

Wiki-Mediated Activities in Higher Education: Evidence-Based Analysis of Learning Effectiveness Across Three Studies

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ABSTRACT

A considerable interest in using Web 2.0 technologies such as wikis in education has been observed recently. Despite the advantages of the wiki technology, a number of questions concerning design of appropriate activities and their learning effectiveness remain open. In this paper, we present the results of three activities involving first-year university students using wikis to learn basic concepts related to information technology. Three activities of different classes were designed and delivered to the students using the framework proposed by West and West (2009). In all studies, a one-group pretest–posttest design was adopted. Results illustrated significant improvement in learning outcomes, particularly for students with low initial performance. The average students' questionnaire score jumped from 39.0/100 to 57.3/100. No significant effect of both students' role in the activity and their school stream on learning gain was observed. Finally, regardless of the activity's class and learning goal, a persistent pattern of high learning gain was observed.

Keywords

Web 2.0, Wikis, Learning activity design, Project-based learning, Collaborative learning

Introduction

The Internet and information and communication technologies (ICT) have a profound impact on our societies (Tapscott, 2009). As a result, the mode of learning is changing rapidly in a digital age (Palfrey & Gasser, 2008). During the recent years, there has been considerable interest in using Web 2.0 technologies in education.

Web 2.0 describes web-based technologies which emphasize on user-generated content. The content is created collaboratively with the opportunity to be shared with peers. Web 2.0 technologies constitute a fertile ground for building project-based learning activities (Duffy & Kirkley, 2004) and create real learning communities because students participate actively in the learning process (Pieri & Diamantini, 2014). In addition, engagement in Web 2.0-mediated activities seems to positively influence both active involvement as well as one's motivation, which are recognized as key issues affecting student performance and learning (Benek-Rivera & Matthews, 2004; Cole, Feild, & Harris, 2004; Waycott, Bennett, Kennedy, Dalgarno, & Gray, 2010a; Waycott et al., 2010b). Most participants report positive experiences when they use Web 2.0 technologies (Ching & Hsu, 2011; Edirisingha, Rizzi, Nie, & Rothwell, 2007; Janossy, 2007). Furthermore, studies suggest that usage of specific Web 2.0 technologies can enhance student learning and collaboration (Carter, 2009; Cormode & Krishnamurthy, 2008; Greenhow, Robelia, & Hughes, 2009; Papastergiou, 2009; Selwyn, 2007). On a broader context, a recent meta-study (Means, Toyama, Murphy, Bakia, & Jones, 2009) concludes that students in online learning conditions performed modestly better than those receiving face-to-face instruction.

Despite the positive aspects of Web 2.0 technologies, a number of questions concerning design of appropriate activities and their learning effectiveness remain open (Gray, Thompson, Sheard, Clerehan, & Hamilton 2010; Tselios, Daskalakis, & Papadopoulou, 2011; West & West, 2009). As it happens with other technologies used in education, there is an implicit perception that wikis could be instantaneously useful in the educational process without tackling the challenges related to their efficient integration in the educational context. For instance, Ching

and Hsu (2011) found that the activity goal needs to be shared in order to promote collaboration. Moreover, Ullrich et al. (2008) concluded that students using micro-blogging encouraged one another to participate and unconstrained active participation resulted in distractions.

Among the Web 2.0 technologies, wikis seem to offer the most dynamic collaboration possibilities (West & West, 2009). A wiki typically offers the ability to freely edit a website, providing features to add, modify, and delete pages as well as to integrate hypermedia (Leuf & Cunningham, 2001). The adopted interaction model is similar to that of a rich text editor with features of collaboration awareness, such as recent changes, actions carried out per participant, and edit-locking functionality (Tselios, Avouris, & Komis, 2008). This open nature of the wiki technology creates significant opportunities for learning (Mindel & Verma, 2006; Raman, Ryan, & Olfam, 2005; Wheeler & Wheeler, 2009). However, it may also be a major obstacle if the context and objectives of the activity are not well defined and/or not effectively communicated to the participants (Jones, 2007; Parker & Chao, 2007).

A wiki, by its very nature, facilitates quick content and organization deployment, which in turn increases the possibility of introducing inaccurate or incredible information or quoting unsubstantiated opinions. However, a wiki also enables all participants to edit and improve the provided content. This process of study, identification, and correction of content through reflection provides the opportunity for educational approaches compatible with socio-cultural views of learning (Cress & Kimmerle, 2008). Wikis as a collaboration tool help students to write better (Mak & Coniam, 2008), promote writing skills (Wheeler & Wheeler, 2009), and can support collaborative knowledge creation (Raman et al., 2005; Wagner, 2004).

Despite the encouraging results and the increasing adoption of wikis as a tool for collaborative learning, there is still the question of how to effectively integrate them into the educational process and which are, if any, the learning gains for the students involved into such an activity (Mason & Rennie, 2008; Pallof & Pratt, 2007). Currently, few studies provide rigorous, evidence-based results on the effectiveness of learning activities mediated by wikis (Biasutti & EL-Deghaidy, 2014; Hadjerrouit, 2014; Hazari, North, & Moreland, 2009; Heimbuch & Bodemer, 2014; Popescu, 2014; Salaber, 2014; Wheeler & Wheeler, 2009).

Preliminary results suggest that social, organizational, and cultural factors of the learning context are the important elements for effective use of wikis in educational practice and not the intermediary technology itself (Twu, 2009). Mindel and Verma (2006) also report that an empty wiki available to online students is not enough. In addition, Raman et al. (2005) indicate that wiki activities aren't successful if there is not any proper planning and familiarity with this technology. Furthermore, Baltzersen (2010) found that students' perceptions are positive if the wiki-based learning activity is carefully planned. As West and West (2009) state (p. 21): "Without context and support, online groups can experience unbalanced participation, a lack of progress and direction, mistrust, misunderstandings, and conflicts." In such cases, the wiki technology may have little impact on student engagement (Cole, 2009; Ebner, Kickmeier-Rust, & Holzinger, 2008).

West and West (2009) have proposed a structured framework to guide the design of wiki-based activities. They identify the following critical factors to add context to the wiki environment: (a) establish a purpose for the wiki project, (b) define and classify the learning goals of the wiki project, (c) design a rich context and problem that support the achievement of the purpose and goals, (d) prepare students for work in the new environment, (e) promote a collaborative process through which active, social learning can take place (West & West, 2009, p. 22). Each team member should have a role with specific responsibilities, since students in group projects might not contribute the same amount of work (Elgort, Smith & Toland, 2008). In addition, according to this framework, wiki-based learning activities are grouped into three classes: knowledge construction, critical thinking, and contextual application.

However, there is a lack of rigorous studies demonstrating the learning effectiveness of such a structured framework. In addition, it remains unknown whether students' role in the wiki activity affects their learning gain. Furthermore, students' secondary education stream may also affect their learning gain in such activities because students of different streams might have a different manner of thinking. The aim of this paper is to investigate the effect of rigorously designed wiki-based activities, according to the framework proposed by West and West (2009), on the learning outcome. In specific, this paper investigates:

- students' learning gain (if any) after each wiki-based activity
- whether the students with lower pretest score benefited from the activity at least to the same extent as students with higher pretest score

- whether students' learning performance was affected by their secondary education stream
- whether students' learning performance was affected by their assigned role

To this end, we designed and implemented three wiki-mediated activities, one for each class (West & West, 2009). In the first activity, the goal was to discuss implications of online social networking. The objective of the second activity was to learn basic aspects of search engines. In the third activity, students applied a usability evaluation technique. A one-group pretest–posttest experimental design was adopted.

The paper is organized as follows. Initially, the research method, the profile of the participants and the design of the activities are presented. Subsequently, the research results are presented, focusing on learning outcomes as assessed by appropriately designed pre-and posttest questionnaires. The paper concludes with a discussion on the findings and directions for future research.

Method

The main goal of this paper was to investigate possible differentiations of students' learning gain (if any) across the three wiki-based activities. A one-group pretest–posttest design was adopted (Oncu & Cakir, 2011) to measure the learning gain as a result of students' engagement in the wiki-mediated activity. Specifically, in order to examine the extent of knowledge and understanding before and after involvement in each activity, students responded to an appropriate online test comprising from 35 up to 40 multiple-choice questions with four answer options. The participants attended courses offered in the Department of Educational Sciences and Early Childhood Education (DESECE) at the University of Patras.

Participants

Twenty-four female first-year university students, aged 17–40 ($M = 19.2$, $SD = 4.5$) participated in the first activity. Students were attending a non-compulsory academic course entitled Introduction to Web Science. The activity took place from 26 May 2010 to 6 June 2010.

The second activity involved 146 students, 144 female, aged 17–40 ($M = 19.2$, $SD = 3.6$). Participants were attending a compulsory academic course entitled Introduction to ICT, and the activity took place from 29 November 2010 to 16 December 2010.

Thirty-six first-year university students, 35 female, aged 18–24 ($M = 19.4$, $SD = 1.2$), participated in the activity. Participants were attending a non-compulsory academic course entitled Introduction to Web Science, and the activity took place from 3 May 2011 to 20 May 2011.

Procedure

Participation in all three activities was one of the four compulsory mini-projects given to the students. The procedure was the following: First, an instruction on the wiki's basic functionality was given to the students. Subsequently, the students familiarized with the wiki tool and practised upon representative tasks, such as creating and editing text, discussing and commenting aspects of the document and inserting and editing photos and videos. Next, a compulsory assignment was presented to them in the form of a wiki, constructed by the researchers. Each wiki included the objectives of the assignment, its structure, detailed implementation instructions, the expected learning outcome, the evaluation criteria, and the representative support material (West & West, 2009). The students worked remotely and, after the assignment deadline, they had to briefly present their work.

The students were divided into groups comprising four or five members each. They were allowed to freely form their groups without any restrictions. Each team member was assigned a specific role in the group (West & West, 2009), such as Collector or Organizer. The available roles and associated responsibilities are delineated in the following. Each project was graded by the researchers on a scale from 1 to 100, according to the evaluation criteria. The score was multiplied by the number of the group members (4 or 5) and was given to the students, who were asked to distribute these points among themselves.

Research materials

For all activities, the Wikispaces service (www.wikispaces.com) was used both for the activity announcement and as the platform provided to the students to construct their wiki. The online questionnaire service Survey Monkey (www.surveymonkey.com) was used to create and distribute the questionnaires of the study. Afterwards, the obtained data were organized and analyzed using Excel 2010 and SPSS v20.0. The initial presentation of the activity to the students and the completion of the questionnaire took place at the departments' computer lab.

The questionnaire was completed by the students at the beginning and the end of each learning activity. It included both demographic and knowledge-acquisition questions. The former were completed only before the wiki-mediated activity and collected personal information regarding Internet and wiki use and adoption. The latter were used as a student learning-assessment instrument and were primarily related to the Facebook service and the wiki tools (first activity), general information about Google's history and services (second activity), and basic aspects and implications of usability evaluation in general and heuristic evaluation in particular (third activity). The students were not informed that they would be asked to complete the questionnaire at the beginning or the end of each activity.

Description of the activities

The design of each activity followed the structured framework proposed by West and West (2009). Students' learning was expected to be achieved by their being engaging into four processes: (a) information seeking and retrieval, (b) argumentation development and refinement to support their thesis in the context of the assignment, (c) collaboration among members, and (d) their involvement with the wiki. Furthermore, in the third activity students had to evaluate a website, which was an additional learning objective for them. In all activities, the topic was selected because it was a notable part of the course's overall outline.

In the first activity, available at <http://ergastiriowiki.wikispaces.com>, the learning goal was to understand and explore basic concepts of social networks, such as Facebook. Students were engaged in a debate exploring opposing sides of the Facebook service. On the one side, involving three out of the six groups with random selection, the students were responsible for directing Facebook's public relations and had to defend against media allegations of Facebook being responsible for a variety of individual and social problems. On the other side, involving the rest groups, the students were asked to compose a critical essay about Facebook, which would focus on its negative impact on the users' social lives, assuming that they were the editors of a newspaper with considerable prestige, social acceptance and validity. The wiki included four segment topics on which students relied to accomplish their task: (a) history and timeline of Facebook, (b) information about its rapid adoption, (c) reasons for Facebook's popularity, and (d) arguments for/against Facebook.

In the second activity, available at <http://googleactivity.wikispaces.com>, the learning goal was to understand basic aspects and implications of search engines. The wiki included ten segment topics on which students relied in order to accomplish their task: (a) Google's founders, (b) Google's history, (c) the page-rank algorithm, (d) search techniques, (e) the technological infrastructure of the search engine, (f) Google's working environment, (g) services provided, (h) Google's business model, (i) usage of search engines in education, and (j) Google as a monopolist threat.

In the third activity, available at <http://web-usability.wikispaces.com>, the students had to study and present the most widely adopted usability evaluation techniques and include basic definitions about human computer interaction and user interface design. In addition, they had to delineate the process required to carry out a heuristic evaluation (Nielsen, 1994). Finally, they had to cooperatively evaluate the departments' website (www.ecedu.upatras.gr), using heuristic rules (Nielsen, 1994).

The first activity required critical thinking, and students had to debate exploring opposing sides of the Facebook service. The second activity engaged students in knowledge construction processes. The third activity belongs to the third class of contextual application, in which students had to apply the heuristic rules that they had learned to evaluate their department's website.

In all activities, the students had to create their own wiki, in which they would develop the theme of the assignment. An exemplary wiki was constructed by the researchers and provided to the students to support them in organizing their wiki and material and in structuring their arguments. Students had to cover the topics of the exemplary wiki, which were organized into subsections (Figure 1). For each topic and sub-topic, an indicative outline and specific arguments were given to the students to develop as well as supporting material and references, mainly in the form of hyperlinks (Figure 1).

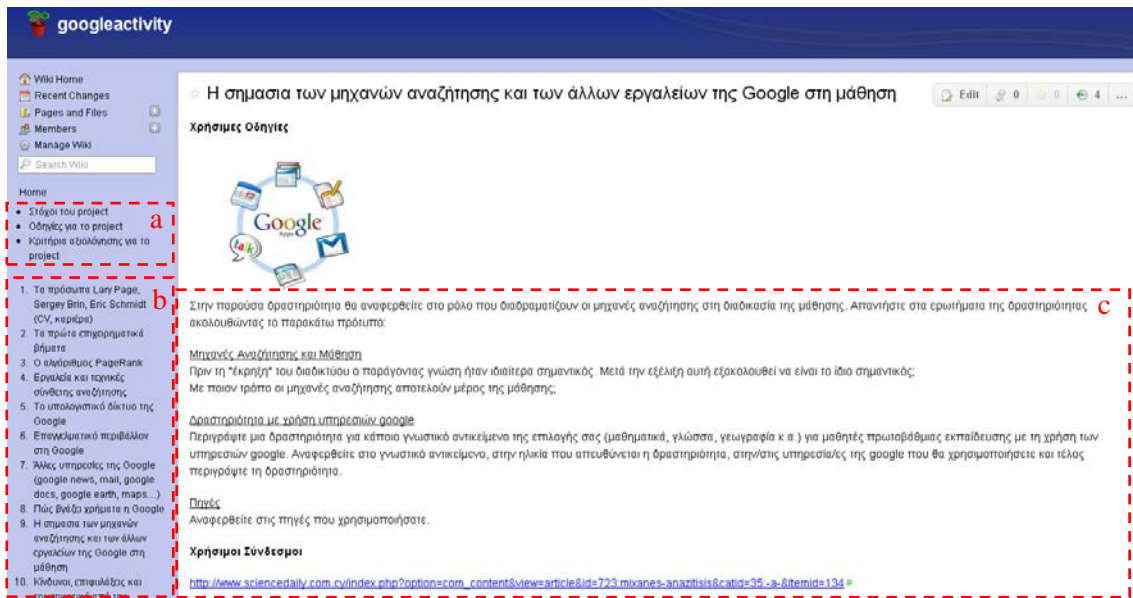


Figure 1. Screenshot of the second wiki-based activity presented to the participants. (a) Navigation to project goals, instructions and evaluation criteria, (b) Navigation to segment topics, (c) Indicative outline, arguments and related material for the selected segment topic

However, the context was not restrictive and the students were encouraged to use additional arguments and material. The use of additional material was not only desirable, but also a discrete evaluation criterion. Given that the open nature of Web 2.0 tools could lead to inappropriate use of content from other sources (Huijser, 2008; Waycott et al., 2010b; West & West, 2009), it was stressed that usage of other's work should follow specific rules. The rest of the evaluation criteria were text relevance, text clarity, argument originality and reasoning, compliance to the provided structure and format guidelines, material appropriateness and richness, and appropriate use of references.

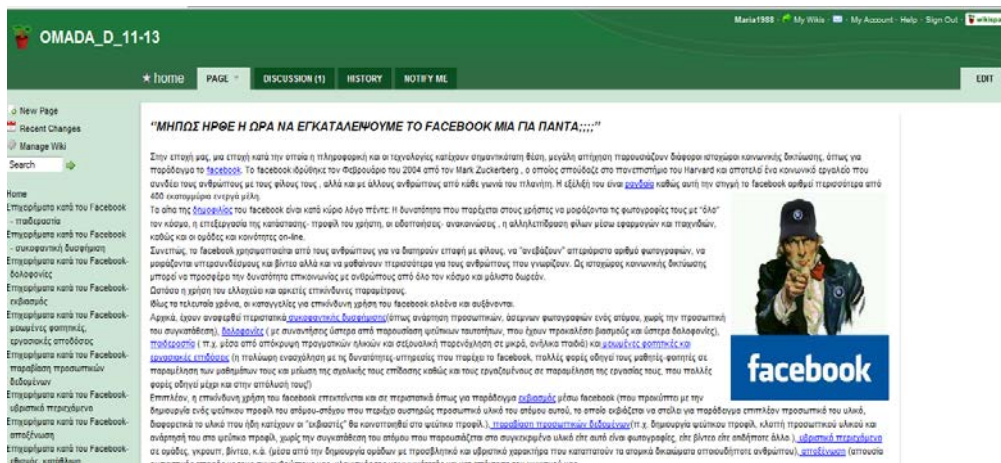


Figure 2. Screenshot of a wiki developed by students

All team members were writers and text editors, but each team member was assigned a role with specific responsibilities so that all students involved in a group would know what to expect from each other (West & West,

2009). In all activities, there were four different roles: (a) Collector, responsible to obtain and organize appropriate material relevant to the subject undertaken by the team; (b) Organizer, responsible to examine the material collected by the Collector for consistency and relatedness with the objectives of the scenario; (c) Editor-in-Chief, responsible for composing the text with the basic arguments according to the objectives of the scenario and posting on the wiki the text and the material produced by the Collector and Organizer; (d) Controller, responsible to check the contents of the work in terms of its appropriateness, consistency, completeness, structure, and compliance with the objectives of the scenario. The students' identity and role were published on the wiki used to describe the activity. Students were instructed to mainly carry out tasks that were related to their assigned role, but they could potentially carry out tasks that were not part of their role. However, the follow-up questionnaire confirmed that the students primarily focused on their initially assigned role. Figure 2 presents an example of a wiki produced by the students involved in the Facebook-related activity.

Results

All in all, we collected data from three wiki-mediated activities involving 206 university students. Table 1 presents participants' demographic-related information in our dataset.

Table 1. Participants' demographic-related information in our dataset

		Activity1: Facebook	Activity2: Google	Activity3: Usability	All Activities
Sample size		24	146	36	206
Age	Mean	19.3	19.3	19.4	19.3
	Range	17–40	17–41	18–24	17–41
Gender	Male	0	2	1	3
	Female	24	144	35	203
School stream	Theoretical	18	114	22	154
	Technological//Scientific	6	32	14	52
Web-usage frequency	Almost none	0	4	1	5
	Some times in a month	3	38	6	47
	Some times in a week	0	7	2	8
	Everyday	21	89	27	137
Prior wikis usage	Yes	3	28	23	54
	No	21	118	13	152

First, reliability analysis was conducted for the three learning assessment questionnaires used. Reliability refers to the extent to which an instrument such as a questionnaire yields the same results under consistent conditions (Nunnally & Bernstein, 1994). It is most commonly measured using Cronbach's alpha, which is a measure of internal consistency. The questionnaires used in both the first and third activities had good internal consistency; alpha = 0.77 and alpha = 0.86 respectively. The questionnaire used in the second activity did not have sufficient reliability (alpha = 0.65) to meet the typical minimum standard of 0.70 (Nunnally & Bernstein, 1994). Six questions increased the alpha to 0.72 when deleted and thus were excluded from subsequent analysis.

Following Nelson et al.'s (2009) rationale, we used the normalized learning gain defined as:

$$G = \frac{post_{score} - pre_{score}}{max_{score} - pre_{score}}$$

This equation has the advantage of "normalizing the observed gain (the numerator) against the amount of possible learning that could be achieved (the denominator)" (Nelson et al., 2009, p. 1797), and thus allows for fair comparison of learning gains for students with different pretest scores.

Table 2 presents descriptive statistics of the collected dependent variables. Overall, students had similar initial scores in the knowledge assessment questionnaire and achieved higher scores after taking part in the wiki-mediated learning activity (Figure 3).

Table 2. Dependent variables grouped by wiki activity

	<i>N</i>	Pretest score [0–100] Mean ± 95% CI	Posttest score [0–100] Mean ± 95% CI	Normalized learning gain [%] Mean ± 95% CI
Activity1: Facebook	24	37.7 ± 4.4	53.3 ± 6.1	22.4% ± 12.5%
Activity2: Google	146	40.2 ± 1.8	58.7 ± 2.3	29.5% ± 4.0%
Activity3: Heuristics	36	35.2 ± 3.7	54.1 ± 6.4	26.4% ± 11.9%
All activities	206	39.0 ± 1.5	57.3 ± 2.1	28.2% ± 3.7%

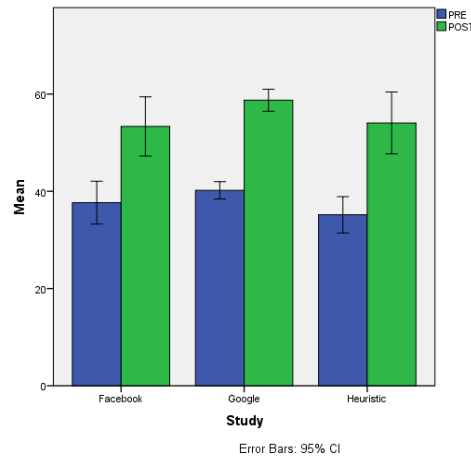


Figure 3. Students' scores in the assessment questionnaire per wiki activity

An initial analysis was conducted to investigate whether there was an effect of activity (three levels) on students' pretest score, posttest score, and learning gain. The assumption of normality was violated for all three dependent variables in at least one level of the independent variable (Shapiro-Wilk tests, $p < 0.01$). Levene's test indicated that the assumption of homogeneity of variance was also violated for both the post-score ($F(2,203) = 5.946, p < 0.01$) and learning gain ($F(2,203) = 4.884, p < 0.01$). Thus, Kruskal-Wallis one-way ANOVA, a non-parametric test, was applied. Results showed no significant effect of activity on students' pretest score ($H(2) = 5.232, p = 0.073$), posttest score ($H(2) = 3.980, p = 0.137$), and learning gain ($H(2) = 1.004, p = 0.605$). These findings support conducting analysis on the aggregated cross-activity dataset.

Additional analysis investigated prior experience of using wikis and web-usage frequency as potential covariates. Results showed no significant effects for both variables and thus they were excluded from subsequent analysis. It should be noted that our dataset is gender-skewed. Thus, any findings reported in the following might not be generalizable to male students involved in wiki-mediated learning activities. In all subsequent statistical analyses, effect sizes were calculated according to Field (2009).

Learning effectiveness of the wiki-mediated activities

A Wilcoxon signed rank test investigated differences between students' pretest and posttest scores in the knowledge assessment questionnaire. A non-parametric test was selected since the distribution of the differences in the dependent variable (test score) between the two related conditions deviated significantly ($D(206) = 0.984, p < 0.05$) from a normal distribution. Results indicated that students achieved significantly higher ($z = 10.698, p < 0.001, r = 0.527$) test scores after participating in the wiki-mediated learning activity. This large effect size (Cohen, 1992) demonstrates the learning effectiveness of properly designed wiki-mediated learning activities in the context of higher education.

Additional analysis on a per-study basis demonstrated the same pattern. Wilcoxon signed rank tests after Bonferroni correction showed that students' achieved significantly higher scores in the knowledge assessment questionnaire after participating in the first activity ($z = 3.373, p < 0.001, r = 0.487$), the second activity ($z = 9.492, p < 0.001, r =$

0.555), and the third activity ($z = 3.812, p < 0.001, r = 0.449$). Figure 3 presents students pretest and posttest scores per wiki activity.

Learning gain for students with low and high pretest performance

Table 3 presents measured dependent variables grouped by students' initial performance as assessed by their pretest scores. To this end, we recoded our dataset as in the following: students with pretest score below or equal to the median were assigned in the low pretest performance condition ($N = 110$), whereas the rest were assigned in the high pretest performance condition ($N = 96$). Posttest scores were similar for both students with low (56.1/100) and high (58.6/100) initial performance. However, students with low initial performance achieved higher learning gain (36.0%) compared to students with high initial performance (19.2%).

Table 3. Dependent variables grouped by students' initial performance

	<i>N</i>	Pretest score [0–100] Mean ± 95% CI	Posttest score [0–100] Mean ± 95% CI	Normalized learning gain [%] Mean ± 95% CI
Low initial performance	110	30.9 ± 1.1	56.1 ± 2.7	36.0% ± 3.9%
High initial performance	96	48.3 ± 1.5	58.6 ± 3.2	19.2% ± 6.3%

A two-tailed Man-Whitney U test investigated the effect of students' initial performance on their normalized learning gain. A non-parametric test was selected because both the assumptions of normality (Shapiro-Wilk tests, $p < 0.001$) and homogeneity of variance (Levene's test, $F(1,204) = 5.696, p < 0.01$) were violated. It was found that students with low initial performance achieved a significantly higher ($z = 4.108, p < 0.001, r = 0.286$) learning gain compared to students with high initial performance. Considering the whole dataset, a significant negative correlation ($r_s = -0.293, p < 0.001$) was also found between students' pretest score and normalized learning gain.

These findings suggest that wiki-mediated learning activities might be more beneficial to students with lower initial performance. However, more investigation and additional studies are required to both verify this finding and identify the specific reasons for this pattern of learning gain.

Effect of students' school stream on learning gain

The students' performance according to the stream that they choose in the secondary education's curriculum is presented in Table 4. The pretest mean score of students who attended the theoretical stream was slightly lower (38.7/100) compared to that of students of the technological or the scientific stream (39.9/100). Students coming from a theoretical background in secondary education also achieved lower posttest scores (56.6/100) compared to those with a technological or scientific background (59.4/100).

Table 4. Dependent variables grouped by students' secondary education curriculum

	<i>N</i>	Pretest score [0–100] Mean ± 95% CI	Posttest score [0–100] Mean ± 95% CI	Normalized learning gain [%] Mean ± 95% CI
Theoretical	154	38.7 ± 1.6	56.6 ± 2.4	27.2% ± 4.4%
Technological/Scientific	52	39.9 ± 3.7	59.4 ± 4.2	30.9% ± 7.4%

A two-tailed Man-Whitney U test investigated the effect of students' school stream on their normalized learning gain. A non-parametric test was selected since the assumption of normality was violated for the group of students who attended the theoretical school stream ($D(154) = 0.918, p < 0.001$). Results showed no significant difference ($z = 0.731, p = 0.465$) in the learning gain achieved by students who attended the theoretical curriculum and who attended the technological or scientific curriculum.

This finding suggests that wiki-mediated learning activities are beneficial to all students, regardless of their secondary education stream of studies. However, one should be cautious with this finding, given that approximately 75% of the students in our sample came from a theoretical school stream.

Effect of students' role in the activity on their performance

Table 5 presents students' performance according to their assigned role in the wiki-based learning activity: Collector ($N = 76$), Organizer ($N = 40$), Editor-In-Chief ($N = 46$), and Controller ($N = 44$).

Table 5. Dependent variables grouped by students' role

	<i>N</i>	Pretest score	Posttest score	Normalized learning gain
		[0–100] Mean \pm 95% CI	[0–100] Mean \pm 95% CI	[%] Mean \pm 95% CI
Collector	76	39.9 \pm 2.6	59.7 \pm 2.9	30.9% \pm 5.7%
Organizer	40	39.7 \pm 3.9	58.3 \pm 5.1	28.2% \pm 9.6%
Editor-in-Chief	46	38.8 \pm 3.1	53.5 \pm 5.2	22.7% \pm 8.9%
Controller	44	37.1 \pm 2.8	56.2 \pm 4.5	29.1% \pm 7.8%

A Kruskal-Wallis one-way ANOVA test investigated the effect of students' role on their normalized learning gain. A non-parametric test was selected since the assumption of normality was violated for the students with the role of Collector ($D(76) = 0.885$, $p < 0.001$), Editor-in-Chief ($D(46) = 0.949$, $p < 0.05$) and Controller ($D(44) = 0.936$, $p < 0.05$). Results showed no significant effect of students' role on their learning gain ($H(3) = 2.674$, $p = 0.445$).

This finding suggests not only that wiki-mediated learning activities were beneficial to all students, regardless of their specific role, but also that the responsibilities of each role were well-distributed.

Conclusions and discussion

In this paper, the results of three activities investigating the effectiveness of wiki-mediated learning were presented. Two hundred and six first-year university students participated in the activities. The design of the activities followed the framework proposed by West and West (2009). Evaluation of the learning effectiveness of the activities was carried out using a one-group pretest–posttest design. The results showed significant improvement in learning outcomes, particularly for students with low initial performance. The average students' questionnaire score jumped from 39.0/100 to 57.3/100. The students with low initial performance (below or equal to the median initial score) showed an improvement of 25.2 percentage points, whereas the students with high initial performance (above median initial score) showed an improvement of 10.3 percentage points. In addition, in all three activities a comparable and significant learning gain was observed. The persistence of the results strongly indicates that students learn with wikis regardless of the activity's class and subject.

In addition, no significant variation between the students' secondary education curriculum (i.e., school stream) and their learning outcome in the wiki-mediated activity was observed. Given that all the three activities were both mediated and related to information technology, students coming from a technological or scientific background were expected to achieve higher learning gain. However, it was found that wiki-mediated learning activities were beneficial to all students, regardless of their previous knowledge in secondary education.

Furthermore, it was found that learning gain is not related with the student's role in the activity. This is in line with previous research (Strijbos, Martens, Jochems, & Broers, 2004; Tselios, Altanopoulou, & Katsanos, 2011; Tselios, Altanopoulou, & Komis, 2011). However, the introduction of roles can help students who work collaboratively to build knowledge (Schellens, Van Keer, De Wever, & Valcke, 2007) and can increase cohesion, responsibility, and awareness in group members (Strijbos et al., 2004). By contrast, De Wever, Keer, Schellens, and Valcke (2010) noticed a varying impact of roles on knowledge construction.

All in all, this paper makes the following contributions related to the effectiveness of wiki-based learning activities:

- Significant and persistent learning gain was found across three activities, which are of different class according to the framework proposed by West and West (2009).
- The learning gain was found to be significantly higher for students of low initial achievement compared to students with high initial achievement.
- Students' role in the activity did not significantly affect their learning gain.

- Student's school stream did not significantly affect their learning gain.

These findings provide evidence that a wiki-based activity with a suitable context and support can substantially facilitate students to achieve higher levels of learning. Given that there is a lack of rigorous studies demonstrating the learning effectiveness of the framework proposed by West and West (2009), these are important findings for teachers, university instructors, instructional designers, and even technologists who are developing wikis and wiki-like platforms.

However, this research is not without limitations. The obtained results do not explain how the students have benefited from their involvement in the wiki activity. Moreover, it is not known to what extent the students were improved in other non-cognitive aspects, such as self-organization, collaboration, attitudes toward technology, and openness (Tapscott, 2009), which are considered important for completing a wiki project. Further studies are required to investigate these issues. Future research goals also involve the design and deployment of additional wiki-based activities in a variety of educational settings (both in tertiary as well as in secondary education) and the investigation of learners' behavioral intention to use wiki technology using technology acceptance models (Tselios, Daskalakis, & Papadopoulou, 2011). In addition, investigation of the interaction between students' observed activity in a wiki and the learning outcome (Katsanos, Tselios & Avouris, 2010; Tselios & Avouris, 2003) will be also examined. Finally, a comparison with other Web 2.0 technology-mediated activities also constitutes a future research goal.

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