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Using Wiki in teacher education: Impact on knowledge management processes and student satisfaction

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ABSTRACT

The current study reports on the use of Wiki as an online didactic tool to develop knowledge management (KM) processes in higher education. This study integrates social constructivist principles to learning where learners are pro-active and collaborative through higher order cognitive processes. The study was administered in two countries, namely Egypt and Italy, to close a gap in the literature with an aim to introduce KM processes in teacher educational programmes. These processes are seen as necessary for teachers' professional skills. Such processes are claimed to enable teachers and therefore schools to evolve in a networked information-driven global society, especially as the complexity of subject knowledge is increasing. It is also a learning experience where teachers learn how to provide their students with educational settings where technology is enabled.

Throughout the study, 27 Egyptian students and 36 Italian students participated in online activities and developed interdisciplinary projects for the primary and preparatory stages while collaborating in a Wiki experience within Moodle platform. The study followed a mixed methods approach that consisted of both quantitative and qualitative data. The authors developed several instruments in order to measure both processes and outcomes of the five-week online activities. This current study is reporting on the use of two closed question instruments and one open question instrument. These were: Knowledge Management Questionnaire (KMQ), Student Satisfaction Questionnaire (SSQ) and a Reflection Questionnaire (RQ). Data were analysed using statistical analysis and inductive content analysis. Results indicate that responses on the KMQ were all reliable >0.70, and fulfilled the five processes of KM and participants were highly satisfied. The results suggest that Wikis can develop teachers' knowledge management processes and fulfil student's satisfaction while collaborating in designing interdisciplinary projects. Future implications and suggestions for teacher education programmes are provided in light of the findings.

1. Introduction

Online learning is a sector of education that is flourishing since it has several advantages for institutions and universities, such as the cut down of educational costs. Despite this mere reason, in the last decade the development of e-learning courses involved a reflection about the best practices, focussing on the methodologies and the techniques to be adopted in the online classes (Amhag & Jakobsson, 2009). The issue of concern is how to innovate online didactics overpassing traditional instructional models that best develop student learning. The social constructivist learning theory was used as a theoretical framework in several research studies (Amhag & Jakobsson, 2009; So & Brush, 2008; Wheeler, Yeomans, & Wheeler, 2008; Wolff, 2010) with a shift from a teacher-centred methodology to a student-centred methodology. In this framework the characteristics of the online activities were redesigned and many methodologies previously developed in traditional teaching such as collaborative learning and knowledge management (KM) were tested in online settings. Such setting is claimed to be a good field for developing collaborative activities through peer social interaction (EL-Deghaidy & Nouby, 2008; Nam & Zellner, 2011; Wang, 2010; Wheeler et al., 2008).

Wikis represent an example of one of the Web 2.0 online tools for developing collaborative activities (West & West, 2009). Through this tool students can add, edit, delete, and compare previous versions of students' work by accessing the history page over time that could

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provide insight into the process of knowledge construction. Therefore Wikis include activities that will involve learners in the construction of 'personal' and 'collective knowledge' (Boulos, Maramba, & Wheeler, 2006), or what is known as 'tactic' and 'explicit' knowledge (Nonaka & Takeuchi, 1995). Wikis can also provide the medium by which learners communicate and negotiate in order to reach a shared understanding of a problem (Bruns & Humphreys, 2005). Lund and Smørdal (2006) stressed that fostering this form of collective cognition "can be conducive to solving problems too complex or demanding for an individual". Cress and Kimmerle (2008) presented a theoretical framework for describing how learning and collaborative knowledge building take place with Wikis. In their view, three aspects are taken into considered: the social processes facilitated by a Wiki, the cognitive processes of the users (externalization and internalization), and how both processes influence each other mutually.

Prior research has highlighted social knowledge construction by students as one of the main benefits of asynchronous online communication in higher education (Kumar & Ochoa, 2011). Moreover, there are studies that have claimed that Wikis, specifically, have special potential for computer-supported collaborative knowledge building and learning (Bruns & Humphreys, 2005; Reinhold, 2006). Quite recently, KM was used as a paradigm for developing online learning and claimed its effectiveness (Yeh, Huang, & Yeh, 2011).

In the research project of this study, a tool for developing online collaboration to design interdisciplinary projects considering social constructivist principles to learning was used. The aim is to examine the impact of participating in Wiki activities on students' knowledge management processes and their perceptions and satisfaction of the Wiki experience. Knowledge management is defined in this study as the process of knowledge sharing and creation via technology, in which learners first organise and internalize explicit knowledge into tacit knowledge and then convert tacit knowledge to explicit knowledge via interactions among different "ecological" systems. This study is specifically related to creating and sustaining knowledge management to form communities of teacher practices and preparing teachers to use technology effectively in the classroom as a requirement of education in the 21st century (Bolick, Berson, Coutts, & Heinecke, 2003). Therefore, teachers must be prepared to integrate technology effectively into instruction. The online activities developed in this study were delivered in an asynchronous e-learning environment and participants were students who were attending teacher education programmes. Quantitative and qualitative data were collected to offer insight into the Wiki learning experience.

2. Theoretical background

Principles of social constructivism, online learning and processes of KM were all combined together in this current study to form its theoretical background, in regard to the use of one of the Web 2.0 technological aspects, specifically Wiki tools. The following sections elaborate on the Wiki tool and knowledge management in terms of its definition and processes.

2.1. The Wiki tool

The word "Wiki", which derives from the Hawaiian words "wee kee wee kee," which means "quickly", was largely used in ICT to define a web-based hypertext tool to support community-oriented authoring, to construct collaboratively hypertexts (Shih, Tseng, & Yang, 2008). Wiki is becoming day by day more popular as a collaborative tool and many social websites developed Wiki tools to facilitate their members to collaborate on creating hypertexts. The Wiki tools are available in many online free share websites (e.g. www.wikispaces.com) and in several platforms used for online learning such as Moodle. Probably the most well known platform using Wiki is Wikipedia http://www.mediawiki.org/wiki/MediaWik which adopts MediaWiki.

Shih et al. (2008, p. 1039) reported the following characteristics of Wiki: *rapidness* since Wiki pages can be quickly set up, modified also in an hypertext format; *simpleness*, because the format of the Wiki pages is simple (instead of the complex HTML) and you can also copy/past a text in a .txt format; *convenience*, because links to other pages, images, and external sites can be conveniently settled up by keywords; *open source* since each member can create, modify and delete the Wiki pages at will and *maintainability* since Wiki maintains a version database, which records its historical revision and content, thus enabling version management. The requirements of a Wiki tool include editing, version management, and other aspects such as commenting and visualising. Cole and Foster (2008) reported that most direct utilisation of a Wiki is as a tool for creating group projects. In this case Wiki became an online working environment supporting creative group processing enabling students to interact, develop ideas, generate outlines and to create the final projects.

Wiki tools have been adopted in some research studies as a collaborative tool, which allowed participants to work online together to build a shared text (Bold, 2006). Some research tested the effectiveness of Wikis: Wheeler et al. (2008) delineated some of the affordances and constraints of Wiki and the conditions to develop the students' confidence in its use. Raman, Ryan, and Olfman (2005) found that Wikis support collaborative knowledge creation and sharing in an academic environment. This support depends on: familiarity with Wiki technology, careful planning for implementation and use, appropriate class size, and motivation of students to engage in discovery learning. Biasutti (2011) considered the participants perspective in the use of Wiki, reporting the following aspects associated with satisfaction: collaborating, comparing ideas, sharing knowledge and skills to support each other, peer learning, analysing and integrating different points of view, the usability of the platform, group planning and workload management.

2.2. KM and online learning

2.2.1. Definitions of KM

KM is a term usually linked to the field of enterprise management. Bassi (1999) defined KM as the process of creating, capturing and using knowledge to enhance organisational performance. Hult (2003) defined KM as the organised and systematic process of generating and disseminating information, as well as using tacit and explicit knowledge to achieve a competitive advantage in the marketplace. Arntzen, Worasinchai, and Ribière (2009) stated that KM encompasses knowledge processes such as creation, usage, storage, sharing, transferring and retrieving knowledge that aim to improve business performances. In general, the related literature perceive KM from two points: one is a view from a technological aspect that helps in knowledge dissemination; while KM is perceived conversely within a social context where knowledge sharing takes place. This dichotomous view led to many organisations implementing KM by looking into the technology aspect first before considering the soft side of culture, leadership, collaboration and communities (Kupusamy, 2009).

Furthermore, in KM literature, there are terms found which specifically relate to 'knowledge' and its formation. These are known as 'tactic' and 'explicit' knowledge. The former relates to personal values and beliefs that are subjective in nature; while the later is logical, objective, can be codified and documented, and takes place in a social context so that it could be easily communicated. According to Nonaka and Takeuchi (1995), the process of embodying explicit knowledge into tacit knowledge is known as "internalization". This was identified in a model that they developed, known by Socialisation, Externalisation, Combination and Internalisation (SECI). Through this process, knowledge is seen as inseparable from the knower and therefore one of the challenges that faces KM is sharing tactic knowledge or even converting it into explicit knowledge (Santo, 2005).

2.2.2. KM and education

Recently KM could be found in other fields than enterprise management. In the field of education, for example, it is possible to apply KM in schools, realising that the major difference between enterprise and education lies in the nature of how things are managed. Nonetheless, Sun (2002) pointed out that the promotion of KM in schools is still very slow. A similar case is found in higher education where KM has not been a high priority, as observations from campuses conclude that sharing processes are not integrated in the daily routines and are far from being an organisational reality. However, there is a growing recognition that KM can enable higher education to evolve more smoothly to a highly interactive and dynamic educational environment (Robson, Norris, Lefrere, & Mason, 2003). This is particularly emphasized through the ideas of Humboldt (cited in Masłowska-Pietrzak, 2011) where the main role of higher education is 'producing' scientific knowledge rather than 're-producing' it. In general, the function of higher education could be summarized as: (1) knowledge creation (academic research), (2) knowledge dissemination (education) and (3) academic service to society (academic knowledge transfer to the society) (Masłowska-Pietrzak, 2011). All functions relate directly to KM show how higher education is the place to expect to find original knowledge created by learners who are allocated in social contexts where they create and share knowledge. Throughout the processes of KM, higher education institutions such as universities could be perceived as the main "cradles of innovative knowledge" (Cheng & Chen, 2008) if the learning environment advocates for activities that incorporate the main aspects and processes of KM.

To sum up, the following explains how the procedures of KM could be implemented by specific activities. In these activities individuals are called 'knowledge workers' who collect data/information from any source; add value to the information; and distribute value-added products to others (Kappes & Thomas, 1993).

2.2.2.1. Knowledge acquisition. Acquisition of knowledge refers mainly to the strategies, tools and methods that could be used in order to finding and acquiring information. There are various locations and tools that could be utilised for this step. Search engines, databases management systems and document management systems show the technological aspects that represent one side of the KM coin. Through KM, there is a vivid opportunity for breadth and depth of knowledge that extends beyond textbooks and class notes.

2.2.2.2. Knowledge internalisation. After information has been found and accessed, the next step is linking this information into previous mental schemata. It also relates to how knowledge is stored and organised. Several cognitive processes that Piaget referred to take place in this step; these are particularly 'accommodation' and 'assimilation' of knowledge. Activities that illustrate this step mainly stress a change in content; structure or meaning that mirrors what could have happened in the individual's tactic knowledge.

2.2.2.3. Knowledge creation. The creation process of knowledge stresses several acts. It could be viewed as an advanced step of those stated before. It starts from the collection of existing knowledge, ending with storage process and passing by processes of coding and classification of knowledge. For knowledge to be created it needs a networked community to help transform tactic knowledge into explicit knowledge collectively. Processes of knowledge creation result in that knowledge with similar characteristics are linked and clustered together. Hence this can be effectively rigorous, forming a knowledge base that could seem as a stimulating point of departure for creative inspiration. In general, the building, production and creation processes emphasise the spiralling dynamics of transforming the tacit/explicit interplay into novel products (Nonaka & Takeuchi, 1995).

2.2.2.4. Knowledge sharing. Knowledge-sharing process is the key to enhance the externalisation and dissemination of knowledge. From the examples of knowledge-sharing activities are seminars, study sessions, training, discussion groups, electronic conferencing and e-mails. Knowledge sharing can provide knowledge seekers access to the necessary knowledge and therefore improve knowledge acquisition. There are three pillars that can help 'sharing' become effective and sustainable: trust and mutual respect, knowledge tagging, and community recognition (Kupusamy, 2009). This brings the attention to the other side of the KM coin, represented in the social aspect. Communities of practice and learning communities present two of the most common terms that describe the social aspects that are formed in KM. Within a community, members share experience and exchange tactic and explicit knowledge. Throughout this process conflict and disagreement could simply take place. The specific activities of sharing and exchanging are the ones that push members of a community to question and make sense of their experiences.

2.2.2.5. Knowledge application and innovation process. Knowledge application and innovation process represents the stage where decisions are made. Knowledge innovation and application is the ultimate goal of KM and its fundamental purpose is to realise the value of knowledge and create new wealth for the community by seeking new inventions, acquiring new knowledge, exploring and mastering the new rules (Chen & Xu, 2010). This refers to the process or habit of applying what one has learned to the job or task at hand. It is the immediate transfer of knowledge to the workplace. Seen holistically, it is about believing in the notions of learning is about contributing, and contributing is about learning and playing with ideas (Kupusamy, 2009). These processes seem to relate directly to teachers' professional skills whether they are learners themselves or designers of educational settings for their school students.

The quote below sums up the processes as a way to discover meaning in their learning:

> "When students formulate projects or identify interesting problems, when they make choices and accept responsibility, search out information and reach conclusions, when they actively choose, order, organize, touch, plan, investigate, question, and make decisions to

reach objectives, they connect academic content to the context of life's situations, and in this way discover meaning". (Johnson, 2002, p. 3).

The following figure shows the five main processes of KM that are intertwined in nature (Fig. 1).

2.3. Summary of the theoretical background

In the theoretical background previously outlined, several research methods and hypothesis were tested and for this reason it is complex to compare individual research and to outline definitive conclusions. However, the strength of the KM paradigm in a blended course was demonstrated (Yeh et al., 2011), but in this case less attention was give to the online tools used. Although the Wiki tool was used in several research studies and was considered effective for developing collaborative activities, only a few research analysed extensively the strengths of Wiki (Wheeler et al., 2008). In terms of student interaction within Wikis, Kumar and Buraphradeja (2010) used the Gunawardena, Lowe, and Anderson's five phases of knowledge construction grounded in Vygotsky's social development theory.

In the background analysis some research that associated KM and collaborative activities was found, but a few associated Wiki with the KM paradigm in collaborative e-learning environments (Raman et al., 2005). In addition, Barker (2008, p. 150) reported that "limited theory-guided research has been conducted on the measurement of KM in virtual communities, and no specific research method has been identified to date to this." Therefore, the aim of the current study was to consider the use of a Wiki within the social constructivism framework to examine the impact this could have on students' KM processes. This could give additional data by presenting more complete research data for online education, involving a sufficiently large number of participants, and employing quantitative and qualitative data collection.

3. Methods

This section deals with the experimental design, participants, instruments and procedure of the study.

3.1. Experimental design and research questions

The experimental design utilised for this study was a one shot case study where participants were involved in the online Wiki activities then administered the instruments of the study. The online activities included group interdisciplinary project design and the study followed a mixed method approach where both qualitative and qualitative methods were utilised (closed and opened questions).

The study set out to investigate the possible impact of the online Wiki activities in developing students' knowledge management processes by answering the following research questions:

(1) What are participants' perspectives of the online Wiki experience?
(2) What is the impact of participating in an online Wiki experience on participants' knowledge management processes?

3.2. Profile of online learners

Purposive sampling was used to select students of this study. Cohen, Manion, and Morrison (2000) defined purposive sampling as sampling for a specific purpose and picking a group who fit a profile. In this case graduates from the same cohort in each country were selected. Those who had the interest and were keen to use digital technologies with their students were the ones who were included in this study.

In Italy, the selected cohort was at the forth-academic year of the degree at the Faculty of Education. The online Wiki course was part of a four credits class for educating teachers of primary school in a University in the North of Italy. In Egypt the course was presented at the School of Education, which is responsible for graduating teachers and providing postgraduate degrees for in-service teachers. The Wiki activities were presented to a cohort of graduate teachers who were attending a 6-h course on teaching strategies presented at one of the governmental universities in Egypt. Through the National Strategic Plan of pre-university education reform in Egypt (MOE, 2008) there is an emphasis on creating a culture of information processing which includes the skills of collecting, analysing, and interpreting data and where the process of knowledge acquisition must be done by the learners themselves.

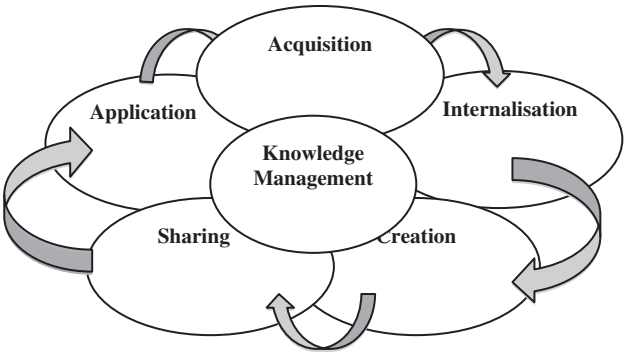

Fig. 1. Knowledge management processes loop.

Demographic information was collected on participants' gender, age, access to the Internet, hours of daily Internet usage and its purpose, in addition to previous experience with online courses. Internet usage was identified as either personal or educational. Personal experiences were defined by informal use of computers (i.e. e-mails, chats and entertainment). Educational experiences were defined by formal use of computers (i.e. courses). There were no statistical differences, by applying a *T*-test, between the two groups ($p > 0.05$). Table 1 shows participant's demographic data in the two countries.

3.3. Instruments

Two closed question instruments were used to assess the results and the processes induced by the Wiki online activities, one about student satisfaction of the course and the other for assessing the application of KM processes. A set of statements were presented and participants were asked to express agreement or disagreement on a 5-point Likert scale ranging from "totally disagree" to "totally agree". Also, a reflection questionnaire, consisting of five open questions, was developed to address the objectives of this research study. The researchers developed all the questionnaires.

3.3.1. Student Satisfaction Questionnaire (SSQ)

The online Wiki activities were assessed using the SSQ, adapted from a previous study (Biasutti, 2011), and based on the theoretical models of student's self-evaluation. SSQ (please see Appendix 1) is composed of 20 closed questions and the three sections of closed questions were as follows:

1) *Wiki tool* (6 items, e.g.: "Use of the Wiki helped me to share ideas with the other students"; "I learned because of information posted by other students' in the Wiki"; "Use of the Wiki promoted collaborative learning");
2) *Didactic material* (5 items, e.g.: "the didactic material was clear"; "the didactic material was useful"; "the didactic material gave ideas for teaching");
3) *Professor* (9 items, e.g.: "the professor encouraged participants to express ideas"; "the professor stimulated the cooperation between participants"; "the professor gave feedback during the activities").

3.3.2. Knowledge Management Questionnaire (KMQ)

The authors developed a KMQ to measure the application of KM processes in online Wiki collaborative activities (please see Appendix 2). Items of the KMQ were developed from reviewing previous studies such as Arntzen et al. (2009) and Yeh et al. (2011). The items of the KMQ were defined in agreement with the following processes of KM theory: knowledge acquisition, knowledge internalisation, knowledge creation, knowledge sharing, and knowledge application. The KMQ consisted of 15 closed questions (e.g. "I documented the type of information needed"; "I categorised the new information in an organised way"; "I applied knowledge to my tasks") and the maximum score for this instrument was 75 while the minimum was 15.

3.3.3. Reflection questionnaire (RQ)

With regard to the qualitative aspects, the RQ was proposed to collect comments and reflections about the processes induced by the online Wiki activities. The following five questions were included to explore the underlying mechanisms that contributed to the effectiveness of the activities:

1) In what way did the online Wiki activities help you to induce changes to your method of teaching and in your teaching philosophy?
2) In which way the use of Wiki influenced the way of working with the colleagues?
3) Indicate how the online Wiki activity helped you to acquire knowledge.
4) Indicate how the online Wiki activity helped you to share knowledge.
5) Indicate how the online Wiki activity helped you to apply knowledge.

Table 1
Demographic data for participants from Italy and Egypt.

Variable	Italian group ($n = 36$)	Egyptian group ($n = 27$)
Gender	Male = 2 Female = 34	Male = 5 Female = 22
Age	Average age = 23.97	Average age = 25.07
Internet access	Yes = 36 No = 0	Yes = 26 No = 1
Hours of daily internet usage	>1 h = 20 2–4 h = 16 >4 h = 0	>1 h = 6 2–4 h = 16 >4 h = 5
The purpose for internet access	Personal = 26 Educational = 10	Personal = 20 Educational = 7
Previous experience with online courses	Yes = 9 No = 27	Yes = 7 No = 20

3.4. Procedure

The online Wiki activities were delivered in the second semester of the academic year 2010–2011. The participants were divided into groups of three or four, where each participant was randomly assigned to one of these groups. It was assumed that the aspects of previous study habits of individual students were decided only by the randomization in-group placement (Nam & Zellner, 2011). During the class, the following principles of KM were promoted (1) acquisition of knowledge; (2) internalisation of knowledge, (3) knowledge creation, (4) developing a culture of knowledge sharing; and (5) application of technological facilities.

Moodle was used as a platform for delivering the online learning course and an asynchronous e-learning environment was set. Students were provided with the Moodle manual that is available online in various languages. The choice of Moodle was made as it is a software package designed using pedagogical principles, mainly social constructivist, it is an open source and it is freely available in various languages. Moreover, an orientation session was carried out with students to make sure that they will be able to use the platform.

The task proposed online was to collaboratively design an interdisciplinary didactic project for the primary or preparatory school. This task was considered because it is a real assignment in the work of a class teacher of primary school in Italy. Tsai (2010) noted that considering authentic problems had a positive effect on the outcomes in collaborative online learning activities. For the Egyptian participants, however, planning interdisciplinary projects is a recent requirement under the National Strategic Plan for re-forming basic education (MOE, 2008) and therefore was an add on to the course presented at the university, a proposed approach for knowledge management, and a holistic view of knowledge necessary for school reform and student learning.

During the online work, which lasted about five weeks, various activities, such as reading tasks, and collaborative group tasks were included. At the beginning students had to read two papers about interdisciplinary curriculum planning in the primary and preparatory schools. The focus of the papers was about interdisciplinary curriculum planning. This was followed by small group activity that consisted of designing an interdisciplinary project for the primary or preparatory education schools using the Wiki online environment. For designing the interdisciplinary project, participants worked asynchronously in groups, where each group used the following planning form: title, abstract of the project, disciplines involved (science was a key discipline in all projects), grade level involved, number of hours (classes), phases of the project, objectives, competences, contents of the activities, teaching/learning strategies, tools/material and student assessment. Students experienced various features of the Wiki, such as adding, editing and reviewing previous versions of the project by accessing the history page.

In the online activities participants had the possibility to share experiences, to mediate understanding and to create joint meanings. The interactions in the Wiki online environment were based on supporting each other and the following principles of KM were promoted: knowledge acquisition, internalisation, creation, sharing, and application. In the platform the function, which enabled visible groups, was settled for allowing everyone to see each other's work. During the activities, there was the support of the professors that acted as facilitators stimulating the main principles of KM. At the end of the course, participants were invited to complete the student evaluation questionnaires without any consultation. It was presented as a way to help the professor to improve the course for next academic year, as well as to provide feedback to raise the quality of the activities. Participants were informed that questionnaires were used for research purposes only and that the data remain anonymous. An average of 30 min was necessary to complete the questionnaire.

4. Results

The collected data consisted of participants' responses to the SSQ, the KMQ and the RQ. SSQ generated quantitative data which were analysed using statistical analysis (descriptive statistics, exploratory factor analysis and Cronbach's alpha) as well as the KMQ. The qualitative comments derived from the RQ (open questions) were analysed using content analysis to determine the underlying processes induced by the online activities.

4.1. Research question one

The first research question asked about participants' perspectives of the online Wiki experience. To answer this question, data were collected from responses on the closed questions of SSQ.

4.1.1. Results of the SSQ

An exploratory factor analysis was used to identify the factor structure of the sub-scales of SSQ. The Kaiser criterion (Kaiser, 1960) and the Scree test were used, and the exploratory factor analysis produced an unrotated one-factor structure for all the sub-scales. The reliability analyses were determined by measuring the internal consistency of each scale calculating the Cronbach's alpha. Alpha coefficients ranging from 0.71 to 0.85 were all well above the 0.70 standard of reliability. The mean, the standard deviation and the Cronbach's alpha were as follows: *Wiki tool* (6 items) mean of 4.33 (SD: 0.34; Cronbach's alpha: 0.73); *Didactic materials* (5 items) mean of 4.19 (SD: 0.34; Cronbach's alpha: 0.71); *Professor* (9 items) mean of 4.56 (SD: 0.37; Cronbach's alpha: 0.85). These results indicate a very high level of student satisfaction while participating in the Wiki experience.

4.2. Research question two

The second research question asked about the impact of online Wiki activities on participants' knowledge management processes. To answer this question data were collected from responses on the closed questions of KMQ and the opened questions of the RQ as well. Main findings are presented below.

4.2.1. Results of the KMQ

In order to assess the consistency of the KMQ, the factor structure was analysed by applying an exploratory factor analysis and principal component analysis (PCA). The orthogonal (Varimax) method with Kaiser normalisation was employed with rotation procedure. Through principal components analysis, five components were extracted according to the following criteria: number of items for each component

(each factor contained at least three items); conceptual independence of every component from the others and minimum percentage of total variance explained by each factor. Also, the following criteria were used in order to determine the definite number of items: adequate reproducibility and factor loadings of 0.35 or higher on the presumed factor. Factors extracted from the questionnaire KMQ explained about 71.04% of total variance:

- factor 1 *knowledge creation* explained about 35.87% of variance (Cronbach-$\alpha = 0.71$);
- factor 2 *knowledge application* explained about 11.11% of variance (Cronbach-$\alpha = 0.80$);
- factor 3 *knowledge acquisition* explained about 9.03% of variance (Cronbach-$\alpha = 0.74$);
- factor 4 *knowledge sharing* explained about 8.65% of variance (Cronbach-$\alpha = 0.73$);
- factor 5 *knowledge internalisation* explained about 6.39% of variance (Cronbach-$\alpha = 0.76$).

Alpha coefficients ranging from 0.71 to 0.80 were all above the 0.70 standard of reliability and the total Cronbach-α was 0.86. The rotated factor matrix is reported in Table 2. Results from factor analysis provided evidence that all the items filled the components significantly (criterion adopted: exclusion of absolute values < 0.35) and items were chosen considering their highest absolute values. The five factors from KMQ have been interpreted by the researchers, respectively, as: *knowledge creation* (e.g. of items: 'I developed new ideas' and 'I developed new concepts'); *knowledge application* (e.g. of items: 'I applied knowledge to my tasks' and 'I referred to best practices'); *knowledge acquisition* (e.g. of items: 'I selected the right information on the internet', 'I summarized the results of the internet search'); *knowledge sharing* (e.g. of items: 'I shared information with my peers' and 'I supported sharing information with others by the use of technological tools'); *knowledge internalisation* (e.g. of items: 'I related new information to previous knowledge', and 'I updated my knowledge repertoire consistently'). The mean and the standard deviation of the factors were as follows: factor 1 *knowledge creation* mean of 4.31, SD: 0.36, factor 2 *knowledge application* mean of 4.07, SD: 0.38, factor 3 *knowledge acquisition* mean of 4.21, SD: 0.35, factor 4 *knowledge-sharing* mean of 4.40, SD: 0.39, factor 5 *knowledge internalisation* mean of 4.33, SD: 0.38; mean of the total of the questionnaire: 4.29, SD 0.37. These results indicate that KM was considered fine along all the factors during the online Wiki activities.

4.2.2. Results of the RQ

Content analysis was employed to categorize the open questions of the RQ. Content analysis was conducted by one researcher who generated initial checklists of categories. The coding of the open questions was later validated by the other researcher who separately checked the data coding. When inconsistencies occurred, the two researchers discussed the disagreements relating to their coding and reached 100% agreement through a process of negotiation. Content analyses based on the participants' responses on each open question are reported below.

Q1: In what way did the online Wiki activities help you to induce changes to your method of teaching and in your teaching philosophy?

Participants indicated that the online activities contributed to their professional development. The categories emerged were social, cognitive, working online and new ways of working. In the social category participants expressed their appreciation about the new way of working based on online collaborating. One participant asserted: "The online activities allow everyone to participate and to create a community of practice: everyone feels reflective and activated to generate knowledge. You can communicate with people from different backgrounds, enriching your learning!". This statement pointed out that the activities allowed participants to compare different opinions and to mediate different positions.

In the cognitive category, participants reported that they learned how to integrate knowledge, sharing different perspectives and ways of thinking, and to develop different views of interpreting facts. Two participants asserted: "I appreciated the possibility of having time to reflect upon and to have the opportunity to express my critical thinking in a discussion"; "to complete and to enrich my concept mapping". These statements pointed out that the online activities were considered by participants a way to build knowledge during networking and to acquire reasoning on specific topics. Also, the development of meta-cognitive abilities was mentioned by one participant: "I was thinking how to evaluate the process by which knowledge is processed in the work group".

In the online working category, participants appreciated to work quietly at home without time constraints such as in presence meetings, to network, to share ideas and materials without being in presence. They appreciated the possibility to communicate immediately and in

Table 2
Rotated factor matrix for the Extraction method: principal components analysis. Rotation method: varimax with Kaiser normalisation criterion.

Item	Factors[a]				
	1.	2.	3.	4.	5.
1. I selected the right information on the internet			**0.818**		
2. I documented the type of information needed		0.352	**0.668**		
3. I summarized the results of the internet search			**0.791**		
4. I related new information to previous knowledge					**0.853**
5. I updated my knowledge repertoire consistently					**0.768**
6. I categorised the new information in an organised way	0.481				**0.497**
7. I developed new ideas	**0.735**				
8. I developed new concepts	**0.790**				
9. I developed new way of teaching	**0.769**				
10. I shared information with my peers				**0.747**	
11. I supported sharing information with others by the use of technological tools				**0.797**	
12. I encouraged a culture of knowledge sharing				**0.691**	
13. I applied knowledge to my tasks		**0.787**			
14. I referred to best practices		**0.813**			
15. I transferred and adapted best practices to my tasks		**0.756**			

[a] Factors: 1. Knowledge creation; 2. Knowledge application; 3. Knowledge acquisition; 4. Knowledge sharing; 5. Knowledge internalisation.

several timings of the day when they elaborated new inputs. They had the possibility to write and to express the opinions clearly and simply, without any possible misunderstandings that may arise when e.g. being in presence engaged in verbal communication. They also learned how to manage the work commitments better.

In the new ways of working category, participants reported new ways of considering their job such as to learn to work on an activity with a share objective and to have the possibility to work gradually and in a planned way. Participants reported also that they developed a new method of working based on networking and they understood how to create a class work environment for developing knowledge sharing.

Q2: In which way the use of Wiki influenced the way of working with the colleagues?

Participants reported several issues about how the use of Wiki influenced their way of working with the colleagues and the following categories were found: teamwork, professional development, cognitive, and ethic.

In the teamwork category, participants asserted that they learned how to work in-group, facilitating the coordination and sacrificing what they designed for the group aims. They developed the sense of accountability and participation. One participant asserted:

> "Wiki requires a high ability for negotiation, you must be able to intervene in the right way and moment, consistent with others and if necessary you must have the courage to reformulate what has been written by others to better fit the whole context. This thing is not always easy to do; you risk creating misunderstandings, especially if the person that sees their work changed does not appreciated that. Wiki is a sort of gym where you can experience all these things".

These statements pointed out that Wiki was considered important for building a shared project and to find a negotiated framework.

In the cognitive category participants reported that Wikis helped them to develop reasoning abilities and being more reflective. One participant asserted: "Wiki helped me to reduce my impulsiveness in proposing a disproportionate number of things and inspired me to make more considered proposals!". This statement pointed out that the use of Wiki induced a reflective practice on the task, selecting the best option to propose the other group members.

In the professional development category participants reported improvement in the way they conceived their work. One participant asserted: "It was like to build a big puzzle together. Wiki developed my ability to design an interdisciplinary project, learning how to modify and how to publish it! I became quicker in the designing process!". This statement pointed out the participant development of the ability of project planning. Another participant asserted the development of the sense of confidence: "We become simultaneous creators of the project and we felt our owners of it. This way of working allowed me to break down the barriers of indecision."

In the ethic category participants reported that Wiki helped them to develop the sense of responsibility when working in team. One participant asserted: "I developed my sense of responsibility for being part a group in designing the project".

Q3: Indicate how the online activity helped you to acquire knowledge.

Participants reported several issues about how the online activity helped them to acquire knowledge and the following categories emerged: teamwork and cognitive.

In the teamwork category, participants reported that they acquired knowledge through their continuous interaction with the other participants. They felt very supported in the process of knowledge acquisition by the exchange of ideas and information with the colleagues through comparing different ideas. Two participants asserted: "I was enriched in terms of disciplinary knowledge and teaching since it took to me an active participation in the definition of objectives, activities and methods to be used in teaching in an interdisciplinary dimension."; "I was enriched by the perspective of the relational and communicative competence required for a real personal involvement in relationships with other colleagues." These statements pointed out that participants were also stimulated in having an active participative role.

In the cognitive category, the process of searching and selecting information was important, but also reading and writing. Two participants asserted: "reading what the colleagues wrote helped me in learning different ways of thinking and working"; "I acquire knowledge through writing which is always a source of mental processing, the incorporation of the text, the further development … it makes you learn the concepts in depth knowledge to select the most important concepts." These quotes demonstrated that to see the writing style of others was also a way to enrich the participants' views. Another process mentioned by participants was reviewing: the review of the project with the additions made by the others was also useful for the participants to gain greater confidence. One participant reported:

> "It was very useful to see the changes and the additions that each component has contributed to the project and to see how the ideas were revised, expanded or modified. There was construction of knowledge and this allowed me to understand my mistakes".

This statement pointed out that to follow the development of the project was a very important aspect of the activities, considering individuals' additions and modifications. This process allowed participants to develop a sense of feedback about the activities and understanding the individual's mistakes.

Q4: Indicate how the online Wiki activity helped you to share knowledge.

Participants reported several issues about how the Wiki activity helped them to share knowledge and the following categories emerged: teamwork, organisation and ethic.

In the teamwork category participants reported that they were stimulated in sharing knowledge when different positions where compared. One participant emphasised: "the interactivity of the application Wiki helped me to share ideas." The extensions, the doubts and the boundaries expressed by the other participants were also relevant in the process of knowledge sharing. One participant asserted: "I shared knowledge through the process of negotiating and the continuous exchange of ideas." Also the process of modification was considered and participants asserted: "Wiki helped me to share my knowledge through the modification of the work of the others, the addition of elements and the correction of some information."; "Wiki is actually based on sharing, it was nice to see how my ideas could became the group's ideas." These quotes provided evidence of how Wiki was considered a good tool for sharing knowledge.

In the organisation category, participants stressed interactivity within the process. One participant asserted: "The Wiki activities helped me share knowledge when each one inserted his/her contributions and everything was integrated and organised. This stimulated me in sharing other ideas and thoughts." This statement pointed out that sharing was a crucial factor. It also illustrated the ability to track the actions of individual members of the group and reading how the evolution of thought was developed through teamwork.

In the ethic category participants reported that when they shared knowledge there was the freedom to interact and modify the work, without constraints. One participant asserted:

"I felt free to write and at the same time constrained by the responsibility to my companions: free because I knew my teammates would, if necessary, correct my mistakes, and because I could not write any nonsense without thinking about it many times: I would not have added unnecessary work to my colleagues."

This statement pointed out the dichotomy in the processes of designing the project. The participant felt free to write, but at the same time she was thinking about the teammates' roles and the possibility that they would correct her mistakes.

Q5: Indicate how the online Wiki activity helped you to apply knowledge.

Participants reported several issues about how the Wiki activity helped them to apply knowledge and the following categories emerged: teamwork and organisation of the work. In the teamwork category participants reported that they were stimulated in applying knowledge, discussing ideas and concepts with their colleagues, and designing a joint interdisciplinary project.

With regard to the organisation category, participants reported that having a clear and organised way of working was important to apply knowledge. One participant stated: "We had a good plan, and that facilitated the process." This statement pointed out that the online activities have proved effective in applying knowledge and management skills because the activities required careful planning and organisation of work. In this framework Wiki was considered a good support as stated by one participant: "Wiki activity helped me to better organise the work: to divide the assignments, to monitor the work, to change unclear aspects, to generate problem-solving activities, which are activities that permit to encode the work internally, feeling that you are mastering the process."

5. Discussion

During the online Wiki activities, the participants developed several skills as reported in the results section. The positive impact of the course was due by several reasons such as the implementation of an appropriate pedagogical approach, an interactive technology tool, clear and organised didactic material, opportunity for participants' collaboration, and support and feedback from the online tutor (Blass & Davis, 2003; Garrison & Anderson, 2003). The professor had an important role in facilitating the processes and in applying the learner centred approach in the online environment (Bower & Hedberg, 2010). During the activities, the professor stimulated participants to develop collaboration during group work and acted as a facilitator rather than imposing ideas. The technology also played an important part in the current study, because the online environment was quite simple, but efficient, permitting participants to work collaboratively, to share experiences, to support each other and to design the interdisciplinary project in collaboration (Bliuc, Ellis, Goodyear, & Piggott, 2011; Bold, 2006; De Smet, Keer, De Wever, & Valcke, 2010; Hew & Cheung, 2008).

The impact of Wiki technologies was assessed by a specific section of the SSQ. The section was titled '*Wiki tool*' that consisted of 6 items which scored 4.33 out of 5. This result demonstrated that participants evaluated very positively the Wiki as a tool for promoting cooperative learning in item such as "Use of the Wiki helped me to share ideas with the other students" and "Use of the Wiki promoted collaborative learning". Wiki was also considered a tool for sharing ideas and developing peer learning in item such as "I learned because of information posted by other students' in the Wiki". These results support the findings of analogue research on collaborative online learning (Cho, Lee, & Jonassen, 2011). Several additional aspects were reported in the qualitative part of SSQ, providing evidence of the underlined mechanisms induced in the participants. Wiki was considered a tool that contributed to their professional development offering opportunities to develop their social, cognitive and ethic skills as well as inducing new ways of working. Participants reported also several aspects about how Wiki influenced their way of collaborating, stimulating the teamwork. This result supports the research findings by studies such as Andrew (2008), and Cress and Kimmerle (2008).

The KM processes were assessed quantitatively by the KMQ, and a five-factor structure was found. The factor *knowledge creation* seems the most important since accounted the most part of the variance. The factor *knowledge sharing* received the highest level of evaluation by participants, providing evidence that the online Wiki activity were particularly relevant for developing this process. The factor *knowledge application* received instead the lowest rate level, showing that there are aspects that could be improved in applying the created knowledge through authentic contexts.

The qualitative RQ provided additional aspects of the participants' experience about the KM process. Participants reported that the online activity helped them to acquire knowledge mainly by team working. They developed cognitive skills such as searching and selecting information, in addition to reflecting and reviewing the work. In this sense, the Wiki acted as a tool for the collaborative creation of knowledge in a dynamic fashion. This could be due to providing for the factors that Raman et al. (2005) stressed which lead to success in collaborative knowledge creation. These aspects are: familiarity with Wiki technology, careful planning for implementation and use, appropriate class size, and motivation of students to engage in discovery learning. Qualitative data from KMQ seem to support these claims, especially that participants in this study were engaged in searching for aspects (concepts, ideas, videos, and pictures) they could include while constructing their interdisciplinary projects and were motivated to use Wiki as a contemporary didactic tool.

The process of knowledge sharing was facilitated by working in groups, negotiating and exchanging ideas, continuously with the other participants (Boulos et al., 2006). The integration and the organisation of the work stimulated also sharing ideas and thoughts. The Wiki enabled participants and the professors to be in continuous discussions throughout the duration of the online activities and helped them to create a knowledge repository. It is noted that effective KM requires a continuous knowledge conversion process between tactic and explicit knowledge (Nonaka & Takeuchi, 1995). The vibrant collaborative environment with its aspects of sharing, caring and creating knowledge therefore seemed to establish the main spirit of KM. Hall and Goody (2007) associated these aspects with improved organisational learning, creation of new knowledge, and knowledge reuse. The processes that were applied in the Wiki environment stress the power of collaborative learning, especially as participants were functioning in a social context of a community of teacher practice, according to Schwartz, Clark, Cossarin, and Rudolph (2004), putting bits and pieces together in a creative and meaningful manner. This again stresses one of the main principles of constructivism that this study framed its theoretical background according to.

Participants developed also their ethic attitudes to respect the work of the others, providing evidence of affective and social issues in computer-supported collaborative learning (Jones & Issroff, 2005). Skiba (2005) stated that the reason for Wiki's wide usage is the ethic of intellectually sharing ideas, as Wikis support social collaboration. Providing that teachers are facilitators and guides, Hew and Hara (2007) found that teachers shared knowledge once they sensed they would gain something from it, whether personally or professionally and with

immediate colleagues. The gain in this study represented both. The personal gain was in the empowerment, active participation, and intrinsic motivation participants reported in KMQ while working in teams. The professional gain was in developing interdisciplinary projects that was new to most of them. The later particularly relates to the application of knowledge, where participants reported that teamwork and organisation were very important: they applied knowledge discussing and designing the interdisciplinary project. In this process having an organised way of working was definitely helping in applying knowledge. This finding is in agreement with what Lamb (2004) asserted about the uniqueness Wikis provide for their users. Through Wikis, participants define for themselves how their processes and groups will develop, usually by making things up as they go along.

6. Conclusion

Teacher education programmes are considered great opportunities to develop professional skills required for future workplace (Biasutti, 2010; EL-Deghaidy, 2010; Seddon & Biasutti, 2009). From the requirements of this era, are those that relate to developing KM processes, as illustrated in this study. KM processes are vital for teachers as they need it for sharing classroom resources, professional knowledge and therefore could enable the adoption of good teaching practices. Hence the role teachers are expected to take within KM settings is that of 'knowledge workers'. Through such role teachers are required to collect information, add value to it and distribute value-added products to others (Kappes & Thomas, 1993). Findings from this study claim that Wikis enable rich, flexible, empowering, collaborative learning environments. Hence participants developed knowledge management processes as they were engaged in knowledge acquisition, internalization, creation, sharing and application. Educational institutions with immense reform projects worldwide require that teachers, students and school administrators are able to deal with the advancements of knowledge in all areas. By incorporating Wikis into the classroom, and the valuable benefits it provides in terms of developing knowledge management processes, teachers can better prepare students for the future. This study is therefore an attempt to close a gap in the literature to highlight the possibility of developing KM processes in teacher education programmes. This attempt comes from calls of previous studies, such as Sheehy (2008) who stressed that KM efforts in education should spread into all parts of the school and its existing organisational boundaries, growing an environment where sharing within the daily routine is encouraged and nurtured. Additionally, Baker's (2005) research, asserted the importance of effective knowledge management within the context of on-going educational processes that can lead both to the successful development of learning improvement and the creation of more stable communities' relationships based on knowledge sharing.

Nonetheless, the results of this study have implications for the filed of research in online collaborative environments, higher education in general and teacher education programmes in particular. Moreover, the various instruments that were designed to investigate the development of KM process and participants' satisfaction with the Wiki online environment could be applied in other contexts where Web 2.0 technologies are used. However, for teachers, a follow-up study could be set where the effects of developing teachers' KM processes are transformed to the classroom with school level students. A further study could be a comparative one where participants are involved in developing interdisciplinary projects using Wikis and others as a control group where the main mean of interaction is face to face.

Appendix 1. Student Satisfaction Questionnaire (SSQ)

Participants' evaluation is one of the methods used for improving the quality of teaching. This questionnaire will provide the organisers with valuable feedback about teaching effectiveness. Your name is NOT required and all information is confidential. We would be grateful if you could complete it as accurately and honestly as possible. Please fill all the items. Thank you for your collaboration!

Please indicate the extent of your agreement/disagreement with the statements by using the following scale:

1 = totally disagree 2 3 4 5 = totally agree.

Wiki tool		**1**	**2**	**3**	**4**	**5**
1	I liked seeing other students' interaction with material I posted in the wiki					
2	Use of the Wiki helped me to share ideas with the other students					
3	Because of using the Wiki, my group was able to come to a consensus					
4	I learned because of information posted by other students' in the Wiki					
5	Use of the Wiki promoted collaborative learning					
6	I felt comfortable having other students edit content I had posted					
Didactic material		**1**	**2**	**3**	**4**	**5**
1	Was clear					
2	Was useful					
3	Was challenging					
4	Gave ideas for teaching					
5	Was connected to my background					
Professor		**1**	**2**	**3**	**4**	**5**
1	Was friendly towards individual participants					
2	Was dynamic and energetic in conducting the groups					
3	Made participants feel welcome to discuss					
4	Encouraged participants to express ideas					
5	Stimulated the cooperation between participants					
6	Stimulated the formation of the online community					
7	Gave feedback during the activities					
8	Gave appropriate suggestions					
9	Helped in solving problems					

Appendix 2. Knowledge Management Questionnaire (KMQ)

Please indicate the extent of your agreement/disagreement with the statements by using the following scale:
1 = totally disagree 2 3 4 5 = totally agree.

During the online activities		1	2	3	4	5
1	I selected the right information on the internet					
2	I documented the type of information needed					
3	I summarized the results of the internet search					
4	I related new information to previous knowledge					
5	I updated my knowledge repertoire consistently					
6	I categorised the new information in an organised way					
7	I developed new ideas					
8	I developed new concepts					
9	I developed new way of teaching					
10	I shared information with my peers					
11	I supported sharing information with others by the use of technological tools					
12	I encouraged a culture of knowledge sharing					
13	I applied knowledge to my tasks					
14	I referred to best practices					
15	I transferred and adapted best practices to my tasks					

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