Individual versus collaborative learning in digital environments: the effects on the comprehension of scientific texts in first year university students.

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Abstract

This contribution proposes an empirical study in which collaborative learning is compared to individual learning on a digital environment such as the web platform Moodle. The context in which this work takes place is the Faculty of Psychology of the University of Bologna. In particular, the research sample is characterized by 263 first year students that participate to the course of "Introduction to Scientific Literature and Language". Students spontaneously have chosen to participate to the course with group A (lectures on Monday) or group B (lectures on Tuesday). The course is structured in blended-learning format, i.e. three in presence lessons and three online activities to be accomplished between two consecutive lectures. For completing the online activities, students were randomly associated to two different online conditions, i.e. collaborative learning and individual learning, independently from group A or B they belong to.

During the 1st and the 3rd lecture students filled in a test of comprehension of the same scientific text while between two lessons they accomplished tasks connected to scientific production (writing an abstract for a scientific paper, blind reviews of two other abstracts, and completing the abstract after receiving the reviewers' comments). By means of Social Network Analysis, at the present moment we have complete the elaboration of the SNA indices for constructing the interpersonal skills profiles both for individual students and for groups. The next step is to complete the evaluation of the two tests of comprehension of the same scientific text for having a comparison between a test and a re-test. After this phase, we will proceed by testing the following hypothesis:

- In general, an increasing on the quality of the comprehension from the 1st to the 2nd presentation of the text A due to the online activities proposed between the two presentations.
- A more evident improvement on those students that have been associated to the Collaborative Learning (CL) condition with respect to those of the Individual Learning (IL) condition;
- Further, a more evident improvement on groups Low Centrality-High Density (LC-HD) than groups High Centrality-Low Density (HC-LD).

Ongoing results show that the first and the third hypothesis are confirmed, while the second hypothesis is not confirmed. One possible explanation about the second hypothesis could reside on the typology of groups, that are constructed by the researchers and not spontaneously created by students on the basis of their pre-existent acquaintances, but further studies are necessary for having a more clear comprehension of this result.

Keywords

Collaborative Learning, digital environments, CSCL, Social Network Analysis, Interpersonal Skills Profile.

Cooperative learning in physical and digital environments

This contribution proposes an empirical study based on two principal conceptual frameworks linked each other. The first is the *cooperative learning* while the second is *computer supported collaborative learning* (CSCL). Collaborative learning defines the relationship that characterizes a group of students and it requires positive interdependence, individual accountability, interpersonal skills, face-to-face promotive interaction, and

ISBN 978-1-86220-225-2

processing (Johnson, Johnson & Holubec, 1994; Johnson & Johnson, 2009[1]). In this definition, we want to emphasize the relational aspect represented by interpersonal skills. In effect, according to Johnson & Johnson (20091), interpersonal skills represent processes connected to communication, trust, leadership, decision making, and conflict resolution, and all these processes are based on relations and interactions. So, an important question that arises from these premises is: how measuring "interpersonal skills"? Is there some indicator, or ensemble of indicators, that we can take as a measure of the interpersonal skills? The studies in the field of the cooperative learning have revealed that having common aims produces interactions that increase the motivation to learn and, in general, improve scholastic outcomes (Johnson, Johnson & Holubec, 1994). These results further highlight the importance of interactions and relations and give even more relevance to the questions we previously proposed.

Even though the definition of cooperative learning explicitly outlines the importance of face-to-face promotive interactions (and physical environments), today we are increasingly involved in cooperation and collaboration dynamics also in distant interactions (and digital environments). In the nineties O'Malley and Scanlon (1990) proposed the term computer supported collaborative learning (CSCL) for specifying those processes of knowledge construction and knowledge sharing mediated by computers, in contrast with the classic face-to-face modality of interaction. By providing environments that support collaboration between students, CSCL pursue three principal effects i.e. enhancing learning processes (Kreijns, Kirschner, & Jochems, 2003), facilitating collective learning (Pea, 1994), and facilitating group cognition (Stahl, 2006).

In their important review on CSCL studies, Resta & Laferrière (2007, p. 69-70) state that the reasons for using technologies for supporting collaborative learning are substantially four:

1 *To prepare students for knowledge society (collaboration skills and knowledge creation)*
2 *To enhance student cognitive performance or foster deep understanding*
3 *To add flexibility of time and space for cooperative/collaborative learning*
4 *To foster student engagement and keep track of student cooperative/collaborative work*

One of the most important problems of the "traditional" collaborative learning is the difficulty to delineate the type of collaboration, but also its quantity and quality. These elements are very crucial if we start from the hypothesis that the individual development in collaborative learning contexts is the results of social relations. According to the theory of the socio-cognitive conflict (Carugati & Gilly, 1993), these latter take origins from the presence of different points of view and, thus, from the need to negotiate a shared meaning. So, the belonging to a group is not a sufficient qualification for developing a socio-cognitive conflict; it is necessary that the collaborative process involves a confrontation of different perspectives and the final negotiation of a shared point of view.

Compared to the physical environments, the digital environments offer some important technical features that could help us to answer to the fourth point underlined by Resta & Laferrière and, further, to try to construct some interesting indicators for representing the idea of interpersonal skills outlined by Johnson & Johnson. In effect, digital learning environments allow to automatically track and elaborate data and punctually record all the exchanges within a group/community. Thereby these environments provide the researcher a large amount of detailed data that make particularly suitable this field of study for applying Social Network Analysis (Garton, Haythornthwaite and Wellman, 1997; Reffay e Chanier, 2002; Matteucci et al., 2008; Mazzoni & Gaffuri; 2009).

The SNA is a technique of inquiry that focuses on the relational structures and on flows of exchange within a group (Wasserman & Faust, 1994), by using two types of representations:

- sociograms (graphs) that graphically represent nodes and their relations (exchanges);
- relational indices that quantitatively represent the dimensions analyzed by SNA (e.g. nodal degree, density, centrality, cohesion, etc.).

The principal advantage of this technique of inquiry is to consider subjects as interdependent units than autonomous and independents, so it is very helpful for studying group dynamics.

Starting from the previous premises, this contribution proposes a confrontation between individual and collaborative learning within a CSCL environment like Moodle. The aims are twice:

- proposing a method for profiling the students interpersonal skills by using SNA;
- verifying the students' comprehension of scientific texts by using their interpersonal skills profiles as factor.

[1] http://www.co-operation.org/

ISBN 978-1-86220-225-2

Methodology: the university course structure and the data collection

The research involved the first year students of the Faculty of Psychology of the Alma Mater Studiorum (University of Bologna), in particular the university course of "Introduction to Scientific Literature and Language". The aim of the course is to introduce students to specific knowledge and competences related to the scientific language, e.g. the structure of a scientific contribution for a congress or the writing of an abstract of a scientific paper. The course has been structured by using a blended learning approach characterized by three lessons in presence and three activities to complete by using the web platform Moodle. We decided for the use of the web platform Moodle since it is an open source environments that has multiple possibility to be customized both in its features and in its tools. In particular it permits to organize the activity individually or in groups and this is a very important aspect for our study since we are interested in the different performance of students which have performed online activity in individual or group manner. Further, for the students associated to the collaborative learning conditions, i.e. working in group, as others web platforms Moodle enables the two main online activities proposed to students in this study: discussing on a web forum and constructing collaboratively a paper by using the Wiki. By using the web forum, students have the possibility to discuss and taking collective solutions for the activity proposed while the wiki permits them di construct collaboratively a paper by writing on a common whiteboard in which each member of a specific group may insert his/her thoughts but also modify the writings of the other members. The system has an historic trace of all the additions and modifications made, so it is possible to return to the previous version anytime.
Before the beginning of the course, students chose their preference for participating to the group A (150 students with three lectures on Monday) or B (150 students with three lectures on Tuesday). After the first lesson, students were asked to perform their registration to the web platform Moodle, and then we have constructed two different online course (conditions) to which students have been randomly associated independently from group A or B they belong to:

- in the first condition, students had to complete online activities individually (IL – Individual Learning);
- in the second condition, students had to complete online activities by collaborating with their pairs within small groups of four students (CL – Collaborative Learning).

In the following table (tab. 1), there's the chronological schema of the activities proposed to students:

Table 1: The activities proposed to students for the course

Group A	Group B
1st lesson (23.03.2009 - 16:00-18:00): • Test of comprehensions of a scientific text (text A)	1st lesson (24.03.2009 - 16:00-18:00): • Test of comprehensions of a scientific text (text A)
1st online activity (from 24/03 to 17/04): • Writing an abstract for a scientific paper	1st online activity (from 24/03 to 17/04): • Writing an abstract for a scientific paper
2nd lesson (20.04.2009 - 16:00-18:00): • Test of comprehensions of a scientific texts (text B)	2nd lesson (21.04.2009 - 16:00-18:00): • Test of comprehensions of a scientific texts (text B)
2nd and 3rd online activity (from 24/04 to 15/05): • Blind review of two abstracts wrote by two other students/groups (from 24/04 to 03/05) • Completing the abstract after receiving the reviewers' comments (from 06/05 to 15/05)	2nd and 3rd online activity (from 24/04 to 15/05): • Blind review of two abstracts wrote by two other students/groups (from 24/04 to 03/05) • Completing the abstract after receiving the reviewers' comments (from 06/05 to 15/05)
3rd lesson (18.05.2009 - 16:00-18:00): • Test of comprehensions of a scientific text (text A – the same text of the 1st lesson) • Review of a scientific abstract	3rd lesson (19.05.2009 - 16:00-18:00): • Test of comprehensions of a scientific text (text A – the same text of the 1st lesson) • Review of a scientific abstract

During lectures, students have completed (individually) a test of comprehension of a scientific text derived from the article of Boscolo & Quarisa (2005). Students were asked to read the text and to answer to 6 comprehension questions. Within two lessons, students were also asked to complete three online activities by the web platform Moodle concerning:

ISBN 978-1-86220-225-2

1 reading a scientific paper and writing the correspondent abstract;
2 the blind review of two abstracts wrote by two other students (for those students of the IL condition) or groups (for those students of the CL condition). In IL condition students were asked to complete an individual blind review while in CL condition students were asked to complete a group blind review;
3 the final proof of the abstract after receiving the reviewers' comments (individually for IL condition and in group for CL condition).

For each activity, students in IL condition were asked to carry out the task individually by using a Wiki while students in CL condition were asked to collaborate by means of a web forum (for discussing and taking decisions) and then to insert their abstract and their reviews within a shared Wiki in which each student had also the possibility to modify the text of the others.

Hypothesis of the research

According to Boscolo & Quarisa (2005), the production of a scientific text (in our case, the 1st online activity) should enhance the comprehension of a scientific text (in our case, the 1st and 3rd lesson).

- So, we made the hypothesis that the 1st and 3rd writing online activities should enhance the comprehension of the scientific text A from the 1st to the 3rd lesson.
- But this improvement should be even more evident for those students associated to the CL condition than those of the IL condition.
- Further, the improvement should be more and more evident for those students that manifest a "good" interpersonal skills profile.

The sample and the interpersonal skills profile by means of the SNA

Participants to the course that performed their registration into the web platform Moodle were 263. 143 students were randomly associated to the IL condition and the other 120 were randomly associated to the CL condition. By following the suggestion of Barkley, Cross, & Major (2005) and Schellens & Valcke (2006), according to which in collaborative learning environment groups need to be small for facilitating the fully participation of students and for developing a group cohesion, students associated to the CL condition were divided into 30 small groups of four students. Even though students frequent the same lectures, since they were freshmen we can assume that they were unlikely to have already constructed a strong friendship one another. On the contrary, most likely they became acquaintance of the other students of their group by means of the collaborative activities proposed within the web platform.
For each groups, we have analyzed the interactions produced within the Moodle's web forum by means of the qualitative coding procedure proposed by Manca, Delfino, Mazzoni (2009) that allows constructing the adjacency matrix with the relational data without noise messages. Data were then analyzed by means of the software for social network analysis Cyram NetMiner version 3[2].

SNA indices for the interpersonal skills profile

SNA is a technique of analysis increasingly used in many fields of study, in physical and digital environments, in which the focus is not only on the individual characteristics, but also on the relation between a network of entities (such as a group or a community, but also a network of communities, organizations, nations, towns, computers, etc.; Mazzoni, 2006). As previously suggested, in this contribution the SNA has been used for constructing a profile of the groups of students (and consequently also of the students) that collaborate within the web platform Moodle. Since the idea is that profiles are representative of the idea of interpersonal skills

(Johnson, Johnson & Holubec, 1994) and since these latter come from interactions (for this reason we are finally inclined to choose the SNA as technique of analysis), we selected three dimensions of the group structure that, in our opinion, fit well with the idea of interpersonal skills: neighbourhood, cohesion and centrality/centralization. For each dimension chosen, the SNA permits to obtain two types of indices: collective indices (such as density, number of cliques and centralization) and individual indices (such as nodal degrees, cliques participation, and centrality). Obviously, these two aspects are related each other and derive from the

[2] Cyram (2009). Netminer 3 3.4.0.d.090924 Seoul: Cyram Co., Ltd.

ISBN 978-1-86220-225-2

interdependent dynamics that characterize a group, a community or a network (in term of contacts, relations, exchanges).
The density of a network (in our case, of a group) is "*'the proportion of possible lines that are actually present in the graph' (Wasserman & Faust, 1994, p. 101) or more simply the percentage of aggregation of its members, derives from the degree of each member, i.e., the totality of direct contacts he/she has activated or received by others"* (Matteucci et al., in press). The density dimension is calculated within the neighbourhood analysis that allows to have many indices from which we selected the following:

- Neighbour in-degree, i.e. the number of group members from which an individual received direct contacts.
- Neighbour out-degree, i.e. the number of group members to which an individual sent direct contacts.

For these two dimensions, we considered both relations (i.e., by dichotomizing data, we considered simply how many group members are directly linked to an individual) and messages (i.e. we considered the values of each relation for having the dimension of direct messages managed by each individual).

Egonet density, i.e. the density of the specific network created around a specific individual.
Taken together, the three indices coming from neighbourhood analysis give us a dimension of the personal networks of each group member by considering both links direction and contacts quantity.
Regarding the cohesion dimension, it allows verifying the presence and organization of sub-structures that characterize a group/community, and also the involvement of the single participants to these sub-structures (Mazzoni & Gaffuri, 2009). For the cohesion we have chosen to look at the cliques index i.e. the number of cliques that characterize a group.

- Cliques are defined as sub-groups of no less than 3 units completely connected one another. According to Mazzoni & Gaffuri (2009, p. 123), *within a network of students in an e-learning context, e.g., a web group that interacts during an initial brainstorming phase or that collaborates for writing a project or a report, the presence of these sub-structures is particularly positive*. We assumed, by following the suggestion of Aviv et al. (2003), that cliques represent areas of active and rich exchange and confrontation of ideas and knowledge, which are essential prerequisites for high phases of critical thinking.

Obviously, since we have constructed small groups, sometimes groups are characterized by only 1 clique that includes all members while in other cases groups are characterized by two cliques.
Actor centrality and group Centralization are two related dimensions that represent, the first, *the importance/prominence of a given node for the communicative structure* and, the second, *the dependence of a network on its "most important" actors* (Mazzoni & Gaffuri, 2009, p. 122). SNA proposes many types of centrality and centralization such as degree centrality, closeness centrality, betweenness centrality, information centrality, etc., each one describing a different way to intend prominence/relevance of an individual within a group (such as leadership, power, influence, status, etc.). We have focused our attention on two specific indices: information centrality and flow betweenness centrality

- Information centrality *focuses on the information contained in all paths originating with a specific actor. The information of an actor averages the information in these paths, which, in turn, is inversely related to the variance in the transmission of a signal from one actor to another* (Wasserman & Faust, 1994, p. 194). In our case this index is very interesting since according to Mazzoni & Gaffuri (2009) it represents a sort of measure of the actors' potential in content transmission.
- Flow betweenness centrality proposes a measure of actors' prominence based on the information flow managed by each one and, conversely, the flow betweenness centralization determines the dependence of the group on actors that manage the higher flow of information.

After having elaborated data and derived all the previous indices, we recoded indices on 4 levels by considering

- 0 as no measure on the index;
- from 1 to 33° percentile as low index level;
- from 34° to 66° percentile as medium index level;
- from 66° to 100° percentile as high index level.

After this passage, we have performed a multiple correspondence analysis for identifying the subjacent dimensions the data structure that sum up the interdependence of the original variables (SNA indices) we considered (tab. 2). For this analysis we have chosen only those SNA indices that indicate a sort of interpersonal skills based on the direction and on the quantity of exchanges (tab 3).

ISBN 978-1-86220-225-2

Table 3: The SNA indices considered for the multiple correspondence analysis and their discrimination measures

Discrimination measures	Dimensions		Mean
	1	2	
Neighbour in-Degree (messages)	,919	,735	,827
Neighbour out-degree (messages)	,899	,702	,800
Information centrality	,682	,226	,454
Flow betweenness centrality	,625	,385	,505
Egonet Density	,642	,306	,474
Total	3,768	2,353	3,060

As show by the discrimination measures (tab. 3), the first dimension correlates with all the variables we examined, while the second is strongly correlated only with neighbourhood indices but less than the first. So, we assume that the first dimension we derived fits better than the second for categorizing individuals by means of the interdependence of the SNA indices and, finally, for constructing individual interpersonal skills profiles based on quantitative relational data. As in the previous cases, also the interpersonal skills profile are constructed by using percentiles and recoding data coming from dimension 1 of the multiple correspondence analysis as follows (tab. 4):

- 0 = no participation
- 1 = low interpersonal skills
- 2 = medium interpersonal skills
- 3 = high interpersonal skills.

Table 4: Students profilation according to the interpersonal skills coming from SNA indices

Interpersonal skills	Quantity of students
No Participation	10
Low interpersonal skills	36
Medium interpersonal skills	37
High interpersonal skills	37

Till now, all variables (indices) proposed are related to actions of single students but, as we described earlier, SNA allows to have also group dimensions that help us in constructing a sort of group interpersonal skills. According to Mazzoni (2007), researches on the productivity of workgroups characterized by different communicative structures show that a strongly centralized structure is more effective when groups are formed

by many participants and are dealing with easy task. However, increasing the task difficulty would benefit decentralized groups since, in these cases, a single leader would risk to be overwhelmed by the quantity of information he/she have to manage and by the responsibility of his/her central position (Gergen & Gergen, 1986). From this premise, we assume that virtual groups having a complex task to accomplish (such as those of this research), high density and low centrality should have a better information managing and, thus, better final results. Starting from this consideration, for each group we calculated the group centralization (by using the variation index of the Flow Betweenness Centrality) and the group density (by considering dichotomized data and thus considering only relations and not quantity of messages). On the bases of the median of the two SNA indices, groups were categorized considering the following poles (tab. 4): High Centralization (HC) vs. Low Centralization (LC) and High Density (HD) vs. Low Density (LD).

ISBN 978-1-86220-225-2

Table 5: Group profiles according to Centrality and Density indices

Group Types	Quantity of groups
LC – LD	5
HC – LD	10
LC – HD	11
HC - HD	4

Ongoing results, discussions and conclusions

In this contribution we present an ongoing empirical research in which, for the moment, we have accomplished some preparatory elaboration. After the elaboration of the SNA indices for constructing the interpersonal skills profiles both for individual students and for groups and after having completed the evaluation of the two tests of comprehensions of scientific texts (with two judges in blind evaluation), we have focused our attention only on scientific text A since with this text we have a the possibility to compare the first and the second presentation and analyse the students' improvement from the 1st to the 2nd test. So, we have tested the following hypothesis, i.e.:

1 In general, an increasing on the quality of the comprehension from the 1st to the 2nd presentation of the text A due to the online activities proposed between the two presentations.
2 A more evident improvement on those students that have been associated to the CL condition with respect to those of the IL condition;
3 Further, a more evident improvement on groups LC-HD than groups HC-LD.

In general the first hypothesis is confirmed and the results of a t-test analysis for paired samples show a significant improvement ($p<.01$) from the 1st to the 2nd presentation of the test A on the comprehension of scientific text.

About the second hypothesis, this is not confirmed since the results from a t-test analysis for independent samples show that there's no significant difference between students associated to CL condition with respect to those associated to IL condition. Further, by analysing the student's improvement from the first to the second presentation of the text A, results show that, even though students improved their performance in both conditions, the improvement of students in condition IL is higher ($p.<.01$) than the improvement of students on condition CL ($p<.05$). One possible explanation about the second hypothesis could reside on the typology of groups that are not spontaneously created by students on the basis of their pre-existent acquaintances but constructed by a random association of students by the researchers. In fact, the initial activity of most groups has been characterized by many problems in finding a common strategy due to the fact that many students didn't connect immediately to the web forum discussions and there was a difficulty in connecting and informing those that had not already accessed the web forum. At the same time, this has created difficulties in the collaboration with members for accomplishing the requested collective activity, but further studies are necessary for having a more clear comprehension of this result.

Lastly, the non parametric analysis for paired sample made on groups confirms the third hypothesis, i.e. groups characterized by Low Centrality and High Density (LC-HD) show a higher improvement than those

characterized by High Centrality and Low Density (HC-LD). This result confirms previous results deriving from other researches in e-learning contexts (Mazzoni, 2007).

Probably, one of the weakest aspects of this work is that web forum messages are analyzed under a quantitative point of view and not under a qualitative one. Really, the codifying procedure used for constructing the relational data of the adjacency matrix is based on a content analysis (Manca, Delfino, Mazzoni, 2009), but it is specifically focused on identifying the receiver-s of a message and it doesn't take into consideration a deeper analysis of the message's meaning. So in future researches it could be very interesting to adopt both the structural analysis performed by SNA and a deeper analysis that considers the content of the messages for analysing also the collaborative construction of meaning.

A second weak aspect of this work is that we didn't consider the previous students' friendship, i.e. the fact that two students that were already "good friends" were associated to the same group in the CL condition. Despite this weakness, considering the quantity of students (263) it is quite unlikely to have two "good friends" on the same group. It is more likely the most of students hadn't a good acquaintance of the other members of his/her group.

ISBN 978-1-86220-225-2

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ISBN 978-1-86220-225-2