AN APPROACH TO EVALUATING CONTRIBUTIONS TO WIKI-BASED COLLABORATIVE WRITING IN AN INFORMAL LEARNING CONTEXT

Draft of:

Trentin G. (2012). An approach to evaluating contributions to wiki-based collaborative writing in an informal learning context. In S. Bocconi & G. Trentin (Eds), Wiki Supporting Formal and Informal Learning, ch. 9 (pp. 175-197). Nova Science Publishers Inc., Hauppauge, NY, ISBN: 978-1-61324-849-2.

ABSTRACT

In the context of so-called Network-Enhanced Informal Learning (NEIL), the ways in which network technologies can support and improve informal learning processes are currently under study. One of the specific topics addressed is how to integrate formal and informal learning processes and render them complementary. A possible approach is the creation of conditions for grafting the typical dynamics of informal learning (e.g. professional problem-solving) onto formal educational situations, particularly favouring those centred on social interaction within the professional communities of practices. Although it is relatively simple to recreate these dynamics, it is not so simple to understand how to measure their effects in terms of: (a) each individual group member's active and tangible contribution to the interactions and collaborative productions; (b) the learning which these dynamics produce in the community members. A connected goal in this context is in fact to understand how formal reward for performance (learning credits, professional and/or economic rewards, etc.) is to be attributed.

In this sense, the chapter aims to illustrate and discuss a methodology which enables evaluation of the collaborative learning process based on professional co-writing in a wiki environment. After considering the effectiveness of co-writing as a peer-learning strategy, the chapter will highlight issues regarding methods for evaluating each group member's contribution to the collaborative process and to the group's overall action. An approach will be discussed to address the problem. It is based upon the elaboration of information traced automatically by wiki, employing survey grids and formulae to calculate participation and contribution indexes. These tools will be illustrated together with their application in an informal learning

situation within a professional community made up of head physicians and health care managers.

The experiment has shown how the combined use of techniques for content and network analysis, applied both to the interactions between community members and to the lattice structure of the wiki, provides a variety of useful information for evaluation purposes.

INTRODUCTION

In his book *Informal Learning* (2005), Jay Cross pointed out a sort of paradox: although "formal" education still absorbs about 80% of total investment in education, most of the knowledge people need for their work is learnt through "informal" channels.

Cross's theory is that this all depends on the persistence of an old-fashioned conception of education. To this we have to add the tendency to keep formal and informal learning processes in temporal sequence, as if there were

- a moment when learning takes place mostly by means of formal recognition, attending a course (formal process);
- a moment, generally after the course, when learning occurs through experience and interaction with others (informal process), without moreover receiving any type of formal acknowledgment in exchange.

For this reason, many years have been dedicated to the study of how to create firm integration and complementarity between these two moments, trying to introduce the typical dynamics of informal learning into formal learning paths (Fukuhara et al., 2010). These dynamics involve individuals tackling their own learning needs autonomously, both by using the info-documental sources available (also) online, and through networked interactions within professional communities whose purpose is to extend the sharing of knowledge and good practices.

One of the possible approaches is to recreate within a formal learning path the same situations which professionals are generally called upon to resolve during their work.

Each new professional problem to be resolved in fact provides the opportunity for new learning. Generally the individual process of problem-solving is divided into a series of quite common steps:

- accessing the Web, a knowledge base, a library, and asking those who have more expertise (in the framework of a specific learning environment, trusting the knowledge of peers encountered through forums, discussion groups etc.);
- seeking out specific learning resources (i.e. e-contents) whose objectives can be related to the problem to be solved, in an attempt to identify methods and procedures that can provide a guide to finding the solution;
- producing original hypotheses (also by collaborating with others within a professional community) in order to experimenting new solutions that could later be translated into new knowledge to be added to the initial knowledge assets (individual and/or of the organisation).

Regarding this latter point, research carried out collaboratively within a professional community is of particular interest; it usually generates informal (peer) learning paths which have natural, effective dynamics (Trentin, 2005):

- if a problem arises, help can be sought from someone who is likely to have already tackled that problem (*socialisation of the problem*);
- if the suggested solution is understood, learning has taken place which will then increase know-how (*socialisation of best practices*);
- even if no immediate solution is found, it is possible to seek allies in the search for one (those who are likely to face a similar problem themselves sooner or later). This collaboration will bring about collective growth in the community which has opted for self-support (*problem-solving aimed at increasing the community's shared knowledge base*).

NETWORK-ENHANCED INFORMAL LEARNING (NEIL)

The role of Network Technology (NT) is strategic in what has been said so far, since it allows the communication taking place within this virtuous circle to be extended, thus increasing the chances of finding a solution (from others or with others) or more than one solution to choose from, also cutting the time required to find it.

This is what can be defined as Network-Enhanced Informal Learning (NEIL), i.e. the result of intersection among NTs, processes of knowledge management/sharing and processes of networked interaction favoured by the professional communities of practices (Figure 1) (Trentin, 2007).

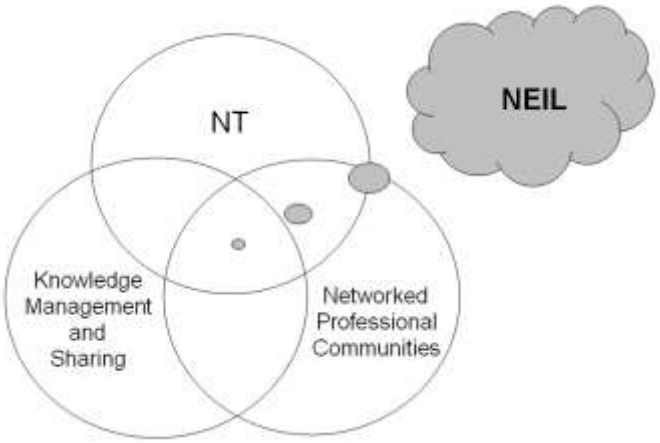


Figure 1 –NEIL as a mixture of technologies and processes able to foster knowledge circulation

In order for NTs to play a really decisive role in linking and integrating the formal and informal learning dimensions, at least two conditions must be guaranteed.

The first requires a re-interpretation of Technology-Enhanced Learning (TEL) in more general terms. It must increasingly be seen as the convergence point of various processes involving: (a) self-study material management; (b) learning process management; (c) professional-knowledge management and sharing (Figure 2) (Trentin, 2007).

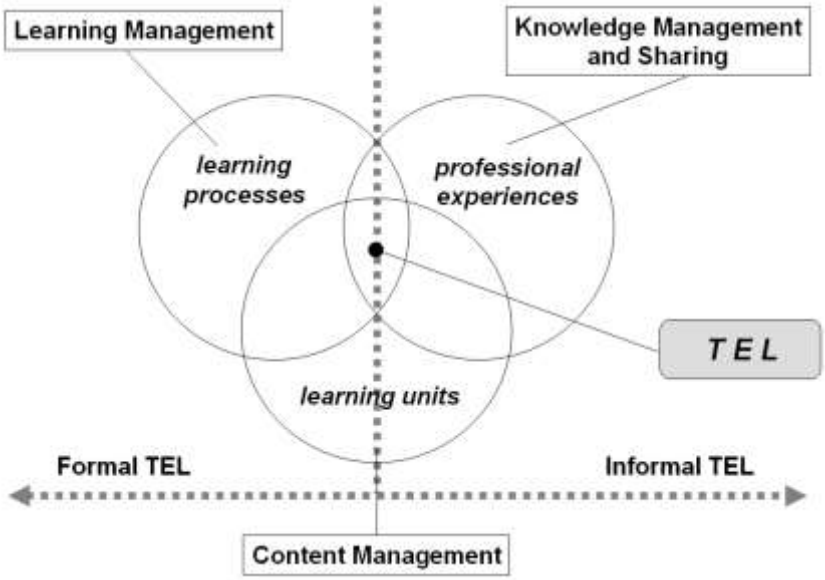


Figure 2 – TEL as an integration of formal and informal processes

For this kind of integration it is necessary to gauge the right mixture of methodological approaches and technological environments so that they can: 1) make it increasingly possible to personalise individual learning activity; 2) foster continuous learning processes self-managed by those directly involved.

The second condition is that formal learning processes become a basis and incubator for informal learning processes (Figure 3):

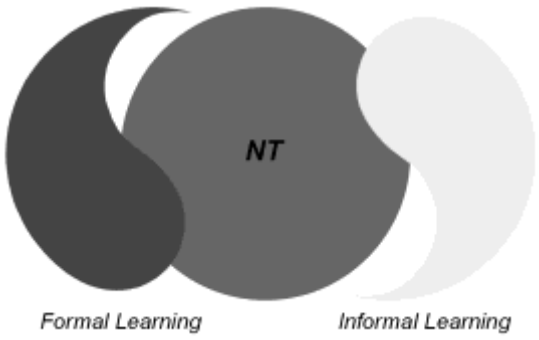


Figure 3a - NTs as facilitator of the process of integration between formal and informal learning

Figure 3b – Formal learning as incubator of informal learning processes

In view of the continuous need for learning throughout one's professional life, the quality of an educational process will in fact increasingly depend on its capacity for enabling users to independently provide for their own continuous education in the specific knowledge domain (Trentin, 2008). This should be done by consolidating the habit of using the multiple resources available from communication technologies (particularly Web 2.0 and mobile technology), ranging from the specific computer applications for

knowledge management and sharing to interaction in online communities of professionals.

In this sense, the sustainability of any technology-supported training event will increasingly depend on its capacity to (Trentin, 2008)

- "formally" educate through paths set up and managed by an institutions;
- "meta-educate", i.e. to exploit the opportunity for using certain methods and technological tools in order to make them a habitual part of a person's professional practice (i.e. using them for daily professional on-the-spot problem-solving).

This evidently requires acquisition of the necessary skills for searching and filtering information sources (Eisenberg and Berkowitz, 1990), for accessing explicit (codified) knowledge and for navigating the sea of social knowledge, i.e. for extracting the knowledge trapped in the myriad of online social networks (see the professional social networks).

AN EXPERIMENT IN THE INTEGRATION OF FORMAL AND INFORMAL LEARNING

In 2008, an experiment in the integration of formal and informal learning was conducted during a highly specialist/professional training session which involved a group of health officers and chief consultants of Local Health Authority (ASL) No. 7, distributed over the territory of the province of Leghorn (region of Tuscany). It involved a total of 33 people divided into three different learning communities of 10-12 units each.

The aim of the training session was to achieve a better understanding of clinical audit[i] practices, using both the study of the authoritative medical documentation and the sharing of the various knowledge and experience which the members of each learning community (with different roles within the Local Health Authority) had acquired on the subject.

Thus it was not a question of organising a series of face-to-face lessons, but rather of accustoming the participants to be independent, both in consulting authoritative sources (explicit knowledge) and in sharing personal experience (i.e. tacit or at least non-explicit knowledge) on the subject and the practices which had so far been adopted, at least by those who had had the opportunity to do so. Since the participants were spread out over the territory, all this was done with the aid of NTs.

The key point was the choice of the educational strategy to be adopted and consequently of the most suitable technology for applying it.

In order to spur the three learning communities to act as online professional communities of practice, a collaborative strategy was adopted, i.e. a strategy aimed at creating the conditions for individual knowledge growth as a result of group interaction (Treleave and Cecez-Kecmanovic, 2001; Garrison, 2003).

The strategy was thus implemented by proposing that each of the three learning communities should collaboratively develop online a sort of handbook on clinical audit which could be easily added to and updated in future. This handbook was to organise all the knowledge acquired both through consultation of the specialist documentation on clinical audit, and through the sharing of experience and practices within each learning community.

Why choose collaborative writing to foster the informal peer-learning process?

Collaborative development of a written text transforms the usually solitary work of writing into a collective process, yielding strong benefits on social and cognitive levels (Clifford, 1992; Sullivan, 1994). Indeed, co-writing processes (Hale & Wyche-Smith, 1988; Guerrero et al., 2003) offer an excellent opportunity not only for practicing reading and writing skills, but also for stimulating reflection, knowledge sharing and critical thinking (Brown and Palincsar, 1989; Scardamalia & Bereiter, 2003). In short, they provide an opportunity to enhance knowledge and skills through a process of strong social connotation (Cooper et al., 1994; Picciano, 2002; Stahl, 2006).

Furthermore, co-writing that is conducted online is almost always done asynchronously, and is mediated and indirect (Weng and Gennari, 2004). Therefore contributors have greater opportunities for reflecting deeply on what they read and write when replying to their remote interlocutors, besides practicing their language skills (Flower, 1996).

This procedure can amplify the contributors' sense that there may be multiple interpretations of the same study topic or discussion point (Cunningham, 1991). It also underlines the fact that interpretations may converge or diverge, highlighting the natural complexity of interrelations within the realms of knowledge.

Apart from the cognitive aspects, it is also worth considering the importance of mastering co-writing techniques, which are increasingly required in the world of work. In many professions, documents, reports, guidelines, project proposals and the like are written collaboratively using network technologies (Lowry et al., 2004).

Moreover, online collaborative writing today, more than in the past, can exploit the many possibilities made available by the *social software* (Boyd, 2003; Malloch, 2005; Notari, 2006; Judd et al., 2010), i.e. the special online applications which enable group distance interaction and collaboration.

The problem of assessing co-writing processes

While the advantages offered by collaborative writing are clear, it does present difficulties from the point of view of assessing the performances of both the single co-writer and of the group as a whole.

This is in fact one of the most debated problems among those dealing with informal learning processes which develop spontaneously inside professional communities (Pasteur, 2011). The crucial point is how to measure the effects produced by these processes in terms both of the active, tangible contribution of each single element of the group to the collaborative interactions and productions, and of the learning which these produce in the community members. It is also important to understand how these results might then be transformed into formal reward (learning credits, rewards, etc) (Gallacher and Feutrie, 2003).

To solve these problems in the experiment, we used a methodological approach which had been developed in an academic context (Trentin, 2009) and was specifically targeted at the organisation of co-writing via wikis. This approach favours the monitoring and assessment of a process of knowledge sharing and mutual/reciprocal learning, and uses a mixed collaborative strategy: shared mind and division of labour (Diaper and Sanger, 1993).

The *shared mind* strategy, in which all the community members work on each single part of the artifact, was applied (a) in the definition stage of the wiki structure (interacting in forum with the aid of graphic representations) and (b) in its final revision, in which each member intervened on other cowriters' pages suggesting modifications, integrations, new hypertextual links, etc.

The *division of labour* strategy was instead applied at the stage of the actual writing of the wikis, where a specific topic for development was assigned to every community member on the basis of his/her previous experience on this topic (technical, administrative or clinical, according to their specific roles in the Local Health Authority). In any case, participants had the chance of inspecting what was being developed in the other sections of the wiki at any moment, in order to create hypertextual links with their own part of the document.

Why choose wikis for the co-writing activity?

In the pre-web 2.0 age, the type of co-writing activity proposed in the trial would have traditionally used interactions through forums or e-mails, circulating the semi-finished products by attaching them to messages or sharing them by means of a common repository.

This process requires a 'central' editor willing to undertake the task of collecting the contributions and shaping the final document according to the group's indications. However, this posed three main disadvantages:

- excessive overhead for one group member, namely the editor;
- the danger that each group member merely concentrates on one branch of knowledge covered in the final collaborative work;
- difficulty in gauging the extent to which each group member had critically examined the overall work, besides performing their individually assigned task.

Wikis were chosen from the various tools offered by Web 2.0 today for collaborative writing for two main reasons: (a) in order to experiment a process of hypertextual co-writing distributed within the professional communities; (b) to study how some specific functions of wiki can be exploited to support the monitoring and assessment of co-writers' activities and their level of contribution to the collaborative work.

The intrinsic features of wiki were thus used to:

- redistribute responsibility for editing the overall document to all group members;
- spur each participant, through specific group-work organization, to collaborate in the various stages in producing the overall work;
- apply an evaluation approach based on analysis of the interactions among participants, on evaluation on each individual's productions and on the reticular structuring of the final work - tasks performed using data from wiki default traces (comments, linkers, tags, versioning) (Trentin, 2009).

Centralised vs distributed editing

Using hypertext approaches for collaborative writing can almost entirely avoid the need to burden a sole editor with the task of managing the different versions of the developing written text. Compared to other 'standalone' hypertext applications like ToolBook, HTML editors, PowerPoint, etc., wikis offer special affordances, above all the possibility of 'distributed writing' (Hart-Davidson et al., 2006). As well as writing and

seeing their own pages in real time, co-writers using a wiki can see the pages that others have published and hypertextually linked, without having to wait for an editor to assemble the various parts developed individually on different personal computers. Furthermore, being able to constantly check the work's state of progress encourages students to find other hypertext links and ideas for developing their own part of the work.

The relationship between co-writing methodology and assessment of the level of contribution

In order to exploit the possibilities offered by the wiki, both for the co-writing and for the assessment of the single co-writers' contributions, it is important to structure the work in such a way that all members are stimulated to take part in each stage of development of the common artefact (Trentin, 2010). Below we give a point-by-point explanation of the methodology suggested to the three different learning communities involved in the trial.

1. *Individual study of recommended materials* – Having been given the theme for the artefact to be developed, group members provided with a list of recommended study materials suggested by an expert in clinical auditing. Some of these may be found in the coommunity's online repository (articles, book chapters, etc.) while others can be retrieved directly from the web using a set of keywords provided by the expert.

2. *Co-planning of the artefact's general structure and division of work* – Having studied the materials, the group is required to draw up collaboratively (in a forum) the hypertext's general structure (sections and first level sub-sections) and to define the layout of the wiki home page. Then the work is divided among the group members (Figure 4).

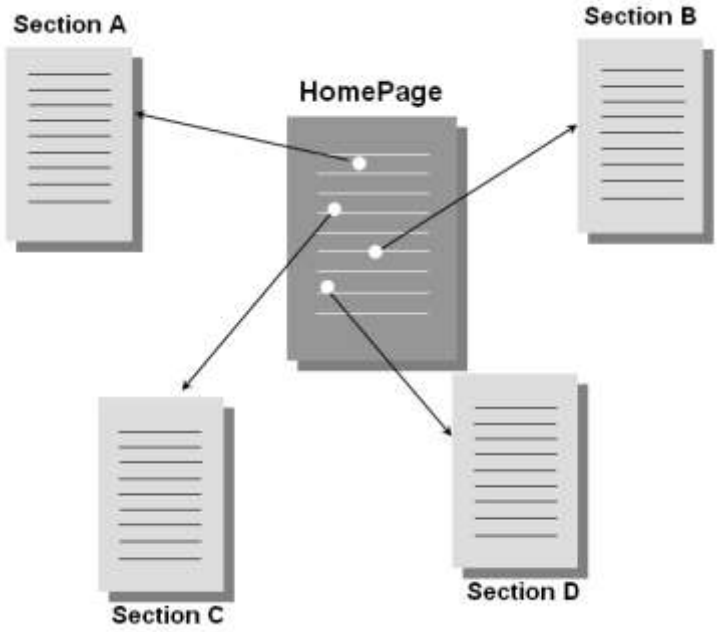


Figure 4 – Assignment of the sections of the text to each single co-author

3. *Development of the various parts of the wiki* – Working individually, the group members develop the section of the text assigned to them and in this manner create a branching hypertext document following a top-down approach. In writing each page,

they are advised to proceed step-by-step (from ‘substance’ to ‘form’): (a) write out the summary; (b) mark the hot-words to be linked to the pages with detailed examinations; (c) format the page.

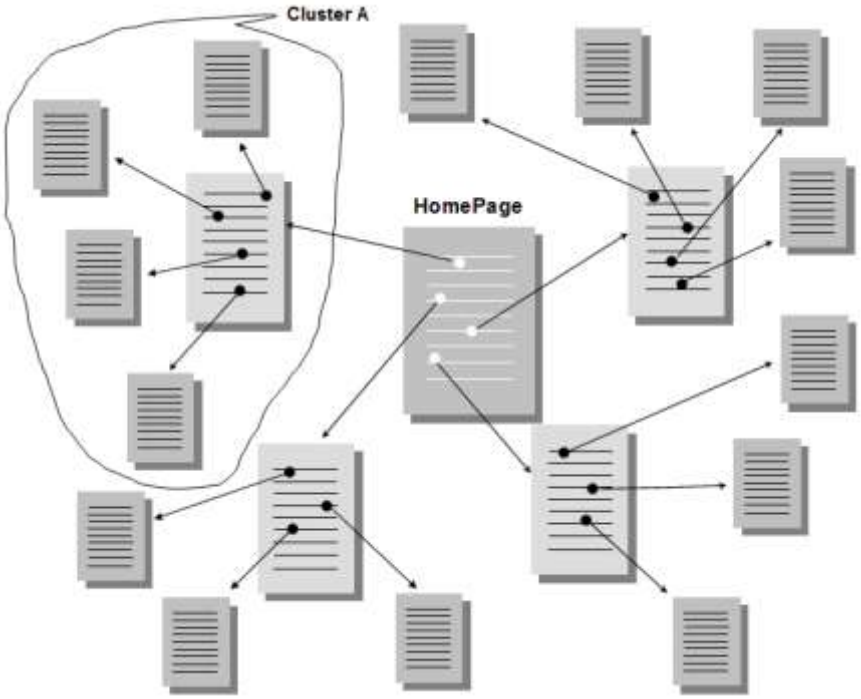


Figure 5 – Development of clusters of pages associated with each section of the text.

4. *Links to pages created by others* – To prevent co-writers concentrating exclusively on their part of the text, they are required to browse the whole hypertext to search for pages compiled by others which may be conceptually linked to one or more pages in their own page ‘cluster’ (Figure 5). Clearly, this activity gets the co-writers to examine the conceptual links throughout the work and fosters a more complete overall vision of the subject. The co-writers are encouraged to perform the task while they are actually developing their pages and not merely leave it to last as an final refinement. Reading the pages of co-authors as they evolve not only sparks new ideas and suggests improvements for the student’s own text, but also helps to avoid duplications especially when two or more students work on conceptually close subject-matters. This also leads to a gradual transformation in the hypertext structure from hierarchical (Figure 5) to reticular (Figure 6).

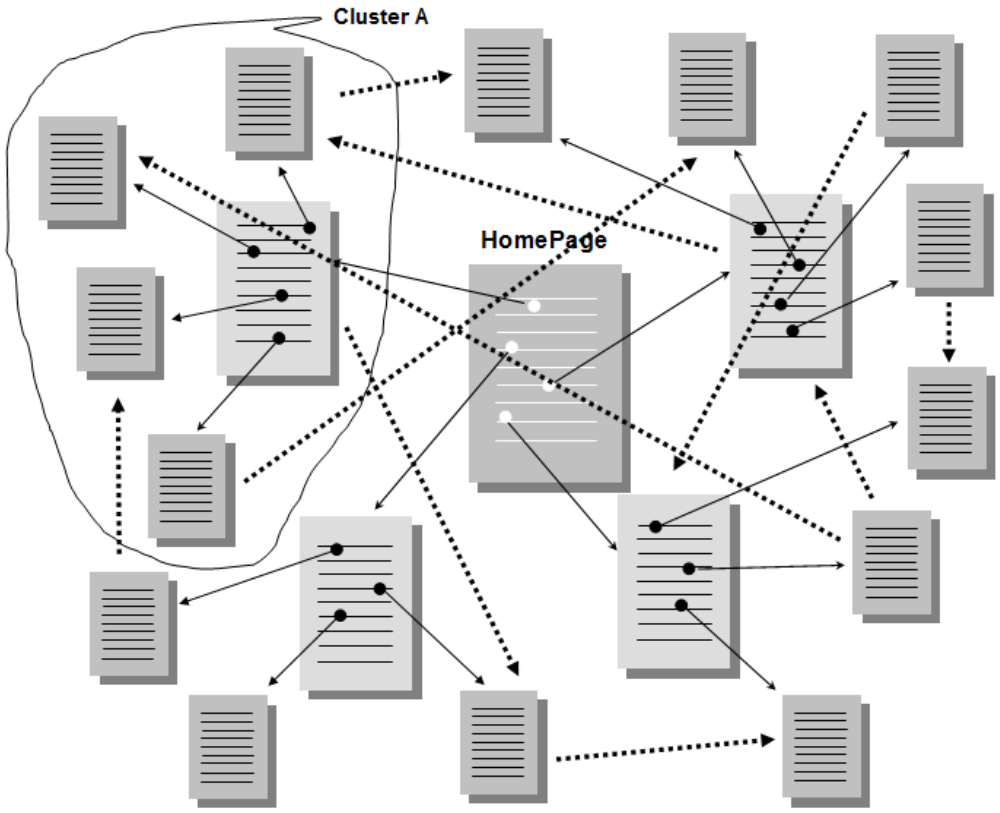


Figure 6 – Creation of link reticule and elimination of possible text duplications.

5. *Peer-review* - Once the different sections of the shared document have been written, the co-writers are asked to peer-review all the pages and suggest to their colleagues how to integrate and improve their respective texts. In this case, the aim – besides that mentioned in point 4 - is to encourage interaction between the author (the co-writer who generated the page) and the users (all the other co-writers accessing it) on the chosen subject (Thompson, 1988). This interaction is facilitated by the 'comments' function associated to each wiki page, through which short dialogues can take place among the different co-authors/users of the hypertext.

Although this way of proceeding may seem rather directive, it is worth remembering that the people involved in the writing of the document had never used writing via wiki and in some cases were even unfamiliar with organising the collaborative writing of a document. So, the 'directive' attitude had a dual purpose:

- to teach a way of organising the collaborative writing of an online handbook via wiki as part of the more general purpose of the experiment, which is to learn how to use social software to support lifelong informal learning;
- to create the conditions for effectively monitoring, then assessing, each single co-writer's level of contribution in the writing of the whole text.

And it is on this second point that the next sections of the chapter will concentrate, looking further into the problems of assessing informal learning processes which originate from the collaborative construction of artefacts.

THE APPROACH ADOPTED FOR ASSESSMENT OF THE COLLABORATIVE PROCESS

The approach to evaluating the individual's contribution towards the collaborative process is founded on the complementarity among analysis of the online interactions, analysis of the data from wiki traces (versioning, tags, comments, linkers), and the co-writers' peer-evaluation.

Details of this are given below; the assessment process for the individual co-writer is differentiated from the assessment process for the group as a whole.

Evaluation of the individual co-writer's contribution

The level of each individual co-writer's contribution takes 4 key factors into consideration that regard their active participation (Trentin, 2009)

1. in the forum used for the planning stage;
2. in the peer-review;
3. in the development of wiki's reticularity;
4. in the development of the contents.

1. *Contribution to forum discussion during the collaborative planning of the document's overall structure* – evaluation is carried out by grouping each group member's messages into three main categories: [A] messages contributing to the content of the group's work (weight 3); [B] messages involving coordination/co-decision (weight 1.5); [C] all other messages (weight 0.5). Table 1 shows the layout of the table used for the data survey.

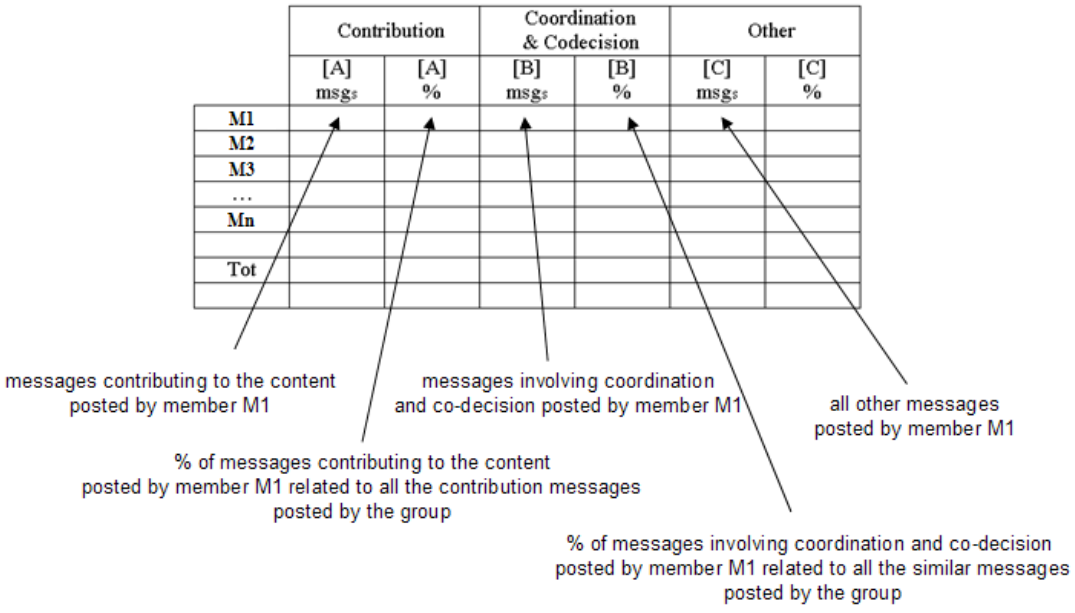


Table 1 – Table used to classify the messages exchanged in the forum.

The categorization of the messages may not be as refined as many others reported in the literature (Henri, 1982; Gunawardena et al., 1997; Bocconi et al., 2000; Ho, 2004) but it has the advantage of providing an easy means to make a fast overall evaluation of each group member's contribution to online collaborative interaction.

Evaluation of the individual's contribution to the forum discussion is therefore calculated as:

$$P_{forum} = 3 \cdot A_{\%} + 1.5 \cdot B_{\%} + 0.5 \cdot C_{\%} \qquad [1]$$

For example, the group member who sent 12% of the contribution messages, 8% of the coordination/co-decision messages and 15% of other messages is given the following mark:

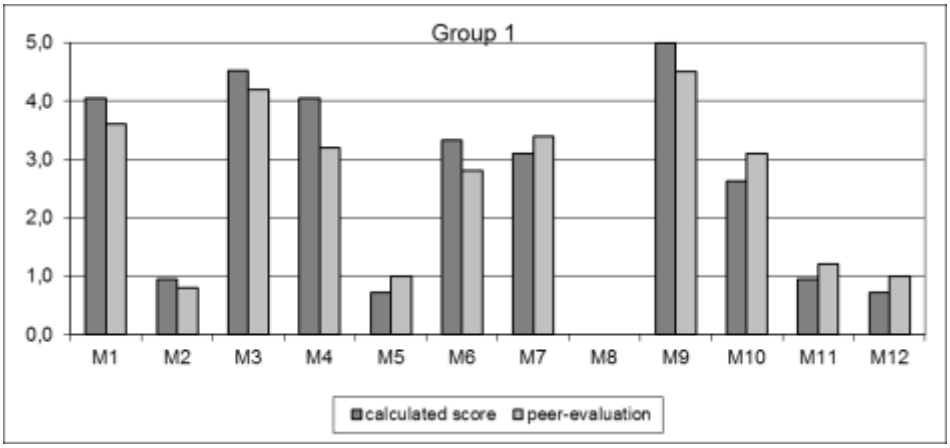
$$P_{forum} = 3 \cdot 0.12 + 1.5 \cdot 0.08 + 0.5 \cdot 0.15 = 0.56$$

This value is then normalized out of 100 with reference to the highest mark in the group. Continuing with the example, assuming that 0.87 is the highest mark scored by a group member, then:

$$P_{forum,norm} = 64.4$$

To check the reliability of the values obtained [1], the group members themselves were asked to evaluate their peers' contributions to forum collaboration, expressed as a mark from 0 to 5. The graph in Figure 7 compares (for each group) the evaluation calculated with the formula [1] (normalized to 5) with the outcome of the peer-evaluation.

[a]



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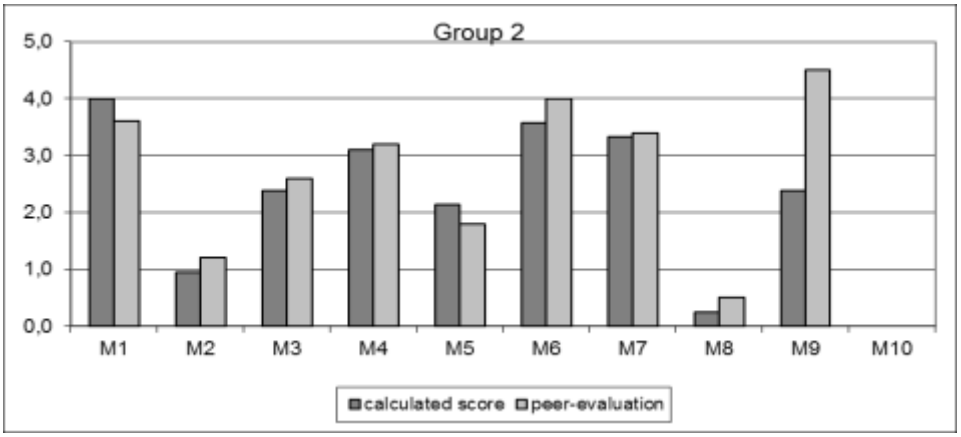


[c]

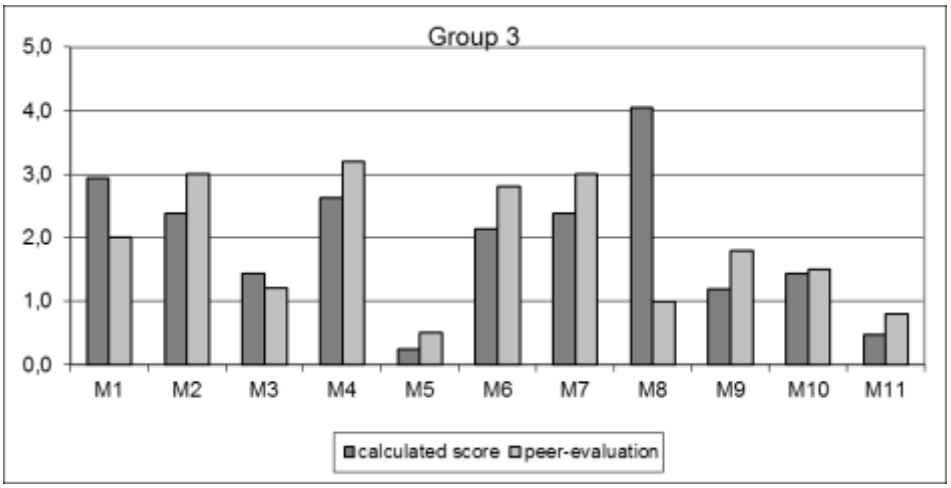


Figure 7 – Comparison between calculated score and peer-evaluation relating to the forum interaction.

It is interesting to highlight a couple of particular cases:

- Group 2 – For community member 9 (M9), the score for peer evaluation is considerably higher than the score calculated with the formula [1]; this shows a discrepancy between the assessments (both subjective) of the external assessor and the members of the group;
- Group 3 – Same situation as the previous one, but in the opposite sense and even more noticeable, for the scores obtained by community member 8 (M8).

Apart from the two particular cases, we can observe a fairly close agreement between the results deriving from formula calculation and those from peer evaluation. We can thus say that, at least for the experiment which involved the three learning groups, the weighted calculation can be considered reliable.

2. *Contribution to peer-review* – This evaluation concerns the comments each individual group member has made during peer-review of colleagues' pages. In this case, the evaluation is carried out by the person who received comments regarding their own pages: a score from 0 to 5 is attributed to each comment received according to how

useful the author found the feedback to be. At the end, each group member's feedback scores are tallied and the mean is calculated. To support the data survey, a specific matrix ('peer-review matrix' – Table 2) is used where:

- the rows correspond to the authors who express an opinion regarding the effectiveness of the feedback they have received from reviewers ;
- the columns indicate the reviewers;
- the row/column intersections report the evaluation (scored on a 5-point Likert scale) by the i-th author based on comments made in relation to their pages by the j-th reviewer; the evaluation considers both the number of comments as well as their overall effectiveness.

	R1	R2	R3	…	Rn
A1	…				
A2		…			
A3			…		
…				…	
An					…
Media					

Table 2 – Table for recording and calculation of peer-review means

In this case too, the mean is then normalized to 100. For example, assuming the i-th group member has a mean of 3.6 and the highest mean scored by a group member is 5, then:

$$P_{peer-review,norm} = 72$$

3. *Contribution to the reticularity of the final hypertext* – This refers to the number of links the individual group member makes between their page cluster and other authors' clusters. Hence, the total number of links is considered and compared to the overall number of links among the different wiki clusters. However, less weight is given to this evaluation than to the previous ones since the number of links often depends on the degree of conceptual relatedness of the topics dealt with on the author's pages to the rest of the pages found in the wiki. As a consequence a cluster, even a high-quality one, may not lend itself to linking with other parts of the hypertext. What's more, not all the links defined by students necessarily have any real conceptual importance.

The value obtained is then normalized to 100. For example, assuming that the i-th group member initiated 11 links from their cluster towards other clusters and that the total number of links among the clusters is 62, then:

$$P_{links,norm} = 17.74$$

4. *Contribution in terms of developed contents* – This is calculated by considering the number of pages and the total number of characters produced by each group member. Here again, less weight is given to this evaluation than to previous ones since it is a quantitative and not qualitative evaluation of each group member's written contributions.

Again, the value is then normalized to 100. For example, supposing that there are 77 pages and a group member has produced 6 of them, then

$$P_{pp,norm} = 7.8$$

Continuing with the example, assuming there are 15,400 words in the wiki and 1,400 of those have been produced by the group member in question, the contribution normalized to 100 is

$$P_{words,norm} = 9.1$$

At the end, the given score would be

$$P_{content,norm} = P_{pp,norm} + P_{words,norm} = 16.9$$

Weight attribution

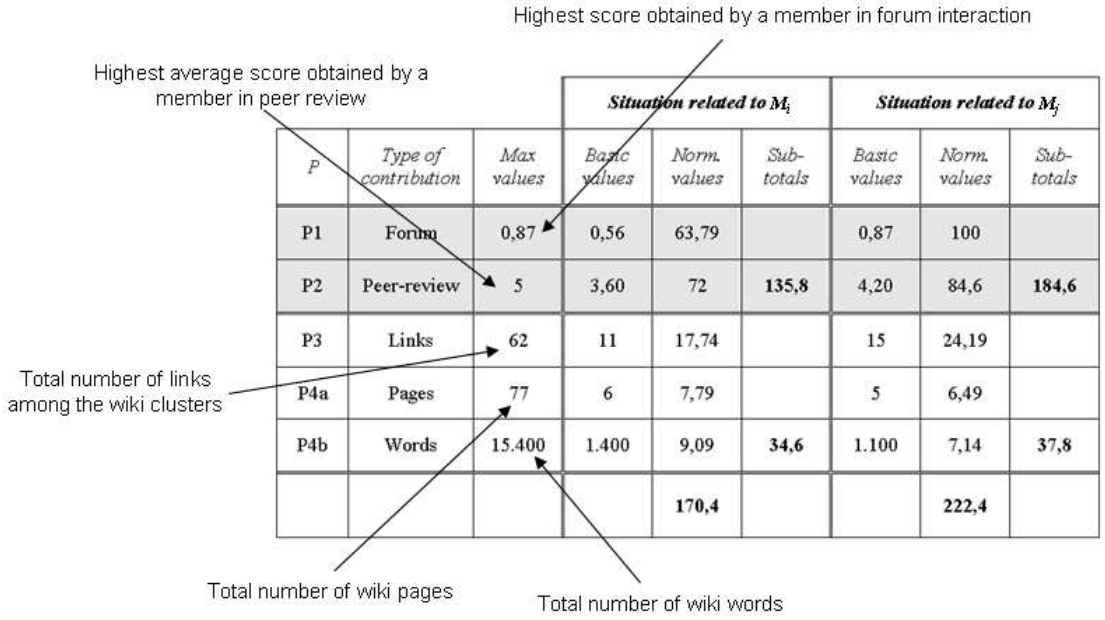
The normalization of values to 100 is purely indicative and another reference value could have been used. What is important is that more weight in this procedure is attributed to contributions related to points (1) and (2) - interaction in the forum for the co-planning of the text and peer-review - than to (3) and (4). This reflects the greater importance attached to collaborative dialogue as a part of the collaborative process.

Calculation of the individual's contribution level

At the end, to obtain the value corresponding to the overall evaluation of a given group member's level of contribution to group-work, the score (normalized) in each above-mentioned evaluation is totalled thus:

$$P_{tot} = \sum P_{norm} = P_{forum,norm} + P_{peer-review,norm} + P_{links,norm} + P_{content,norm}$$

For example, Table 3 compares the results of an average group member (M_i) to the results of group member (M_j) who obtained the highest outright score.



P	Type of contribution	Max values	Situation related to M_i Basic values	Norm. values	Sub-totals	Situation related to M_j Basic values	Norm. values	Sub-totals
P1	Forum	0,87	0,56	63,79		0,87	100	
P2	Peer-review	5	3,60	72	**135,8**	4,20	84,6	**184,6**
P3	Links	62	11	17,74		15	24,19	
P4a	Pages	77	6	7,79		5	6,49	
P4b	Words	15.400	1.400	9,09	**34,6**	1.100	7,14	**37,8**
				170,4			**222,4**	

Table 3 – Comparison of the results of two different contributors.

As already mentioned, the difference in results is mostly determined by the sum of the first two values (135.8 versus 184.6) and much less by the sum of the second two (34.6 versus 37.8). However, this does not mean that the contribution in terms of links and inserted pages should be disregarded, rather that it ought be evaluated as an element of product quality and not as an indicator of group members' contribution level.

Evaluation of collaboration level within the group

Evaluation of the collaboration level within the group is based on the combination of the individual evaluations referred to in the previous section. It depends on three main factors (Trentin, 2009):

1. distribution of forum contributions during collaborative planning of the document's structure;
2. contribution to peer-review;
3. contribution to the reticularity of the final hypertext.

1. *Distribution of forum contributions during collaborative planning of the document's structure* – This evaluation used incidence tables to record interactions among participants in a discussion group. An incidence table is a grid with sender/receiver (S/R) double-entry (Mackenzie, 1966) (Table 4). There were as many incidence tables used for the evaluation as the categories of messages indicated in Table 1. Supposing that there are *n* attendees, the table will measure *n* by *n*, and each cell will represent the number of times that each participant has interacted with another group member. The sub-totals of each column represent the number of message emissions, and the sub-totals of each row the number of receptions. The table's overall total represents the number of communications[1] that have taken place within the group. Using the data collected in the table, it is possible to build up a series of graphic projections that help in understanding to what degree communication is spread across the group or centred on a few individuals.

	S 1	*S 2*	...	*S n*	*Total R*
R 1	…	1		2	5
R 2	2	…		4	8
...	…	…	…	…	12
R n	3	2		…	4
Total S	15	8	4	11	…

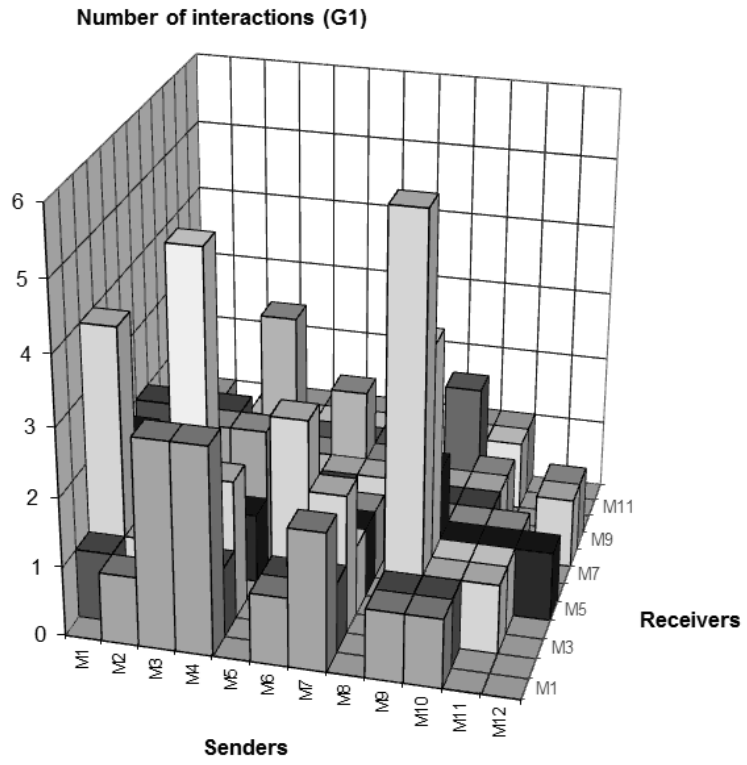
Table 4 – Example of incidence table.

Let us consider for example the graphs shown in Figure 8, which refers to the messages concerning the content of group-work within the three learning communities used here as a case-study. The X-axis indicates the participants as senders, the Y-axis

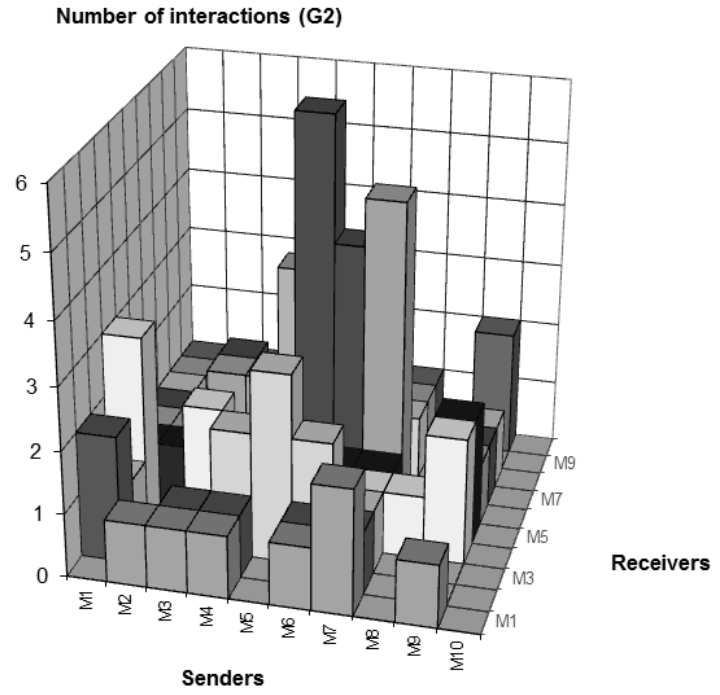
[1]. The total number of communications does not necessarily correspond to the total number of messages exchanged in the computer conference, given that a message may contain information addressed to more than one receiver.

shows the same people as receivers, whereas the Z-axis reports the number of communications.

[a]


Number of interactions (G1)
6
5
4
3
2
1
0
M1
M2
M3
M4
M5
M6
M7
M8
M9
M10
M11
M12
Senders
M11
M9
M7
M5
M3
M1
Receivers

[b]



[c]

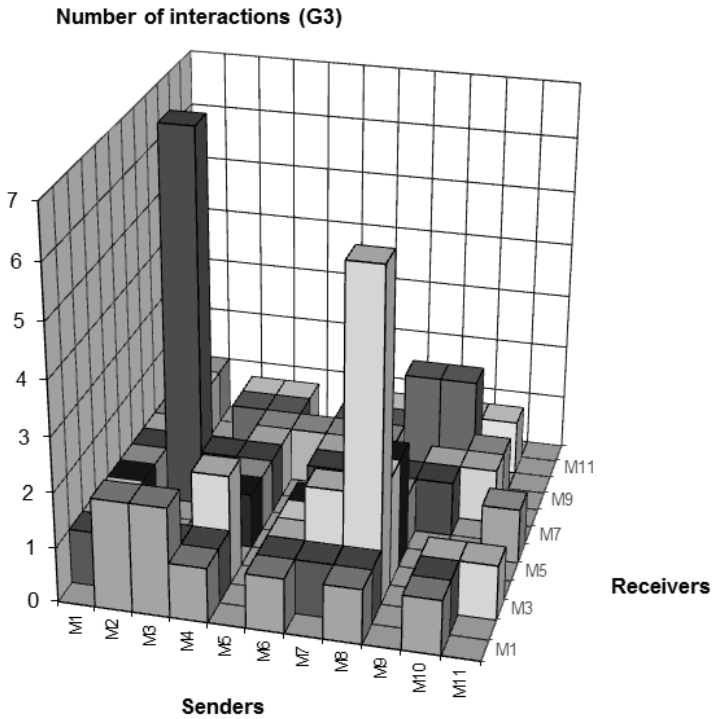


Figure 8 – 3D projection of the incidence table relating to the forum interaction.

The projections show fairly clearly that in Group 3 there was less interaction than in the previous two groups, and that this interaction was centred on just a couple of members. The situation is different from Group 1, where the interaction was more evenly distributed.

In this regard, starting from the incidence table we can study the centrality index [Mackenzie, 1966], i.e. how far the communication is centred on one or more participants. With reference to Group 1, the incidence was 0.442, which means a fairly evenly-distributed interaction even though it is centred on a subgroup of participants. As might be expected, for Group 3 the index was 0.174.

Again basing our considerations on the incidence table we might go on to analyse the reticularity of the exchanges, using for example the graphs produced with Social Network Analysis (SNA) applications. However, the 3D representation (like the one in Figure 8) was found to be more effective in that, besides representing the distribution of the communication (plane XY), it also makes it possible to show the intensity of the interactions (read on axis Z), i.e. the number of communication acts among the interlocutors.

2. *Contribution to peer-review* – This evaluation is based on the total number of comments made by students during peer-review and the effectiveness of their contribution. To evaluate the peer-review of the overall group, the 'peer-review matrix' was used to produce a corresponding 3D graphic projection. As an example, we show in Figure 9 the graphic projection for Group 1. Here we can see in particular that, although the number of comments is high, only in some cases has a high value been attributed to them. In other words, higher interaction does not correspond to a greater significance of these interactions. In fact, a qualitative analysis of the comments inserted in the wiki pages reveals that many of these comments were simply appreciations of the work done by the colleague rather than true suggestions as to how to modify/improve it. Similar types of comment emerged both in the other groups and in other situations applying the same methodology (Trentin, 2009).

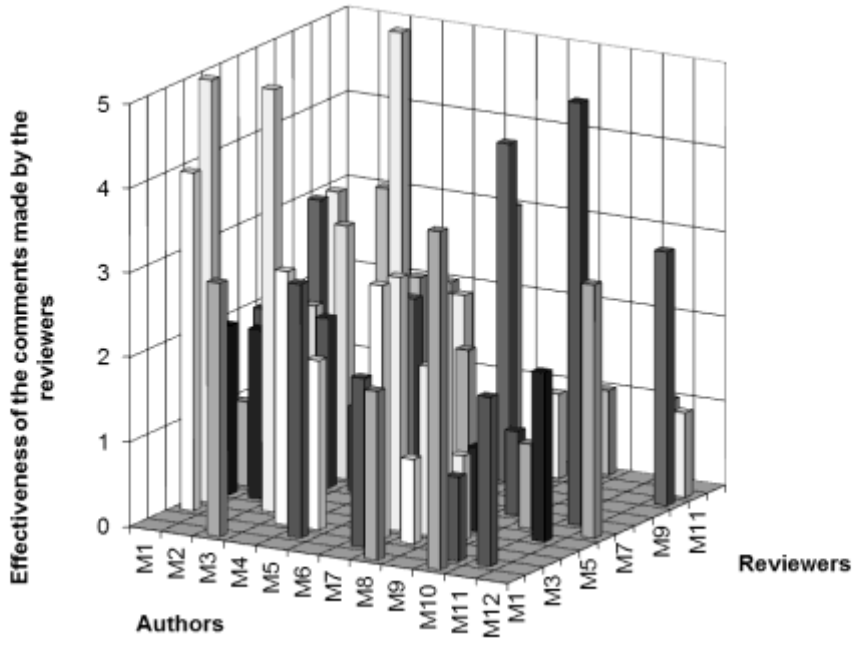


Figure 9 – Projection relative to assessment of the comments in Group 1.

3. *Contribution to the reticularity of the final hypertext* – Other than in terms of actively participating in planning the hypertext, of developing pages and sending constructive comments, the level of contribution also takes into account the hypertext's annotated links. The reason for this is that each hypertext link conveys a cognitive contribution, i.e. the conceptual connection among two or more sub-domains belonging to the same cognitive domain. The level of the wiki's reticularity is evaluated on the number of 'linkers' indicated by the wiki, namely the number of links directed to a given page. As with forum interaction, it is possible to create an incidence table (linking/linked pages) as a means for carrying out a network analysis of the hypertext's reticularity.

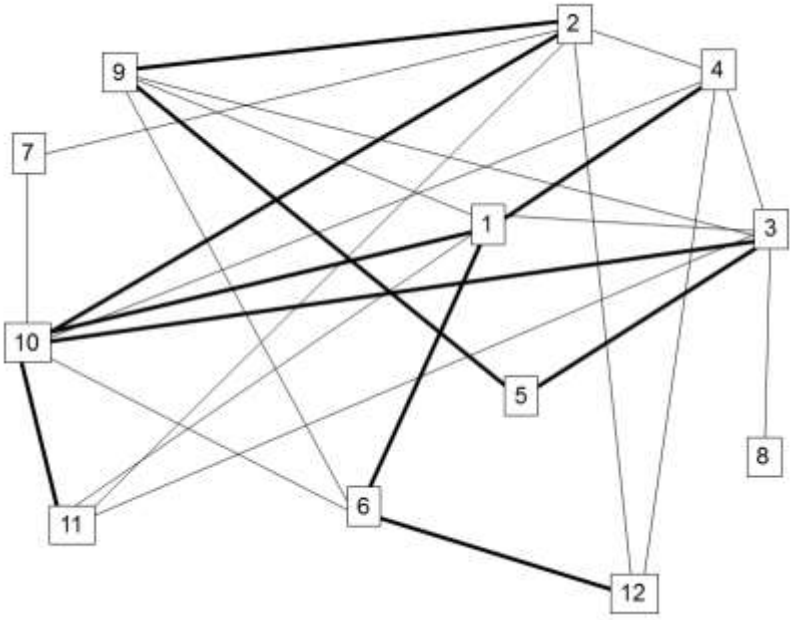


Figure 10 – Network of connections between the different page clusters of the hypertext.

In Figure 10 an example referring to Group 1 is given:

- the numbered points correspond to the page clusters developed by each individual student; in this sense the lines refer to the connection between any page of cluster N and any other page of cluster M;
- the bold lines correspond to a reciprocal link (outward-inward).

The figure shows fairly uniform distribution of the hypertext's reticularity with the exception of clusters 7 and 8. The low number of links may not necessarily be due to the group member's lack of care in searching for connections between their own pages and others; it often depends on the lack of conceptual closeness among the topics dealt with in the respective clusters.

CONCLUSIONS

The planning of an evaluation activity entails defining some key aspects such as the aims of the evaluation itself, the means and tools to perform it and the way of analyzing the results obtained.

In the case of a collaborative learning based on co-writing, there are at least three elements to be evaluated: the product of co-writing, the process implemented by the group and the learning of the subject content.

Evaluation of the product and level of knowledge achieved by the group members can be performed satisfactorily with traditional approaches based on the qualitative analysis of both the co-produced text and the written contributions of each group member. The problem arises in evaluating the co-writing process, in particular the level of contribution that the individual has made to the group and to the distribution/centralization of the collaborative process.

In the experiment referred to in this chapter, co-writing was used as a spur to an informal learning process which involved three different groups of health sector professionals.

The process of co-writing was assessed using a method which had been worked out and trialled in the academic context (Trentin, 2009). The aim was also to verify its applicability to a different context from that of formal teaching, where the level of students' active participation is often determined by the teacher's summative assessment and consequent awarding of a mark.

The approach adopted is based on crossing the data from the tracking of the social software used for co-writing (forums and wikis) with the peer evaluation conducted inside the learning community.

Also in the context of high-level professional training, the experiment confirmed that the assessment approach adopted allows conclusions to be drawn about collaborative learning from two different angles: first, regarding the single contributor and secondly, regarding the group as a whole. Specifically, it was found that:

- evaluating each group member's level of participation and contribution on the basis of both objective data (number of messages, amount of material produced) and subjective data (teacher's evaluation and peer-evaluation) has proved effective, particularly regarding the collaborative dialogue process: forum interaction for the co-planning of the text and peer-review;
- evaluating the level of group collaboration is facilitated by the combined use of 3D graphic projections and network analysis techniques. The projections are more effective in highlighting the intensity of the interrelations (both in the interaction among participants and among the links between the hypertext pages), while the network analysis techniques are more useful in representing their level of reticularity.

While the method was seen to be effectively applicable in both the contexts where it was tested (firstly in higher education and then in high-level professional training), the type of contribution offered by the community members was rather different in the two different situations. The reason for this is closely linked to the circumstances in which the co-writing process was set up: a precise request from the teacher in the case of the students; a real professional need in the case of the doctors and health officers.

In the university learning groups, most of the knowledge used in the production of the wiki came from books and materials provided by the teacher. Here the collaborative writing of the wiki served mainly to activate self-help dynamics in processing, organizing and synthesising the knowledge coming from the "official" sources (formal collaborative learning).

In the professional groups on the other hand, much of the knowledge exchanged and used in the preparation of the wiki came from the community members' direct experience. In this sense we can say that the writing of the wiki did in fact foster an informal learning process based on the sharing of knowledge acquired from actual experience.

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[i] Clinical Audit is a process involving the systematic, critical analysis of the quality of health care provided. It uses information collected in a number of ways to determine that the right interventions are undertaken, on the right patients, in the right way and at the right time. The overall aim of clinical audit is to improve patient outcomes by improving professional practice and the general quality of services delivered. This is achieved through a continuous process where healthcare professionals review patient care against agreed standards and make changes, where necessary, to meet those standards. Above all, clinical audit is a professionally lead process, core to the improvement of standards of health care delivery, a process that can be facilitated or enabled by the application of sophisticated computer software. Such audit can be undertaken at local or at a national level and must be repeated in an iterative method, to ensure that changes have been made and that quality of patient care is continuously improved.
Don't regard clinical governance as just another project or a superficial makeover. It is a root and branch transformation of the way clinical care is provided by the National Health Service (Scally & Donaldson, 1998)