

Using a wiki to evaluate individual contribution to a collaborative learning project

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Abstract

One critical issue arising in the educational use of collaborative learning concerns the teacher's difficulty in evaluating the contribution and participation of each student in group-work. This article aims to illustrate and discuss a methodology that enables evaluation of the collaborative learning process based on co-writing in a wiki environment. After considering the effectiveness of co-writing as a strategy of collaborative learning, the article will highlight issues regarding methods for evaluating each student's contribution to the collaborative process and to the group's overall action. A solution will be proposed to address the problem. It is based upon the elaboration of information traced automatically by wiki, employing survey grids and formulae developed ad hoc to calculate participation and contribution indexes. These tools will be illustrated together with their application in two university courses. Results demonstrate the added value given by the proposed approach to the evaluation process of co-writing. However, these findings also highlight critical issues and some possible remedies for the lack of specific wiki functions to automatically extract information required for quantitative analysis of the actions taken by members of the learning group.

Keywords

collaborative learning, co-writing, evaluation, networked learning, social software, university teaching.

Introduction

Traditional educational environments are often characterised by a process whereby the teacher assigns a learning activity that is generally carried out autonomously by the student. However, this strips the learning process of a fair amount of its social dimension (Bornstein & Bruner 1989; Sullivan 1994). So the idea of fostering collaborative learning strategies presents itself as a means of strengthening this dimension by creating the conditions for individual cognitive development as a result of group interaction (Treleaven & Cecez-Kecmanovic 2001; Garrison 2003).

In the specific area of networked collaborative learning (Haughey & Anderson 1998; Trentin 2006), these strategies are often implemented by assigning a group of students with the task of collaboratively discovering the solution to a given problem (collaborative problem-solving) or developing a written text (co-writing) based on a given argument (Trentin 2004).

Online activities now can benefit greatly from the enormous possibilities offered by social software (Malloch 2005; Alexander 2006). These include wikis, which are characterized by a variety of unique and powerful information-sharing and collaboration features that offer key advantages, such as allowing learners to be actively involved in their own knowledge construction (Boulos *et al.* 2006), as well as improving co-writing processes (Parker & Chao 2007) and facilitating their monitoring. For example, some of these affordances include the possibility

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- to implement distributed collaborative writing (Lowry *et al.* 2004a); and
- to exploit some embedded wiki functions (versioning, tags, comments, linkers) to support the monitoring of both the students' activities and their level of contribution to the collaborative work.

This latter affordance is significant, as teachers often experience difficulty in evaluation when proposing co-writing activities to their students (Shen *et al.* 2004; Swan *et al.* 2006). The problem lies not only in evaluating the level of learning produced by the process itself, but also in gauging the actual degree to which the individual has actively participated in and contributed to the shared written work (Macdonald 2003; Collazos *et al.* 2004).

This paper aims to provide a solution to this problem by presenting and analysing a methodological approach for organizing co-writing based on the use of the wiki as a means for managing the evaluation of collaborative learning processes.

Co-writing and collaborative learning

Collaborative development of a written text transforms the student's ordinary, solitary written work into a collective process, yielding strong benefits on a social and cognitive level (Clifford 1992; Sullivan 1994). Indeed, co-writing processes (Hale & Wyche-Smith 1988; Guerrero *et al.* 2003) offer an excellent opportunity not only to practise reading and writing skills, but also to stimulate reflection, knowledge sharing and critical thinking (Brown & 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 so asynchronously, and is mediated and indirect (Weng & Gennari 2004). Therefore, students have greater opportunities to reflect deeply on what they read and write when replying to their remote interlocutors, besides practising their language skills (Flower 1996).

This can amplify the students' sense that there may be multiple interpretations of the same topic of study 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.

Besides the cognitive aspects, it is also worth considering the importance of mastering co-writing techniques, which are increasingly being 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.* 2004b).

However, while co-writing offers clear advantages for the learning process, it also presents obstacles in the evaluation of each student's

- contribution to the development of the artefact produced by the group; and
- level of progress in reaching the educational objectives of the course.

These matters represent the key research issues that have stimulated the study and experimentation reported in this paper.

Wikis, co-writing and evaluation

The literature reports many experiences in the educational use of wikis (Byron 2005; Notari 2006; Parker & Chao 2007). Several of these have addressed the problem of evaluating the contents that students have developed and the level of learning/competences reached in developing them (Bruns & Humphreys 2005; Hamer 2006). On the other hand, it would seem that the area regarding evaluation of the collaborative process carried out by students has not yet been fully dealt with. The aim of this research has therefore been to define and test a new methodological approach to the organization of co-writing via wiki, which enables evaluation and monitoring of collaborative learning. The research has centred on two successive editions (2005–2006 and 2006–2007) of an online course on Network Technology & Human Resources Development (NT&HRD) at the Political Science Faculty of the University of Turin, and has involved around 30 students.

Why choose wikis for co-writing?

One of the NT&HRD modules envisages the collaborative development of a short thesis. In previous years, this activity was carried out using the traditional method

of interacting via computer conference and sharing individual contributions as attached files. 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; and
- difficulty in gauging the extent to which each group member had critically examined the overall work, besides performing his or her individually assigned task.

It was subsequently decided in later editions to try using a wiki as a co-writing environment, exploiting the potential it offered 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; and
- establish an evaluation mechanism 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).

PBWiki (<http://www.pbwiki.com>) was adopted for the experimentation, a choice made solely on the basis that this application is free of charge; it allows password access and both a classic and WYSIWYG editor.

From centralized to 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 with other 'standalone' hypertext applications such as 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, students using a wiki can see the pages that others have published and hyper-textually 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.

General rules for distributed editing

Co-writing calls for general rules to be defined for drafting the shared document (Lowry *et al.*, 2004b). The purpose of this is not only to ensure the stylistic homogeneity of the final document, but also to define effective co-writing strategies for reaching the learning objectives that one intends to pursue.

Style-wise, students are asked to agree on typographical rules, such as the formats to be used for characters and paragraphs, names of recurring hot-word links (returns to the general index, to the head of the section managed by each student and so on) and their position in the text.

As to co-writing strategies, these are generally defined by the teacher because there is an educational objective involved (Cohen 1994; Felder & Brent 2001).

In NT&HRD, for example, the objective is to develop the students' ability to summarize the subjects being studied and to identify as many conceptual links among them as possible. Therefore, students are advised to use a sort of top-down strategy and write the summary of each subject in no more than 20 lines per page. If they wish to write an exhaustive description and find there is insufficient space, they are to highlight hot-words in the text that link to further pages with a detailed examination of the corresponding concepts. This process may be repeated to no further than three levels of depth from the home page.

The co-writing methodology for development of the shared document

To fully benefit from the possibilities offered by wiki for co-writing and collaborative learning evaluation, the students' work should be organized so that everyone is motivated to play a part in each development stage of the shared script. The methodology adopted in the NT&HRD course is illustrated here point by point:

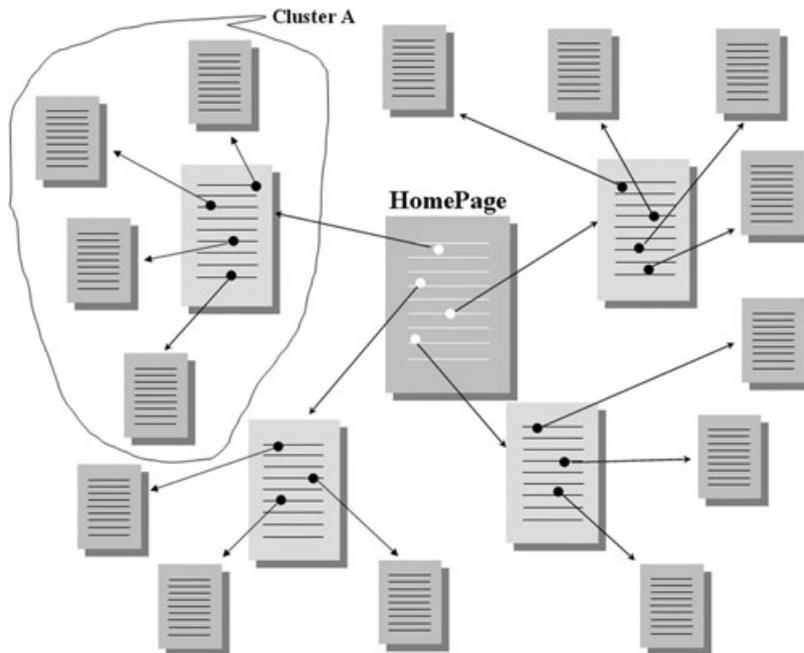


Fig 1 Development of clusters of pages associated with each section of the text.

- 1 *Individual study of recommended materials* – Having been given the theme for the short thesis, students are provided with a list of recommended study materials. Some of these may be found in the course's online repository (articles, book chapters, etc.) while others can be retrieved directly on the web using a set of key words provided by the teacher.
- 2 *Co-planning of the hypertext'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 subsections) and define the layout of the wiki home page. Then the work is divided among the group members.
- 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 the above-mentioned top-down approach. In writing each page, they are advised to proceed step-by-step (from 'substance' to 'form'): write out the summary; mark the hot-words to be linked to the pages with detailed examinations; and format the page.
- 4 *Links to pages created by others* – To prevent students 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' (Fig 1). Clearly, this activity gets the students to examine the conceptual links throughout the work and fosters a more complete overall vision of the subject. The students are encouraged to perform the task while they are actually developing their pages and not merely leave it for last as 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 (Fig 1) to reticular (Fig 2).

- 5 *Peer review* – Once the different sections of the shared document have been written, the students 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 student who generated the page) and the users (all the other students accessing it) on the chosen subject (Thompson 1988). This interaction is facilitated by the 'comments' function associated to each wiki page, through which short

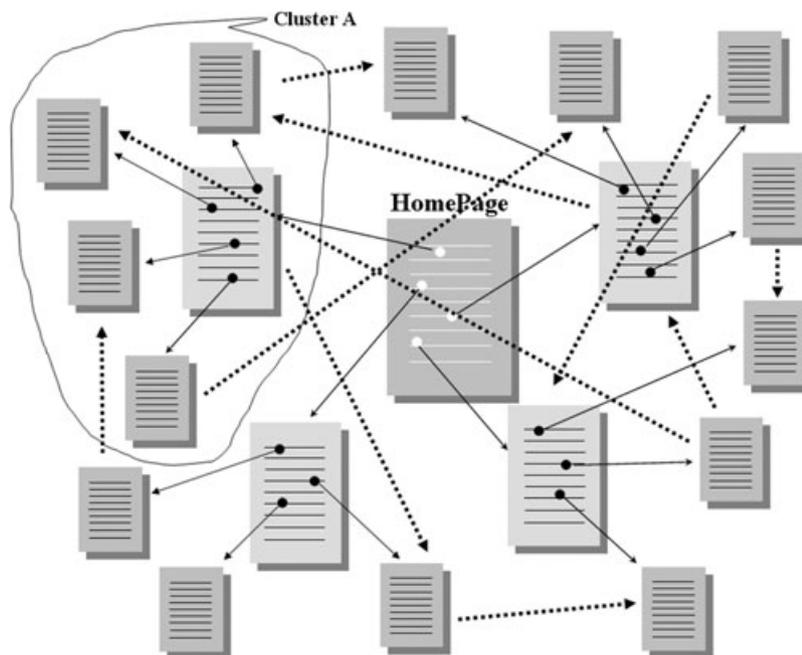


Fig 2 Creation of link reticule and elimination of possible text duplications.

dialogues can take place among the different contributors/users of the hypertext.

The evaluation of collaborative learning

In the NT&HRD course, evaluation of collaborative learning is based on three key elements:

- The *level of learning* (achievement of set objectives) – this is centred on qualitative evaluation of the wiki pages produced by each student (pertinence, accuracy, completeness, terminological usage, etc.), on the significance of the conceptual links between their own pages and those developed by other students, on the ability to discuss and argue during online interactions in forums (while collaboratively planning the hypertext structure) and by the comments posted on the wiki pages during peer review.
- The *products developed* individually or collaboratively by the students – this evaluation is performed by the teachers as well as the students themselves. The teacher judges the overall product in terms of coherence with the assigned task, reticular and conceptual structure, accuracy, completeness, stylistic homogeneity, source of references, etc. The students are required to give a qualitative evaluation on the parts developed by all the other group members (peer evaluation of the product).

- The *collaborative process* followed by students to carry out the online activities – the focus here centres both on individuals’ contribution levels and on interaction within the group in the collaborative performance of the task. Since this directly concerns the central theme of the experimentation, it will be dealt with in detail in the second part of the article.

Evaluation of the collaborative process and contribution levels

The approach to evaluating the individual’s contribution toward the collaborative process is founded on the complementarity among analysis of the online interactions, analysis of the data from wiki traces and the students’ peer evaluation.

Before giving a detailed description of the method adopted and of the tools used for applying it, it is worth pointing out that

- the tables below, which were used to calculate the different contribution and participation indexes, were prepared using Excel spreadsheets and annotated with simple routines for calculating parameters (to be discussed later) and for the graphic projections; and
- the data contained in the tables were extracted manually, an approach that might lead to some criticism because it is a time consuming procedure for the teacher.

	Contribution		Coordination & co-decision		Other	
	[A] msg:s	[A] %	[B] msg:s	[B] %	[C] msg:s	[C] %
S1						
S2						
S3						
...						
Sn						
Tot						

messages contributing to the content posted by student S1

per cent of messages contributing to the content posted by student S1 related to all the contribution messages posted by the group

messages involving coordination and co-decision posted by student S1

per cent of messages involving coordination and co-decision posted by student S1 related to all the similar messages posted by the group

all other messages posted by student S1

Fig 3 Table used to classify the messages exchanged in the forum.

Evaluation of the individual student's contribution

The level of each individual student's contribution takes four key factors into consideration that regard their active participation:

- in the forum used for the planning stage;
- in the peer review;
- in the development of the wiki's reticularity; and
- 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 student'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); and (c) all other messages (weight 0.5). Figure 3 shows the layout of the table used for the data survey.

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 student's contribution to online collaborative interaction.

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

$$P_{forum} = 3 \cdot A_{\%} + 1.5 \cdot B_{\%} + 0.5 \cdot C_{\%} \quad (1)$$

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

$$P_{forum} = 3 \cdot 0.12 + 1.5 \cdot 0.08 + 0.5 \cdot 0.15 = 0.56 \quad (2)$$

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:

$$P_{forum, norm} = 64.4 \quad (3)$$

To check the reliability of the values obtained (1), the students themselves were asked to evaluate their peers' contributions to forum collaboration, expressed as a mark from 0 to 5. The graph in Fig 4 compares the evaluation calculated with formula (1) (normalized to 5) to the outcome of the peer evaluation.

As the comparison shows close agreement between the objective calculation and the subjective evaluation (peer evaluation), the weighted calculation can be considered reliable, at least in this case-study.

2 *Contribution to peer review* – This evaluation concerns the comments each individual student has made

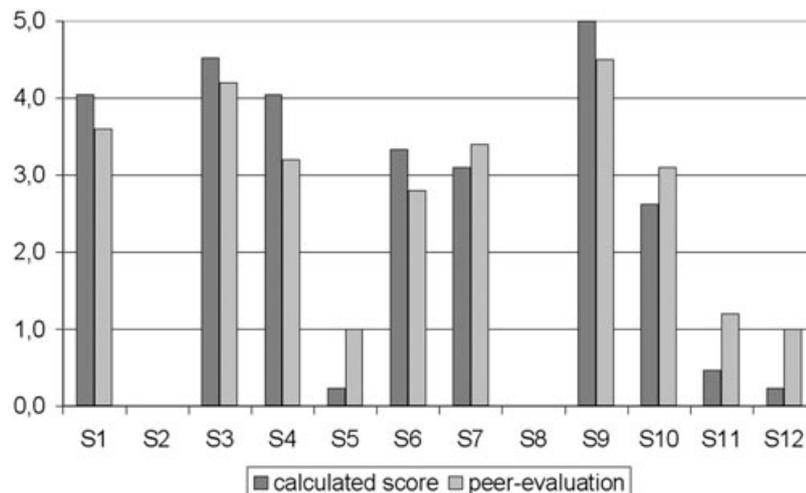


Fig 4 Comparison between calculated score and peer-evaluation relating to the forum interaction.

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 student’s feedback scores are tallied and the mean is calculated. To support the data survey, a specific matrix (‘peer-review matrix’) 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; and
- 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.

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

$$P_{peer-review, norm} = 72 \tag{4}$$

3 Contribution to the reticularity of the final hypertext – This refers to the number of links the individual student 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 student initiated 11 links from their cluster towards other clusters and that the total number of links among the clusters is 62, then:

$$P_{links, norm} = 17.74 \tag{5}$$

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 student. Here again, less weight is given to this evaluation than to previous ones (points 1, 2) since it is a quantitative and not qualitative evaluation of each student’s written contributions.

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

$$P_{pp, norm} = 7.8 \tag{6}$$

Highest score obtained by a student in forum interaction

Highest average score obtained by a student in peer review

<i>P</i>	Type of contribution	Max values	Situation related to S_i			Situation related to S_j		
			Basic values	Norm. values	Sub-totals	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	

Total number of links among the wiki clusters

Total number of wiki pages

Total number of wiki words

Fig 5 Comparison of the results of two different contributors.

Continuing with the example, assuming there are 15400 words in the wiki and 1400 of those have been produced by the student in question, the contribution normalized to 100 is:

$$P_{words, norm} = 9.1 \quad (7)$$

At the end, the given score would be:

$$P_{content, norm} = P_{pp, norm} + P_{words, norm} = 16.9 \quad (8)$$

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 student's level of contribution to group work, the score (normalized) in each above mentioned evaluation is totalled, thus:

$$P_{tot} = \sum P_{norm} = P_{forum, norm} + P_{peer-review, norm} + P_{links, norm} + P_{content, norm} \quad (9)$$

For example, Fig 5 compares the results of an average contributor (S_i) with the results of contributor (S_j), who obtained the highest outright score.

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

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:

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

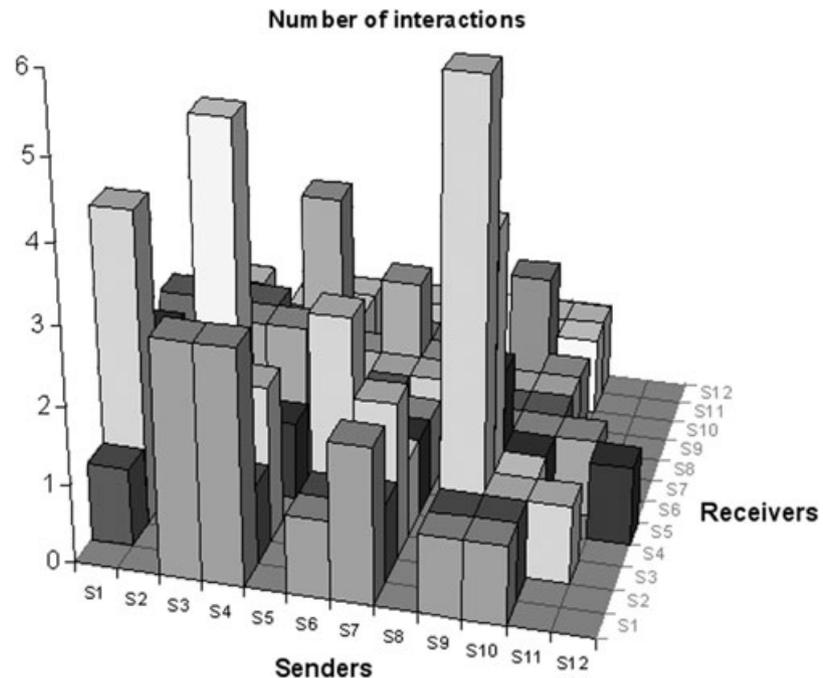


Fig 6 Projection of the incidence table relating to the forum interaction.

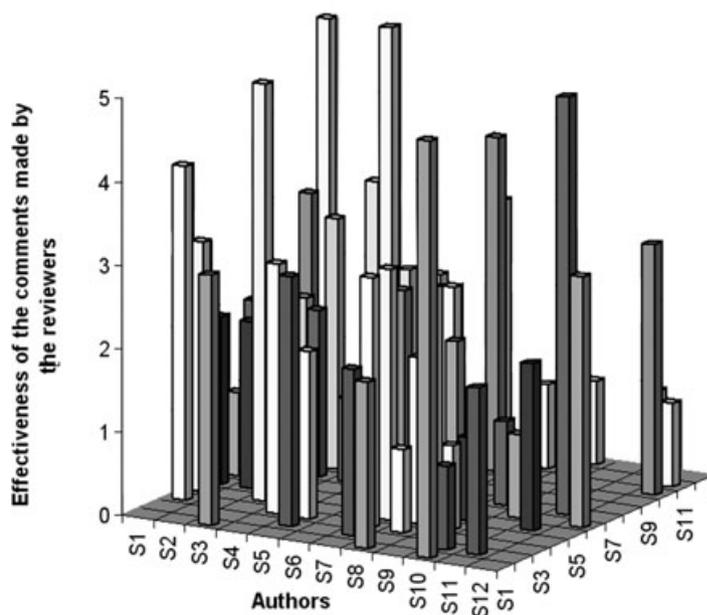
1 *Distribution of forum contributions during collaborative planning of the document's structure* – This evaluation used incidence tables to record interactions among participants in a discussion group. An incidence table is a grid with sender/receiver (S/R) double entry (Mackenzie 1966). There were as many incidence tables used for the evaluation as the categories of messages indicated in Fig 3. 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 subtotals of each column represent the number of message emissions and the subtotals of each row the number of receptions. The table's overall total represents the number of communications¹ 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.

Let us consider for example the graph shown in Fig 6, which refers to the messages concerning the content of group work within one of the two NT&HRD courses used here as a case-study. The X-axis indicates the participants as senders, the Y-axis shows the same people as

receivers, whereas the Z-axis reports the number of communications.

Using the incidence table, the *centrality index* (Mackenzie 1966) can also be studied, which measures to what extent communication centres around one or more participants. The index in this case was 0.421, implying fairly evenly distributed interaction even though centred around a subgroup of participants.

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 graphic projection. The graph in Fig 7 provides an example from the NT&HRD course considered. Although there are many comments in this particular case, only some have been credited with a high value. In other words, a fair amount of interactive vivacity has occurred but the interaction does not carry much significance. Indeed, an analysis of the comments made on the wiki pages has shown that many were appreciations of a classmate's work rather than effective suggestions on how to modify and improve it.



Reviewers Fig 7 Projection relating to the comments evaluation.

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.

In Fig 8,

- 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; and
- 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 4, 9 and 11. The low number of links may not necessarily be due to the student's lack of care in searching for con-

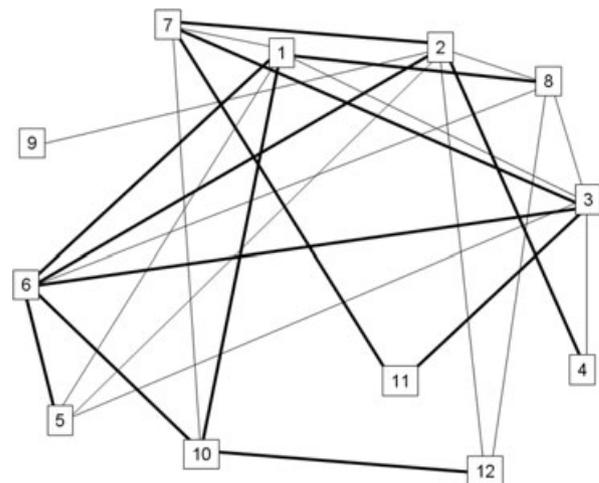


Fig 8 Network of connections between the different page clusters of the hypertext.

nections between their own pages and others; it often depends on the lack of conceptual closeness among the topics dealt with in the respective clusters.

Research conclusions and developments

As pointed out by Rowntree (1981), 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 analysing the results obtained. These aspects have to be taken into account

during the instructional design process as a guarantee that, while carrying out the educational activity, the above mentioned survey methods and tools can be applied to meet the evaluation goal.

In the case of 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 students can be performed satisfactorily with traditional approaches based on the qualitative analysis of both the co-produced text and the written contributions of each student. 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.

For this reason it is customary for teachers adopting collaborative learning strategies to build their own tables and simple formulas to facilitate the monitoring of participation and interactions of their students during group work. Starting from this observation, the research described here aimed to contribute towards codifying a possible methodology to manage evaluation of the process entailed collaborative learning.

The proposed methodology tackles the issue by cross-referencing what can be traced by the social software used for co-writing with the peer evaluation performed within the group. To this end, the co-writing activity was organized to facilitate those surveys required for the application of the proposed evaluation methodology.

The conclusions that can be drawn from field experimentation of the methodology regard two different perspectives, that of the individual student and that of the overall group. Specifically, it has been found that:

- evaluating each student's level of participation and contribution on the basis of both objective data (number of messages and 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. Thus, the survey tables and calculus parameters used may be considered valid not just for co-writing activities but more generally for any asynchronous communication activity; and
- 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.

Application of the method proposed here also proved to be a good test bed to help teachers understand weaknesses in the way they organize co-writing for their students and how these may influence evaluation of the individual's participation/contribution of the group's overall action and of the final product developed collaboratively.

The use of the proposed methodology therefore helps the teacher to understand how to plan co-writing so that all the students are motivated to participate actively and collaboratively.

The results from the experimentation may be regarded as positive, even though the procedures and the tools used still require refinement, especially to reduce the time and manpower demands of the surveys and processing.

The research undertaken has identified some functionalities that could be embedded in wiki environments to automate part of the quantitative analysis of the actions performed by members of the learning group. The idea is to automate some of the activities related to building incidence tables and peer-review voting, and this could be a theme of future development research. For example, the teacher could be given the opportunity to mark the forum messages and categorize them so that the respective incidence tables can be generated automatically with weighted calculations. Ways are also being explored of allowing automatic analysis of the wiki database for retrieving and mapping (tabulating and graphing) the reciprocal links among the pages. This analysis could also prove useful for quantitative evaluation of the interactions among the contributors by enabling automatic generation of a specific incidence table for comments via cross-referencing of the name of a page author with those making comments on that page.

In conclusion, the future development of the research described in this paper will involve 'equipping' a general purpose wiki engine with specific functions related to

the process of evaluating collaborative interactions. This will lead to a special purpose wiki to be used as a support for teaching based on collaborative learning.

Notes

¹The 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.

References

- Alexander B. (2006) Web 2.0: a new wave of innovation for teaching and learning? *Educause Review* **41**. Available at: <http://www.educause.edu/ir/library/pdf/ERM0621.pdf> (last accessed 2006).
- Bocconi S., Midoro V. & Sarti L. (2000) Evaluating the quality of online courses. In *Proceedings of the IFIP, 16th WCC2000* (eds D. Benzie & D. Passey), pp. 66–73. Publishing House of Electronics Industry, Beijing, China.
- Bornstein M. & Bruner J. (eds) (1989) *Interaction in Human Development*, The Crosscurrents in Contemporary Psychology Series. Lawrence Erlbaum, Hillsdale, NJ.
- Boulos M.N.K., Maramba I. & Wheeler S. (2006) Wikis, blogs and podcasts: a new generation of web-based tools for virtual collaborative clinical practice and education. *BMC Medical Education* **6**. Available at: <http://www.biomedcentral.com/content/pdf/1472-6920-6-41.pdf> (last accessed 2007).
- Brown A. & Palincsar A. (1989) Guided cooperative learning and individual knowledge acquisition. In *Knowing, Learning, and Instruction* (ed. L.B. Resnick), pp. 393–451. Lawrence Erlbaum, Hillsdale, NJ.
- Bruns A. & Humphreys S. (2005) Wikis in teaching and assessment: The M/Cyclopedia project. *Proceedings of the 2005 International Symposium on Wikis*, San Diego, CA. Available at: <http://snurb.info/files/Wikis%20in%20Teaching%20and%20Assessment.pdf> (last accessed 2006).
- Byron M. (2005) Teaching with tiki. *Teaching Philosophy* **28**, 108–113.
- Clifford J. (1992) Responses to the essays: toward an ethical community of writers. In *New Visions of Collaborative Writing* (ed. J. Forman), pp. 170–176. Boynton/Cook, Portsmouth, NH.
- Cohen E. (1994) Restructuring the classroom: conditions for productive small groups. *Review of Educational Research* **64**, 1–35.
- Collazos C., Guerrero L., Pino J. & Ochoa S. (2004) A method for evaluating computer-supported collaborative learning processes. *International Journal of Computer Applications in Technology* **19**, 151–161.
- Cooper M., George D. & Sanders S. (1994) Collaboration for a change: collaborative learning and social action. In *Writing With: New Directions in Collaborative Teaching, Learning, and Research* (eds S.B. Reagan, T. Fox & D. Bleich), pp. 31–46. SUNYP, Albany, NY.
- Cunningham D.J. (1991) Assessing construction and constructing assessments: a dialogue. *Educational Technology* **31**, 5–8.
- Felder R. & Brent E. (2001) Effective strategies for cooperative learning. *Journal of Cooperation and Collaboration in College Teaching* **10**, 66–75.
- Flower L. (1996) Negotiating the meaning of difference. *Written Communication* **13**, 44–92.
- Garrison D.R. (2003) Cognitive presence for effective asynchronous online learning: the role of reflective inquiry, self-direction and metacognition. In *Elements of Quality Online Education: Practice and Direction* (eds J. Bourne & J.C. Moore), pp. 47–58. Sloan-C, Needham, MA.
- Guerrero L., Mejias B., Collazos C., Pino J. & Ochoa S. (2003) Collaborative learning and creative writing. In *Proceedings of the First Latin American Web Congress, Santiago, Chile* (eds R. Baezal-Yates & D. Schwabe), pp. 180–186. IEEE Computer Society Press, Los Alamitos, CA.
- Gunawardena C.N., Lowe C.A. & Anderson T. (1997) Analysis of a global online debate and the development of an interaction analysis model for examining social construction of knowledge in computer conferencing. *Journal of Educational Computing Research* **17**, 397–431.
- Hale C. & Wyche-Smith S. (1988) *Student Writing Groups: Demonstrating the Process*. Wordshop Productions, Tacoma, WA.
- Hamer J. (2006) Some experiences with the ‘contributing student approach’. *Proceedings of the 11th Annual SIGCSE Conference on Innovation and Technology in Computer Science Education*, Bologna, Italy. Available at: <http://portal.acm.org/citation.cfm?id=1140123.1140145> (last accessed 2007).
- Hart-Davidson W., Spinuzzi C. & Zachry M. (2006) Visualizing writing activity as knowledge work: challenges & opportunities. In *Proceedings of the 24th Annual Conference on Design of Communication* (eds R. Pierce & J. Stamey), pp. 70–77. ACM, Myrtle Beach, SC.
- Haughey M. & Anderson T. (1998) *Networked Learning: the Pedagogy of the Internet*. McGraw-Hill, Toronto.
- Henri F. (1982) Computer conferencing and content analysis. In *Collaborative Learning Through Computer Conferencing* (ed. A.R. Kaye), pp. 117–136. Springer-Verlag, Berlin.
- Ho C.H. (2004) Assessing electronic discourse: a case study in developing evaluation rubrics. In *Proceedings of the 14th Annual Meeting of the Society for Text and Discourse (ST&D)*, Chicago, IL.

- Lowry P.B., Nunamaker J.F., Curtis A. & Lowry M.R. (2004a) Implementing distributed collaborative writing in traditional educational environments. *IEEE Transactions on Professional Communication* **47**, 171–189.
- Lowry P.B., Curtis A. & Lowry M.R. (2004b) Building a taxonomy and nomenclature of collaborative writing to improve interdisciplinary research and practice. *Journal of Business Communication* **41**, 66–99.
- Macdonald J. (2003) Assessing online collaborative learning: process and product. *Computers and Education* **40**, 377–391.
- Mackenzie K. (1966) Structural centrality in communication networks. *Psychometrica* **31**, 17–26.
- Malloch M. (2005) *E-learning 2.0*. Available at: <http://www.knownet.com/writing/elearning2.0> (last accessed 2006).
- Notari M. (2006) How to use a wiki in education: wiki based effective constructive learning. *Proceedings of the 2006 International Symposium on Wikis*, Odense, Denmark. Available at: <http://www.wikisym.org/ws2006/proceedings/p131.pdf> (last accessed 2007).
- Parker K.R. & Chao J.T. (2007) Wiki as a teaching tool. *Interdisciplinary Journal of Knowledge and Learning Objects* **3**, 57–72.
- Picciano A.G. (2002) Beyond student perceptions: issues of interaction, presence and performance in an online course. *Journal of Asynchronous Learning Networks* **6**, 21–40.
- Rowntree D. (1981) *Developing courses for students*. MacGraw Hill, Maidenhead, Berkshire.
- Scardamalia M. & Bereiter C. (2003) Knowledge building. In *Encyclopedia of Education*, (ed. J.W. Guthrie), pp. 697–706. Macmillan Reference, New York.
- Shen J., Cheng K.E., Bieber M. & Hiltz S.R. (2004) Traditional in-class examination vs. collaborative online examination in asynchronous learning networks: field evaluation results. In *Proceedings of the Americas Conference on Information Systems 2004*, New York City, NY.
- Stahl G. (2006) *Group Cognition: Computer Support for Building Collaborative Knowledge*. MIT Press, Cambridge, MA.
- Sullivan P.A. (1994) Revising the myth of the independent scholar. In *Writing With: New Directions in Collaborative Teaching, Learning, and Research* (eds S.B. Reagan, T. Fox & D. Bleich), pp. 11–30. SUNYP, Albany, NY.
- Swan K., Shen J. & Hiltz S.R. (2006). Assessment and collaboration in online learning. *Journal of Asynchronous Learning Network*, **10**. Available at: http://www.sloan-c.org/publications/JALN/v10n1/v10n1_5swan.asp (last accessed 2006).
- Thompson E.H. (1988) Ensuring the success of peer revision groups. In *Focus on Collaborative Learning: Classroom Practices in Teaching English* (ed. Jeff Golub), pp. 109–116. National Council of Teachers of English, Urbana, IL.
- Treleaven L. & Cecez-Kecmanovic D. (2001) Collaborative learning in a web-mediated environment: a study of communicative practices. *Studies in Continuing Education* **23**, 169–183.
- Trentin G. (2004) Networked collaborative learning in the study of modern history and literature. *Computers and the Humanities* **38**, 299–315.
- Trentin G. (2006) Networked collaborative learning in university teaching. *Educational Technology* **46**, 20–25.
- Weng C. & Gennari J.H. (2004) Asynchronous collaborative writing through annotations. *Computer Supported Cooperative Work* **6**, 578–581.