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A comparative analysis of forums and wikis as tools for online collaborative learning

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ABSTRACT

The current paper presents a comparative analysis of forums and wikis as tools for online collaborative learning. The comparison was developed analyzing the data collected during a collaborative experience in an asynchronous e-learning environment. The activities lasted five weeks and consisted of forum discussions and designing a project in a wiki environment. The research method included both quantitative and qualitative analyses. A quantitative comparison of forums and wikis was developed applying the coding scheme based on the following indicators: (1) inferencing, (2) producing, (3) developing, (4) evaluating, (5) summarizing, (6) organizing, and (7) supporting. The qualitative aspects were assessed using an open-ended questionnaire for collecting participants' perspectives on the functionality of the collaborative tools. Results provided evidence of the different processes during the forum and wiki activities: processes such as inferencing, evaluating, organizing and supporting characterized forum discussions while wikis induced mainly processes of producing and developing. Different purposes were also evident: forums were useful for discussing, sharing ideas while wikis were used for developing a common collaborative document. In addition, the perceived time involved in performing the activities was different: forums were easier to access than wikis, while wikis required more time and were more difficult to use than forums. As a general conclusion it is not possible to state the superiority of one tool over another because each has its own characteristics and could be used with different purposes. Forums and wikis could have complementary functions and should be organized to complete each other for scaffolding students' self-regulated strategies and learning. The findings are discussed in the framework of designing collaborative virtual courses with proper tool selection.

1. Introduction

Online learning is an established procedure for proposing classes at University and the expansion of online activities induced a reflection on the best practices and tools to be used during the e-learning classes (Hou & Wu, 2011; Yücel & Usluel, 2016). Collaborative and cooperative didactic methods were tested and considered optimal for delivering courses (Lin, Hou, & Tsai, 2016). These methods were developed under the socio-cultural approach in which learning is based on interaction and knowledge co-construction (Wegerif, 2006). These conceptualizations offered the possibility to carefully control the quality of

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the learning strategies induced (Miranda, Marzano, & Lytras, 2017) with an approach based on process and meta-cognition development. In this framework several tools were developed for Computer Supported Collaborative Learning (CSCL) which stimulated aspects such as ideas generation, originality (Ardaiz-Villanueva, Nicuesa-Chacón, Brene-Artazcoz, de Acedo Lizarraga, & de Acedo Baquedano, 2011), and project-based learning (Lin & Tsai, 2016). Many tools were tested and assessed and most of them had a positive impact on students' processes and skills (Lan, Tsai, Yang, & Hung, 2012). Nowadays there are several virtual tools available, many of them seem interchangeable. What is missing in this research scenario is a comparison between different collaborative tools (Meyer, 2010) for defining their peculiarities and how to choose one or another in relation to the characteristics in the contexts and the purposes of the activities.

The current study aims to address this issue comparing two tools for CSCL namely forums and wikis. The data were collected in an asynchronous e-learning environment during a five weeks collaborative online experience. The activities consisted of forum discussions and designing a project in a wiki environment. 87 students pursuing different degrees at the School of Humanities in an Italian university participated in the study. The research method included both quantitative and qualitative analyses in order to provide evidence of the participants' perspective of the tools' functions and to understand the processes comprehensively (Twinning, Heller, Nussbaum, & Tsai, 2017).

2. Literature review

2.1. Tools for CSCL: forums and wikis in higher education

There is a growing interest in the possibilities that Web 2.0 technologies offer to education. These include information and communication technology (ICT) tools such as forums and wikis and a variety of other social-network (Kear, Woodthorpe, Robertson, & Hutchison, 2010). Many of these tools have a great potential for teaching and learning, even if they were not produced for educational purposes. Several tools are commonly used for communicating, producing, storing and documenting the steps of the activities. Some tools may appear similar. However, they have different properties and can have a different impact on learning (Wang & Woo, 2008). Two of the most popular tools used for CSCL in online activities are forums and wikis which are presented in the following paragraphs.

2.1.1. Forums in higher education

Forums are Web 2.0 tools for developing online discussions. Several terms are used to describe forums and several kinds of forums have been adopted in virtual environments and platforms such as FirstClass and Moodle. The most common forum allows participants to interact with text-based messages without time and place restrictions (Goggins & Xing, 2016). The forum communications are posted, stored and preserved in a repository and are easy to access since they are ordered following specific discussion topics (Wang & Woo, 2008). Forums are available in several platforms which include an interface for surfing through the various topics selecting messages and replies. Forums are used for general applications and are extensively applied by higher education institutions in training activities. They are considered useful tools for developing the cognitive dimension and the reasoning of the participants. A typical task includes reading a text and discussing it online.

2.1.2. Wikis in higher education

Wikis are Web 2.0 tools for writing online a text in collaboration. Wiki is a Hawaiian word which means 'quickly' and it is commonly utilized to account the quickly edited and the collaboration during the online work. Wikis were developed under the socio-cultural approach and the engagement theory framework. Shih, Tseng, and Yang (2008) considered the main features of wikis as follows:

- Rapidity: the wiki documents can be speedily accessed, constructed and changed.
- Simplicity: wikis utilize an easy scheme to format the pages, instead of the complicated HTML.
- Open source: each participant can set up, change and remove the wiki pages whenever necessary.
- Convenience: participants can easily link wiki pages to other pages and external sites.
- Maintainability: a saved database with the history of all previous revisions and content developed in the wiki pages is accessible to manage and track all editions that were made in a chronological order. These data are useful for monitoring the advancement of the content.

Wikis allow pupils to edit and modify a text collaboratively. In a wiki environment students develop knowledge collaboratively sharing ideas constantly. During peer supported activities the control of the student learning process is promoted through the involvement of meta-cognitive skills (Biasutti, 2015a; 2015b; Ng, 2016).

2.2. Research about tools for online collaboration

Several studies were carried out concerning the tools for supporting online collaborative learning developed in Web 2.0 environments. At the beginning, only the features of the instruments and basic statistic data such as the people registered and how many of them were using the tools were offered (Wolff, 2010). More recently several studies assessed the tools analyzing

the participants' perspectives. These methods included qualitative and quantitative instruments such as interviews and questionnaires. Often a mixed-method approach was also adopted in which the data from different sources – including e.g. a text analysis – were used for triangulation (Miyazoe & Anderson, 2010). The indicators and constructs used for the assessment consisted of aspects such as the classroom climate induced by the tools (Ardaiz-Villanueva et al., 2011), and the knowledge management processes involved in the activities (Biasutti & EL-Deghaidy, 2012).

Regarding the classroom climate, Ardaiz-Villanueva et al. (2011) assessed the effectiveness of wikideas and creativity connector tools to stimulate the generation of ideas and originality by university students. The method 'think actively in a social context' was applied and findings showed that the tools helped the students to generate, evaluate and select the most relevant ideas and to form teams for project execution. In addition, the method used created a positive classroom climate for students.

Knowledge management processes were assessed by Biasutti and EL-Deghaidy(2012) who showed that wikis can develop teachers' knowledge management processes and fulfill student's satisfaction while collaborating in designing online interdisciplinary projects. Several aspects were mentioned by students about how wiki influenced their way of working with peers which were included in the following categories: teamwork, professional development, cognitive, and ethic aspects.

2.2.1. Comparison of tools for online collaboration in higher education

The research compared collaborative online tools such as forums, blogs and wikis regarding aspects such as functionality, effectiveness, usability and sociability highlighting their strengths and weaknesses.

Regarding functionality, Wang and Woo (2008) compared the blog and the forum. These tools may seem similar superficially but in reality they have different features regarding the purposes and the learning processes induced. The authors concluded by arguing that blogs and forums should be structured to complement each other in order to make learning more effective. A systematic comparison of learners' interactions while using wikis with discussion vs. a forum with attached MSWord documents during collaborative problem-based activities was developed by Ioannou, Brown, and Artino (2015). Findings highlighted that forums had an expanding nature while wikis had a condensing nature. Participants seem to be more collaborative during wiki activities while more cooperative during discussions.

Regarding effectiveness, Miyazoe and Anderson (2010) compared the following three online writing activities in a university course: forums, blogs and wikis. Findings showed that wikis were considered by students the most favorable, followed by blogs and forums. Students associated the forum activities with thinking, having opinions, and having to write material that would then be read by their peers. The blogging experience was considered a personal exercise of writing about themselves. The wiki was associated with translation, useful, and fun indicating that this tool was useful for virtual collaboration. However, although the students considered wikis positively, they reported a certain level of difficulty in using wikis. Also the levels of student learning for various assignments that used Web 2.0 tools (blogs, online discussions and wikis) and a non-2.0 format (a research paper) were considered by Meyer (2010). An open-ended survey and standard qualitative analytical tools were used for the assessment. Findings highlighted that online discussions were preferred because students had the possibility to share ideas and concepts, blogs were considered acceptable while wikis generated contrasting opinions. Wikis were considered negatively for issues related to group assignments and for technical reasons because wikis did not allow working synchronously, while the positive comments concerned wikis as tools to support learning.

Regarding usability and sociability, Kear et al. (2010) collected the students' perspectives on forums and wikis. While wikis were considered superior to forums as tools for collaborating on shared documents, wiki's development was considered slower and more difficult than using forums. Regarding the social aspects of online communications, during wiki activities students lost interactivity and a sense of community that can be developed within a forum. Another aspect relates to the access to the workspace, the control and the 'open' nature of the wiki. Students claim that the contributions should be maintained within the working group, rather than being open to other web users. In addition, participants were uncomfortable in editing each other's work in the wiki, while they were more comfortable in forum activities, where no post can be changed. These problems were considered linked to communication issues and were given the term 'sociability'. Kear et al. (2010) argued that both usability and sociability were key components of Web 2.0 tools that have to be carefully considered when designing high quality online collaborative environments.

2.3. Summary of literature review and research questions

The literature analysis provided evidence that online tools were assessed for a specific hypothesis with a variety of methods and, in some cases, relatively small groups of participants were involved. Evaluation included the administration of final course questionnaires to students. Several aspects which characterize student learning were considered such as the classroom climate and the knowledge management processes. Wikis seem to have a positive impact on students and support the development of higher order processes such as thinking skills (Donnelly & Boniface, 2013) and knowledge management skills (Biasutti & EL-Deghaidy, 2012). However, few studies compared the functions of the tools such as forums and wikis in online collaborative learning activities (Kear et al., 2010). Moreover, the actions and the processes used by students while using these tools were not deeply considered. The current research aims to answer to the call for more research on the similarities and differences between Web 2.0 collaborative tools (Ioannou et al., 2015) and to add some missing data to this scenario. The processes induced by two tools, namely forums and wikis, during collaborative online activities utilizing

quantitative and qualitative data collection techniques with a sufficiently large sample of participants were analyzed. The following research questions were considered:

(1) Are there differences between forums and wikis in terms of processes activated?
(2) What are the participants' perspectives of the most significant features of the forums and wikis?

3. Method

3.1. Participants

Participants were recruited in a university in Northern Italy. In total 87 students pursuing degrees at the School of Humanities connected with primary education participated in the study. Students were completing at least their second year of the university courses. Participants ranged in age from 22 to 56 (mean age 33), and most of them were female (M = 7, F = 80); this proportion is similar to the general sex ratio of primary school teachers in Italy.

3.2. The virtual activities

Participants worked in a Moodle platform with an asynchronous practice performing two online activities during a period of five weeks. The first activity focused on discussing while the second on planning. During the first activity participants discussed in a thematic forum how to develop interdisciplinary teaching strategies in primary school. In the second activity they designed an interdisciplinary project for primary schools in a wiki environment. The first activity consisted of discussing texts on interdisciplinary curriculum design that were offered online. Participants discussed the advantages and disadvantages of interdisciplinary curriculum design and how to develop teamwork in the primary school. Participants also discussed the implementation of an interdisciplinary working model in their schools.

The second task focused on interdisciplinary curriculum planning and involved participants in designing an interdisciplinary project in the primary school in a wiki virtual environment. Two or more disciplines have to be included in the framework of the interdisciplinary project which included several actions such as defining the objectives, determining the didactic methods, identifying the content that could link the disciplines, structuring the content in meaningful activities, defining the tools and assessing the activities. This task was an authentic activity for primary teachers rather than an artificial work. This strengthened the ecological validity of the study because previous research provided evidence of the improvement of collaborative learning when it is applied to tasks embedded in an authentic context (Biasutti, 2011). Participants designed the project in small groups of 4–5 students working asynchronously and 19 wikis groups were established in the virtual online environment.

The activities were facilitated by a professor who promoted student participation and provided feedback in the asynchronous environment and accomplished the role of online tutor. During the virtual activities several options for sharing contents, socializing experiences, managing knowledge, constructing joint meanings were offered to participants who had the possibility to assist each other during the learning process. Screenshots of discussion forums and wikis are reported in Figs. 1 and 2.

3.3. Data collection and questionnaire

The research method included both quantitative and qualitative analyses. The evaluation of the collaborative tools considered the following two levels: (1) a content analysis of the forums and wikis interactions and (2) a self-evaluation questionnaire for collecting the participants' perspective on these tools.

Regarding the content analysis, all the interactions developed in the forums and wikis were collected and subsequently analyzed. The coding scheme developed by Biasutti (in press) was used for developing a quantitative comparison of forums and wikis considering the following themes: (1) inferencing, (2) producing, (3) developing, (4) evaluating, (5) summarizing, (6) organizing, and (7) supporting.

Regarding the self-evaluation questionnaire, an open-ended questionnaire was administered for assessing the qualitative aspects and collecting the participants' perspective on the functionality of the collaborative tools. The following open-ended questions were included in the questionnaire:

(1) Please, describe the aspects of the forum activities you consider the most valuable?
(2) Please, describe the aspects of the forum activities you consider should be improved?
(3) Please, describe the aspects of the wiki activities you consider the most valuable?
(4) Please, describe the aspects of the wiki activities you consider should be improved?
(5) Please, describe the differences between forum and wiki tools?

These questions evoked a wide range of participants' perspectives focusing on the strengths and weaknesses of the online tools.

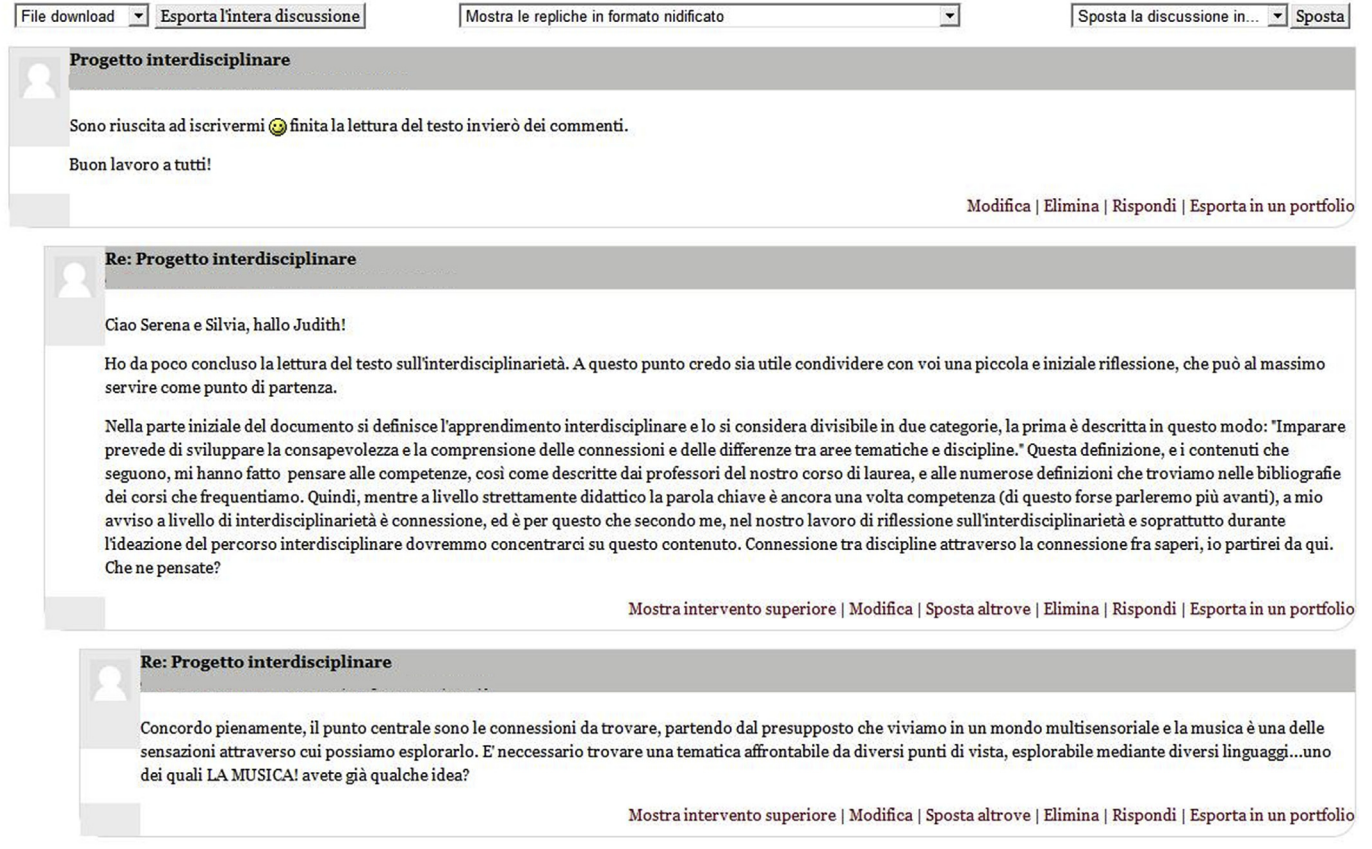

Fig. 1. Screenshot of the discussion forum.

Fig. 2. Screenshot of a wikis project.

3.4. Procedure

The online collaborative activities involved participants in reading tasks, online forum discussions and wiki project designing tasks in small groups. At the end of the online activities participants were asked to complete the open-ended questionnaire presenting this activity as an occasion for collecting feedback to improve the online activities for the following year. Participants were informed that the questionnaires remain anonymous and were encouraged to give accurate answers. The questionnaire was accessible in the internet and an average of 15 min was necessary to complete it.

All the research procedures and activities performed by the participants in the current study were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards such as the American Psychological Association (APA) Ethical Principles of Psychologists and Code of Conduct. The participants provided written informed consent.

4. Analyses and results

The collected data consisted of all the interactions developed in the forum and wiki activities and the self-evaluation questionnaire. The results are given according to the two research questions previously presented. The first research question regards the differences between forums and wikis in terms of processes activated; the second, the participants' perspectives on the most significant features of forums and wikis.

4.1. Research question one: differences in the processes between forums and wikis interactions

The data were comprised of the transcripts of 19 forum discussions and of 19 wiki projects. Regarding forum discussions, there were 1038 total interventions (mean 54.6 interventions per group) for a total of 102,291 words (mean 5383.7 words per group). In the forum discussions, the interventions of the online tutor had been excluded from this analysis. The group that had the largest number of interventions was group 4 with 154 messages posted while the group that had the lowest number of interventions was group 18 with 15 messages.

Regarding wikis, the 19 wiki projects had a total of 57,789 words (mean 3052 words per group) and there were 1494 different versions of the projects (mean 78.6 versions per group). There was a lot of variability within the groups: group 4 had the maximum number of versions with 324 different versions, while group 19 had only 6 versions. The largest project (group 11) had 6290 words and 63 versions and the shortest (group 13) had 1340 words and 16 versions. For the wiki documents all the previous versions realized by participants for deducting the development of their work were analyzed.

The coding scheme developed by Biasutti (in press) was adopted to analyze the transcripts of the forum discussions and wikis activities, which consisted of the following themes: (1) inferencing, (2) producing, (3) developing, (4) evaluating, (5) summarizing, (6) organizing, and (7) supporting. Table 1 reports the coding scheme used for forum and wiki analyses and the supporting quotes for the seven themes which are described below. During inferencing participants provided reflections and thoughts dealing with the materials and the project, during producing they offered thoughts and generated ideas for building the project, during developing they proposed extensions and revisions of previous ideas, during evaluating they assessed the proposals, the material and the framework of the project, during summarizing they generated synthesis of the discourses, during organizing they shared information on the performance of the virtual activity, during supporting they meta-communicated, assisted each other and verbalized feelings. All forum and wiki interactions were analyzed and codified according to these seven categories. Sentences or parts of sentences were used as the unit of analysis and the interactions were broken down into manageable units. The seven themes used for the coding process were self-excluding: one interaction could be fitted under only one category. At the end of the coding process, all of the forum and wiki interactions were codified according to the coding scheme. The coding process was performed by two independent researchers who separately coded the data. In order to determine consistency among evaluators, a reliability analysis was computed calculating the Kappa statistic. The reliability for the two coders was Kappa = 0.77 for forums and Kappa = 0.79 for wikis. These data show that there was high agreement between the two coders, interpreting the coding scheme reliable. The analysis provided the percentages on each of the themes across the forum and wiki activities which are reported in Table 2.

A group comparison was conducted with a chi-square test to examine the differences among the individual themes during forum and wiki interactions. The chi-square statistic was significant ($p < 0.001$) for all the themes. Percentages of interactions and chi-square statistics in each of the seven themes for the forum and wiki interactions are reported in Table 2.

The chi-square test demonstrated that there were significant differences in the behaviors adopted during the forum and wiki activities: in the forum the interactions were based mainly on inferencing, evaluating, organizing and supporting whereas wikis interactions were based on producing and developing. Percentages of producing and developing were lower in forums than in wikis where generating ideas, principles and extensions were the core processes. Regarding the differences, in the forum the theme of inferencing was used for proposing assumptions, reflections, beliefs, personal experiences while in wikis inferencing was used when links and references were introduced. In the forums the theme of organizing regarded the management of the virtual work discussing procedural information about task assignments and deadlines, while in wikis technical issues were reported. In the wikis the other three themes of evaluating, summarizing and supporting were not relevant while in forum accomplished important functions. Evaluating was a way both for assessing and expressing

Table 1
The coding scheme used for forum and wiki analyses and supporting quotes for the seven themes.

Categories	Themes	Supporting quotes
1.1. Reflections 1.2. Beliefs 1.3. Experiences and examples 1.4. Links 1.5. References	1. Inferencing	"The connection with physical education stimulates the curiosity in children because they have the ability to move about and to experience the music actively and in a playful form. Pupils are more motivated and involved. Learning is linked directly to real life experiences." "Regarding my internship experience, interdisciplinarity was not prominent, but fortunately the teachers teach more than one subject and then they can develop connections between disciplines (e.g. my mentor very often uses music to teach Italian) Moreover, interdisciplinarity is present in school interdisciplinary projects but, in my opinion, they are not interdisciplinary projects but multidisciplinary projects." "https://www.youtube.com/watch?v=MAY1UoQYMHk"
2.1. Ideas and proposals 2.2. Framework and work approach	2. Producing	"It would be nice to connect music to more disciplines and not only to one, because in this way we stimulate a network of knowledge in the children." "I thought that it would be very interesting to teach children the construction of a sound path, which represents the sound reality in which they live." "We could organize a trip to the Archeopark and set up a play on the theme: The music of prehistory" "Why not to draw a map of the disciplines involved? And then we can work on the individual activities." "Let's define the areas of competences and then we will deduct the objectives."
3.1. Developments 3.2. Revisions	3. Developing	"We could also add some pictures regarding the specific emotions …" "I would say that if we are starting from the story of Gianna, children may also build instruments or use the Orff instruments. Then they could experience gestures while playing the instruments." "We can change the order of our activities: …" "I think we can add the schedule to the project"
4.1. Evaluation of material 4.2. Evaluation of proposal 4.3. Evaluation of framework and work approach	4. Evaluating	"I also like the video that Ester suggested!" "Paolo, your idea concerning the relationship between plants and music sounds interesting." "Emilia, very well done to launch a new proposal!" "The goals are too generic, and the prerequisites are missing. The theme is not exciting and it is difficult to fit it in the framework of our work."
5.1. Summaries of discussions 5.2. Summaries of proposals	5. Summarizing	"The main concepts that emerged during our discussion about interdisciplinarity includes the following points: …" "Considering the various ideas, we can conclude: working in a second class, linking music to geography." "I'll try to summarize what I understood (but I'm not completely sure): The film is the starting point and then we select two Stories of Walt Disney and we will use the sounds and the music …"
6.1. Task assignments 6.2. Deadlines 6.3. Platform 6.4. Technical issues	6. Organizing	"With regard to the drafting of the summary, I think you should write it" "We are a bit late and we have to close this first part by the end of the week" "I do not know where I'm wrong, but I can not create the table in wiki despite having entered all the necessary parameters." "I just don't see the song and a red x in the upper left corner appeared." "I can't see the link with youtube, (but maybe that's just my problem)" "I had some issues in uploading the material"
7.1. Meta-communications 7.2. Regards 7.3. Reinforcements 7.4. Facilitations 7.5. Feelings	7. Supporting	"With regard to interdisciplinarity, I'll share with you some ideas that I had last night …" "Dear colleagues, very nice to have you all online! I am very happy to work with you and certainly the final result will be very satisfactory" "I am also very excited to share this experience with you" "I can help you in translating into Italian the material" "What can I say Chiara! You read my thoughts!" "It seems to me that things are going the right way!"

Table 2
Percentages for forum and wiki interactions and chi-square statistics for forum and wiki comparison in the seven themes.

Tool	1. Inferencing	2. Producing	3. Developing	4. Evaluating	5. Summarizing	6. Organizing	7. Supporting
Forum	19%	13%	4%	17%	2%	23%	22%
Wiki	6%	42%	45%	0%*	0%*	7%	0%*
Chi-square (df)	162.50 (1)*	335.28 (1)*	810.81 (1)*	420.57 (1)*	40.09 (1)*	452.61 (1)*	577.01 (1)*

*$p < .001$.

agreement, for reaching consensus regarding the ideas and proposals of the group members. Summarizing – the last form of interaction utilized in the forums – was used at a certain point during the work with the purpose of synthesizing the most relevant aspects of the discussions and the preferences for specific proposals. Supporting addressed the social dimension of the virtual work including meta-communications, welcome messages, regards, reinforcements and personal feelings. These forum interactions assisted teamwork building and strengthened the collaboration in the group.

4.2. Research question two: the participants' perspectives on forums and wikis

Content analysis was used to analyze the answers to the questions of the open-ended questionnaire using a qualitative method as reported by Biasutti and EL-Deghaidy (2015). Families and codes were identified from data regarding the five individual questions. The qualitative analysis was performed with the Atlas.ti software, which ensured a systematic control of the data.

The analyses included the following steps: during the first step the answers were read, defined and coded, elaborating a coding scheme, in the second step relations were identified and the codes were sorted into families. The analysis began internalizing the material, consisting of reading multiple times the answers of the open questions in order to develop familiarity with the material. The internalization was followed by the definition of discernibly different answers and the allocation to them of specific codes. The Atlas.it software was useful for developing the analysis and controlling the selection of quotes from the answers. The process of allocating codes included a revision of the initial codes by re-reading the answers to prevent redundancies. "Before generating a new code it was verified whether it was possible to set the quotation in an existing one and only in the case where it did not fit a new code was eventually generated" (Biasutti & EL-Deghaidy, 2015, p.344). This is the more complex phase of the analysis which involved the development of codes as few, as large and as comprehensive as possible. The second step of the analysis consisted of identifying relations and sorting the codes into families which could be considered an advanced level of categorization. The allocation of the codes into families allowed synthesizing the results into a few relevant families, which summarized the content of the codes. The final product of the analyses were the codes and the families which were used for coding all the answers of the open questions.

The codes used for coding the data were self-excluding: one quote could be included only in a single category of the coding scheme. At the end of the coding process, all of the answers were coded according to the coding scheme. This process was repeated individually for all five open questions. In addition, the frequency distribution was calculated for each code. The coding process was subsequently corroborated by an expert who individually verified the coding scheme and the codification of the answers. Any different findings were debated until full accord was reached.

Regarding open question one (the most valuable aspects of the forum activities), participants reported several aspects of the forums' impact on their interactions and their perspectives on the processes activated during the online activities. The families highlighted during the analysis were: teamwork, cognitive, communication, operating, emotive/ethical (the complete list of families and codes are reported in Table 3).

In the teamwork family, participants highlighted the development of several skills such as collaborating, confronting, discussing and networking. Sharing ideas, experiences and material was another crucial process during the forum activities. Also, conciliating was considered a useful skill which engaged participants in reaching a consensus and defining the most valuable approach to follow. In the cognitive family, participants highlighted several processes utilized during the activities connected with the knowledge management process. Reasoning, inferencing on specific topics and analyzing were considered key processes of forum discussions. In addition, actions such as selecting information, organizing ideas and internalizing concepts were mentioned as crucial components of the online forum activities as well as assessment processes such as

Table 3
Families, codes and frequency distribution for the strengths of forums (open question 1).

Families	Codes	Frequencies
Teamwork	Collaborating	32
	Sharing	25
	Confronting/discussing	21
	Conciliating	11
	Networking	4
Cognitive	Reasoning/inferencing	15
	Analyzing	13
	Evaluating perspectives	12
	Synthesizing positions	11
	Selecting	8
	Organizing ideas	6
	Comparing interpretations	5
	Critical thinking	4
	Internalizing concepts	3
	Building shared knowledge	2
Communication	Asynchronous communication	11
	Writing instead of speaking	8
	Having written reports	7
Operating	Functional software	14
	Directness of sharing ideas	11
	Connecting when needed	7
Emotive/Ethical	Feeling supported	11
	Goodwill	7
	Respecting others' ideas	5
	Accepting observations	3

comparing different interpretations and evaluating perspectives. The overall aim was to synthesize different positions and build a shared knowledge between participants. Critical thinking was the general skill mentioned by participants demonstrating that forum activities were useful for developing reflective thinking skills. In the communication family, participants reported the peculiarities of the forum interactions and considered valuable the asynchronous way of communicating. They also noted a different way of communicating using writing instead of speaking and they considered having written reports that could be accessed at any time helpful. In the operating family, participants mentioned the advantages of the forum during the activities: the forum tool was considered a functional software for a direct sharing of ideas. They appreciated not having time constrains and the possibility of being connected when needed and when they had time. In the emotive/ethical family, participants highlighted feelings and ethical principles used during the virtual activities. Participants felt constantly supported: goodwill and support were relevant feelings. Regarding ethical principles, participants reported accepting observations and respecting others' ideas as key principles during the forum interactions.

Regarding question two (the forum activities that were considered to be improved upon), participants reported several aspects that need improvements. The families highlighted during the analysis were: teamwork, cognitive, operating (the complete list of families and codes are reported in Table 4).

In the teamwork family, participants highlighted that a different level of engagement and the scarce cooperation were the most relevant aspects. Sometimes there were delays in answering and students had to wait for the interventions of their mates and these late responses affected the management of the activities. In addition, the occasional difficulty in reaching an accord during the online activities was another relevant factor. In the cognitive family, participants highlighted that understanding the ideas of the others, making online decisions and discussing asynchronously, were challenging processes. Synthesizing was also considered a difficult task to do online. In the operating family, participants complained about the slow Internet connection and the problems in uploading the files. They asked for synchronous discussion applications such as an audio chat to have the possibility to talk synchronously during the activities.

Regarding question three (the most valuable aspects of the wiki activities), participants reported several aspects of the wiki's impact on their interactions and their perspectives on the processes activated during the online activities. The families highlighted during the analysis were: teamwork, cognitive, organization, operating, emotive/ethical (the complete list of families and codes are reported in Table 5).

In the teamwork family, participants highlighted that commitment and constant interaction were the successful ingredients. Being constantly supported by other group members during the small group activities was considered valuable. The virtual collaboration was based on constructive participation and sharing efforts, and students perceived being part of a collective work. Regarding the cognitive family, participants highlighted that wikis were relevant for applying knowledge, generating ideas and developing plans. Wikis were considered helpful for combining, modifying and revising texts and students learned to collaborate during the wiki activities. Regarding the organization, wikis provided a guide for participants, stimulating them to follow a framework and to design a plan. Participants organized their work assigning tasks to each member of the group and developed the work constantly with a step by step progression. Regarding operating, participants considered wiki a complete and flexible tool where they can have a direct intervention and a constant control of the activities. They considered it precious to work on a shared document and to have the possibility of consulting past versions of their work. Regarding the emotive/ethical family, participants highlighted feelings such as the availability to work with the colleagues. They felt that what they were doing was productive. They understood that mutual respect was crucial during the virtual activities and they felt a responsibility when changing the ideas of the others.

Regarding question four (the wiki activities that were considered to be improved upon), participants reported several aspects that needed improvements. The families highlighted during the analysis were: teamwork, cognitive, communication, organization, operating (the complete list of families and codes are reported in Table 6).

Regarding teamwork, the divergent level of participation, the limited collaboration and the late cooperation were the main issues. The cognitive difficulties included understanding others' plans and modifying the work developed by other participants. Learning to work differently was another aspect which affected the perceived functionality of the tool. In the communication family, participants claimed the lack of non-verbal communication and face to face interaction. Also a direct

Table 4
Families, codes and frequency distribution of the weakness of forums (open question 2).

Families	Codes	Frequencies
Teamwork	Different engagement	10
	Scarce cooperation	9
	Delay in answering	8
	Reaching an accord	4
Cognitive	Understanding the ideas of others	8
	Deciding virtually	7
	Synthesizing	6
	Discussing asynchronously	6
Operating	Slow Internet connection	15
	Uploading files	8
	Adding synchronous tools (chat)	5

Table 5
Families, codes and frequency distribution of the strengths of Wikis (open question 3).

Families	Codes	Frequencies
Team work	Virtual collaboration	32
	Constructive participation	10
	Constant interaction and support	9
	Shared effort	7
	Commitment	6
	Being part of a joint work	3
Cognitive	Generating ideas	26
	Modifying/revising texts	19
	Developing plans	15
	Combining texts	11
	Applying knowledge	5
	Learning to collaborate	4
Organization	Having a framework	12
	Designing a plan	10
	Appointing tasks	6
	Developing a progressive work	5
	Proceeding step by step	4
Operating	Complete and flexible tool	14
	Direct intervention	11
	Working on a shared file	9
	Consulting past versions	8
	Constant control of the activities	7
Emotive/ethical	Responsibility in changing others' ideas	8
	Mutual respect	6
	Productive work	6
	Availability	4

Table 6
Families, codes and frequency distribution of the weakness of wikis (open question 4).

Families	Codes	Frequencies
Teamwork	Divergent participation	11
	Limited collaboration	7
	Late cooperation	6
Cognitive	Understanding others' plans	7
	Modifying other parts	6
	Learning to work differently	3
Communication	Lacking non-verbal communication	6
	Lacking a face to face contact	6
	Lacking contact with material	2
Organization	Limited time	18
	Workload management	12
	Odd work partitioning	7
	Scarce coordination	6
	Low synchronization	4
Operating	Copy/past issues	15
	Including images	11
	Scarce layout	8
	No synchronous modification	7
	Small window	6
	Modifying characters	5
	Uploading the attachments	4

contact with the material was mentioned as a critical issue. Regarding organization, participants complained about the limited time available for elaborating the project. Another issue was the workload management and partitioning the work equally among the group members. Furthermore, the scarce coordination and the low synchronization during the activities were mentioned. Regarding operating, participants asked to improve the layout of the software and a bigger window for working. The copy/past function from word to wikis created problems when applied in the activities. Other issues regarded inserting images, modifying characters in the document and managing the attachments. In addition, participants claimed that a synchronous modification and changing the text when other colleagues were working in wikis was impossible and asked for a tool for working synchronously.

Regarding question five (the differences between forum and wiki tools), participants reported several features that make the difference between forums and wikis. The families highlighted during the analysis were: forum and wiki (the complete list of families and codes are reported in Table 7).

Table 7
Families, codes and frequency distribution of the forum/wiki comparison (open question 5).

Families	Codes	Frequencies
Forum	Expressing opinions	22
	Sharing ideas	21
	Contrasting ideas	15
	Evaluating perspectives	15
	Useful for clarifying doubts	11
	Deep understanding	8
	Direct access	7
Wiki	Tool for collaborative writing	35
	Collective producing	21
	Complex tool	20
	Slow process	15
	Less communication	9
	Contributing to a unique process	3

Forums were considered useful tools for expressing opinions, for sharing and contrasting ideas, and evaluating perspectives. Forums induced a deep understanding of the topic and were also useful for clarifying doubts. Wikis were defined as good tools for collective producing and for collaborative writing, contributing to a unique process. Forums were considered having a more direct access than wikis, while wikis were perceived as requiring more time and inducing a slow process. In addition, wikis were described as more complex and difficult to use than forums. Regarding the social aspects induced by the use of the tools, participants claimed that during the wiki activities there was less communication and interaction than with the forum activities.

5. Discussion

A comparative analysis of forums and wikis was developed in the current paper. The data were collected in an asynchronous environment during a collaborative online experience. The research method included both quantitative and qualitative analyses and two main issues were investigated: the differences in the processes and the participants' perspectives of the most significant features of the forums and wikis.

Regarding the processes, the content analysis of the interactions provided evidence of the differences among forums and wikis: processes such as inferencing, evaluating, organizing and supporting were more evident during the forum discussions than in the wikis, while wikis induced mainly activities such as producing and developing. These results support the findings of related research on collaborative online learning (Ardaiz-Villanueva et al., 2011; Gielen & De Wever, 2015; Lin, Hou, Wang, & Chang, 2013), where it was found that reflecting and evaluating were typical actions of the forum, while constructing, modifying and revising a text characterized the wiki activities (Biasutti & EL-Deghaidy, 2015).

The qualitative aspects were assessed using an open-ended questionnaire for collecting the participants' perspective on the functionality of the collaborative tools. Both forums and wikis were considered tools that contributed to their professional growth offering opportunities to develop their cognitive, social, and ethical skills as well as inducing new ways of working (Kwon, Liu, & Johnson, 2014). They learned to collaborate and to support each other in a virtual environment (Biasutti & EL-Deghaidy, 2012). Several aspects were reported providing evidence of the commonalities and the differences of the tools which could be synthesized in the following aspects: cognition, sociability, and usability.

Regarding cognition, the open question data confirmed the results of the content analysis previously discussed. Different purposes in using forums and wikis were evident: forums were useful for sharing ideas, discussing, and evaluating perspectives, while wikis were used for developing a common collaborative document. Aspects such as selecting information, reasoning, inferencing on specific topics, comparing various interpretations, internalizing concepts, evaluating and synthesizing different positions were reported for the forums, while wikis involved generating ideas, developing plans, combining, modifying and revising texts. Forums were considered to induce a deeper understanding than wikis. This result supports the research findings by Miyazoe and Anderson (2010). The cognitive issues for forums included understanding the ideas of the others, deciding virtually and synthesizing, while understanding others' plans, modifying other parts and learning to work differently were the issues that emerged during the wiki activities.

Regarding sociability, both tools permitted participants to work collaboratively, to support each other and to perform the collaborative work. Forum activities were characterized by confronting, collaborating, networking and negotiating while wikis induced feelings of commitment, constant interaction and support, constructive participation and feeling part of a joint work. These results are in line with the previous literature (Hou & Wu, 2011; Tseng & Yeh, 2013). Regarding the weaknesses, forums and wikis had common problems such as different engagement and participation levels, the low collaboration levels and late responses. Finding an agreement was a specific issue for forums, while during wiki activities participants reported communication problems such as the lack of non-verbal communication, face to face contact and touching the material. These findings are in agreement with previous research by Kear et al. (2010), in which students reported that during wiki activities they lost any sense of interactivity and of community that can be developed within a forum.

Regarding usability, both tools were considered complete and flexible software for online collaboration (Wang & Woo, 2008). The directness of sharing ideas was appreciated for forums while wikis were convenient for having a framework, designing a plan, assigning tasks and developing a progressive work. Participants appreciated having direct intervention on the document and a constant control of the activities. Moreover, in the case of wikis working on a shared file and consulting past versions was considered useful. Common issues regarded technical problems such as slow Internet connection and participants willing to use synchronous tools such as audio chats. This result is in line with other research in which participants complained that wiki does not allow working synchronously (Meyer, 2010). Regarding the differences, wikis were considered complex tools inducing a slower process than forums. Also the perceived time involved in performing the activities was different: forums were considered easier to access than wikis, while wikis required more time and were more difficult to use than forums. This result is in agreement with Miyazoe and Anderson (2010) who argued a certain level of difficulty in using wikis in their subjects and Kear et al. (2010) who reported that wiki's development was considered slower and more difficult than forums.

As a general conclusion of the current study, it is not possible to state a superiority of one tool over another because each tool has his own characteristics and functions. Forums and wikis have complementary functions and should be organized to complete each other for scaffolding the students' learning. In addition, it would be relevant to differentiate which of the characteristics regarding cognition and sociability are due to the orientation of the tools and which are derived from the activity performed.

Regarding cognition, the orientation of forums is toward the use of processes such as sharing information and contrasting ideas, while the activity performed induced profound reasoning on interdisciplinarity, internalization, elaboration and synthesis of the concepts that emerged during the discussions. Participants developed an understanding of the ideas of others, and improved their skills to make online decisions. For wikis the orientation is toward the use of processes of modifying and revising texts, while the specific activity performed induced developing plans, generating ideas, combining and revising texts. Participants developed an understanding of others' plans, and they learned to modify the work respecting group intentions.

Regarding sociability, both tools are designed to support collaborative activities allowing access to the documents to multiple users. Forum is oriented toward behaviors such as interacting, confronting, and negotiating while wikis induced collaboration in elaborating a shared document. The characteristics derived from the activity for the forum included the possibility to exchange feelings and comments for supporting teamwork and to discuss organizational issues. These aspects developed a sense of community during the forum activities (Kear et al., 2010). Conversely, these aspects were not developed in the wikis activities which focused on designing the interdisciplinary project. In addition, evaluation was evident during the forum activities while it was missing during the wiki activities.

Regarding possible educational applications, these findings could be useful when designing collaborative virtual courses and deciding proper tool selection. The current study has several limitations such as the generalization of its findings in other contexts. Attentiveness could be taken into account when extending the findings to participants with different characteristics. The perspectives expressed by participants and the processes demonstrated during the collaborative activities could be influenced by the topic of the activities and the background of the students. Further research is necessary in order to verify whether similar results would occur in different settings, with different students and activities. The percentages of the identified processes could be collected in other contexts with students from different degrees, and disciplines as well.

5.1. Implications for further research

The results of the current study are a platform for developing future research on the processes involved in the use of online tools highlighting the implications for student learning. The findings also have implications on the research of tool assessment in virtual collaborative environments, and support the need for further studies on the nature of other online tools. Forums and wikis are the most extensive tools but analyzing the characteristics of tools such as blogs and chat could be interesting for highlighting their features.

Another issue regards the quality of online activities, which was not reported in the current study. A quality assessment could be useful for verifying through further research which kind of processes are most used by successful groups during the forum and wikis activities. The current findings could be considered a starting point from which to reflect on how to use ICT tools and to evaluate the effects on the quality of virtual activities. Reflecting the processes could give inputs for focusing further research on the meta-cognitive level and the development of self-regulated strategies of students. Implementing didactic activities on processes rather than products could be crucial for students' skills development in virtual classes.

Conflict of interest

No potential conflict of interest is reported by the author.

References

Ardaiz-Villanueva, O., Nicuesa-Chacón, X., Brene-Artazcoz, O., de Acedo Lizarraga, M. L. S., & de Acedo Baquedano, M. T. S. (2011). Evaluation of computer tools for idea generation and team formation in project-based learning. *Computers & Education, 56*(3), 700–711.

Biasutti, M. (2011). The student experience of a collaborative e-learning university module. *Computers & Education, 57*(3), 1865–1875.
Biasutti, M. (2015a). Creativity in virtual spaces: Communication modes employed during collaborative online music composition. *Thinking Skills and Creativity, 17*, 117–129.
Biasutti, M. (2015b). Assessing a collaborative online environment for music composition. *Educational Technology & Society, 18*(3), 49–63 (ISSN: 1436-4522n online and 1176-3647 print; Impact factor 1.018).
Biasutti, M. (2017). A coding scheme to analyse the online asynchronous discussion forums of university students. *Technology, Pedagogy and Education*. in press.
Biasutti, M., & EL-Deghaidy, H. (2012). Using Wiki in teacher education: Impact on knowledge management processes and student satisfaction. *Computers & Education, 59*(3), 861–872.
Biasutti, M., & EL-Deghaidy, H. (2015). Interdisciplinary project based learning: An online wiki experience in teacher education. *Technology, Pedagogy and Education, 24*(3), 339–355.
Donnelly, D. F., & Boniface, S. (2013). Consuming and creating: Early-adopting science teachers' perceptions and use of a wiki to support professional development. *Computers & Education, 68*, 9–20.
Gielen, M., & De Wever, B. (2015). Scripting the role of assessor and assessee in peer assessment in a wiki environment: Impact on peer feedback quality and product improvement. *Computers & Education, 88*, 370–386.
Goggins, S., & Xing, W. (2016). Building models explaining student participation behavior in asynchronous online discussion. *Computers & Education, 94*, 241–251.
Hou, H. T., & Wu, S. Y. (2011). Analyzing the social knowledge construction behavioral patterns of an online synchronous collaborative discussion instructional activity using an instant messaging tool: A case study. *Computers & Education, 57*(2), 1459–1468.
Ioannou, A., Brown, S. W., & Artino, A. R. (2015). Wikis and forums for collaborative problem-based activity: A systematic comparison of learners' interactions. *The Internet and Higher Education, 24*, 35–45.
Kear, K., Woodthorpe, J., Robertson, S., & Hutchison, M. (2010). From forums to wikis: Perspectives on tools for collaboration. *The Internet and Higher Education, 13*(4), 218–225.
Kwon, K., Liu, Y.-H., & Johnson, L. P. (2014). Group regulation and social-emotional interactions observed in computer supported collaborative learning: Comparison between good vs. poor collaborators. *Computers & Education, 78*, 185–200. http://dx.doi.org/10.1016/j.compedu.2014.06.004.
Lan, Y. F., Tsai, P. W., Yang, S. H., & Hung, C. L. (2012). Comparing the social knowledge construction behavioral patterns of problem-based online asynchronous discussion in e/m-learning environments. *Computers & Education, 59*(4), 1122–1135.
Lin, C. L., Hou, H. T., & Tsai, C. C. (2016). Analyzing the social knowledge construction and online searching behavior of high school learners during a collaborative problem solving learning activity: A multi-dimensional behavioral pattern analysis. *The Asia-Pacific Education Researcher, 25*(5–6), 893–906.
Lin, P. C., Hou, H. T., Wang, S. M., & Chang, K. E. (2013). Analyzing knowledge dimensions and cognitive process of a project-based online discussion instructional activity using Facebook in an adult and continuing education course. *Computers & Education, 60*(1), 110–121.
Lin, J. W., & Tsai, C. W. (2016). The impact of an online project-based learning environment with group awareness support on students with different self-regulation levels: An extended-period experiment. *Computers & Education, 99*, 28–38.
Meyer, K. A. (2010). A comparison of Web 2.0 tools in a doctoral course. *The Internet and Higher Education, 13*(4), 226–232.
Miranda, S., Marzano, A., & Lytras, M. D. (2017). A research initiative on the construction of innovative environments for teaching and learning. Montessori and Munari based psycho-pedagogical insights in computers and human behavior for the "new school". *Computers in Human Behavior, 66*, 282–290.
Miyazoe, T., & Anderson, T. (2010). Learning outcomes and students' perceptions of online writing simultaneous implementation of a forum, blog and wiki in a EFL blended learning setting. *System, 36*(2), 185–199.
Ng, E. M. (2016). Fostering pre-service teachers' self-regulated learning through self-and peer assessment of wiki projects. *Computers & Education, 98*, 180–191.
Shih, W. C., Tseng, S. S., & Yang, C. T. (2008). Wiki-based rapid prototyping for teaching-material design in e-Learning grids. *Computer & Education, 57*(3), 1037–1057.
Tseng, H. W., & Yeh, H.-T. (2013). Team members' perceptions of online teamwork learning experiences and building teamwork trust: A qualitative study. *Computers & Education, 63*, 1–9.
Twinning, P., Heller, R. S., Nussbaum, M., & Tsai, C. C. (2017). Some guidance on conducting and reporting qualitative studies. *Computers & Education, 106*, A1–A9.
Wang, Q. Y., & Woo, H. L. (2008). The affordances of weblogs and discussion forums for learning: A comparative analysis. *Educational Technology, 48*(5), 34–38.
Wegerif, R. (2006). A dialogic understanding of the relationship between CSCL and teaching thinking skills. *International Journal of Computer-supported Collaborative Learning, 1*(1), 143–157.
Wolff, T. E. (2010). The patent information user group-collaborating via the PIUG wiki and discussion forums. *Computers & Education, 32*(2), 141–144.
Yücel, Ü. A., & Usluel, Y. K. (2016). Knowledge building and the quantity, content and quality of the interaction and participation of students in an online collaborative learning environment. *Computers & Education, 97*, 31–48.

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