

Students' collaborative patterns in a wiki-authoring project

Towards a theoretical and analysis framework

Athanassios Jimoyiannis and Dimitrios Roussinos

*Department of Social and Educational Policy,
University of Peloponnese, Korinthos, Greece*

Abstract

Purpose – The purpose of this paper is to present a case study investigating students' patterns of collaborative content creation in a wiki project that was designed to promote self-directed and collaborative learning in the context of a university course. In addition, it proposes a new organizational and analysis framework of students' constructive and collaborative activities in wiki-authoring projects.

Design/methodology/approach – The key notion, around which the present conceptual and research framework was built, is that a wiki integrates a content space and a social (discussion) space both considered in collaborative manner. The analysis of student contributions to their wiki was organized along two dimensions: interaction and refection posts were analyzed using the framework of Community of Inquiry; content contributions to the wiki pages were classified into five categories: creating a new page, content expansion, content reorganization, content enrichment (with video, images or hyperlinks) and editing and grammatical corrections.

Findings – The analysis of the research data revealed important information that could help to depict an overall representation of individual interactions and contributions, students' collaborative performance within wiki groups as well as the overall evolution of the wiki content. The findings showed that properly designed wiki projects can be effectively introduced in higher education with the aim to support students to improve their authoring and collaborative skills through critical thinking, peer interaction and reflection.

Research limitations/implications – The findings of this study are limited by the specific sample and the context of implementation. Future research will be directed to various educational contexts and to include in the analysis students' experiences and learning outcomes of wiki-authoring activities.

Practical implications – The results provided supportive evidence that successful wiki-based projects in higher education depend on the way students' individual and collaborative authoring contributions are interwoven. Effective wiki-based interventions should consider students' learning as the outcome of both, individual and collaborative work, determined by self and peer reflection in wiki groups.

Originality/value – The originality and the significance of the present study are justified by the conceptual framework proposed which can guide both aspects of students' learning presence within self-directed wiki-authoring projects, i.e. research and educational practice (design and monitoring).

Keywords e-Learning, Collaborative learning, Self-directed learning, Wikis, Collaborative authoring

Paper type Research paper

1. Introduction

The emerging web technologies and the diffusion of open educational resources have promoted new pedagogical strategies and new forms of e-learning interventions in higher education and professional development as well. The web has been transformed from an information medium to an open platform where content can be collaboratively created, adapted, expanded and shared among members in connected groups or networks (Dede, 2011; McLoughlin and Lee, 2010). Among Web 2.0 applications, wikis have received intense educational and research interest because of their participatory, authoring and collaborative characteristics. They have been widely promoted as collaborative tools that enable students to be actively involved and work with peers, to review and create content, to share content and ideas and, finally, to construct new knowledge in a collaborative manner (Hadjerrouit, 2014; Judd *et al.*, 2010; Lin and Reigeluth, 2016). Due to their organizational and pedagogical features, wikis offer enhanced opportunities to the students to express and exchange ideas, to share resources and content, and to implement group work through critical, reflective and collaborative thinking (Roussinos and Jimoyiannis, 2011).



Existing research findings have shown that wikis can support collaboration, facilitate peer review, encourage reflective writing and promote students' movement from surface learning to deeper understanding and knowledge construction (Bradley *et al.*, 2010; Wheeler *et al.*, 2008; Xiao and Lucking, 2008). Learning through wiki-based activities takes place through a process of writing and adding individual knowledge to existing content. Collaboration with other learners leads to individual learning and, at the same time, knowledge is expected to evolve within a community of learning (Moskaliuk *et al.*, 2012).

Despite the growing body of studies about educational wikis (Bradley *et al.*, 2010; Li and Zhu, 2013; Trentin, 2009; Woo *et al.*, 2011), existing literature lacks a consistent framework for investigating students' collaboration patterns during wiki-based activities and the evolution of their wiki products. In the latter years, educational research was directed toward studying students' collaborative patterns in wiki-writing processes (Du *et al.*, 2016; Lai *et al.*, 2016; Li and Zhu, 2013; Roussinos and Jimoyiannis, 2013).

This paper presents an investigation on university students' collaborative authoring of wiki content, in the context of self-directed wiki-based project. The theoretical background of wiki-based learning that supports the present research is presented in detail. The proposed working framework offers a combined analysis schema of students' collaborative authoring actions in the wiki pages and the related interaction posts in the wiki forum. Following, the results of an empirical investigation are presented, which offer new information regarding students' interaction, creativity and collaboration in wiki-based authoring projects.

2. Theoretical background

As a result of their non-hierarchical and collaborative attributes, wikis have been used in educational settings in many different ways and learning objectives. Typically, wikis are considered as the most appropriate tools for long-term projects and group activities, where a communal space is required for discussions, ideas and content sharing, and collaborative creation of new content artifacts. Wikis offer enhanced opportunities to the students for engagement, group working, critical thinking, analysis and synthesis of ideas, and collaborative creation of content through interaction and reflection, by extending the narrow limits of the classroom (Hadjerrouit, 2014; Judd *et al.*, 2010; Moskaliuk *et al.*, 2012; Roussinos and Jimoyiannis, 2011; Trentin, 2009; Wheeler *et al.*, 2008).

2.1 Collaborative affordances of wikis

There are three main features that justify why wikis are efficient tools to support collaborative and constructivist learning approaches (Roussinos and Jimoyiannis, 2011).

Web editing space. A wiki constitutes an efficient web-based authoring space, available to a group or even a whole community of learners, which enables collaborative editing and content creation. Students, in particular, can add, delete and modify any part of the common wiki content. In addition, they can incorporate hyperlinks to other content (e.g. wiki pages and the web), and multimedia (graphics, simulations, video and sound).

Discussion space. Every wiki page incorporates a separate discussion space. Using this tool, the students have the opportunity to exchange information about new topics and basic concepts, to present and test their knowledge, to discuss and negotiate ideas about changes, improvements and revisions in the particular wiki page. Shared understanding and knowledge construction is thus expected to appear through common negotiation processes that take place within the wiki.

Revision history. Successive changes and versions of the wiki pages can be stored in the wiki history and they are available to be compared and presented in a backward format. The students, and the educators as well, can trace revisions and develop an overall view of the wiki evolution process. Any participant can contribute to the wiki content and reflect on others. Therefore, students' contributions are emerging in a non-hierarchical, indirect and collaborative manner.

As a result of the key features above (i.e. editing, discussion and history tools), wiki environments can operate as content composition systems, information repositories, online discussion spaces and collaboration spaces. Therefore, they can effectively support long-term projects that require a central community space for work planning and management, virtual meetings and discussions, content sharing, as well as constructive and collaborative procedures.

2.2 Toward a framework of wiki-based collaborative authoring

Student generated content through engagement, reflection and collaborative construction was a critical factor in the wiki project presented in this paper. The primary objectives of student generated content are to stimulate peer participation and collective knowledge by making transparent individual learning trajectories and to promote collaboration, creativity and identity among peers in a learning community (Jimoyiannis, 2015). Literature suggested two main categories of student generated content in Web 2.0 spaces: student performance content and student professional content (Ehlers, 2013; Jimoyiannis, 2015; Lee and McLoughlin, 2007).

Student performance content is dynamically and spontaneously generated by the students in an authoring project. The development/evolution of the wiki pages reflects completed assignments, artifacts or deliverables and provides evidence of the overall learning process (e.g. successive contributions, drafts of solutions, descriptions of mistakes, students' difficulties, peer interaction and feedback, collaboration indicators, etc.). Student performance content may include retrieved content after student-directed information searching and evaluation processes. The students use the wiki pages to share web resources and open content with peers, as well as to discuss about and reflect on them. In addition, content contributions in the form of students' summaries, reviews, reflective and collaborative writing are also expected to appear in wikis. Successive contributions in multiple content formats (text, visual, audio and video) constitute dynamically evolving artifacts through learners' creating, adding, suggesting, expanding, reorganizing, enriching and correcting content. Discussion content is another type of content produced after asynchronous communication and discourse in the wiki forum. Typically, it includes questions and replies, proposals and guidelines, new ideas, feedback, support or commentaries to existing content contributions in the wiki pages.

Finally, student professional content is produced by the students that participate in a specific educational-learning trajectory. It is actually a long-term procedure which represents a coherent view of a topic or knowledge domain under study; i.e. the wiki evolution process and the artifact (the wiki product), which reflect students' performance content in order to achieve the quality criteria of domain professional content.

The analysis above concludes that student performance content constitutes the main challenge in wiki-based interventions and determines the transition from tutor-led to open learning approaches, where the wiki content will be constructed by the learners themselves in a dynamic and evolving manner. Ideally, this reflects a social process of learning which is of long-term value for every individual student and his peers in a working group.

However, there is little research that focuses on studying the characteristics of the collaborative authoring process and the consequent collaborative learning that both appear to happen when students develop their understanding through social interaction, i.e. by sharing, negotiating and creating new information in a wiki environment. The conceptual and research framework proposed in this study is that a wiki integrates a content space and a social (discussion) space both considered in a collaborative manner. Actually, this is an emergent learning process that promotes individual learning and at the same time, community learning. The asynchronous interaction process among students is combined with content material creation activities (both individual and collaborative) through the wiki. Collaboration with peers is based on debating and explaining ideas, sharing resources, and participating in common inquiry activities. During the process of collaborative wiki authoring, the students can share their knowledge with others and harness existing content

in order to add or expand their own knowledge. It is thus expected that students will become active members of a learning community.

Figure 1 depicts an integrated framework that could guide the design and the implementation of wiki-based collaborative authoring projects. It includes four mutually related phases: introduction, exploration, implementation and integration. Students' social and collaborative learning skills that could lead to the creation of a new-common digital artifact, the wiki product, are directed by a pedagogy based on:

- engagement, interaction and self-direction;
- an evolving culture of group working and learning from each other;
- collaborative and reflective creation of new content; and
- building a sense of community and the notion of common creation.

3. Literature review

The academic literature review indicated that wikis were used in various educational contexts and levels, i.e. in primary (Pifarré and Fisher, 2011; Woo *et al.*, 2011), secondary (Grant, 2009) and post-secondary education (Hughes and Narayan, 2009), undergraduate and post-graduate education (Brodahl *et al.*, 2011; Naismith *et al.*, 2011; Roussinos and Jimoyiannis, 2011; Zorko, 2009), and teacher professional development (Wheeler and Wheeler, 2009).

In addition, a growing interest was recorded regarding the use of wikis in higher education in the context of collaborative learning. However, there is little consensus on the

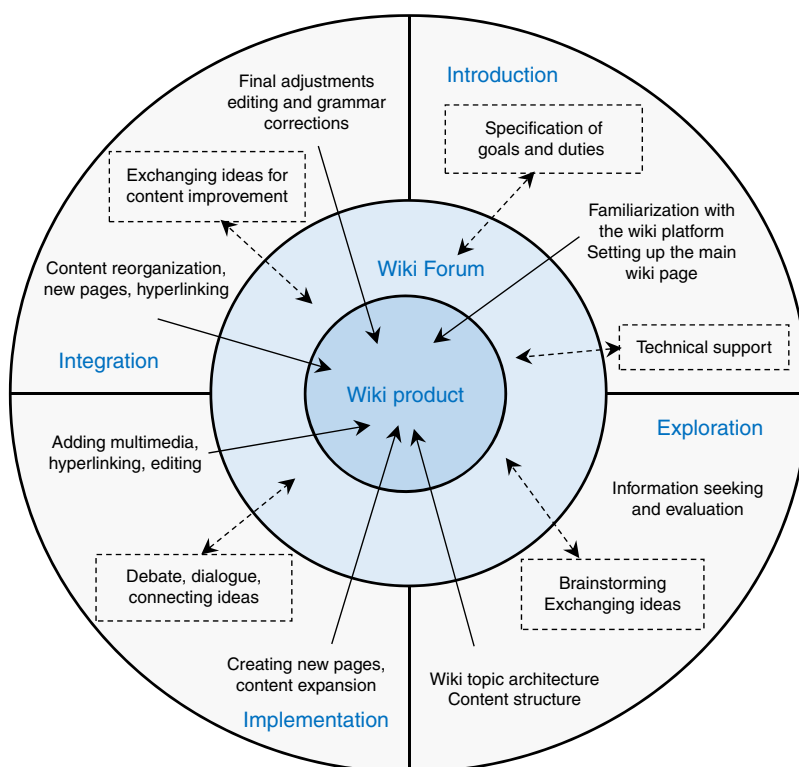


Figure 1.
Integrated framework
for the design of wiki-
based collaborative
authoring projects

best ways to integrate wikis with other student activities and existing technologies (Naismith *et al.*, 2011). Judd *et al.* (2010) suggested that a sound pedagogy is necessary to promote participation and collaboration among students in wiki-based learning.

To present a detailed classification of current research regarding wikis in education, we have identified four main categories, as following.

3.1 Educational approaches of wikis

Literature review on the pedagogical approaches of using wikis suggested various types of educational interventions. However, most applications in educational practice do harness more than one of the aspects below. For example, wikis were effectively used as course management tool in undergraduate courses (Zorko, 2009; Bradley *et al.*, 2010). Stafford *et al.* (2014) introduced wiki-based exercises to a long-running cognitive psychology course. Over two yearly cohorts, they found that the students who participated in the wiki collaborative tasks scored higher on the final written exam.

Wikis were also applied, in various contexts, as group authoring and collaboration tools (Neumann and Hood, 2009; Trentin, 2009; Kessler, 2009; Kost, 2011; Li and Zhu, 2013). They were used to enhance writing skills in primary (Pifarré and Fisher, 2011) and secondary education students (Mak and Coniam, 2008). Recently, in the context of a university course of English as foreign language, Lai *et al.* (2016) examined students' collaboration patterns and their performance in wiki-based collaborative writing projects.

In addition, wikis have been widely used as spaces to support project-based learning (Alyousef and Picard, 2011; Lin and Kelsey, 2009; Roussinos and Jimoyiannis, 2013). Hoffmann (2008) studied the use of wikis as research and data collection tools. Recently, Lawrie *et al.* (2016) reported on the effectiveness of a wiki notebook, in a chemistry inquiry laboratory toward supporting students' collaborative content creation as well as their learning and assessment.

Hutchison and Colwell (2012) explored the use of a wiki as a tool to support an online professional learning community among induction and mentor teachers. Likewise, Ng (2016) applied wikis in preservice teacher professional development and investigated, through the lens of self-regulated learning, teachers' ability to apply their pedagogical knowledge and skills in order to create learning materials for young children.

3.2 Student perceptions and difficulties in wikis

The majority of the published studies has been directed toward students' perceptions of wikis as educational environments and the difficulties they face during wiki-based learning initiatives (Li, 2015; Naismith *et al.*, 2011; Witney and Smallbone, 2011; Zorko, 2009). Existing literature has shown that most students are generally positive about collaborative wiki projects and they consider that wikis are effective and easy to use technologies (Bradley *et al.*, 2010; Roussinos and Jimoyiannis, 2011; Woo *et al.*, 2011).

On the other hand, literature review indicated four major categories of students' difficulties and barriers in wiki-based learning: poor culture and feelings of group work and publicity, lack of collaborative skills, lack of ownership regarding the wiki product and technical difficulties on using the wiki tool. Zorko (2009) found that the students preferred to use face-to-face communication and other familiar tools, like e-mail and MSN, in order to discuss about their contributions and improve their wiki creations. Karasavvidis (2010) argued that students' difficulties to collaborate with others are related to their lack of skills, attitudes and strategies that could help them to be effectively engaged in wiki collaborative tasks. Similarly, Elgort *et al.* (2008) observed that a significant number of students preferred to work alone to implement their assignments rather than contributing to their group wiki.

In addition, many students appear to have problems with regards to the ownership of the wiki product. Wheeler *et al.* (2008) reported that the students were resistant when their contributions were deleted or modified by peer members in their group.

3.3 Analysis of the wiki product

Another research dimension concerns the wiki itself, as a product. Basically, the analysis uses system records/log files and quantitative data representing students' individual and group actions within wikis (e.g. Bradley *et al.*, 2010; Kessler, 2009; Trentin, 2009; Wheeler *et al.*, 2008).

Using Social Network Analysis methods, Kimmerle *et al.* (2010) proposed a model to visualize co-evolution of Wikipedia artifacts and the authors involved. By adopting that knowledge is a socio-cultural process within a community, Cress and her colleagues proposed a co-evolution model of the cognitive (personal) system and social (wiki) system to describe the collaborative knowledge construction by authors in Wikipedia (Cress and Kimmerle, 2008; Moskaliuk *et al.*, 2012). Their model has been applied to depict the interplay between externalization of individual knowledge into a shared artifact (a Wikipedia topic), and the internalization of information from this artifact (based on adjusting and changing existing conceptual schemata) that is expected to lead to individual learning.

3.4 Analysis of student collaborative patterns in wikis

Despite the promising uses of wikis in educational practice, empirical research on investigating students' collaborative patterns and the consequent impact on their learning is rather limited. The need to outline an integrated framework of analyzing students' engagement, interaction and collaborative creations in wikis has been advocated by many researchers (Bradley *et al.*, 2010; Trentin, 2009; Woo *et al.*, 2011). Recently, the research has been directed to analyze patterns of interaction in small groups during wiki collaborative writing in language learning. Hadjerrouit (2014) observed that students were more concerned about content formatting and adding information to existing wiki pages rather than to revise peer contributions.

Roussinos and Jimoyiannis (2013) identified four different types/patterns of collaboration among university students in wiki groups of four to five persons: low-visible interaction, evidenced by content contribution from one or two individuals and few messages among group members; low-collaboration pattern, where students worked individually and exhibited low interaction and collaborative creation of content; moderate collaboration, where most members in the group participated with a significant number of content contributions and parallel discussions-ideas interchanging; and high-collaboration pattern, where almost all students in the group exhibited an equivalent contribution and efficient collaboration by co-creating their group wiki.

Similarly, Li and Zhu (2013) analyzed the nature of computer-mediated interaction among students that performed collaborative writing tasks with wikis, in the context of an English as a foreign language course. They investigated three small groups which displayed three distinct patterns of collaboration: the students did all collectively contribute and were mutually supportive, one student had the control of the wiki while group members had unequal contribution, and there was no peer interaction and mutual scaffolding.

3.5 Rationale and research questions

This study was designed with the ambition to shed light into students' engagement, reflective dialogue and collaborative development of wiki content, in the context of self-directed authoring project activities, upon which knowledge construction is expected to appear. Therefore, the research objective was to apply and evaluate a new conceptual framework to analyze wiki-authoring activities. The proposed working framework offers a new analysis schema that combines students' contributions to the wiki space organized along two dimensions: collaborative authoring actions in the wiki pages and interaction and reflection posts using the Community of Inquiry (CoI) model (Garrison *et al.*, 2000, 2001).

The following research questions were addressed:

RQ1. Can we achieve a consistent and mutually interrelated view of wiki-authoring contributions along individual and group levels?

- RQ2. What is the nature of individual and group performance in wiki-based collaborative authoring activities?
- RQ3. Can we depict the evolution of students' collaborative activities in long-term wiki projects?

30

4. Study and method

4.1 Context and research design

The wiki-based intervention presented in this paper was designed and implemented in the context of a first semester obligatory course, entitled “Introduction to Information and Communication Technologies”, offered at the Department of Social and Educational Policy, University of Peloponnese, in Greece. It was designed as a blended course that included face-to-face sessions in the classroom combined with online collaborative work in the wiki.

A total of 47 students were enrolled in this graduate course. They were randomly assigned into 11 groups including four or five students. Every group was required to investigate a specific ICT topic regarding its technological and societal aspects. The students were asked to collaboratively create a comprehensive topic in the wiki related to the course and, specifically, to social or educational aspects of ICTs. They were informed that they were both, mutually and individually, responsible to collaboratively create their wiki by planning, discussing, authoring, modifying and criticizing their group wiki pages.

The overall wiki project was administered by the authors and the development process (workflow) was structured into four phases, as shown in Figure 2. The instructors were continually providing the necessary technical assistance and guidelines regarding the design of the wiki, facilitating students' interaction and discourse in the wiki forum, and encouraging them to share their knowledge and collaboratively create new content in the wiki.

Wikispaces was the hosting platform. Separate wiki pages were prepared by the authors for reference, like Help, Students (personal information details), Resources and Wiki news. Figure 3 shows a screenshot of the wiki page related to the subtopic “ICT and vulnerable social groups” which was included in the Group 1 wiki-topic entitled “ICT and Society.”

The case study approach was used because of three reasons (Cohen *et al.*, 2007): this method is suitable for analytical description rather than statistical generalization of students' engagement in the wiki activities; it helps to find out whether the results support the theoretical framework proposed regarding in wiki-based authoring activities; by collecting both quantitative and qualitative data we expect to achieve a rich description of activities and their chronological evolution, to reveal both individual and group events, and to attain a comprehensive understanding of students' collaborative patterns in the wiki activities.

The results presented in this paper concern two groups of four students, named Group 1 and Group 2. Their wiki topics could be considered as indicative examples of students' collaborative content creation in the whole course project.

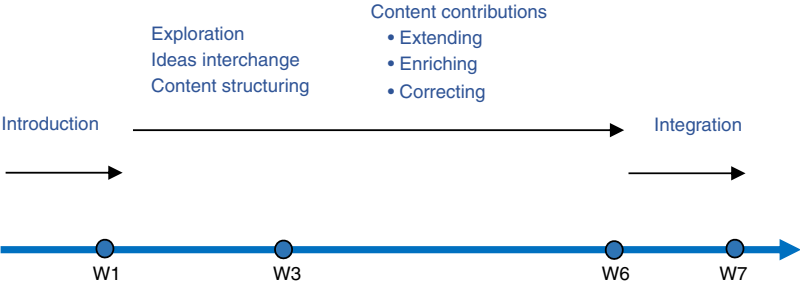


Figure 2.
The structure
and phases of the
wiki project

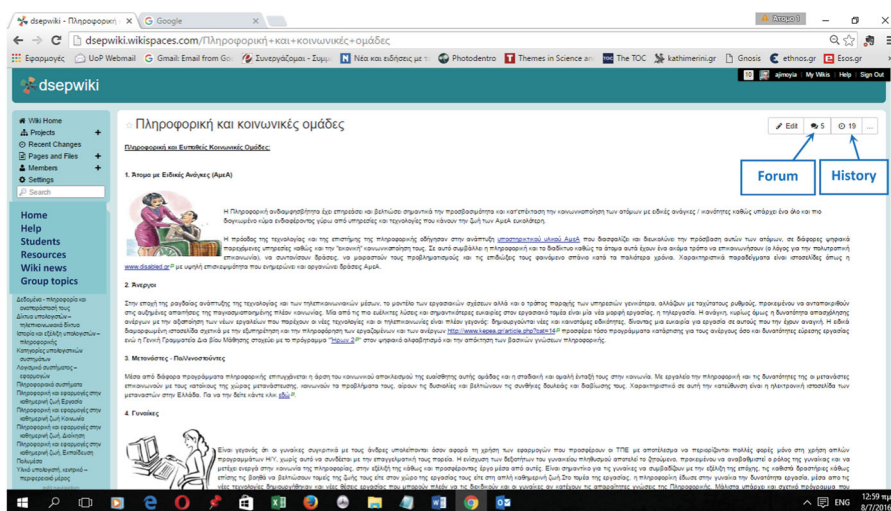


Figure 3.
An example
of wiki pages

Notes: Subtopic, ICT and vulnerable social groups

4.2 Analysis framework

The theoretical foundations that determine this particular research were rooted in the socio-cultural theory of knowledge construction that takes place within a community (Scardamalia and Bereiter, 2006). It is expected that knowledge is constructed when many members (learners) are able to contribute to the evolving-emerging process of content creation within the wiki community. Content expansion, content modifications, incorporating multimedia (photos, videos and animations), and linking content to internal wiki pages as well as the web, are good examples of new knowledge construction.

The analysis framework proposed in the present paper includes two dimensions, as far as the students' contributions to the wiki pages are concerned:

- (1) Students' interaction and reflection: students' posts in the wiki discussion area typically incorporate questions and replies, proposals and guidelines, suggestions for content resources, new ideas or comments to existing content as well as personal communication and mutual support. Their analysis was implemented by using the CoI model (Garrison *et al.*, 2000), which is a reliable theoretical and methodological tool to describe the procedures that support a comprehensive, collaborative and constructive educational experience, applicable in various online learning environments (e.g. Shea and Bidjerano, 2009; Jimoyiannis and Angelaina, 2012). The model is based on three dimensions that reflect students' interaction and enable knowledge construction within the wiki group: social presence, cognitive presence, and teaching presence (Table I).
- (2) Content changes (authoring): the analysis of student performance content in the wiki was implemented by using a new classification schema proposed in this paper. Therefore content changes were split into five categories: creating a new page, content expansion, content reorganization, content enrichment (with video, images or hyperlinks) and editing and grammatical corrections (Table I). Content analysis was implemented by also taking account of the posts previously appeared in the discussion space that can be associated to particular students' contributions.

Table I.
Analysis framework
of students'
contributions to
the wiki pages

Dimensions	Elements	Categories
Students' interaction and reflection	Social presence	Open communication Emotional expression Group cohesion
	Cognitive presence	Triggering Exploration Integration Resolution
	Teaching presence	Design and organization Facilitating discourse Direct instruction
Content contribution	Creating a new page	New page
	Content expansion	Adding-expanding content New ideas, synthesis of ideas
	Content reorganization	Deleting text content
		Moving text within the same page
		Moving text into other page
	Content enrichment	Adding images and videos Hyperlinking
	Corrections	Grammatical Format

5. Results

5.1 Individual contributions

Elaboration of students' ideas, through dialogue and debate, and the consequent meaningful integration into the various wiki topics are critical indicators of collective knowledge construction within the wiki groups.

Table II shows an overall view of students' performance. Group 1 is an example of high-content contribution and moderate student interaction. Their topic was related to ICT in education and included 34 wiki pages with 269 edits and 52 discussion posts. Students' individual contribution patterns represent moderate collaboration among peers; most members in this group contributed to the wiki content with a significant number of edits but few numbers of posts.

On the other hand, the students in Group 2 exhibited a higher level of collaboration. All students in this group had a balanced-equivalent contribution with wiki edits and postings, which reflects an efficient way of collaboration and co-creation of wiki content. Students' performance in the Group 2 wiki included a total of 40 pages with 405 edits and 162 discussion posts. The value of the average posts per member (40.5) is an indicator of tight interaction among peers in this group and collaborative content creation, which was the outcome of enhanced dialogue, learning presence and collaborative construction within the wiki group.

Table III shows the results of students' content contributions in Groups 1 and 2, classified within each category of the analysis schema. Despite that the rates of students in Group 2 were higher, their contribution patterns appeared quite similar in both groups.

Table II.
Edits and posts
per member in the
wiki groups

<i>Group 1</i>	S1-1	S1-2	S1-3	S1-4	Group average
Edits	86	121	59	3	76.3
Edits (%)	32.0	45.0	21.9	1.1	
Posts	7	21	22	2	13.0
Posts (%)	13.5	40.4	42.3	3.8	
<i>Group 2</i>	S2-1	S2-2	S2-3	S2-4	Group average
Edits	128	53	125	99	101.3
Edits (%)	31.6	13.1	30.9	24.4	
Posts	57	22	60	23	40.5
Posts (%)	35.2	13.6	37.0	14.2	

Editing and grammar corrections were the most frequent actions. This confirms the findings of Hadjerrouit (2014), who observed that content formatting was the most frequent student action followed by adding information and links. Students in Group 1 preferred to pay more attention on content enrichment by including in their wiki pages images, graphics, video YouTube and hyperlinks to external websites. On the other hand, the students in Group 2 tended to collaboratively expand content in their wiki pages in a more systematic way (20.4 percent of their overall contributions were assigned into this category). Figure 4 depicts the frequency of content contributions in both groups.

5.2 Collaboration and wiki evolution

Overviewing the archived versions of the wiki pages and individual contributions (inquiry, sharing resources, interchanging and negotiation of ideas, interaction with peers, suggesting content changes, content authoring and co-creation) has reflected students' learning behavior, including group working, information research abilities and communication skills, ability to examine issues using different perspectives, collaboration and achieving new knowledge in specific ICT topics.

Content analysis of the postings showed that students, in general, were successfully engaged into the wiki activities. They provided one another with social and emotional support thus creating a CoI, which was continuously evolving through dialogue, ideas interchange, content resources sharing, and collaborative creation of wiki content. Table IV presents indicative examples of student contributions to the wiki forum, classified in elements and categories according to the CoI model.

Content contributions	Frequency (%)	
	Group 1	Group 2
New wiki page	9.7	8.3
Expansion	17.6	20.4
Reorganization	6.7	5.7
Enrichment	23.1	18.7
Editing	42.9	47.0
Total	100	100

Table III.
Classification of
content contributions
per wiki group

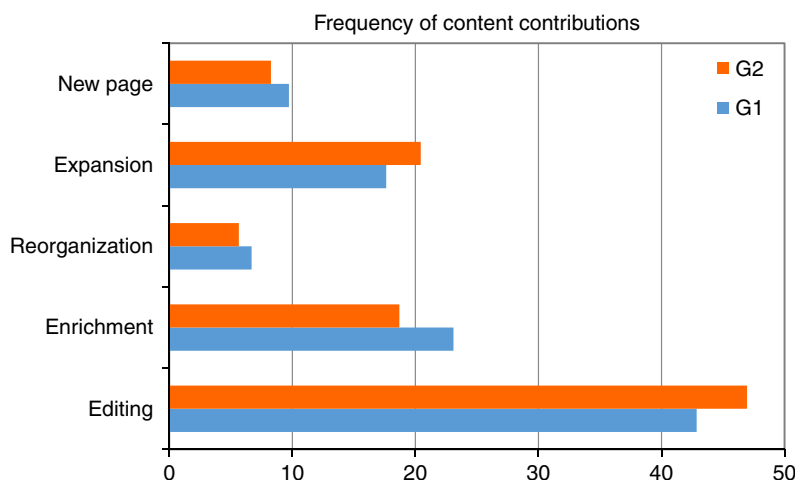


Figure 4.
Classification (percent)
of student content
contributions
per wiki group

Elements	Indicators	Transcript examples
Social presence	Open communication	I have just seen your suggestions!! Best wishes for a good starting!!! You are right! Your example is still relevant
	Emotional expression	Very good!!! I think it's fine now ... It is better without the bullet! ... ☺ Let's have fun!! It's not bad! ☺
Cognitive presence	Group cohesion	Here I am, too. During the weekend I had the opportunity to make a brief exploration of our topic ... I agree with F as far as the organization of our activities Best wishes for a successful project! Hi girls!! I have done some corrections to the home page but, after saving, the pages "New school" and "asynchronous learning" disappeared ... I do not know how to recover them ... Can you help me?? Do not worry. I have recovered all the pages. Everything is under control!!!
	Triggering	I have started a new page entitled "The Information Society" presenting information about the impact of ICT to the various sectors of society. Please, make corrections and add new content material in this page
	Exploration	I have done changes in the main wiki page and also in some other pages, where I found minor grammatical and syntactical flaws. I have also added some new ideas ... Feel free to make any changes I have read the new content you have added. I found it quite interesting. If we could agree and finalize the structure of this page, I would suggest to add new information found in the following websites ...
	Personal view	I agree with Tonia ... I would suggest including a more generic introduction about the impact of ICT in society before focusing on specific issues, i.e. how ICTs can be integrated in our society and what are the main benefits. I would suggest including some other topics like ICT and disabled people, youth, mass media, etc. It is also interesting to focus on females, for example mothers working from distance, e.g. at home. They are not all clear to me but I think it could be a good starting point to write our introduction. What are your opinions?
	Explanation	I have done some changes to the main page because it seemed a little rough. I think it is good to make an outline of the main phases of using ICTs in education. Some historical data should be also included. Of course, you can make any changes or remove anything you consider superfluous. I have also added some new links, images and videos which, hopefully, can help to improve our wiki content. I feel that it is more interesting now
	Integration	I would suggest to make a reference to education and its connection to the workplace. So, we can enrich our content material. Actually, education and society are tightly interrelated areas
	Design and organization	Dear Maria, we have already discussed about the structure of this section, the sub-topics included, etc. I do believe that including an extended text is not exactly what we need to do. I feel that it is worthy to add more page links, videos, new resources, etc. like the modifications done by Helen
	Facilitating discourse	So, we need to discuss about the main topics. It does not make any sense to add new text without looking at the main objective. It is not good to expand our work to themes that have been assigned to other groups ... we can make a link to their page. However, we could leave it pending until the final phase, in case that the work of the other groups is not satisfactory
	Direct instruction	Tutor: you have started very well but let me remind some tips: First, add the terms Information Society and Information and Communication Technologies in the main wiki page; then you can create links to the corresponding-existing pages Keep the format of your wiki pages as simple as possible Be careful while typing; let always a space after comma or dot Use paragraph alignment Add your bibliography in end of the main wiki page Feel free to contact me if you have any difficulties

Table IV.
Coding and
analysis scheme

Figure 5 offers a visualization of the collaborative content creation along the timeline of the wiki project. In Group 2, almost all students performed efficiently and contributed in a balanced and equivalent way with both, content edits and discussion posts. The development process of the wiki indicates a dynamic and emerging community among participants based on students' self-directed initiatives in the wiki pages, along the various developmental phases. They interacted with each other, they shared ideas and jointly created their wiki content, even during the Christmas break. It appears that students in this group negotiated and discussed in a consistent way about their writing actions as well as the main ideas/concepts to be presented in their wiki pages. Wiki-Group 2 appeared as a cohesive working group where all members were mutually responsible and influenced each other to contribute and improve their creations. On the other hand, Figure 5 shows that the students in Group 1 were systematically collaborating, mainly, during the exploration phase and the first weeks of the content creation. Their contribution activities in the wiki were getting slower, along the timeline evolution of the project.

6. Conclusion

This paper reported on an investigation concerning the design and the implementation of a wiki authoring project implemented in the context of a university course with the aim to promote students' learning through self-directed and collaborative activities in the wiki platform. A new analysis framework was proposed which is rooted in the key collaborative affordances of wiki environments (editing, history and discussion tools). It uses a combined analysis of successive content in the wiki: student edits, classified into

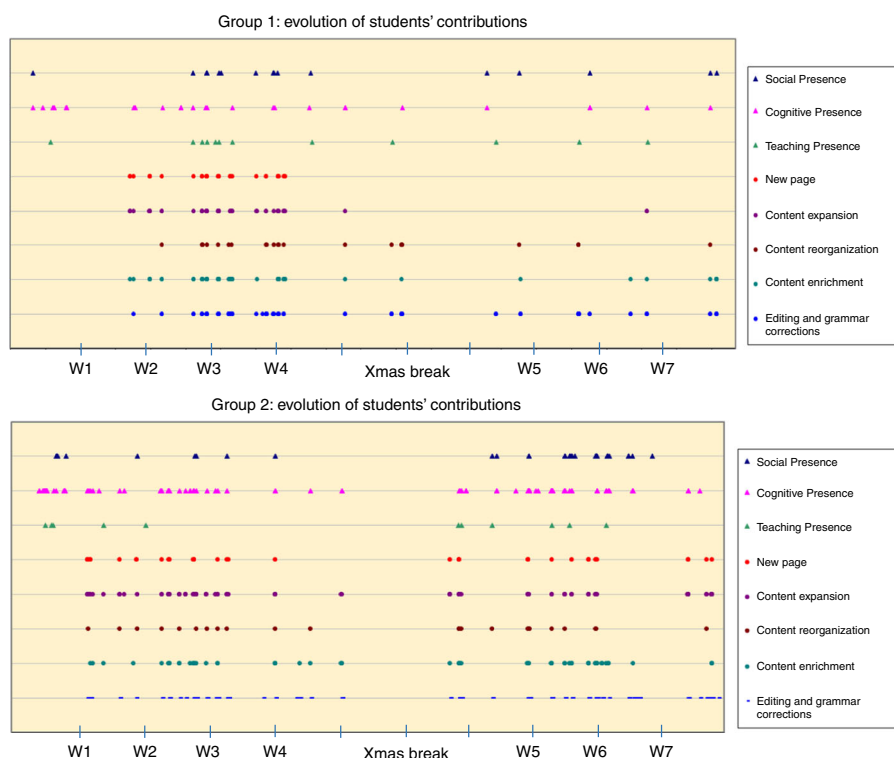


Figure 5.
Evolution of students'
contributions to the
wiki pages

five categories: new page creation, content expansion, content reorganization, content enrichment, and editing-grammatical corrections, and the related discussion posts, using the CoI model.

The research findings showed that wikis can be effectively introduced in higher education and support students to improve their authoring skills, critical thinking, peer interaction and reflection, as well as their collaborative skills. The results provided supportive evidence that successful wiki-based authoring strongly depends on the way students' individual and collaborative contributions are interwoven and combined. Therefore, an effective wiki-based e-learning initiative should consider students' learning as the outcome of individual and collaborative work, which are determined by self- and peer-reflection in the wiki group. In this context, it is expected that students can achieve higher cognitive levels through communication, collaboration and critical thinking within a supportive community of learning.

The proposed framework of depicting students' collaborative and constructive procedures in wiki activities contributes to the existing literature and could guide both learning design and future research in wiki-based learning. In addition, this study provided important information that can help both researchers and educators to monitor and visualize the evolution of students' collaborative activities in long-term wiki projects. It is thus expected that the conceptual framework proposed in this paper could help educators and instructional designers to adopt an open learning philosophy toward implementing wiki-authoring projects with the aim to enhance students' engagement, authoring skills, reflection, and collaborative learning.

The present study is limited by the specific sample and the context of implementation. Another limitation is related to the fact that we were not able to capture data regarding students' interaction off-line (outside the wiki platform). Therefore, the analysis of students' interaction and reflection was mainly based on their presence in the wiki. Third, the study was carried in a group of young students who were just starting their university studies; we are expecting, therefore, that student collaboration actions might be influenced by their strong attitudes of rote learning and individual work that are prevalent in Greek schools.

Our current efforts are addressed toward depicting students' learning presence along wiki-based activities by using social network analysis of their contributions to online discourse in order to identify students' connections, the individual learners' profile, and the influence by peers when they share knowledge, common practices and values. In addition, qualitative interview data extracted from the participants is expected to reveal important information about students' learning presence and knowledge construction, within an evolving community built in the wiki.

References

- Alyousef, H.S. and Picard, M.Y. (2011), "Cooperative or collaborative literacy practices: mapping metadiscourse in a business students' wiki group project", *Australasian Journal of Educational Technology*, Vol. 27 No. 3, pp. 463-480.
- Bradley, L., Lindstrom, B., Rystedt, H. and Vigmo, S. (2010), "Language learning in a wiki: student contributions in a web based learning environment", *Themes in Science and Technology Education*, Vol. 3 Nos 1-2, pp. 63-80.
- Brodahl, C., Hadjerrouit, S. and Hansen, N.K. (2011), "Collaborative writing with Web 2.0 technologies: education students' perceptions", *Journal of Information Technology Education*, Vol. 10, pp. 73-103.
- Cohen, L., Manion, L. and Morrison, K. (2007), *Research Methods in Education*, Routledge, New York, NY.
- Cress, U. and Kimmerle, J. (2008), "A systemic and cognitive view on collaborative knowledge building with wikis", *Computer-Supported Collaborative Learning*, Vol. 3 No. 2, pp. 105-122.

- Dede, C. (2011), "Reconceptualizing technology integration to meet the challenges of educational transformation", *Journal of Curriculum and Instruction*, Vol. 5 No. 1, pp. 4-16.
- Du, H.S., Chu, S.K.W., Chan, R.C.H. and He, W. (2016), "Collaborative writing with wikis: an empirical investigation", *Online Information Review*, Vol. 40 No. 3, pp. 380-399.
- Ehlers, U.-D. (2013), *Open Learning Cultures: A Guide to Quality, Evaluation, and Assessment for Future Learning*, Springer, Berlin and Heidelberg.
- Elgort, I., Smith, A.G. and Toland, J. (2008), "Is wiki an effective platform for group course work?", *Australasian Journal of Educational Technology*, Vol. 24 No. 2, pp. 195-210.
- Garrison, R., Anderson, T. and Archer, W. (2000), "Critical thinking in a text-based environment: computer conferencing in higher education", *The Internet and Higher Education*, Vol. 2 Nos 2-3, pp. 87-105.
- Garrison, R., Anderson, T. and Archer, W. (2001), "Critical thinking, cognitive presence and computer conferencing in distance education", *American Journal of Distance Education*, Vol. 5 No. 1, pp. 7-23.
- Grant, L. (2009), "'I don't care do UR own page!' A case study of using wikis for collaborative work in a UK secondary school", *Learning, Media and Technology*, Vol. 34 No. 2, pp. 105-117.
- Hadjerrouit, S. (2014), "Wiki as a collaborative writing tool in teacher education: evaluation and suggestions for effective use", *Computers in Human Behavior*, Vol. 32, pp. 301-312.
- Hoffmann, R. (2008), "A wiki for the life sciences where authorship matters", *Nature Genetics*, Vol. 40 No. 9, pp. 1047-1051.
- Hughes, J.E. and Narayan, R. (2009), "Collaboration and learning with wikis in post-secondary classrooms", *Journal of Interactive Online Learning*, Vol. 8 No. 1, pp. 63-82.
- Hutchison, A. and Colwell, J. (2012), "Using a wiki to facilitate an online professional learning community for induction and mentoring teachers", *Education and Information Technologies*, Vol. 17 No. 3, pp. 273-289.
- Jimoyiannis, A. (2015), "TPACK 2.0: towards a framework guiding Web 2.0 Integration in educational practice", in Khine, M.S. (Ed.), *New Directions in Technological Pedagogical Content Knowledge Research Multiple Perspectives*, Information Age Publishing, Charlotte, NC, pp. 83-108.
- Jimoyiannis, A. and Angelaina, S. (2012), "Towards an analysis framework for investigating students' engagement and learning in educational blogs", *Journal of Computer Assisted Learning*, Vol. 28 No. 3, pp. 222-234.
- Judd, T., Kennedy, G. and Cropper, S. (2010), "Using wikis for collaborative learning: assessing collaboration through contribution", *Australasian Journal of Educational Technology*, Vol. 26 No. 3, pp. 341-354.
- Karasavvidis, I. (2010), "Wiki uses in higher education: exploring barriers to successful implementation", *Interactive Learning Environments*, Vol. 18 No. 3, pp. 219-231.
- Kessler, G. (2009), "Student-initiated attention to form in wiki-based collaborative writing", *Language Learning & Technology*, Vol. 13 No. 1, pp. 79-95.
- Kimmerle, J., Moskaliuk, J., Harrer, A. and Cress, U. (2010), "Visualizing co-evolution of individual and collective knowledge", *Information, Communication and Society*, Vol. 13 No. 8, pp. 1099-1121.
- Kost, C. (2011), "Investigating writing strategies and revision behavior in collaborative wiki projects", *CALICO Journal*, Vol. 28 No. 3, pp. 606-620.
- Lai, C., Lei, C. and Liu, Y. (2016), "Tablets@university: the nature of collaboration and perceived learning in wiki-based collaborative writing", *Australasian Journal of Educational Technology*, Vol. 32 No. 3, pp. 80-95.
- Lawrie, G.A., Grøndahl, L., Boman, S. and Andrews, T. (2016), "Wiki laboratory notebooks: supporting student learning in collaborative inquiry-based laboratory experiments", *Journal of Science Education Technology*, Vol. 25 No. 3, pp. 394-409.
- Lee, M.J.W. and McLoughlin, C. (2007), "Teaching and learning in the Web 2.0 era: empowering students through learner-generated content", *International Journal of Instructional Technology and Distance Learning*, Vol. 4 No. 10, pp. 21-34.

- Li, K. (2015), "Learning styles and perceptions of student teachers of computer-supported collaborative learning strategy using wikis", *Australasian Journal of Educational Technology*, Vol. 31 No. 1, pp. 32-50.
- Li, M. and Zhu, W. (2013), "Patterns of computer-mediated interaction in small writing groups using wikisv", *Computer Assisted Language Learning*, Vol. 26 No. 1, pp. 61-82.
- Lin, C.-Y. and Reigeluth, C.M. (2016), "Scaffolding wiki-supported collaborative learning for small-group projects and whole-class collaborative knowledge building", *Journal of Computer Assisted Learning*, Vol. 32 No. 6, pp. 529-547, doi: 10.1111/jcal.12140.
- Lin, H. and Kelsey, K.D. (2009), "Building a networked environment in wikis: the evolving phases of a collaborative learning in a wikibook project", *Journal of Educational Computing Research*, Vol. 40 No. 2, pp. 145-169.
- McLoughlin, C. and Lee, M.J.W. (2010), "Personalised and self-regulated learning in the Web 2.0 era: International exemplars of innovative pedagogy using social software", *Australasian Journal of Educational Technology*, Vol. 26 No. 1, pp. 28-43.
- Mak, B. and Coniam, D. (2008), "Using wikis to enhance and develop writing skills among secondary school students in Hong Kong", *System*, Vol. 36 No. 3, pp. 437-455.
- Moskaliuk, J., Kimmerle, J. and Cress, U. (2012), "Collaborative knowledge building with wikis: the impact of redundancy and polarity", *Computers and Education*, Vol. 58 No. 4, pp. 1049-1057.
- Naismith, L., Lee, B.-H. and Pilkington, R.M. (2011), "Collaborative learning with a wiki: differences in perceived usefulness in two contexts of use", *Journal of Computer Assisted Learning*, Vol. 27 No. 3, pp. 228-242.
- Neumann, D.L. and Hood, M. (2009), "The effects of using a wiki on student engagement and learning of report writing skills in a university statistics course", *Australasian Journal of Educational Technology*, Vol. 25 No. 3, pp. 382-398.
- Ng, E.M.W. (2016), "Fostering pre-service teachers' self-regulated learning through self- and peer assessment of wiki projects", *Computers and Education*, Vol. 98, pp. 180-191.
- Pifarré, M. and Fisher, R. (2011), "Breaking up the writing process: how wikis can support understanding the composition and revision strategies of young writers", *Language and Education*, Vol. 25 No. 5, pp. 451-466.
- Roussinos, D. and Jimoyiannis, A. (2011), "Blended collaborative learning through a wiki-based project: a case study on students' perceptions", *International Journal of Digital Literacy and Digital Competence*, Vol. 2 No. 3, pp. 15-30.
- Roussinos, D. and Jimoyiannis, A. (2013), "Analysis of students' participation patterns and learning presence in a wiki-based project", *Educational Media International*, Vol. 50 No. 4, pp. 306-324.
- Scardamalia, M. and Bereiter, C. (2006), "Knowledge building: theory, pedagogy, and technology", in Sawyer, R.K. (Ed.), *The Cambridge Handbook of the Learning Sciences*, Cambridge University Press, New York, NY, pp. 97-118.
- Shea, P. and Bidjerano, T. (2009), "Cognitive presence and online learner engagement: a cluster analysis of the community of inquiry framework", *Journal of Computing in Higher Education*, Vol. 21 No. 3, pp. 199-217.
- Stafford, T., Elgueta, H. and Cameron, H. (2014), "Students' engagement with a collaborative wiki tool predicts enhanced written exam performance", *Research in Learning Technology*, Vol. 22, available at: <http://dx.doi.org/10.3402/rlt.v22.22797>
- Trentin, G. (2009), "Using a wiki to evaluate individual contribution to a collaborative learning project", *Journal of Computer Assisted Learning*, Vol. 25 No. 1, pp. 43-55.
- Wheeler, S. and Wheeler, D. (2009), "Using wikis to promote quality learning in teacher training", *Learning, Media and Technology*, Vol. 34 No. 1, pp. 1-10.
- Wheeler, S., Yeomans, P. and Wheeler, D. (2008), "The good, the bad and the wiki: evaluating student-generated content for collaborative learning", *British Journal of Educational Technology*, Vol. 39 No. 6, pp. 987-995.
- Witney, D. and Smallbone, T. (2011), "Wiki work: can using wikis enhance student collaboration for group assignment tasks?", *Innovations in Education and Teaching International*, Vol. 48 No. 1, pp. 101-110.

- Woo, M., Chu, S., Ho, A. and Li, X. (2011), "Using a wiki to scaffold primary-school students' collaborative writing", *Educational Technology and Society*, Vol. 14 No. 1, pp. 43-54.
- Xiao, Y. and Lucking, R. (2008), "The impact of two types of peer assessment on students' performance and satisfaction within a wiki environment", *Internet and Higher Education*, Vol. 11 Nos 3-4, pp. 186-193.
- Zorko, V. (2009), "Factors affecting the way students collaborate in a wiki for english language learning", *Australasian Journal of Educational Technology*, Vol. 25 No. 5, pp. 645-665.

Corresponding author

Athanassios Jimoyiannis can be contacted at: ajimoyia@uop.gr

For instructions on how to order reprints of this article, please visit our website:

www.emeraldgrouppublishing.com/licensing/reprints.htm

Or contact us for further details: permissions@emeraldinsight.com