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Review

Integration of wikis in education: a qualitative systematic review

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Abstract
The use of Web-based technologies in education and ways they can improve teaching and learning have been the focus of interest in the educational community during the recent years. In this regard, wikis are one of the most promising technologies. Many research studies have been presented that integrate wikis in educational settings. The abundance of the corresponding research work creates the need for a systematic survey. In this survey of the research on wikis in education content analysis is used to record and compare the conclusions of 110 recent empirical studies that used wikis in educational settings. The specific studies were published from 2014 to 2021. The conducted search was not limited to a specific level of education but involved all the corresponding levels of education. The key aspects of the educational use of wikis are outlined and clarified. Furthermore, information and suggestions that will be useful to future researchers, as well as teachers who want to integrate wikis into their teaching practice are provided. To the best of our knowledge, there is no other survey of the research that discusses all such aspects regarding wikis in education.

Keywords Wikis · Online learning · Distance education · Self-directed learning · Collaborative learning

1 Introduction

The educational community has recognized the importance of technology in learning and thus has focused on the use of modern technologies in the educational process. More specifically, the benefits of the Internet and Web 2.0 applications have drawn the attention of researchers, who tried to incorporate them into education [1–4]. Special importance is given to wiki technology as a way to "support emerging models of innovative, online pedagogies that can foster the development of essential competencies for a networked age" [5].

Karipidis and Prentzas [6] describe wiki as "a Web-based platform providing an attractive collaborative environment based on asynchronous communication and several other facilities". As wiki is a web tool, it is frequently used for distance learning education, while its collaborative features support a socio-cognitive approach in learning. It can also be described as a "flexible tool", as it can be used to teach a variety of subjects and support the education of any number of students [7, 8].

On the other hand, researchers have pointed out some difficulties in the use of wiki in education. These remarks led them to a number of proposals intended to overcome these difficulties, with the aim of addressing some technical problems related to wikis, as well as improving the way of using them. In this respect, the present study aims to explore

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Table 1 Study focus (Deng [9])

Study focus	Number of papers	Percentage
Collaboration or interaction	22	20
Participants' perceptions or experience	65	59
Pedagogical values of wiki	50	45
Comparison of wikis with other methods/media	8	7
Acceptance and motivation	24	22
Instructional design of wikis	12	11

Table 2 Wiki-supported activities (Deng [9])

Categories	Number of papers	Percentage
Individually authoring or editing	35	32
Sharing or recording information	24	22
Peer reviewing or commenting	41	37
Participation/involvement of teacher	21	19
Collaborative work	85	77
Peer discussion	18	16
Involvement of outside experts/students/audience	7	6

and evaluate the findings of researches concerning the development of the wiki tools in education and propose new insights in this field.

This paper is structured as follows. Section 2 describes a bibliographical overview, presenting three meta-analyses relevant to the subject. Section 3 presents the research questions and the process for selecting the surveyed papers. Section 4 analyzes and evaluates the derived findings. Finally, the conclusions are presented.

2 Literature review

Many researchers have worked in the use of wikis for educational purposes. Therefore, one can find numerous such papers in Google Scholar, even if the corresponding search is narrowed in the title of the papers.

Due to the large number of corresponding papers, a relevant discussion needs to categorize the derived findings so that they may be compared and evaluated. In general terms, the corresponding categorization takes into account the educational context of the research, the derived benefits, difficulties (or problems) in exploiting wikis and the conditions that provide an effective use of wikis. Researchers and teachers may utilize this information in order to enhance the educational practices and the benefits derived for all participants (i.e., students and teachers).

Given the aforementioned, a meta-analysis of work involving the use of wikis in education is very useful. However, there are few such efforts as recent literature indicates. In a recent meta-analysis, Deng [9] presented 110 empirical studies regarding the use of wikis in higher education. The specific studies were published from 2000 to 2016. According to him, the focus of these studies can be classified into six categories (Table 1).

As can be seen from Table 1, the focus of some studies falls into more than one category. Deng focused on the tasks carried out with wikis. He classified them into one or more of the seven categories depicted in Table 2.

In a relevant survey of the research on wikis in education, Trocky and Buckley [10] studied 27 papers about the use of wikis in higher education which were published from 2009 to 2015. They narrowed their research to four main uses of wikis: (a) writing skills, (b) collaboration, (c) knowledge acquisition, and (d) centralized repository. This survey has common features with the one conducted by Deng.

A critical factor that contributes to the success of wiki education is the learning theory that teachers follow. According to the TPACK (Technological Pedagogical Content Knowledge) model, the characteristics of the pedagogical approach should be relevant to the technological means used [11]. Deng points out that teachers followed socio-cognitive learning theories when the goals involved collaborative work or encouragement of interaction among

learners and among learners and teachers through the wiki environment. In contrast, constructivism was preferred mainly for individual writing tasks and for the purpose of peer assessment.

There were some aspects, though, that did not attract the attention of the researchers. For instance, Deng pointed out the need for further research in order to compare the potential of wikis in education with the respective potential of other media. The results of this comparison would assist in defining the proper use of wikis. It is also important to identify the way that wikis can be used in combination with traditional teaching methods. Deng also maintains that more research work needs to be carried out in a wider social context in which outside experts, teachers and students can participate. In other words, there is a need to identify the role of online communities in the context of the educational use of wikis.

In another meta-analysis, Stoddart, Chan, and Liu [12] focused only on research studies involving collaborative writing with the assistance of wikis. The specific studies were conducted from 2007 to 2012. They ultimately selected ten papers that contained tips for educational planning. Their main suggestions can be summarized as follows:

- Before the study program, learners need to be introduced to the concept and benefits of collaborative learning.
- Learners need to be familiarized with the wiki tool they will use.
- Learners need to be well informed about the tasks they have to fulfill and the corresponding deadlines.
- Learner assignments need to be organized into smaller tasks and deadlines need to be set for each task.
- Feedback processes should be established.
- Methodology of critiques should be explained.
- A framework for assessment and evaluation of the tasks among groups must be set.

The aforementioned three papers are part of an effort to identify the features and specific nature of wiki-based learning, as well as to illustrate the benefits and the problems that arise. Our survey of the research on wikis in education intends to present these aspects but follows a different approach compared to the aforementioned studies.

In particular, we did not limit our interest only in higher education as the other two surveys but we included research work from all educational levels including adult education. Furthermore, our research surveys the most recent work, i.e., work that has been published between 2014 and 2021.

Moreover, a scrutinized reading of the papers and the content analysis method led us to a number of research questions. Thus, we collected a considerable amount of data and created a comprehensive overview in the field of wiki education.

Furthermore, in contrast to the other surveys, our investigation relies on the fact that the credibility of the results is relevant to the way research and education program are designed and implemented. And this is because it is not unusual for the research and education program to be carefully designed but to find fault with the way investigation is held, or vice versa. In this respect, our aim is to spot weaknesses found in previous studies in the fields of research and education, in order to help future researchers to avoid such mistakes.

3 Aims and research questions

The main aim of our investigation was to study the research work relevant to the integration of wikis in education and thus to organize and provide a thorough discussion of the findings. Based on the content analysis of the relevant papers, we collected information that answers the following research questions:

- Research Question 1: What was the involved level of education?
- Research Question 2: How many learners participated in the study?
- Research Question 3: Where did the learners come from?
- Research Question 4: How long did the wiki-based learning process last?
- Research question 5: Which wiki platform was used?
- Research Question 6: What subject was taught?
- Research Question 7: What was the focus of each research study?
- Research Question 8: How was data collected?
- Research Question 9: What were the main findings (i.e., benefits, problems and suggestions) of the researchers?

In the following section, the findings of the investigation are presented. It should be mentioned that several of the surveyed research studies do not provide explicit information about all the above research questions.

4 Methodology of the research

Due to the large number of relevant papers, the search focused only on papers that:

- describe empirical education research regarding wikis,
- were written in English and
- were published in the last seven years (from 2014 to 2021) in journals included in indexes of Web of Science.

The papers were selected in three stages. In the first stage, the 'Publish or Perish' tool (version 7) was used in order to retrieve academic citations from Google Scholar setting the required limitations for the purposes of the investigation [13]. More specifically, using the specific tool we searched for papers that:

- were published from 2014 to 2021 and
- included in their title the keywords 'wiki' or 'wikis' in combination with one of the following 21 keywords: 'education', 'educational', 'learning', 'teacher', 'teachers', 'teaching', 'student', 'students', 'school', 'schools', 'university', 'learner', 'learners', 'course', 'courses', 'class', 'classes', 'classroom', 'classrooms', 'collaboration' and 'collaborative'.

In this way, 42 different combinations were created through 'Publish or Perish' and 1492 papers were retrieved. Table 3 depicts the number of papers retrieved for each combination of keywords.

In the second stage, we removed the duplicate entries and we selected only the papers published in journals included in the Core Collection indexes of Web of Science (i.e., 'Science Citation Index Expanded', 'Social Sciences Citation Index', 'Arts & Humanities Citation Index' and 'Emerging Sources Citation Index'). Thus, from the 1492 papers initially retrieved, 127 were left. 30 of them were included in the Science Citation Index Expanded, 66 in the Social Sciences Citation Index,

Table 3 First stage of paper selection process

ID	Combination of terms	Number of papers	ID	Combination of terms	Number of papers
1	'wiki' and 'education'	72	22	'wikis' and 'education'	38
2	'wiki' and 'educational'	15	23	'wikis' and 'educational'	12
3	'wiki' and 'learning'	230	24	'wikis' and 'learning'	95
4	'wiki' and 'teacher'	15	25	'wikis' and 'teacher'	6
5	'wiki' and 'teachers'	36	26	'wikis' and 'teachers'	17
6	'wiki' and 'teaching'	49	27	'wikis' and 'teaching'	18
7	'wiki' and 'student'	62	28	'wikis' and 'student'	22
8	'wiki' and 'students'	116	29	'wikis' and 'students'	39
9	'wiki' and 'school'	25	30	'wikis' and 'school'	12
10	'wiki' and 'schools'	0	31	'wikis' and 'schools'	4
11	'wiki' and 'university'	42	32	'wikis' and 'university'	9
12	'wiki' and 'learner'	3	33	'wikis' and 'learner'	1
13	'wiki' and 'learners'	27	34	'wikis' and 'learners'	19
14	'wiki' and 'course'	34	35	'wikis' and 'course'	11
15	'wiki' and 'courses'	14	36	'wikis' and 'courses'	4
16	'wiki' and 'class'	12	37	'wikis' and 'class'	5
17	'wiki' and 'classes'	3	38	'wikis' and 'classes'	3
18	'wiki' and 'classroom'	22	39	'wikis' and 'classroom'	21
19	'wiki' and 'classrooms'	5	40	'wikis' and 'classrooms'	3
20	'wiki' and 'collaboration'	43	41	'wikis' and 'collaboration'	24
21	'wiki' and 'collaborative'	211	42	'wikis' and 'collaborative'	93

7 in the Arts & Humanities Citation index and 47 in the Emerging Sources Citation Index. The sum of these numbers is greater than 127 because some journals are included in more than one index.

In the final stage, we rejected those that were not in English or did not refer to empirical research. Ultimately, 110 papers that met all the criteria were selected and included in this survey of the research on wikis in education.

The next step was to record the information contained in the papers using the content analysis method. This method is a "research technique for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use" [14]. An important advantage of this method that suits the needs of our research is that it can be used both as a quantitative and a qualitative method [15–17]. In this way, it gives the opportunity to form accurate statistics by answering the 'what', 'how many', 'why', and 'how' questions and draw useful conclusions [17]. Thus, we have adopted this rationale in our work, reaching both quantitative and qualitative conclusions, which are presented in the relevant section.

Moreover, this method may be used in an 'inductive' or 'deductive' way. Inductive reasoning is the process of developing conclusions from collected data by weaving together new information into theories [15]. In this case, the researcher uses the data to develop conclusions, explanations and interpretations [18]. On the other hand, in deductive reasoning the researcher looks for predetermined, existing subjects by testing hypotheses or principles [15]. In other words, deductive content analysis is used when the structure of analysis is operationalized on the basis of previous knowledge and the purpose of the study is theory testing [16]. In our research, we followed the inductive approach, although we took into account the findings of the previous meta-analyses in order to form an initial view of the field. Then we recorded a lot more information, which allowed us to understand and outline the field of wiki education in greater details.

In order to collect data, we applied a methodology proposed by the relevant literature [15, 16, 19]. More specifically, the papers were read by two independent researchers who identified and encoded their key points (open coding process). In the next step, these codes formed a unity and categories (themes) were created. This process was repeated more than once for each paper, making changes and additions to the codes and categories. In the final stage, the researchers used the categories and through a critical synthesis of the findings came to useful conclusions, which are listed in the relevant section.

During all the previous steps, the two researchers worked independently for the sake of the validity of the research [15]. After completing their work, they compared their notes and where any inconsistencies were found, they were resolved by discussing and re-evaluating the papers.

5 List of findings

5.1 Research question 1: What was the involved level of education?

The vast majority of the research studies involved higher education (81.6%). This is rather expected, as most researchers are in higher education (i.e., teaching staff members, postgraduate students, PhD candidates, postdoctoral researchers). Research could be organized and carried out more easily in their workplace and the findings could be used firstly by them in order to improve their teaching practices. However, there were also studies which involved primary school students [20–25], secondary education [26, 27], and adults [28–35]. Finally, there were some studies involving students from different levels of education (i.e., primary and secondary education) and others that involved higher education students and in-service school teachers [30, 36–38]. Table 4 depicts the number of studies corresponding to each level of education. The Appendix depicts the involved level of education for each study.

It is worth noting that in many of the courses organized in higher education the participants were either pre-service teachers [34, 39–46] or in-service teachers [28, 30, 33, 34]. This shows that teachers in primary and secondary schools tend to use wikis for their educational purposes.

Table 4 Level of education involved in the studies

Level of education	Number	Percentage
Primary education	6	5.5
Secondary education	3	2.7
Higher education	90	81.8
Adult education	7	6.4
Students from primary and secondary education	4	3.6

Table 5 Number of learners in the studies

Number of learners	Number of studies	Percentage
Up to 10 learners	8	7.3
11 to 25 learners	15	13.6
26 to 100 learners	55	50.0
Over 100 learners	28	25.5
Not explicitly mentioned	4	3.6

Table 6 Countries of origin of participants

Country	Number of studies
China, USA	16
Spain	13
UK	9
Taiwan	7
Canada	6
Iran	5
Turkey	4
Australia	3
Malaysia, Germany	3
Austria, Brazil, Finland, Greece, Italy, Norway, Serbia	2 (for each country)
Albania, Cyprus, Denmark, Egypt, France, Hungary, Iceland, Indonesia, Israel, Ivory Coast, Lithuania, Mexico, Netherlands, Philippines, Portugal, Russia, Singapore, Slovenia, South Africa, South Korea, Sweden, Uruguay	1 (for each country)

5.2 Research question 2: How many learners participated in the studies?

The number of learners that participated in the studies varied from less than ten to over a hundred. Table 5 classifies the studies into five categories according to the number of learners mentioned. In the first category, the studies included up to ten participants. These are limited-scale studies. The second category consists of studies in which participants reach up to 25 students, approximately the size of a typical school class. On average, these studies involve 18.6 learners. In the third category, the number of learners is over 25 and up to 100 with an average of 56.4 students. Most of these studies were aimed at higher education students. The fourth category involves large-scale studies in which the participants ranged from over 100 to 500, with an average of 205.5 learners. Finally, in four studies the number of learners is not explicitly mentioned. The flexibility in the number of learners participating in the studies and the positive outcomes indicate that wikis can successfully support different types of educational settings.

5.3 Research question 3: Where did the learners come from?

The participants in the studies came from 39 different countries (Table 6). China, the United States and Spain have a double-digit percentage. The fact that there are countries from around the world on this list proves that the use of wikis in education is well approved by the educational community. Certain studies involved learners from more than one country, e.g., [47].

5.4 Research question 4: How long was the duration of the studies?

The duration of the studies ranged from a few days to several months. Especially in higher education, wikis supported the educational process during the academic semester, so the duration of the corresponding studies lasted from a few months to a whole semester. According to these observations, the studies explicitly mentioning the duration

Table 7 Duration of the studies

Categories in terms of duration	Number of studies	Percentage
Short-term studies (up to 4 weeks)	6	5.5
Medium-term studies (from 5 to 10 weeks)	13	11.8
Long-term studies (more than 10 weeks)	36	32.7
Not explicitly mentioning the duration	55	50.0

Table 8 Wiki platform used in the studies

Platform	Number of researches	Percentage
Wikispaces	21	19.1
Moodle	13	11.8
MediaWiki	12	10.9
Google Sites	6	5.5
Pbworks	5	4.5
Blackboard	5	4.5
Other wiki platforms (DokuWiki, Zoho Wiki, Wikipedia)	3	2.8
Semantic wikis	2	1.8
LAMS	1	0.9
Not explicitly mentioned	42	38.2

were classified into three categories, i.e., short-term studies that were completed up to 4 weeks, medium-term studies lasting from 5 to 10 weeks and long-term studies lasting up to 6 months (Table 7). It should be mentioned that in several of the studies the actual duration is not explicitly mentioned.

As Table 7 shows, most of the studies explicitly mentioning the duration were long-term and medium-term studies. One of the possible reasons has already been mentioned and is related to the duration of the academic courses. But perhaps the main reason is that the use of a wiki takes time in order to offer the expected results, since students need to become familiar with the wiki environment and the collaborative methodology.

5.5 Research question 5: Which wiki platform was used?

Various platforms were used in the studies as shown in Table 8. The most widely used platform was the wiki platform Wikispaces. Despite its popularity, its operation was suspended on January 31, 2019. Therefore, future researchers must look for other solutions. Another popular platform choice was the wiki platform MediaWiki. It is open-source software that can be installed on a private server and configured appropriately. Its features make it an attractive alternative to Wikispaces as long as the appropriate staff members are available in order to install and configure the software. Another alternative wiki platform is PBworks which is already well known in the educational community [5].

In some studies, other wiki platforms were used such as DokuWiki and Zoho Wiki. In other cases, researchers used wiki functionality embedded in other online learning platforms, such as Moodle, Blackboard or LAMS. Google Sites was also used. Finally, semantic wikis, which follow the Semantic Web philosophy, constitute a relatively new category of wikis.

5.6 Research question 6: What subject was taught?

Wikis were used as a supporting educational tool in a rich variety of subjects. Special reference can be made to the teaching of English, Informatics and pedagogical subjects (Table 9).

5.7 Research question 7: What has been the focus of each research?

The studies dealt with various research questions that provided different viewpoints of the educational use of wikis (Table 10). Certain studies involved multiple research questions.

Table 9 Teaching subjects in the studies

Subject	Number of studies
English as a second/foreign language (ESL/EFL), English for Academic Purposes, English for Specific Purposes (ESP)	22
Pedagogy	20
Informatics	13
Management, Sales	7
Medicine, Nursing	7
Chemistry	6
Finance, Accounting	4
Writing techniques, language	4
Foreign language teaching (except English)	3
Mathematics, Statistics	3
Biology	2
Media and communication	2
Natural science	2
Aeronautics	1
Food Technology	1
Forestry	1
Geography	1
Physiotherapy	1
Psychology	1
Social issues	1
Not explicitly mentioned	8

Table 10 Focus of each study

Focus of the study	Number of studies
Wiki as an educational tool	43
Wiki as a collaboration tool	31
Relationship among various factors	23
Investigation of learners' knowledge and attitudes	10
Wiki as a professional tool	9
Wiki as an assessment tool	6
Comparison of wikis with other tools	4

The predominant point of view examined the role of the wiki as an important educational tool. Special attention was given to its impact on the improvement of knowledge and skills, to the way it influenced the educational process generally as well as its contribution on distance or blended learning.

The second most frequent matter of research was the evaluation of the wiki as a communication tool. Contemporary socio-cognitive theories emphasize the importance of social interaction to the establishment of knowledge. Hence educators try to align themselves with such educational practices. In this respect, it is important to confirm the wiki's value as a reliable tool of communication.

A large number of studies investigated the relationship between various factors involved in the educational process. Some of these comparisons were between individual characteristics of students and learning outcomes, the way the UTAUT (Unified Theory of Acceptance and Use of Technology) model worked and the perception of wikis by learners, the collaboration among groups and the learning outcomes, the anonymity during collaborative writing, the stress that might occur, the type of the tasks selected and its effect on collaboration, etc. In the study of the above factors, special attention was given to the role of the wiki.

To a smaller extent, researchers dealt with the beliefs and attitudes of learners. They were mainly interested in learners' intention to use wikis and the perceived benefits in terms of learning, collaboration and assessment. The wiki's ability to act as a tool of professional development and assessment also drew the attention of certain researchers.

On the contrary, there was less interest to the comparison of wiki with other tools. However, a few studies attempted to compare wikis with discussion forums, Skype, blogs, Google docs, virtual learning environments and social networks. The researchers attempted to highlight the benefits of each tool and determine the appropriate way to use them.

5.8 Research question 8: How were data collected?

Data were collected by using either quantitative or qualitative methods or sometimes a combination of the two methods. Table 11 summarizes the methods of collecting data, as well as the frequency that each one was used. As the total number indicates in Table 11, in several studies multiple methods were used.

Questionnaires were frequently used as a method of collecting data. It was a handy tool in order learners' views and attitudes to be recorded [43, 48–50]. In most cases, the questionnaires were completed either before or after the wiki-based process. In some studies, however, questionnaires were completed before and after the wiki-based process to enable the comparison of the corresponding answers [51–55].

The researchers who used tests as a data collection method followed the same pattern. Usually, tests were held before and after the wiki-based process [27, 56, 57]. The aim was to evaluate the extent to which learners improved by participating in the overall process. On the contrary, when the tests were conducted only at the end of the process, the researchers sought to determine the achievement of cognitive goals they had set from the beginning. In this case, the students' assignment on the wiki was frequently used to collect the corresponding data.

Very often researchers used wikis in order to record the way learners worked. In this case, the researchers derived insights from the additions and changes made by learners to wiki content and from their posts in the discussion forum. Then, qualitative analysis of the corresponding data was carried out to reach conclusions about the degree of participation and collaboration developed in the wiki environment. In some cases, the relevant data was collected automatically using specialized software [37, 58].

Interviews are a qualitative method of data collection in order to get a deeper understanding of the framework and relationships developed during the research. Interpersonal contact enables the researchers to direct the discussion in the aspect they desire, to ask clarifications, and finally to focus on the aspects that are of greater interest to them.

Another qualitative method of data collection used in the studies was the observation of learners' behavior during the wiki-based process. In this case, the wiki is usually used in a computer lab so that the tutor can observe how the team members work together [24]. However, this approach seems to be in contrast with wiki philosophy, whose main features are online work and support of asynchronous communication. These two characteristics are eliminated when the above practice is applied, as students are in the same room and communicate synchronously.

Finally, reflective reports were used in certain studies [59–61]. Such reports enable learners and tutors to express their thoughts and assess the whole process.

5.9 Research question 9: What were the conclusions (benefits, problems, suggestions)?

Most researchers have praised the value of wikis in education. Table 12 summarizes the main educational benefits identified by the researchers. The number of studies reporting on each benefit is an indication of frequency of occurrence or/and the importance of each finding.

Table 11 Data collection methods

Data collection methods	Number of studies
Completion of questionnaires	79
Use of wiki's history of changes and/or use of wiki content	61
Interviews	32
Testing or assignments	15
Observation	14
Reflective reports	7

Table 12 Benefits derived from wiki use in education

Benefits of wiki use	Number of studies
A wiki is a useful multipurpose educational tool	28
Reinforces participation, interaction and collaboration	28
Improves learners' skills	18
Enriches knowledge	11
Improves the quality of assignments	11
Increases learners' motivation	8
Provides various ways of objective assessment	7
Promotes professional development	6
Enhances critical ability	6
Provides a friendly and flexible environment that facilitates learning	4
Helps on information sharing	3
Helps reduce learners' stress	3
Supports the establishment of learning communities	1

As seen from Table 12, some studies identify more than one main benefit of using wikis. On the contrary, some of the studies revealed several weaknesses in the educational role of wikis or in the process of exploiting wikis in education. The main ones are summarized in Table 13.

In certain studies, the assignments were delivered towards the end of deadlines. This means that the work of learners was not available to their peers for a sufficient amount of time in order to study it, provide constructive comments and assist in its improvement. The delivery of assignments slightly before the deadline was the case in previous research studies as well [62–65]. There may be various reasons for this. Two such reasons are mentioned in Allwardt [62]. More specifically, certain group members did not complete the part of the work they undertook or did not respond on time to fellow students' queries. Moreover, certain students mentioned that the overall work should have been partitioned into smaller parts and separate deadlines needed to have been set for fulfilling each part of the work. They deemed this necessary because they did not know how to partition the work by themselves. However, although Leung and Chu [64] structured the overall work of students into four main stages (i.e., literature review, discussion with the tutor, presentation in plenary session and submission of final project) with separate deadlines, they noticed that students in all groups mainly worked slightly before the deadlines set. Further reasons are the inappropriate time management and utilization

Table 13 Problems found during educational use of wiki

Weaknesses—problems	Number of studies
Technical issues related to the wiki platform	11
Delivery of the assignments towards the end of deadlines	7
Shortage of time	7
Limited feedback from peers	7
Unequal contribution of team members	7
Problematic or superficial collaboration	6
Lack of self-confidence	5
Problems with the technological infrastructure	4
Limited knowledge of (or limited experience with) wiki functionality	4
Reduced participation	4
Absence of a channel of direct communication or interpersonal contact	3
Development of stress due to first contact with wiki technology or due to the assessment and feedback procedure	3
Lack of collaborative skills	2
Concern for issues of plagiarism and/or corruption of texts	2
Leadership problems	1

from the students' part, their perceived shortage of time to fulfill their tasks and difficulties that they may face with the wiki tool and the overall process.

A collaborative process requires the contribution of all learners. However, research has shown that the work in wiki-based activities is not distributed evenly among learners. This uneven division of labor involves the contribution in preparation of content and provision of feedback. That is, some students contribute less than others [30, 57, 66] or they even made no contribution at all [30]. According to Du et al. [30], the level of education played a role in this aspect. More specifically, the results showed that the contribution was more even among higher education students compared to students in the other two levels. Furthermore, the work was more evenly distributed among secondary education students compared to primary education students.

Shortage of time is mentioned by students as a problem (e.g., [49, 61, 67]. Wiki-based work concerns the preparation of content and the interaction with peers. Students mentioned that additional time was required to fulfill their tasks.

Peer feedback is necessary as it assists in improving the quality of the produced work [43]. However, various researchers mentioned that learners provided limited feedback to their peers. For instance, Judd et al. [68] and Peled et al. [43] reported that peer feedback was superficial. Peled et al. [43] attributed this to the unwillingness of learners to provide and receive constructive peer feedback whereas Judd et al. [68] attributed it to deficient collaboration skills. Ahlholm et al. [36] reported that learners mainly dedicated time to search for information and prepare content and they dedicated limited time to provide feedback to their peers. Further reasons for insufficient feedback are discussed in [69]. More specifically, learners that were confused, had not understood certain aspects or regarded their opinions as erroneous, chose not to ask for assistance to avoid the acceptance of their helplessness. This behavior hinders the development of interaction and provision of feedback. Poyas [70] discussed a further aspect regarding feedback. More specifically, learners were unwilling to provide critical feedback publicly (e.g., in wiki discussion pages) and preferred other means of communication such as face-to-face interaction and e-mail.

The implementation of wiki activities requires learners' individual contribution in creation of content and provision of feedback to peers. Studies have shown that the individual contribution of learners is rather uneven and most work is done by a few learners. Obviously, this affects the produced content and learners' attitude towards teamwork and group assessment.

In certain cases, learners faced difficulties in their work because they had limited knowledge of (or limited experience with) wiki functionality. Different types of learners faced this problem such as in-service teachers [63], undergraduate students [49, 71], postgraduate students [45] and primary education students [23]. The amount of experience of the student with wikis also tested statistically significant for how effective the student perceived the wiki to be as a tool to enable collaboration among students [71].

Students need to work inside and outside the educational institution but there may be problems with the corresponding technological infrastructure. In some cases, it may be difficult or impossible to work outside the educational institution. For instance, the Internet connection outside the educational institution may be slow [7, 61, 72, 73], unstable [73] or unavailable [73]. Furthermore, at home there may be no Internet connection [62, 74] and the required hardware may be not available [75]. However, there may be problems with the available infrastructure within the educational institution as well especially in cases of limited budgets. For instance, students in [23, 24] reported that the school network was slow and that there were problems with the available school computers (e.g., crashes and problems with keyboards). A further issue may involve slow server response time [7, 75].

Learners need to cite the corresponding sources of the wiki content. However, this is not always the case resulting to plagiarism. Karasavvidis [76] mentioned that learners often used text from sources available on the Web without citing them and presented it as their own work. In various studies, learners expressed their concerns about plagiarism involving the wiki content they prepared [49, 71, 77]. Students may also fear that their own work will be plagiarized [71]. In certain cases, students also fear the vandalism of content they prepare [71].

Wiki tools inherently support only asynchronous interaction among users. Asynchronous interaction ensues from the content that is collaboratively created. Furthermore, several wiki tools encompass discussion forum facilities. Wiki functionality may also be exploited to create message boards involving events and news [78]. However, asynchronous interaction may not always cover the needs of the participants [48] and real-time interaction may be necessary. Real-time interaction may be achieved through face-to-face interaction and use of synchronous communication tools. A conclusion drawn in various studies is that these means of interaction are necessary. Indicative studies in which students mention the need for synchronous communication tools without explicitly stating the use of such tools are [21, 63, 79, 80]. Synchronous communication tools used in studies were instant messaging tools [23, 81], chat tools [65, 78], videoconference tools [65] and phone devices [30]. Instant messaging proves useful in notifying students about changes in

the content [81]. The need for face-to-face interaction is mentioned in various studies such as [21, 46, 63, 79–81]. There are reports that students interacted with each other for considerable time in face-to-face meetings compared to their interaction through the wiki environment [74, 81].

The development of stress among learners is mentioned in certain studies. For instance, Yusop and Basar [61] reported the anxiety of learners due to their previous lack of experience with wiki technology. This anxiety was slowly overcome at the end of the corresponding time period. Feedback and evaluation may also create stress. More specifically, Demirbilek [82] reported that learners were stressed in terms of providing negative feedback. They considered that this would affect their relation with peers because the identity of the person that provides feedback is known to others.

Participation of learners in the activities is needed throughout the corresponding time period in order to promote a spirit of collaboration. This is not always the case since reduced participation was reported in certain studies. As reported in [30], a study involving three education levels (i.e., primary, secondary and higher education), learners may not perform content and comment actions very frequently. More specifically, about 75% of primary and secondary education students performed less than two content actions in the period of a month while over 50% of them performed less than one content action within a month. The corresponding portions of higher education students were 13% and 0%, respectively. These results show that a portion of students in all education levels does not perform frequent content actions. The results in the specific study also showed that a minority of students in all education levels performed two or more comment actions within a month since most of them performed a comment action once or less than once per month. Reduced participation was reported in whole-class collaborative knowledge building by Lin and Reigeluth [83].

The role of group leaders is to assist in managing the collaboration among the group members. Leadership issues were mentioned in [23]. More specifically, certain leaders imposed their will to group members. Group members had to accept ideas of the leader, their ideas were not accepted by the leader and this had a negative impact on their interest in the collaborative process and their writing experiences.

Researchers took all these findings into consideration, especially the drawbacks, in order to improve the way wiki learning can be more effective. As they note, teachers have a key role as they have to adopt new roles, as those of the facilitator and the organizer of the educational strategy. In order to use the wiki efficiently, teachers should abandon behaviorist practices and follow socio-cognitive and constructivist learning theories [84].

The careful planning of the assignments is another important factor in the success of the program [84]. These exercises should take into account students' prior knowledge. Clear instructions must also be given to keep a balance between the degree of structure of the program and the potential for self-action. Setting a timetable for the completion of each task helps students to complete their assignments regularly, thus avoiding frustration.

Exercises must use wiki technology and promote collaboration [85] in order to be compatible with the technological and pedagogical context of education. It is also important that they are based on authentic problems or situations to attract learners' interest [21, 86] and that they are fun for students and develop positive attitudes towards the teaching process [87].

Many motivational theories have highlighted the importance of establishing positive attitudes, such as Theory of Reasoned Action [88], Technology Acceptance Model [89], Theory of Planned Behavior and Motivational Model [90]. In order to contribute to this attitude, teachers should promote the benefits of wiki [61, 71], and its collaborative nature [91],as, for example, can be achieved by organizing preparatory training programs for students that will enable them to use the wiki [61, 82] and the necessary digital knowledge and social skills, such as communication, collaboration, negotiation, etc. [47]. Such actions will enhance students' self-confidence and self-esteem, and strengthen their motivation [92].

Teachers have the responsibility of separating students into groups. Ensuring heterogeneity [47, 93] enriches the team with knowledge and skills, while defining roles [94] helps prevent tensions and organize work. Teachers should explain the guidelines to students [82], as well as guide and support them [82, 95, 96].

Adopting nicknames when writing on a wiki can reduce student's anxiety and allow feedback that will be useful for improving work [82]. In addition, the ability to allow public viewing of the tasks creates motivation and competition among trainees [58].

Another advantage of wiki is its ability to support a variety of assessment formats for both groups and for each individual member. One of them is the use of anonymous assessment rubrics, which [58] helps to strengthen the involvement of learners in the evaluation process and develops their critical thinking.

Despite the great importance of the role of the teacher, there are also many other factors that influence the success of the wiki-supported learning. Providing the necessary facilities is one of them. For example, according to Yusop and Basar [61] if wiki is used within the school environment, high internet speeds must be provided. The choice of the wiki platform is also important as it should meet the needs of education as well as to reduce the potential problems [97]. In

addition, if learners live in remote places and wiki is used for distance learning it is important to use synchronous communication technologies such as instant messaging [81] or social networks [53]. The value of this choice is reduced when the wiki is integrated into a blended learning context or learners meet face-to-face.

In conclusion, the use of wiki in education is an effective educational tool when it is carefully planned and students and teachers are appropriately trained.

6 Discussion

The findings of our research correspond with those of Deng [9], and Trocky and Buckley [10]. Research supporting the educational use of wikis recognizes the contribution of wikis to the development of collaboration and effective interaction between learners. They also investigate participants' intention to use wiki and their views on wikis' educational role. Our research supports, like the previous ones, socio-cognitive and constructivist approaches of teaching for the effective use of wiki. In this respect, the most common ways to use wikis are the exchange of information, the collaborative writing and the problem-solving techniques.

Our findings are also in agreement with the research of Stoddart et al. [12], as the advice and principles underlying the researchers' support for a wiki training program are still in use.

However, our research is far more extensive and describes the scope of the educational use of wikis in a more comprehensive way. Thus, our research shows that:

- The vast majority of the research concerns higher education.
- Wiki is a flexible tool as it works effectively both in small and large number of learners and for the teaching of many subjects.
- Its special features have attracted the interest of researchers from around the world.
- Training programs usually last from two to six months.
- There are several wikis platforms, with various features.
- Researchers have used a wide range of tools to collect their data.
- There were significant benefits as well as several problems concerning the educational use of wiki.

The benefits of using wiki can be found in the entire educational process. Although wiki is an educational tool addressed to students, its success is seen in the whole educational process, as innovative pedagogical techniques and approaches are used. As has already been mentioned, wiki's correspondence with modern socio-cognitive learning theories [28, 49, 57, 98–101] makes it popular among scholars. Its collaborative features in combination with the asynchronous form of communication it supports can develop social interaction, reflection and critical thinking. In addition, the online nature of wiki enables it to incorporate distance learning or blended learning.

However, it has become clear that in order for the above functions of wiki to be effective but there must be a set of rules and conditions related to the curriculum, trainers and trainees. These include careful program design, motivation for trainees, selection of appropriate assignments, training of trainers, use of collaborative learning techniques and preparation of students.

It is worth noticing the need to focus on the role of the selection and use of appropriate pedagogical approaches in order to foster the effectiveness of collaborative learning [47, 81]. Although almost all of the articles mention collaborative learning, it is not clear the way it was succeeded. This is a major lack of the articles as the success of the collaborative approach depends on a number of conditions, such as:

- The appropriate age of students [102],
- The agreement to set a common goal [103],
- The appropriate composition of groups and the media that supports communication between learners [104],
- The presence of social skills, such as communication, building and maintaining confidence, leadership and conflict management [105],
- The presence of carefully designed tasks that are suitable for collaborative teaching [104],
- The presence of positive interdependence, individual accountability/personal responsibility, face-to-face promotive interaction, group processing and social skills [103, 106].

However, in most of the articles we studied, we felt that the preparatory actions for developing collaboration were limited to the forming of working groups. This lack questions the validity of the conclusions of these researches, since there are several cases in which factors responsible for reduced co-operation are not taken into consideration.

Another issue that needs to be better clarified in many articles is how to integrate wikis in online or blended learning methods. Since the main feature that researchers are trying to take advantage of is the asynchronous communication that wikis provide, there are two options: either to use them in a strictly online setting, or to ensure distance collaboration in between two live encounters in a blended learning environment.

However, in some cases the researchers report that the trainees used the computer lab while working with the wiki [24, 95, 100], without specifying whether it was possible to communicate with each other within this space. But such a possibility would negate the benefits of distance communication. In other studies, the form of the training was not specified [42, 107–109] or was simply mentioned (online or blended) without giving detailed implementation information [25, 51, 59, 110–112].

Apart from these clarifications, time needs to be allocated to ensure the success of the project. As several researchers commend [49, 61, 67, 82, 113, 114] the instructor should take time to organize training, oversee the process, promote the dialogue and evaluate students. On the other hand, learning with wikis is also time-consuming for learners as they need to organize their thoughts in a consistent way before they write them down. Working with other students also requires a great deal of time. Reading posts, critical evaluation and correction of texts are just some of the actions that students allocate time.

Students must therefore have strong motivation to get involved in such a learning process. In some cases the motivations are external, such as marks. Ideally, however, the motivations should be internal and stem from an understanding of the benefits achieved through social interaction. To reinforce these incentives, teachers should spend extra time organizing preparatory programs.

In conclusion, it can be claimed that such initiatives are undertaken only by teachers who are fully aware of the importance of their work and are willing to do it in the best possible way. In addition, students benefit from the process when they understand the value of collaboration and exchange of views and thus allocate time and effort.

If we study the relevant literature, from the appearance of the wiki to present, we will only notice that significant steps have been done towards the educational function of wiki. Yet, in recent years, there seems to be moving slowly by investigating the same subjects, focusing mainly on higher education and repeating the same advice to teachers. It is time to move forward and explore new areas and different aspects of the educational use of wiki. In our opinion, it is necessary:

- To conduct more research in primary, secondary and adult education.
- To classify the benefits, problems and conditions of effective use of wiki programs, depending on the level of education, because the context is different as well as the skills and knowledge of the learners, the problems they face [23] and the goals that set.
- To design longer-term programs because wiki education requires time to be familiarized and effectively used.
- To explore the potentials of wiki to promote reflection, critical thinking and the establishment of online learning communities.
- To investigate the impact on collaboration so as to create an action plan for wiki.
- To enhance the literature with researches in which schools from remote areas of the same country, different countries and different cultures will participate, in order to explore the impact of wiki on multiculturalism.
- To investigate the differences that arises when introducing wiki in the context of distance learning and blended learning.

7 Conclusion

The purpose of this research is to investigate aspects of the educational use of the wiki by analyzing relevant articles. According to our findings, most researches focused on the use of wiki as a collaboration and learning tool. A smaller number of studies compared and contrasted those factors that influenced the successful educational use of the wiki or investigated students' attitudes and views about and use of the wiki as a teaching or professional tool. A variety of means were used for data collection, such as questionnaires, wiki history tool, interviews, tests, etc.

In most cases the learners were university students. However, there were programs addressed to primary and secondary school students as well as to adults. The most popular wiki was Wikispaces, followed by the wiki of Moodle

platform and Mediawiki. A wide range of subjects were taught with the help of wiki. As far as the number of participants is concerned, it varied from a few learners to some hundreds. The programs usually lasted from 2 to 6 months and the learners came from 39 different countries. The pedagogical theory applied was social constructivism and collaborative learning. Finally, according to researchers studying wikis in education, there is much value of using wikis for educational purposes, yet many problems can be encountered, so special attention should be given to the conditions that ensure the success of this approach.

The basic limitation of our research is the selection of a small number of relevant articles out of the thousands published in journals. However, we selected our articles from high quality journals, creating an accurate sample that outlines the aspect of wikis' educational development. In addition, comparing our findings with those of previous surveys of the research on wikis in education, we aimed to enhance the credibility of our work through an indirect triangulation.

In any case, it is necessary to repeat such surveys at a regular basis. In this way there will be a record of the updated information. In our view, the interval between such attempts should not exceed three years, due to the large number of relevant articles. This vast number of publications concerning wikis is the best proof of their popularity among the education community Finally, an extension of this paper, which focused on citing mostly statistical data derived from the literature review, would be a deeper exploration of common themes, patterns, and implications among studies on Wikis in education.

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Data availability No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate This material is the authors' own original work, which has not been previously published elsewhere. The paper is not currently being considered for publication elsewhere. The paper reflects the authors' own research and analysis in a truthful and complete manner. The paper properly credits the meaningful contributions of co-authors and co-researchers. The results are appropriately placed in the context of prior and existing research. All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference. All authors have been personally and actively involved in substantial work leading to the paper and will take public responsibility for its content.

Competing interests On behalf of all authors, the corresponding author states that there is no competing interests.

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