form ideas together.

5. The current study

This study is part of a larger design-based research project involving both primary and secondary schools teachers and students, with the aim of improving scientific learning through technology and active involvement in research from the teachers. Unlike some of the findings obtained in a previous iteration (e.g., Pifarré & Li, 2012; Pifarré & Kleine Staarman, 2011), this research study aims to conceptualize L2L2 skills using different types of data (see below). Specifically, the research questions raised by this study are the following:

RQ1. What kind of L2L2 skills emerge when students are engaged in in-pairs F2F interaction and in between-pairs wiki-written interaction during the wiki project?

RQ2. To what an extent do L2L2 skills differ in in-pairs F2F interaction and in between-pairs wiki-written interaction during the wiki project?

RQ3. What are the inter-relations between the L2L2 features displayed in the two collaborative modes: “in-pairs F2F interaction” and “between-pairs wiki-written interaction”?

5.1. Data collection

There is little research that captures both F2F and on-line interaction in technology-enhanced learning environment of the type that our research is based on. Since the focus of our study is on developing the concept of L2L2 skills in different types of interactional work during a wiki project, we supervised and analysed thoroughly the work carried out by one group of six students in the wiki environment and their in-pairs face-to-face interactions (three pairs). To help us capture the L2L2 skills in action, we combined data collection methods of classroom interactional work (e.g., Wegerif, Mercer & Rojas-Drummond, 1999; Mercer, Wegerif & Dawes, 1999) and online

interaction (e.g., De Wever, Schellens, Valcke & Van Keer, 2006).

Firstly, the wiki logs containing the students' writing contributions were downloaded. A total of 941 words were written in the wiki negotiation page by the three pairs. Secondly, the face-to-face interactions were video recorded, transcribed verbatim and professionally translated from Catalan to English for analysis. In order to ensure translation accuracy, researchers discussed each utterance which might cause potential misunderstandings. A total of 250 minutes' of interaction data were recorded.

5.2. Analytical approach

The data comprises wiki logs from negotiation page and the F2F interaction transcripts. Data was analysed adopting an extensively used methodology for the analysis of classroom talk called sociocultural discourse analysis which focuses on the use of language as a social mode of thinking (Mercer, 2004). This analysis approach follows the principles of mix-methods (e.g. Johnson & Onwuegbuzie, 2004) by combining qualitative and quantitative methods so that weaknesses are counterbalanced and evidence of more than one kind is generated. Mercer (2010) stated that in sociocultural discourse analysis, qualitative methods work with the basic data that remains throughout the whole learning process and it allows the analysis of the nature and functions of dialogue in promoting learning and thinking over time. This qualitative analysis is then integrated with quantitative analysis, usually in the form of codes or categories that helps to give a macro perspective of the educational processes.

Building on previous work in this field (e.g., Wegerif et al., 1999; Pifarré & kleine-Staarman, 2011), we followed a thematic analysis approach using principles of Grounded Theory (Glaser & Strauss, 1967) to identify the L2L2 skills.

We established a two-stage approach for the F2F interactional data, in order to differentiate the L2L2 skills and the distinctive features developed during the project. The first stage focused mainly on qualitative discourse analysis in order to reveal processes of the joint knowledge construction (Mercer, 2004, 2008; Mercer et al., 2017). We reviewed all the data and divided them into segments, each having a clear focus based on the content of the data. Then we read each segment to analyse its meaning and assigned it an L2L2 feature, for example, "proposing new and valuable ideas to move the collaborative task forward". Then we used these features as series of codes, which were later reviewed and categorised. Similar features and codes were

grouped together and became themes, such as: acknowledging, thinking together and elaborating ideas. In turn, these themes were further grouped together and became L2L2 skills, for example, “mutual engagement”.

Finally, after thorough investigation of the data and further literature review, four main L2L2 skills were established. These skills were “distributed leadership”, “mutual engagement”, “group reflection” and “group assessment”.

During the second stage, and with the assistance of QSR Nvivo, a code was assigned to all the segments identified in the F2F interactional data. This enabled us to obtain a quantitative picture of L2L2 skills emerged from in-pairs F2F interaction. This provided us with a holistic overview of the role that each L2L2 skill has in this knowledge-building activity as well as a comparison between in-pairs F2F and between pairs for each skill. According to Wegerif et al., (2017), this way of combining quantitative measures and qualitative insights can create a better overall understanding of a phenomena investigated.

Regarding the written data extracted from the wiki logs, we performed thematic content analysis and followed Henri’s (1992) analytical approach, an approach widely used for analysing on-line interactions (e.g., De Wever et al., 2006). Wiki logs were first divided into units of meaning by using semantic features such as ideas, argument chains, and discussion topics, or by regulating activities such as making a plan, asking for an explanation, or explaining unclear information; to carry out this task, the researchers used QSR NVivo.

Subsequently, a code was assigned to each meaningful unit. Similar to the interactional data analysis procedure, the meaning of each unit was assigned a code, the codes were categorised as subthemes, and eventually subthemes were grouped to become a list of themes which became, in turn, part of an L2L2 skill.

Characteristics or themes of each L2L2 skill were reviewed jointly by the researchers until the definition of each skill was established. This is a recursive procedure.

Appropriate ethical procedures were followed, with consent forms obtained from the school authorities, as well as parents and students. Pseudonyms were assigned to all students.

6. Findings and discussion

6.1. Characterizing L2L2 skills in the wiki project (RQ1)

While using the wiki, students collaborated in two different interactional modes: in-pairs F2F interaction and between-pairs in wiki-written interaction. Here, we are interested in studying the kind of L2L2 skills that emerged in the collaborative work and the characteristics of each skill.

After conducting the data analysis presented in the previous section, we can distinguish four types of L2L2 skills, namely distributed leadership, mutual engagement, group assessment and group reflection. As seen in Figure 2, the four skills are almost evenly distributed through the dataset. An initial assumption can be made here that these four L2L2 skills are equally important in a successful collaborative wiki project.

Next, we will describe what these four L2L2 skills mean. Firstly, the **distributed leadership** skill describes those participants' contributions that lead to a specific course of action or decision which result in proposing the next steps or managing the task, proposing valuable ideas to move the task forward (e.g. "we could write..." or "the final text should start with..."), asking key questions to move a discussion forward and summarising group thinking. This skill also involves establishing ground rules for working well together. Secondly, the **mutual engagement** skill describes those participants' contributions which result in acknowledging and recognizing each other's viewpoints, engaging in discussion and thinking together about the topic (e.g. science in this project). This skill also involves giving/looking for evidence, elaborating topic ideas, and developing and extending topic arguments. Thirdly, participants show **group reflection** skills when they actively reflect on the task, on the process and on the progress of their own and others' work. Finally, **group assessment** skills involve the assessment and evaluation that participants carry out of themselves and others.

As discussed earlier, we find that L2L2 skills have not been clearly defined with sufficient evidence in previous literature. We propose definitions of L2L2 skills based on experimental data, and our methodological procedure has revealed clear-cut boundaries between the four skills, especially between distributed leadership and mutual engagement, both of which have been expressed in somewhat 'fuzzy' terms in previous literature (Schwarz et al., 2015). Unlike previous research (e.g., Yang, Wegerif & Jones, 2012; Schwarz et al., 2015; Shollen & Brunner; 2016), our work conceives mutual

engagement skills as those related to thinking together about the topic, in other words, it includes actions that may boost the learning opportunities for students to understand the meaning and significance of the topic. On the other hand, distributed leadership skills take into account those students' contributions that lead to a specific course of action to solve the task collaboratively. Finally, it is worth highlighting the distinction between group reflection and group assessment skills. Thus, group reflection skill focuses on considering, regulating and controlling learning processes while group assessment refers to giving value about others' work and ideas.

Added to the above definitions, the reader can find the definitions and the distinct features of each L2L2 skills further illustrated with examples in Appendix 1.

In the following section we present and discuss the distinct features of each of the L2L2 skills.

6.2. Characterizing L2L2 skills in in-pairs F2F interaction and in between-pairs wiki-written interaction in the wiki project (RQ2)

The four L2L2 skills are present in the two modes of collaboration designed in our wiki project. Nevertheless, as shown in Figure 3, we found differences in how the distinct features of the four L2L2 skills were displayed in the two modes of collaboration. In in-pairs F2F interaction, students displayed more mutual engagement (42%) and distributed leadership (31%) skills. However, in between-pairs wiki-written interaction, students displayed a higher amount of group assessment (38%) and group reflection (26%) skills. This result suggests that the combination of F2F interaction mediated by technology and interaction through technology could be more powerful because it may facilitate the emergence of more and more specific features of L2L2 skills. This, in fact, can make learning more self-regulated, flexible, transformative and adaptable to different situations (Fleischer, 2012; Li, Kai, Chu, Ki & Woo, 2012; Slakmon & Schwarz, 2014). Therefore, in the following section we will analyse the main features of each L2L2 skill and how they unfolded in the two collaborative modes of the project.

6.2.1. Distributed leadership

Figure 4 represents the frequency of the presence of distributed leadership skills in our data in the two collaborative modes. The percentage of the display of leadership moves is higher within the F2F interactions of the pairs (31%) than through the on-line contributions in the wiki between the pairs (20%).

Figure 4: Distributed leadership features

The two pie charts depicted in Figure 4 represent the presence of the different patterns of leadership moves in the two collaborative modes designed in our study: in-pairs F2F interaction (pie chart on the left, Figure 4) and between-pairs through the writing wiki contributions (pie chart on the right, Figure 4). In-pairs F2F interaction revealed five distinguishing features of leadership moves whereas in between-pairs wiki-written interaction there were only two. These features are presented, compared and contrasted below.

Proposing new and valuable ideas to move the collaborative task forward is the most common feature in both modes. Students in in-pair interactions postulate a new idea to write in the wiki (see example in appendix 1).

In between-pairs wiki-written interaction: this feature consisted in proposing sentences that should be written in the common text. For example, pair 1, after two turns in the wiki offering different arguments about the difficulties in establishing a human colony in Mars, proposed how to start writing the text: *we consider that the text could start with “we think that a human colony will not be able to be established in the Mars planet because... ”*. This example also suggests a possible reason for a higher presence of this feature in between-pairs wiki-written interaction. In our opinion, the leadership moves in the wiki have a strong task-orientation and the purpose of these moves is to contribute to achieving the goals of the group task by proposing new ideas. Research studies have differentiated between task-orientated and relation-orientated leadership moves, which suggests that task-orientated moves emerge through action and they help the group to achieve goals (Li et al., 2007).

Management of the task is highly present in between-pairs wiki-written interaction (40%) and less frequent in in-pairs F2F interaction (12%). This is because managing and organising the next actions of the group to fulfil the collaborative task is a priority

of between pairs wiki-interaction. In addition, analysis of the in-pair F2F interaction shows a 12% presence of the moving forward leadership feature. Management of the task and **moving it forward** have been seen as vital leadership elements of group effectiveness process (Li et al., 2007), in which students' moves are focused on group improvement and orientated to master the group task (Norton, Ueltschy Murfield, & Baucus, 2014).

Weaving and orchestrating the actions of the other members in order to better solve the task is only present in in-pairs F2F interaction (28%). This leadership feature contributes to creating a context for collaboration based on ground rules, respect and trust and it encourages equal participation of both members of the pair and acceptance of others' ideas (see appendix 1). Jones (2014) emphasizes that creating a context that could frame and value distributed leadership is a key feature for increasing the collective engagement of non-formal leaders, participation and democratic decision-making to solve a task collaboratively. Li et al. (2007) named this type of leadership move 'relationship-orientated'.

Another task-orientated leadership move is **summarising group thinking**, which is a distinct pattern found in our work and which is not present in other leadership studies; furthermore, it is only present in F2F interaction. The summarising of group thinking has two purposes in our study: a) to frame the collaborative work in the pair, which means that students summarised the ideas displayed by the other pairs in the wiki as a means of framing the discussion and the work within the pair; and b) to write the wiki-contribution to be shared with the other pairs, in which case students summarised the discussion carried out in in-pair F2F interaction and this summary helped them to write the contribution in the wiki.

In our view, these arguments provide experimental evidence that students have appropriated the characteristic of the wiki as a transparent collaborative environment in which all participants' contributions are located in a unique space (Lundin, 2008). In our study, students have used this intrinsic wiki characteristic to be aware of the key collaborative actions to move the group task forward and as a medium for displaying distributed leadership moves.

6.2.2. Mutual engagement

Research claims that interactive technologies can afford opportunities for learners to deeply engage with key content ideas (Hennessy, 2011). Nevertheless, the extent to which collaboration is productive in ways that lead to conceptual understanding depends on the quality of collective engagement in a shared activity. Some researchers view engagement in technology as co-occurring with knowledge co-construction involved in sense-making, with both being dynamically interrelated (Sinha, Rogat, Adams-Wiggins, & Hmelo-Silver, 2015).

In our study, mutual engagement is displayed largely in in-pairs F2F interaction (42.5 %) and in 16% of between pairs wiki-interaction (see the bar charts in the middle of Figure 5).

Mutual engagement in in-pairs F2F interaction involves three distinct features: thinking together, acknowledging and elaborating ideas; on the other hand, in between-pairs wiki-written interaction it consists of only thinking together and elaborating ideas (Figure 5).

The category of “**Thinking together**” was the most frequent pattern of the mutual engagement skill in in-pairs F2F interaction and this skill was used when students were engaged in a discussion about the topic. Students would start by reading aloud the wiki contributions written by the other members of the group, follow this with a discussion on the topic and ideas involved in the wiki contribution, and finish by writing collaboratively the pair wiki contribution. For between-pairs wiki-interaction the focus was placed on thinking for possible ideas through dialogues, making progress in solving the collaborative task through the use of domain-specific topic, justification of identified solutions, particularly after having weighed alternative solutions to the problem, and the building of topic connections and synthesis.

In both modes of interaction, the wiki environment afforded the emergence of mutual engagement in thinking together because wiki provides a space which collects all users’ contributions and within this space it is simple to discuss and further think about others’ ideas.

In between-pairs wiki-written interaction the most frequent pattern of mutual engagement skill was **elaborating ideas (62%)**, in which students develop and further extend the idea proposed by other members of the group. This category is less featured

in in-pairs F2F interaction because the purposes of interaction in these modes are different. We can assume that in-pairs F2F interaction is more focused on acknowledging (29%) and discussing the ideas from other teams and thinking about other possible ideas (thinking-together category). In contrast, in between-pairs wiki interaction the focus is on explaining ideas and one's position in order to convince other teams to follow and accept their scientific point of view. Therefore, extending and elaborating the arguments is crucial.

The wiki environment allows all the members to easily add new information for others' consideration, to expand the contents under discussion including others' positions, and to build on others' ideas. The data collected in our study provides experimental evidence of the ways in which wiki afforded students' development of an intersubjectivity orientation towards other participants' perspectives and promoted an intermental zone for collective thinking which could contribute to individual learning (Mercer, 2013). Students in the wiki project showed trust in each other's ideas and shared ideas to be openly negotiated, even at the risk of disagreement and conflict.

Gresalfi & Barab (2011) claimed that the design of CSCL environments needs to provide tasks capable of creating opportunities for students to grapple with the meaning and usefulness of content and to encourage students to make deep connections, as these can lead to robust learning. The wiki project design in our study certainly reached this target.

6.2.3. Group reflection

In our study, there is a greater occurrence of group reflection features in between-pairs wiki-written information (26%) than in in-pair F2F interaction (18%). Three features emerged in relation to group reflection: reflection on the work developed inside the pair, reflection on the task and group progress (with the other pairs of the group), and reflection about strategies. These three features were displayed in in-pairs F2F interaction, but only two of them were found in between-pairs interaction, as displayed in Figure 6.

The category of reflection on in-pairs work was displayed in both collaborative modes. In in-pairs interaction, it refers to regulating and coordinating what and how to

do the work in-pair in order to develop their wiki contribution. For example Student 1 says *'Let's see. Let's keep reading and know their opinion to this ...'* as a prior stage to starting the collaborative work in the pair.

On the other hand, in between-pairs this type of reflection is more focused on communicating the work they have done to progress the task, which might help the other pairs to reflect on how to better proceed to solve the collaborative task. For example, pair 2 communicates in the wiki negotiation page as follows: *We have added at the end of the text the solution for the oxygen problem.* This type of talk constitutes a large part of the group reflection category: 46% in in-pairs and 50% in between-pairs.

Reflection on the group progress involves a strong intersubjectivity orientation as students showed considerable concern for others' contributions: as a reaction towards their own work and as a process that can impact on group work. Students made comments such as *"let's see what they have answered to our contributions"* and then reflected in the pair to see how to follow on. Usually they regulated the group processes to carry on during the in-pair work and with the other pairs in the wiki.

Reflection on group progress is critical in collaborative work as reflections provide students with opportunities and avenues to regulate their learning in groups and possibly to plan the next step (Yang, Wegerif & Jones, 2012). In the following example, pair 1 reflects on group work progress and writes in the wiki: *You almost always value our comment but few times bring new information.* In this example students reflect on the quality of other pairs' contributions to solving the task and stimulate the others pairs' processes in order to be more focused on the content of the task.

The third type of group reflection is **on strategies**, when students focus on discussing strategies to complete the task. Reflection on strategies only occurs in in-pair group reflection and it shows ongoing reflection on solving strategies. The features of group reflection characterised in our study resemble the concept of socio-metacognition: research on metacognition has produced information on how an individual and a group use metacognitive knowledge and metacognitive skills to become aware of their thinking and to exert control over their cognitive actions (Pifarré & Cobos, 2009).

6.2.4. Group Assessment

This L2L2 feature occurred more frequently in between-pairs wiki interaction than in in-pairs F2F interaction, taking up 38% and 9% respectively. A possible reason for this is that the nature and objective of the task within each mode may have had an impact.

In both collaborative modes of our study, students paid more attention to assessment and evaluation of others' work. It is important for pairs to provide each other with feedback and to argue for their positions in order to make progress with the task. Further analysis shows subtle differences in the evaluation of others' work between the two collaborative modes. When students engage in in-pair evaluation of the other's work, they purely focus on the content, providing supportive comments or alternative views with reasons. However, when students provide between-pair assessment, they provide two types of evaluation, namely feedback on project content and feedback on linguistic features. As shown in Table 1, Example 1, Pair 3 (Students 5 & 6) evaluate the contribution from the other pair (Students 3 & 4) in a positive way in saying they agree, by emphasizing the fact that *'human colony it is not possible'*. In Example 2, Pair 1 provides a suggestion to Students 3 & 4 that they should check the spellings in their contribution to enhance the quality of their work. Similar feedback can be observed in Example 3, but in this contribution the pair took the initiative to make corrections.

Wiki gives learners the opportunity to think about and discuss what might be appropriate responses and approaches to tasks. Students can consider all the group contributions to solve the task and can look back on and assess a group's progress in a project. In our study, this wiki affordance opened powerful opportunities for students to learn about their current limitations in solving the problem collaboratively. Previous studies have made claims for long-term training in the skills of group-assessment (Dochy, Segers, & Sluijsmans, 1999) and other have shown unsatisfactory results concerning peer assessment as a collaborative activity (Kollar, 2009), as the assessment often focuses on the assessors and is not addressed at the assessed. Our study has shown that wiki affordances help students to focus group assessment on the common product and our students developed collaborative assessment skills in a relatively short period of time.

6.3. Discussing the inter-relationships among the L2L2 skills displayed in the two collaborative modes in the wiki project and their role in facilitating group learning

processes (RQ3)

In the previous sections we have argued that L2L2 skills enable learners to co-construct ideas in a critical and collaborative manner and we have illustrated how these skills facilitated both the completion of the set task and communication both in-pair and between pairs.

The data suggests that these four skills are interrelated and they were used differently by participants to carry out the tasks. In this section, we are interested in analysing in-depth the inter-relations between the four L2L2 skills and how participants in a collaborative project unfolded these skills to co-construct ideas or complete a task. We will illustrate this point using an example. Figure 8 is a flowchart of the first turn in the wiki of Pair 2 when logging into the wiki project to try to build ideas on Pair 1's contribution. The text from Pair 1 is as follows:

We believe that in the text of Pair 2, it would be necessary to improve the spelling a lot, but we also think that humans will not be able to go to Mars. About the text of Pair 3, it is true that the trip would be too long. A possible title for the final text could be: "A human colony in Mars, possible or impossible?"

The left-hand column of Figure 8 shows the various actions from Pair 2 and the different L2L2 skills used; the squares display the actions involving discussions within the pair, and ovals display the writing action taken by the pair. The right-hand column of Figure 8 shows, for each action, an extract of the in-pair F2F interaction or an extract of the pair-written contribution in the wiki.

Firstly, Figure 8 displays how the pair worked during one turn in the wiki; we can distinguish eleven different actions taken by the pair, three of them involved writing in the wiki and the other eight involved discussion. Secondly, it can be seen how the L2L2 unfolded during the turn in the wiki, both in in-pair discussion and in written wiki contributions. As is shown in Figure 8, at the beginning the pair displayed a group assessment skill, then two leadership moves and one mutual engagement skill, which lead the pair on to writing a contribution in the wiki in which students developed an idea: *we have a possible proposal that is that we cannot go to Mars because...*

Thirdly, the example presented in Figure 8 displays some of the inter-relations between the L2L2 skills. For example, it can be appreciated that leadership moves in

which both members of the pair attain mutual goals, establish ground rules and summarise group thinking, may encourage the two members of the pair to be mutually engaged in the task resolution when both members share, discuss and build on each other's ideas and create a dialogic space to co-construct common understanding. Subsequently, high mutual engagement in F2F interaction in which participants acknowledge each other's contributions and share/discuss their ideas will allow for successful distributed leadership, as the students will co-construct their plans. For example, in extract 3 (Figure 8) the summary of the group ideas by Student 3 enhanced a mutually engaged discussion in the pair about how to write in the wiki their idea that it is not possible to go to Mars.

Furthermore, the display of skills that moved the two members of the pair to mutual engagement and distributed leadership may prompt group assessment and group reflection between pairs in wiki-written interaction. In the wiki project, students reached the objective to be committed to creating a truly shared digital text by considering, reflecting on and evaluating others' contributions; these are co-reflective processes about others' ideas, thoughts, arguments and information. These co-reflection processes can, in turn, lead to reconstruction and reorganization of meaning (Clark, 2009). This argument is exemplified in extract 6 (Figure 8), in which students engaged in a discussion on how the title proposed by Pair 2 did not represent the group idea that "*it is not possible to go to Mars*". The fact that students in F2F interaction mutually discussed and elaborated arguments to support their idea promoted the display of group assessment skills in the wiki contribution.

In conclusion, the examples presented in this section add more experimental evidence to the claim that the pedagogical design of combining the two collaborative modes in the wiki project, namely, in-pair F2F interaction and between-pairs wiki-written interaction, created a powerful collaborative environment for the development of more features of L2L2 skills. Students developed different patterns of L2L2 skills when working in two different collaborative modes in a wiki project. Equally, these L2L2 skills enabled the participants to jointly complete a challenging task.

7. Conclusions

This study set out to clarify and define L2L2 skills which are essential in developing 21st century learners. In the context of a small-scale study, we have provided data-based definitions of the L2L2 skills with evidence, by analysing collaborative in-pair and between-pair talk. The primary result of this study is that we have defined the four L2L2 skills, namely distributed leadership, mutual engagement, group reflection and group assessment, and identified their key features by using experimental data from a science wiki project. As outlined in the previous sections, the features of these four skills were not articulated clearly in previous research and we found that it was difficult for researchers and teachers to fully understand and use these skills when analysing the students' work.

A second significant result of our study is that the four L2L2 skills unfold both when the participants complete the task collaboratively and also in the two modes of collaboration, and that there is a strong inter-relationship between these skills. For example, high distributed leadership whose ground rules are jointly established might encourage the students to be mutually engaged in task resolution.

A third finding of our study is that the combination of two modes of collaboration – i.e. F2F interaction mediated by wiki technology and written interaction through wiki technology- has provided a powerful collaborative learning environment that facilitates the emergence of different and more features of L2L2 skills.

Furthermore, this study contributes with empirical evidence to expanding our knowledge about the role of technology in supporting productive dialogue (Major, Warwick, Rasmussen, Ludvigsen & Cook; 2018), which will enable to foster the development of key L2L2 skills. Our work shows that wiki technology facilitates the emergence of L2L2 skills because the wiki environment (i.e. a typical CSCL platform) offers a space for students to engage in and work collaboratively to solve a problem. Besides, the presence of wiki technological facilities (i.e. equal and democratic participation, multiuser editions, content tracking) has shaped the way how children think (Wegerif, 2015) and develop specific skills to learn together.

In addition, our research provides evidence of the paramount role of pedagogy in promoting the emergence of L2L2 skills. Two pedagogical instruments are worth mentioning: a) the two collaborative modes designed in our study (i.e. in-pair F2F and between pairs) seem to be crucial in the creation of peer interaction opportunities to

develop more L2L2 features; and b) the pedagogical decision of using monitored student participation in the wiki activity (i.e. pairs took turns to work in the wiki) promoted paced and timed contributions, which is important especially when working with young learners or less experienced wiki users. This pedagogical decision prompted what Wegerif (2015:64) calls *Internet Dialogue*, characterised by the reversal and intertwining of an inside (in our study, in-pair's talk) and outside (between-pairs wiki-written) dialogue, which encouraged a process whereby every time students worked in the wiki, they found others' new ideas (i.e. outside dialogue) to consider, build on or reflect on (i.e. inside dialogue).

Limitations and future research

There is a need to design a large-scale empirical study to implement the dialogic technology-enhanced pedagogy and find out whether a similar project can work with other teachers and educational contexts. Moreover, and due to space and time limitations, this paper only used interactional data in articulating the characteristics of the L2L2 skills and the role of technology in facilitating these skills. Further insights into the moves between L2L2 skills and the value of technology in facilitating these skills might be revealed if participants were interviewed.

Based on the above considerations and findings, future studies might focus on large-scale research, and use multiple (and mixed) methods in data collection and analysis in order to add more empirical evidence in defining and characterising L2L2 skills.

Our study claims that the proposed pedagogical use of the wiki merges two different modes of interaction that provide richer learning opportunities for the development of L2L2 skills. However, there is a need for further research that focuses on studying the role and importance of each collaborative mode in the development of specific features of L2L2 skills.

Furthermore, this study used text-based wiki technology, with information presented linearly rather than spatially. With the design of new technology, future research may involve more visual-based tools in collaborative group work, such as Cacao, which might help researchers see how L2L2 skills are conceptualised and developed in different dimensions in these multimodal technologies.

As a final word, we would like to emphasise the importance of promoting L2L2 skills in order to facilitate educational transitions from knowledge acquisition to knowledge creation in the globalised world, especially with the affordances of technology. Only by equipping learners with these skills will they become more open-minded, flexible, creative and ready to establish leadership and collaboration in learning. Our study has contributed to show that the dialogic use of the technology can support the emergence of these skills.

ACKNOWLEDGEMENT

This research was funded by the Ministerio de Economía y Competitividad of the Spanish Government (projects number: EDU2012-32415 and EDU2016-80258-R).

ACCEPTED MANUSCRIPT

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Figure caption

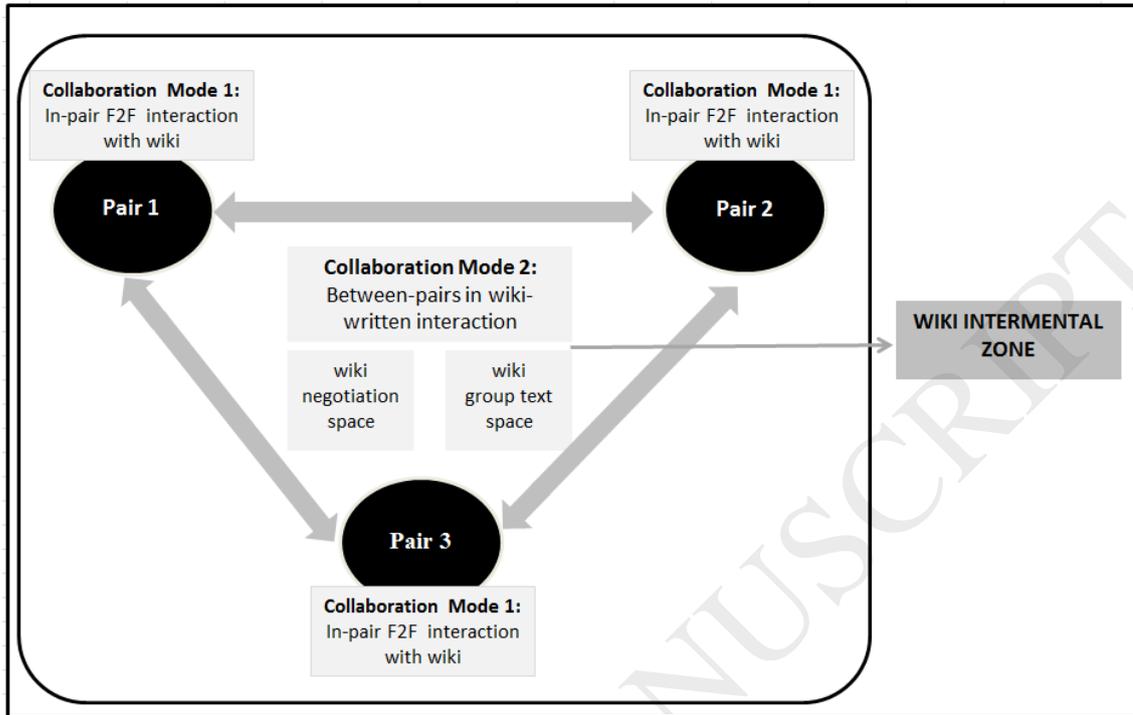


Figure 1. Collaboration modes during the third phase of the wiki project

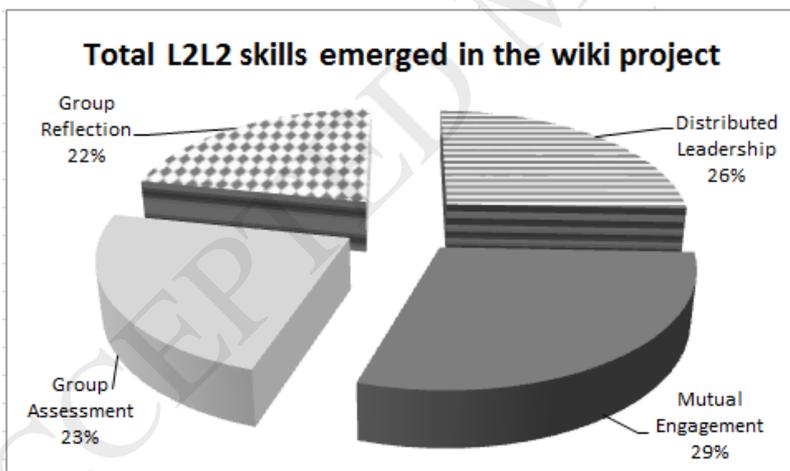


Figure 2: All L2L2 skills emerging in the wiki Project

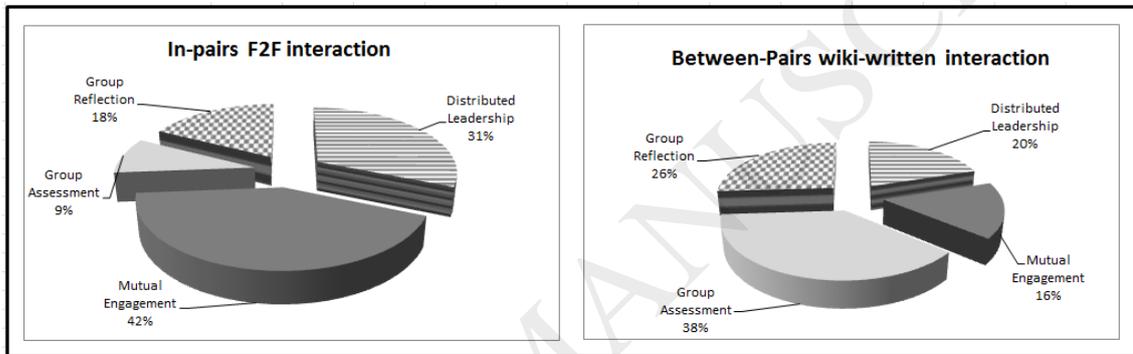
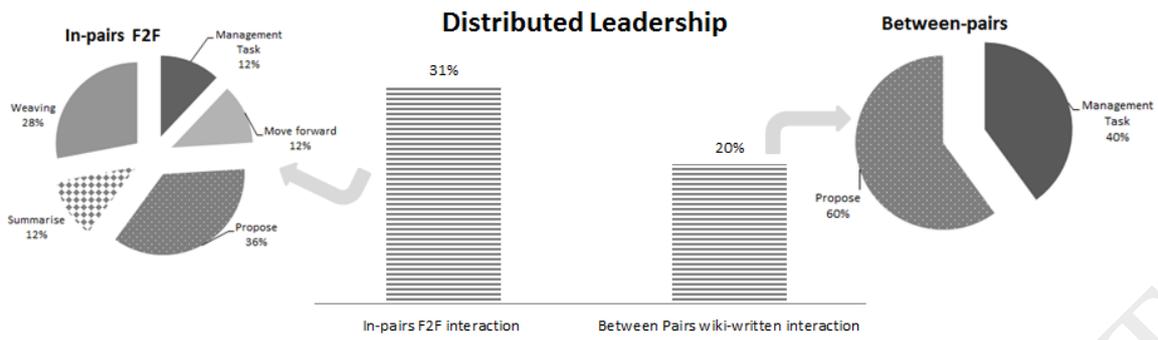


Figure 3. L2L2 skills displayed in the two collaborative modes of the wiki project: in-pairs F2F interaction and between-pairs wiki-written interaction

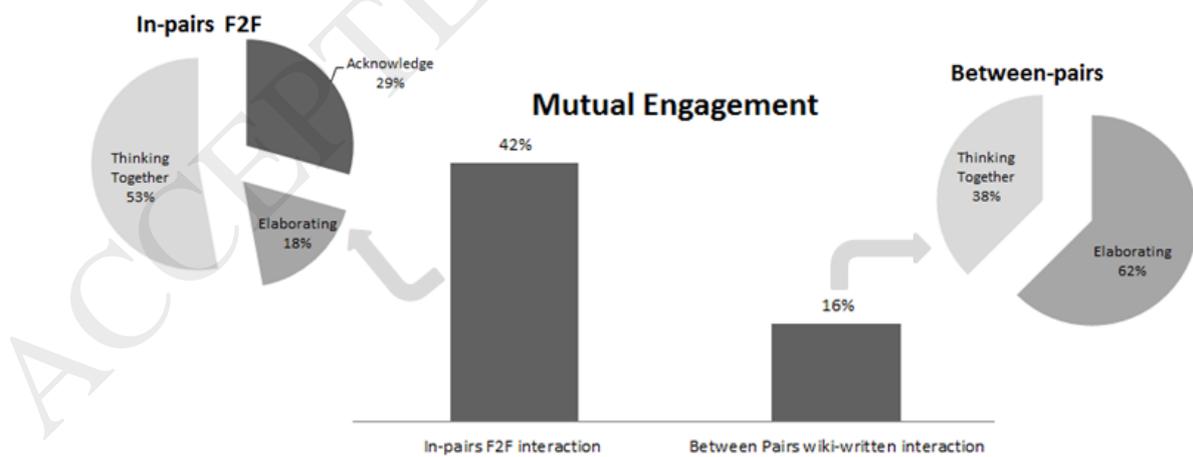


Figure 5: Mutual engagement features

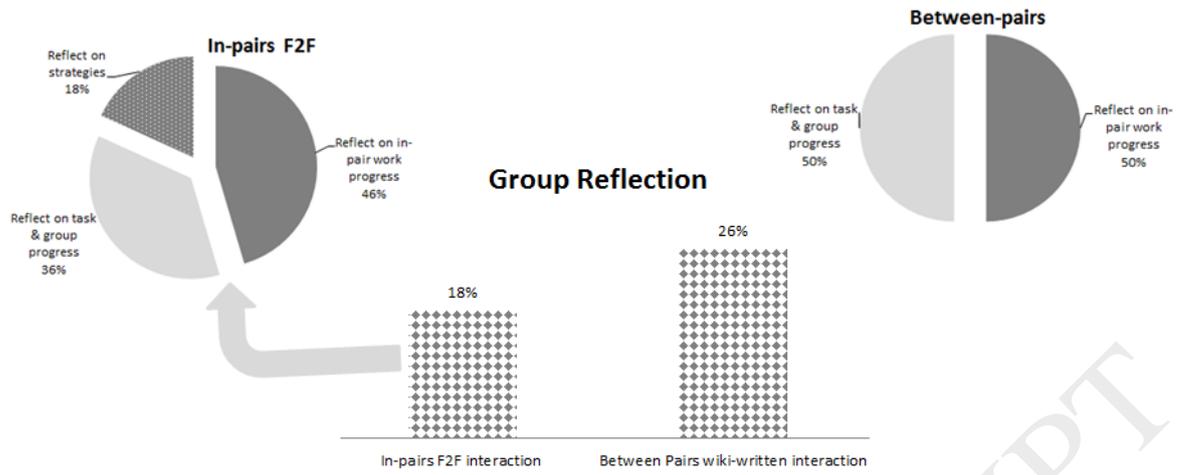


Figure 6: Group reflection features

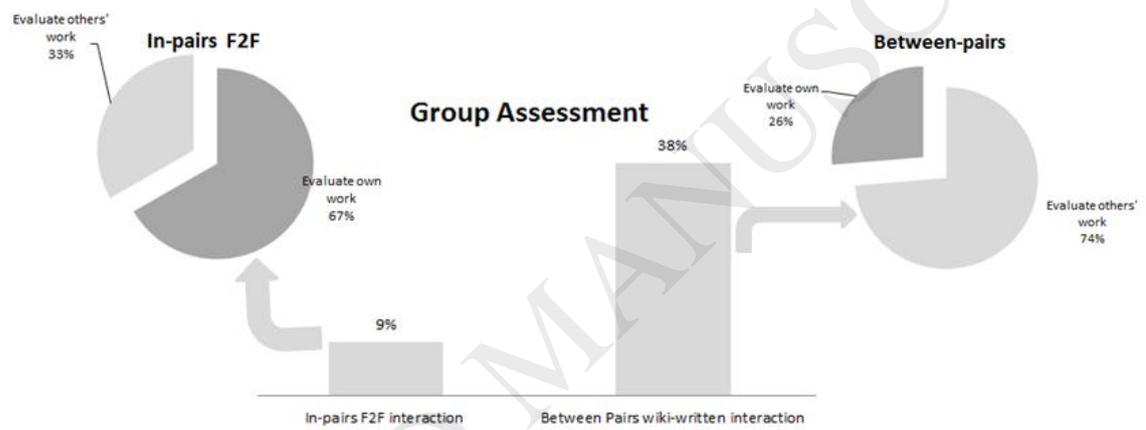


Figure 7: Group assessment features

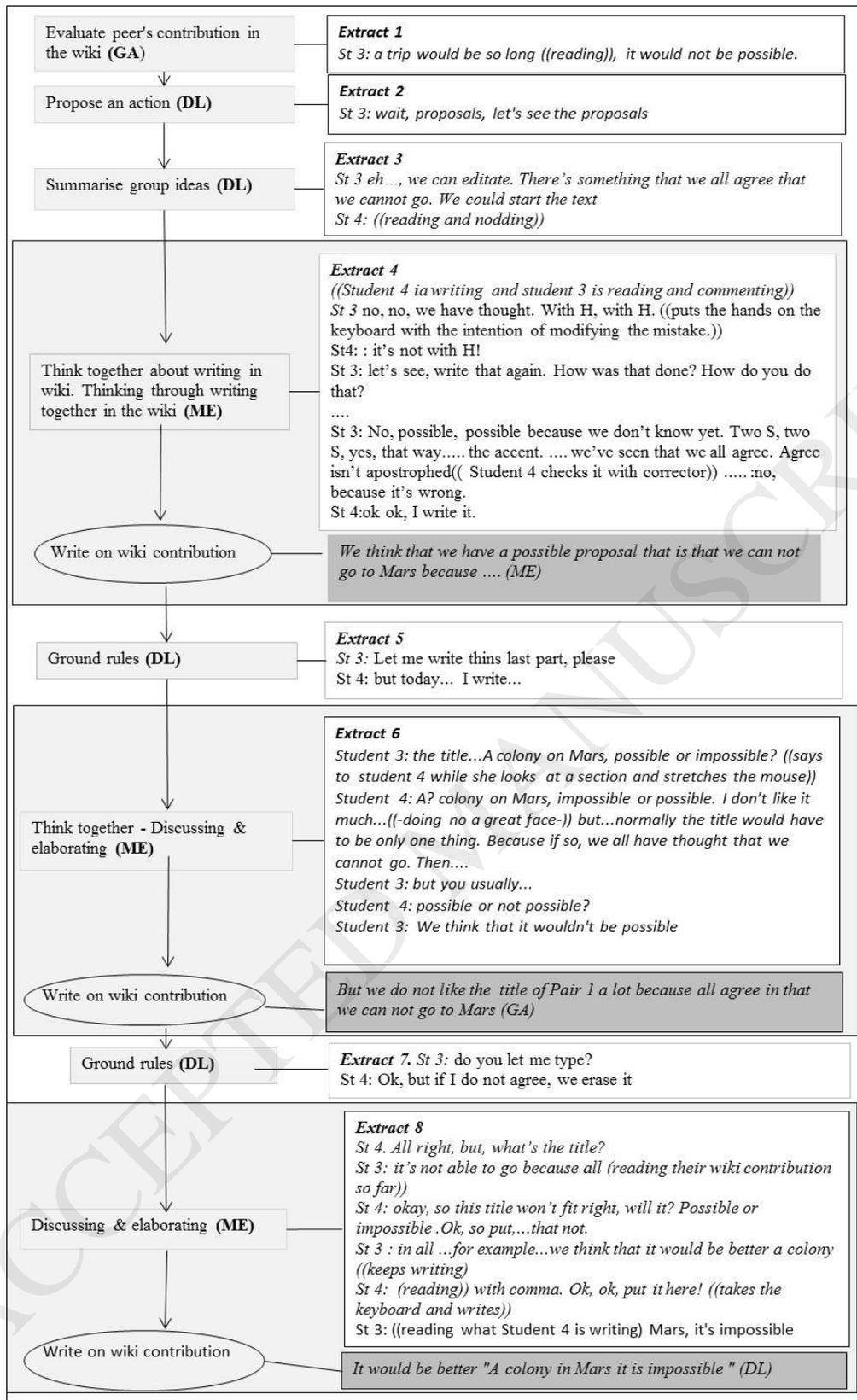


Figure 8. Workflow of the first turn in the wiki of Pair 2. Legend: DL – Distributed Leadership; ME – Mutual Engagement; GA – Group Assessment

Table 1. Examples of group assessment

Example 1. Pair 3 contribution	We also agree on the title that Student 3 & 4 have proposed because all agree that human colony it is not possible
Example 2 Pair 1 contribution	We believe that in the text of Student 3 & 4, it would be necessary to improve the spelling a lot
Example 3 Pair 1 contribution	We have corrected almost all the mistakes in the negotiation page

ACCEPTED MANUSCRIPT