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Influence of Several Years Use of Wiki on Academic Motivation Improvement*

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In this paper we study the influence on students' motivation of using wiki-based teaching and learning in academic settings over a period of several years. The goal is to improve academic motivation and stimulate more effective learning habits by accumulating knowledge and using the repository of previously accumulated knowledge. With the aim of studying the effects of several years of wiki-based teaching and learning on university students' motivation, data are collected and analysed by means of usage logs analyses, survey-questionnaire based method, and final exam results analysis based on the data taken from faculty archive over three academic years. The case study included students on five Information Systems related courses, on average 150 per academic year. The results indicate that the adoption of the Wiki Learning System in teaching and learning process increases students' motivation.

Keywords: wiki; teaching and learning; academic motivation

1. Introduction

The wiki idea has first found wide acceptance within technical communities, and then also within other communities, such as the free and open source software community for example [1]. Wiki has become particularly popular for communication, collaboration and online communities, building as well as knowledge sharing and reusing it [2]. Wiki is social computing application without predefined structure. It is adaptable, useful for collaborative writing, knowledge management, and is open and free. A wiki can be identified as a set of linked web pages that are incrementally created by a group of users that collaborate among themselves. Nowadays, we also witness the wide acceptance of the wiki in educational settings, from middle school, through high schools to academic institutions. Teachers all around the world recognize that wikis have huge potential for use in educational scenarios as a support for the teaching and learning process [2–7]. Using wiki as a course delivery tool improves communication and the students' involvement on course topics [5–7]. Further, wiki facilitates enable easier tracking of the development of new knowledge, more effective content development, and more objective knowledge assessment [3, 4]. Course design and organization is much more responsive when wiki is used as a teaching tool. Students find learning easier and much more interesting if the teacher applies an adequate wiki adoption model. However, involving wiki in educational settings does not necessarily guarantee to be success on its own [3].

We introduced the Wiki Learning System (WLS) into our teaching practice for the first time in the 2002/2003 academic year with the goal of trying to improve students' motivation to continuously learn and work during the whole semester. The lack of motivation was indicated by the unsatisfactory low interest level of students to enrolling for the final exam at the first term. At the Faculty of Electronic Engineering, University of Nis, examination the system is organized around six regular terms as follows. After attending a course, students are entitled to apply for the final exam of the course in any one of the six regular terms. The final exam usually consists of a written test or/and oral examination for which students get credit points. Motivation to enrol on final exam in the first exam term immediately after the course has finished (in contrast to postponing it for a later term) clearly indicates a student's motivation to learn. Academic motivation is very important for academic success and reflects a student's level of persistence, interest in the subject matter, and overall academic effort [8]. Hence, we identified the need to adopt innovative pedagogical methods to improve motivation. Based on literature research, we found that active learning techniques [9–13] and constructivist theory- [14–16] based approaches may result in higher levels of student engagement. Thus, we decided to include these techniques in our teaching practice. We based the decision on published studies showing that students adopt and like to work with such a system while, at the same time, their motivation as well as collaboration skills are improved [3, 7, 17, 18]. We adopted the concept of blended learning [19] that

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further includes a mix of active learning, computer-supported collaborative learning and problem-based learning techniques. In the context of successful adoption of the learning methodologies, the WLS is of crucial importance as the facilitating platform for effective collaboration and knowledge sharing. Such wiki-based teaching and learning is justified by cognitive constructivism [14] in a sense that students learn by actively constructing new knowledge, not by passive digestion of the served information. We also used WLS for course management, educational content accumulation, and knowledge sharing.

Most of the research published on wiki-based learning collects students' engagement data during a single academic semester. Traditionally, the research method that is adopted is focused on asking the participating students to fill in a questionnaire after the semester is finished. Results are positive when the primary research focus is on the factors that show wiki adoption among students. We are aware that wikis have been in use in more than one semester in a number of institutions, such as Georgia Tech, since 1998 [20] and the University of Hertfordshire since 2005 [17]. However, to the best of our knowledge, there are no published research results where a wiki is progressively used in multiple consecutive semesters, over a period of several years, and engages several different generations of students, and how multi-semesters of wiki use reflects on the students' motivation to learn. Our hypothesis is that multiple years of wiki usage leads to knowledge accumulation within WLS year by year, which further has positive impact on the students' motivation to learn. It should be noted that we need to adopt an adequate wiki-based teaching and learning model as well as WLS design in order to accumulate knowledge. Thus, in this paper we give an overview of WLS design and the wiki-based teaching and learning model that we used and continuously tested in practice. We assume that the knowledge being accumulated includes course material developed by teachers, material developed by students, reviews published within WLS, sets of tags, sets of literature references, final exam questions, tutorials, students published project and lab exercises. We also assume that the students' learning efficiency increases when they have open access to examples from previous generations of students and literature, when they can exchange knowledge between themselves at any time, and when they have 24/7 teachers support.

We consider motivation as one of the main factors influencing students' attitude and learning behaviour [21]. We follow the concept of motivation developed by Deci and Ryan [22], where to be motivated means to be moved to do something. Thus, we regard students' motivation to learn as students' engagement to contribute actively to WLS during the semester, and enrol on the final exam at the first term. We adopt the combination of face-to-face and online learning settings in order to improve intrinsic as well as extrinsic academic motivation [21]. Within a face-to-face setting the teacher can provide instruction and feedback, which should help students who are in need of external regulation [23]. For such extrinsically motivated students the lack of the regulation can limit their overall academic motivation. On the other hand, in the online setting intrinsically motivated students have the freedom to choose their own individual learning path. In the blended learning context, we combine both motivations, and we are interested in finding out whether wiki-based teaching and learning influence students' motivation to learn in general. A few studies used the self-report situational motivational scale developed by Guay *et al.* [24] in order to measure learners' motivation. This method measures situational intrinsic motivation and extrinsic forms of motivation by using a seven-point Likert scale. Further, student engagement can be measured as self-perceptions measured by questionnaires, interview responses, rating scales used by teachers and others, and behavioural measures (time spent on a particular activity, types of activity selected, persistence in the face of difficulty, intensity of attention and time-on-task, classroom attendance) [25].

We base our study on the data collected over several years of our successful first-hand experience in teaching five Information Systems related courses (ISC) at the Faculty of Electronic Engineering, University of Nis, where the wiki was intensively used. An integrated multi-method approach was used in order to examine the impact of multi-semesters wiki-based teaching and learning, together with continuous knowledge accumulation on the students' motivation for continuous learning. This multi-method is composed of WLS traffic analyses with the data obtained from web server and WLS log files, survey-questionnaire based method, and final exam results analysis based on the data taken from the faculty archive. The results obtained have shown that students' motivation increases, together with an improvements in student engagement and an increase in activity over the whole semester, as well as high motivation to learn for the final exam in the first term.

2. Background

2.1 Wiki technology

Computer technology has so far experienced exponential growth and the Internet has approximately

the same growth rate, indicating similar networking effects between individuals and the overall system. The fundamental difference is that instead of transistors connected by a silicon fabric on a chip, the Internet connects humans on a global social network fabric, and makes them an inherent part of the system. Such complex systems in which software interacts with other software, systems, devices, sensors and with people are called software-intensive systems [26]. Software-intensive systems based on Internet and featuring a high level of human participation are represented by several technologies and systems recently recognized as Web 2.0. Wiki is one of the flagship technologies of the Web 2.0, together with other constituents such as RSS, Social Networks, Ajax, Flex, Tagging, Blogs, Content sharing, Multimedia sharing, etc. As the list of Web 2.0 constituents indicates, the distinction between technology, system, human behaviour, emergent intelligence, communication, social systems, and networks is not as sharp as it traditionally used to be. In the rest of the section, we refer to wiki as a technology, while assuming all different aspects as already mentioned.

Wiki can be identified as a technology for knowledge management and group collaboration [27]. In [28], wiki is identified as a set of linked web pages that are incrementally created by a group of users who collaborate among themselves. The incremental nature of wiki results in the creation of a system storing shared knowledge that comes from multiple sources. The on-line encyclopedia Wikipedia (the most famous wiki project) proves the effectiveness of the process. On the other hand, we also refer to a wiki as a website that allows users to add content that may be editable by other users [29]. The main characteristics of a wiki can be summarized as follows [29–32]: 1) rapidness: new content is rapidly constructed; everyone can easily and quickly create new pages and add new content; 2) simplicity: a simple markup scheme for wiki text formatting; 3) openness: the freedom in changing someone else's wiki page [3]; 4) version control: wiki keeps track of how users modify pages, records page changes and keeps extensive page histories [2,33]; 5) search: a wiki search is parameterized, based on page names, page content, as well as content of the files found as page attachments. Some of the common wiki features are: browser independence, text editing, embedded images, numbered, bulleted and hierarchical lists, tables, embedded multimedia, search, emoticons, calendar, RSS, link checking, drawing tools, equation editor, and many others that can be embedded into wiki using standard plugin mechanisms. Wikis are applied in many different fields and for many different purposes. Wikis are flexible enough to support a variety of application domains, including teaching, research, and academic administration [5].

2.2 Wiki in education

The self-initiatives of teachers in different educational institutions as well as institution-supported programmes have resulted in a growing number of online teaching and learning environments. Teachers often create these environments simply as a convenient content delivery tool. They mainly apply such environments on the courses that are project-based and problem-solving oriented. The courses include case studies and assume tools for the students' engagement in collaborative and individual knowledge building. However, such courses often impose a teaching process that is much more demanding for the teachers.

Wikis are receiving growing attention among teachers, academics and educators in general as a teaching process collaboration tool. The most cited reasons for their growing popularity are [3]: low setup cost, relative ease of use, and low-cost support for collaboration. Every wiki user may make an individual contribution to the shared content and make it more interesting, readable, comprehensive, competent, etc. The same content may be shared between multiple users, while at the same time providing the content's persistence for an extended period of time. Therefore, the state of knowledge captured within the wiki remains up-to-date and dynamic.

A number of case studies for using the wiki in education can be found in the literature, ranging from conference papers to books. In [7], the authors present ten case studies for using the wiki in education, collected from different teachers in different educational settings. In [34], the authors give objectives for applying a wiki-based glossary to develop university course content. A wiki based framework for blended learning is presented in [17]. Most of the case studies on using wiki in education report positive results. The positive experiences are reported regarding using wikis throughout the whole education process, starting from the preparation of a new wiki based course up to using wiki in analyses of the course at the end of the education process. It also includes support and encouragement to students to collaborate with other students, the creation of the study material that would benefit future generations of students, learning how to work in collaborative teamwork environments, etc. [18]. However, not all of the reported case studies results are positive. For example, a failed experiment in using wiki technology to support student engagement with the subject matter of a course is reported in [33]. The authors tracked students' activities based on the number of posts to the wiki, and they

found that after five weeks there were no new posts to it. They give some interesting pedagogical challenges for teachers and present a series of reflections to guide teachers who are considering wiki technology as a teaching aid. They concluded that poorly designed and supported integration of a wiki into existing teaching formats lead to failure. In [30] the authors present the results of two case studies where students neither created new articles nor edited existing articles; they only accessed existing articles, implying that the use of wiki in education is much more complicated, and it needs more time to develop a kind of 'give-and-take' generation.

2.3 Motivational theory

Motivation is a concept that is regarded as important in starting or taking action. Behaviourist theories view motivation as a response to stimuli limiting motivational research to only that which is observable [35], while cognitive theories acknowledge the role of an individual's thoughts, beliefs, values and emotions in motivation.

Motivation to learn is paramount to students' success as many studies have explored. Motivation has an important influence on a learner's attitude and learning behaviour [21], and as such it is alterable and can be positively or negatively affected by the task, the environment, the teacher and the student [36]. Academic motivation can be enhanced through the use of certain instructional strategies and through course design, social interaction with other students and faculty, and by positively influencing student belief in the value of academic tasks and in their ability to complete them successfully [8]. Teachers have a strong influence on the type of motivation of students. In order to improve students' motivation, teachers need to know their goals, interests, and values; how students are affected by teachers and other students; and how to design instruction that teaches and motivates [37].

There are several different motivational frameworks for online learning environments [21]. Intrinsic and extrinsic types of motivation have been widely studied and the distinction between them has shed important light on educational practices [38]. Intrinsic motivational theory has been used to explore students' engagement in online environments [39, 40]. Research findings have shown that online students are more intrinsically motivated than students within face-to-face settings [41]. Wide cited self-determination theory [22] is a motivational theory that is built on the fundamental premise of learner's autonomy. It concerns supporting intrinsic tendencies to behave in effective ways. Self-determination theory has also been widely researched and practised. When students are intrinsically motivated, there is no need for outside incentives such as gaining good grades, avoiding negative consequences, passing a course in order to earn a degree [41]. In contrast, students that are extrinsically motivated undertake activities for reasons separate from the activity itself [38]. Studies that have explored adoption of self-determination theory into online learning settings focus on intrinsic motivation, while particularly more autonomous types of extrinsic motivation are ignored [41].

3. Wiki-based teaching and learning

In this section, we present the WLS design that we use for implementation of the wiki-based teaching and learning model in our teaching practice.

3.1 Wiki learning system design

We address the need for web based collaborative systems in education by developing the WLS. It is aimed at support collaboration, workflow and process management, interaction, knowledge sharing and dissemination, and heterogeneous information integration. Such dynamic collaboration is of the crucial importance for attaining uncommon and extraordinary results among students.

The WLS user interface consists of five common areas (see Fig. 1). The header (A) consists of the site title, search and sign-in areas. Content of the menu bar (B), located on the top of the page just below the header, can be edited by teachers at any time as any other wiki page. However, the menu bar represents the basic navigational structure that reflects the list of courses and, as such, very rarely changes. Note, if we want to scale the number of courses to a large number, the top menu could be easily implemented in a more dynamic fashion. However, in our current environment we do not need the dynamic approach. In addition to the navigation bar on the top, there is a navigation bar on the left side of the screen (C). The structure of the left navigation bar is dynamic and depends on the current wiki page. Teachers have the right to edit the left navigation bar page. In this way, teachers are able to change its content according to a perceived navigational activity for each individual page. The students have editing rights in the main area (D) only. Any student may create a wiki page and consequently can set edit as well as view rights for the created page. The area (E) displays the title of the current wiki page. It also contains icons for functionalities for the current wiki page content manipulation, such as editing, printing, adding comments, page history view and working with attachments on the page. In addition to the common areas that constitute the structure of each page, (A)–(E), Fig. 1 shows additional custom elements that are easily entered as part of wiki page content. Segment (F) is tag cloud used with the goal

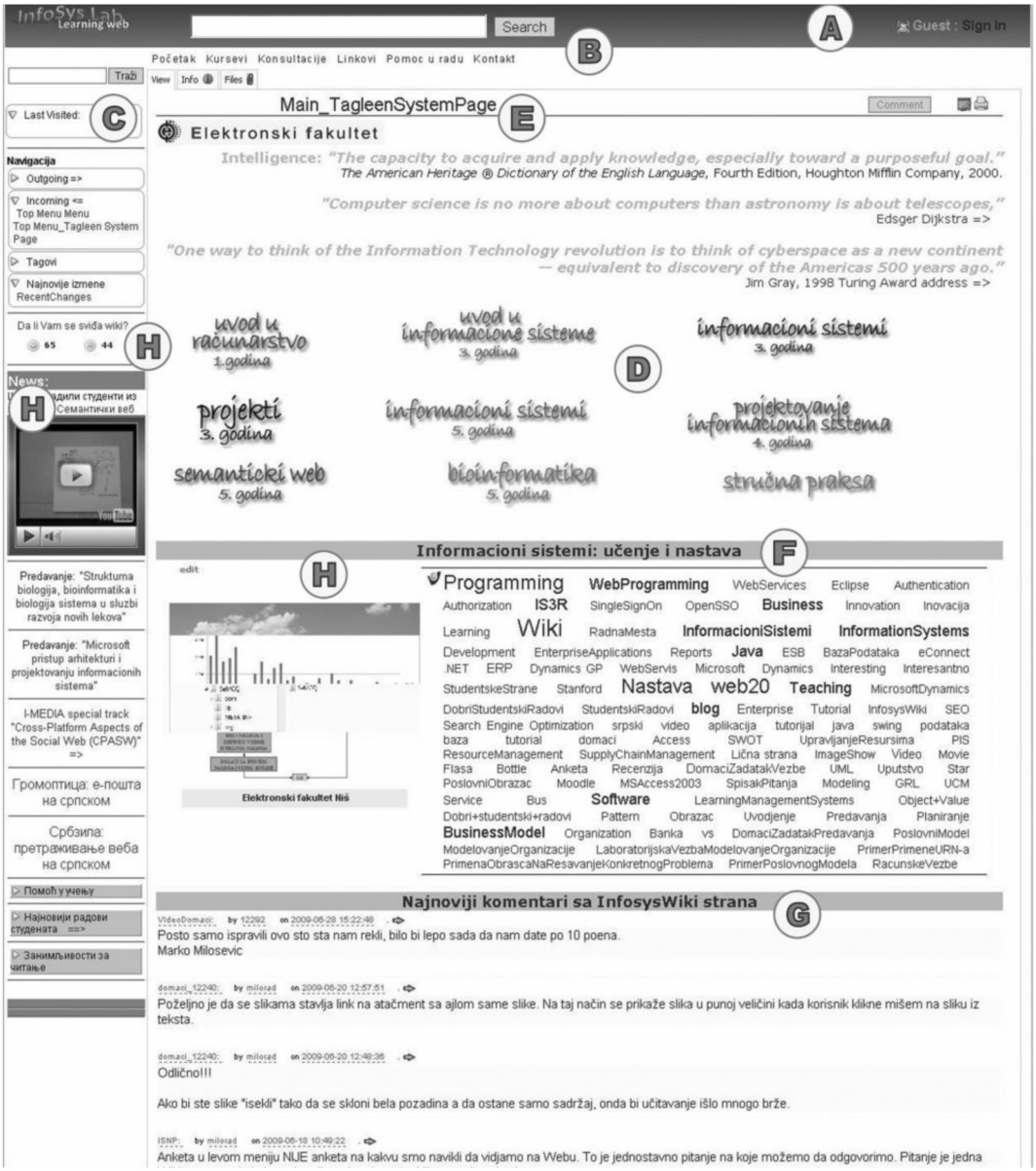

Fig. 1. Wiki Learning System: teaching and learning wiki home page of Intelligent Information Systems Lab at Faculty of Electronic Engineering, University of Nis.

of improving navigability of the wiki and is implemented following the Collaborative Wiki Tagging design approach [42]. Section (G) is a short list of comments and notes that students can leave on any page in the system. Elements labelled (H) are wiki widgets for image show, YouTube (www.youtube.-com) movie view, and wiki page based question pool, respectively. Note also that the content of the left menu is context dependent in the sense that different pages have different menu content. A detailed description of the wiki widgets functionality, usage and implementation details are outside the scope of this paper.

We have adopted an agile philosophy for software development as well as an overall system design for the WLS. At the software development level, we use plugin architecture with a slow-changing core engine and a number of plugins implementing different functionality features. At the system level, we identify the few core collaborative mechanisms of the WLS, map the mechanisms into sets of system features, and implement them using a constantly evolving base of software plugins. In the case of WLS, the system represents a constant 'work-in-progress': it represents its own documentation such that new features are immediately deployed and eventually used by end users as well as designers, system administrators and teachers.

We identify several collaborative mechanisms as important for our WLS design. For each of the proposed mechanisms, we developed set of features necessary for its implementation, but comprehensive discussion of the implementation of the collaborative mechanisms is outside the scope of this paper. In the rest of the section, we briefly describe a few of the most important mechanisms and concepts: a) system login and working groups, b) interaction over content, c) interaction over structure, and d) interaction over presentation semantics.

The WLS is structured as an open-access system where any user is allowed to contribute either by adding new content or by making changes to existing content. However, it is also very complex and heterogeneous in usage patterns (students, professors, system administrators, software developers, private groups, etc.) as well as in the content types (text, files, multimedia, services, software, etc.). Also, there is a constant input flux of spam attempts as is characteristic for most open systems on Web. So, we introduced an authentication and authorization layer that allowed us to support the complex requirements and to remain open at the same time. There are several permission types defined but only two are commonly used: VIEW page content and EDIT page content. The permissions are defined in the same way for individual users and groups of users. We keep our WLS system open-access. By default, any guest user is granted VIEW access rights while logged in users are granted EDIT rights as well (unless explicit restriction of the access rights is stated on the specific page). Several users can interact over the same content and work on the same data.

Interaction over structure means that participants in the WLS may change not only content but also the link. This concept is currently supported by the features such as a set of automatically generated page neighbourhood links (links pointing to the page and links pointing from the page), page specific drop-down menus, and context specific content. Page neighbourhood links are a content navigation aid but also may be valuable as a simple semantic navigation tool.

Interaction over presentation semantics is represented by importing inter- and intra-wiki or any other web page or a part of its content into some WLS page content. The user can build the page by composing parts of some other internal as well as external pages. We follow non-predefined structure of the wiki, and it is up to students to structure the form as well as the content of their pages. At the same time, we closely follow what is going on within the system, try to identify actual student needs, and answer the need by upgrading the system's features accordingly. The WLS implements link the structure based query mechanism in the form of a plugin. Simple link patterns may be used as input queries for the plugin, which further applies the patterns on the link neighbourhood of the current page. The result of the query is a set of wiki pages. The plugin may be configured to emit the resulting set in different formats: as a set of links to wiki pages or as a set of strings of names of wiki pages. In addition, the plugin can return a concatenation of the content of pages from the resulting set. This feature is heavily used throughout the system due to its dynamic nature and its light but effective semantics. The query plugin is very powerful on its own and further discussion is beyond the scope of this paper.

Since the wiki starts with no predefined structure, the basic constituents of the WLS in our case are the students', teachers' and courses' home pages. Students usually put links to wiki pages that they have been created, photos, personal information, etc. They are the owners of their home pages and they are the creators of templates for their home pages. The same situation is with teachers, but the teachers are the owners of the course home pages. The course home page has links to: the notice board, course program, lectures, exercises, students' projects, students' lists (holds a list of students' names and links to students home pages if they exist). The links to course material are provided in the lectures and exercise course pages. Further discussion on the WLS patterns is beyond the scope of this paper.

3.2 Wiki-based teaching and learning model

We first introduced the WLS into our teaching practice in 2003. Since then, we have constantly been adjusting the WLS as well as our teaching methodology with the goal of effectively answering the observed students' and teachers' needs. At the start, WLS represented a simple wiki-oriented web site with some basic content management features and mechanisms. We offered students the opportunity of actively participating in content creation and modification on a collaborative way. The students adopted new methods of working, and they started to contribute and use the web site as a light learning support tool. The scenario used that year gave positive results with regard to wiki adoption by the students and the WLS became more important for our everyday work. In the beginning, there were as few as 10 active WLS students. In the last three years, the average number of active WLS students grew approximately to 150 per academic year. Based on the experience, we developed and adopted the wiki-based teaching and learning model that we describe in more details in the rest of this section.

We could reflect on our pedagogical conceptual and methodological approach along the lines of 'anything that involves students in doing things

and thinking about the things they are doing' [9]. Students are actively engaged throughout the whole semester. The course consists of traditional classroom and laboratory exercises with intensive WLS use. At the beginning of the semester, the course program is clearly defined (topics of lectures, dates of presentations, lab exercises, etc.), and students are introduced to it. The traditional classroom exercises provide educators with a resource to introduce the most important problems related to the topic under consideration They also give basic points of reference to students so that they are able to jump quickly into further literature research and problem discussions. The teachers explicitly present the core concepts and the most important methodological steps that will enable students to start learning through independent research.

The WLS accumulates heterogeneous course related knowledge because teachers and students are collaborating together in the content creation. Students are welcome to contribute to the WLS and publish their work. Students are rewarded with additional credit points for active participation including any of the voluntary contribution to WLS, and additional work on assigned projects, particularly successful presentations, etc. The additional credit points collected in this way represent 5% of the total course credit points. Teachers monitor the students' participation and students can earn 55% credit points before the final exam. It should be noted that, due to the WLS, teachers are in a constant real-time 24/7 interaction with all active students. Students can create wiki pages with formatting as a personal or group choice, free of any outside limitation or constraints in the form of formatting templates. Students are aware that any other participant can edit each wiki page (or contribute to the page) and everyone is welcome to do so. Note, in the default access rights configuration, we allow a Guest role to view pages but not to edit them. All registered and authenticated users are allowed to view as well as edit the pages. The page creator may change the default access rights to any other access rights configuration. The contents of the students' lab exercises are accumulated and may be used by other students as supplementary literature. All students are welcome to put comments on the work of others. Students can put projects and homework on the WLS in the form of wiki page(s) and/or attached files as concomitant material. In addition, students augment their work on lab exercises by encountering other students' viewpoints.

Figure 2 shows the model that we use in our teaching and learning environment. This model represents an iterative process involving a series of steps for credit points collecting. After a lecture module is completed (1), teachers publish accompanying exercises for students (2). Teachers give students the freedom to choose one of the published exercises or devise their own example that fits the main module's subject. When students finish their exercises, they publish it at WLS (3). All WLS users, teachers and students, are welcome to review and give comments on all WLS contributions (4) (especially to students' contributions) with the goal of improving the appropriateness and quality of the material. In each iteration, students collect credit points (5). There is a minimum number of credit points that must be collected as a requirement for the final exam. The students' work and activities are actively monitored during interviews made in laboratory classes: each student presents what he/she has contributed to the last lab exercise. Based on the quality of the work and the presented student knowledge, teachers give credit points to the students. If the teacher notices some kind of work anomalies, he or she can track the activities back to each individual student and check any plagiarisms or inaccuracies that may occur in the student's work. By using these principles, students work through several such cycles, their workload is evenly spread over the whole semester, and they complete

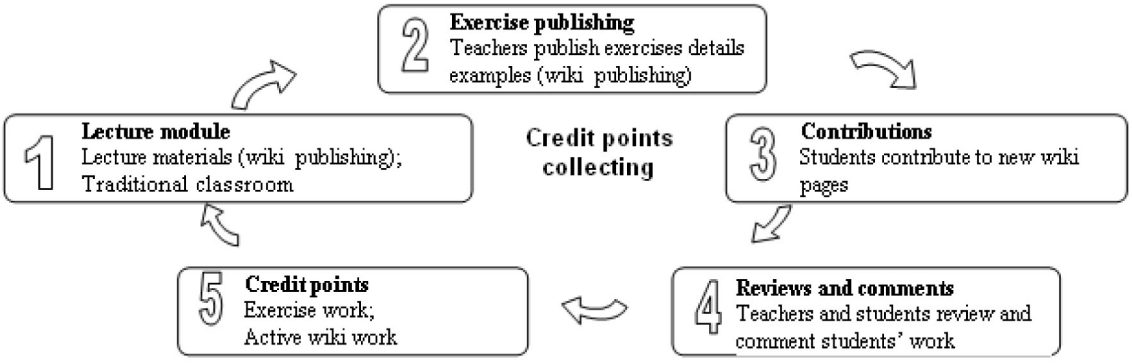

Fig. 2. Wiki-based teaching and learning model.

60% of the exam before finals. Finally, they go to the final exam where they should collect at least half of the remaining 40% of the total credit points.

4. Procedure

In order to assess the pedagogical performance of the WLS and the wiki-based teaching and learning model we determine students' acceptance level of the WLS based teaching and learning model and their motivation to learn. This section presents identified research questions as well as instruments used for data collecting. Further, a description of the case study is given.

4.1 Research questions

With the goal of exploring how to improve students' motivation continuously over multiple years, we formulated the following questions:

RQ.1. Can wiki-based teaching and learning continuously increase knowledge accumulation after several years of usage?
RQ.2. Does accumulated knowledge have a positive influence on the students' learning and motivation to learn?
RQ.3. Does the students' learning behaviour change as the level of knowledge accumulated in the WLS changes?
RQ.4. Does WLS support continuous improvement in the effectiveness of learning over multiple generations of students?

4.2 Methodology and instruments

The research methods adopted to explore wiki usage in an educational process are traditionally focused on case studies in the following way: 1) A group of students is offered the opportunity to use the wiki; 2) An educational wiki environment is set up to run for one semester; and 3) the participating students are asked to fill in a questionnaire after the semester is over. Since we have several years' study and exploration of student motivation, this paper uses a multi-method approach based on three instruments. The first instrument is based on the data collections obtained from usage logs (web server and wiki log files). All log files archived over the several years of use are collected. We consider behavioural measure as a method for motivation measuring [25] and we used WLS attendance as a measure of students' extra activities. We used this instrument for exploring motivation at the whole student generation level in general. The second instrument measures student satisfaction and acceptance level of the wiki-based teaching and learning environment with the accumulated knowledge repository, since satisfaction is identified as an important factor in students' learning effectiveness [43]. This instrument uses a survey-questionnaire based method with five-point Likert scale based questions and double-choice questions, as used in several published studies exploring the influence of a wiki on the educational process [17, 33] and studies exploring the influence of web-based tools in education [44–46]. This survey includes questions concerning the students' interaction with the WLS. The third instrument measures the students' motivation to learn in other courses that the same group of students attend during the same academic year by means of data obtained from the faculty archive about final exam results.

4.3 Data collection

Using the first instrument, data were collected during the 2006/2007, 2007/2008 and 2008/2009 academic years. The second instrument was used to collect data during June 2009. The questionnaire was anonymous. Using the third instrument, data were collected during January and June of 2006/2007, 2007/2008 and 2008/2009 academic years.

4.4 Case study: 'Information Systems' related courses

Information Systems related courses at the Faculty of Electronic Engineering, University of Nis (Serbia) include five courses. The average number of students that attend this group of courses is about 150 per academic year. The course with the largest number of students attending is Information Systems for the Computer Science major. This course is in the 14-week long second semester of the third year, and comprises 28 lecture hours (one 2-hour session per week) and 42 laboratory hours (one 3-hour session per week). The study was carried out from the beginning of 2006/2007 until the end of the 2008/2009 academic year.

5. Results and discussion

5.1 The first instrument: wiki learning system structure

We analyse the structure of the WLS by means of WLS log files and Web server log files. We extracted WLS usage data including the data about new users, page views, pages created, page edits, revisions and attachments. We used the principles of descriptive statistics to represent the collected data in a more compact form [47]. This approach is common for describing the basic features of experimental data. Inside descriptive statistics, we map frequency tables [48] as appropriate for presenting our data. For the data representation by descriptive statistics, we used the SPSS 17.0 tool.

Based on the data presented in Table 1, we can

Table 1. WLS structure. users, new wiki pages, page views, revisions and attachments

Year	Number of users	Number of new wiki pages	Number of page views	Number of revisions	Uploaded attachments
2006	67	99	27352	2287	151
2007	201	728	70911	6473	1468
2008	212	1137	104094	8477	1140
Total	480	1964	202357	17237	2759

Table 2. WLS Structure: users' activity on new content creation

Year	Average number of created wiki pages per user	Number of users that created pages	Total number of users that created pages in their first year after registration	% of users who created pages
2006	6	10	8	44.4%
2007	2	112	99	82.5%
2008	3	148	83	74.8%

notice an increase in the number of registered users in the year 2007, from 67 up to 210 users, which we explain by the increase in the number of students that attend our courses as well as in the change in teaching methodology towards using the WLS as a teaching tool. The total number of pages created since introducing the WLS up to the end of 2008 year is 2545, while the number of created pages since 2006 is 1964. We identify a constant increase in the number of pages created per year, while a significant growth is notable for the year 2007 when 728 pages were created. We explain the growth by the increase in the number of registered users and the rise in the students' motivation to contribute. The continuous progress throughout the years in page views and number of revisions is evident from the data in Table 1. What we mean by 'revision' can be explained in the following way: editing a wiki page using the plain text editor, as is the case in WLS, goes in two phases. First, the user is presented with the wiki text of the page content in the plain text editor. After completing a change in the text, the user submits the text and the new page content is saved in the system. The WLS then saves the new version of the page as well as the previous version of the page. The new version of the page is called a *revision*. Each wiki page edit with saved changes produces a new revision. Consequently, the number of wiki page revisions corresponds to the number of wiki page editing accesses with changes saved. Edit access with saved changes represents actual content contribution.

Users' activity data is further classified into users' activity on new content creation (new wiki pages) and users' activity on wiki pages revisions (content modifications). Data about the users' activity on new content creation is given in Table 2. We note a decrease in the average number of wiki pages created per user in year 2007, while the total number of users that create new wiki pages is increasing. Most of the students created new wiki pages in 2007 and 2008, indicating that most of students have created personal wiki pages as a way of getting involved in interaction within the WLS.

Users' activity on wiki pages revisions is presented in Table 3. A significant decrease in the average number of revisions per wiki page was noted in 2008, but more research is needed to provide an explanation of the students' behaviour. Further, approximately half of the students in years 2007 and 2008 actually worked on wiki content and page revisions.

5.2 The second instrument: survey-based results

In this section, we present data on student satisfaction with the WLS, wiki adoption, and wiki-based learning, collected using a pool questionnaire distributed to students attending our classes. The questionnaire used three questions with a five-point Likert scale and six double-choice questions to measure the students' opinions. The anonymous survey was conducted within the group of 44 undergraduate students in their third academic year. The questionnaire was organized in two parts, where the first part contained five-point Likert scale based questions while the second part contained double-choice questions. Table 4 shows the formulation of questions from the first part of the questionnaire, the order in which they were presented, and the

Table 3. WLS structure: users' activity on wiki pages revisions

Year	Average number of revisions per wiki page	Number of users that work on revisions %
2006	5	23.9%
2007	6	58.7%
2008	3	51.4%

Table 4. Opinion scale questions to rate the WLS system with a range of possible answers

Question	Response scale
Q1: How would you rate WLS system used as course management tool?	Very bad (1) → Excellent (5)
Q2: How would you rate usability of material used in course for students' learning?	Not usable at all (1) → Highly usable (5)
Q3: How would you rate wiki as idea for using in education?	Not god idea at all (1) → Very good idea (5)

Table 5. Descriptive statistics: data statistic for the questions from Table 4

Question	*N* statistic	Mean statistic	Std error	Std deviation
Q1	44	3.34	0.112	0.745
Q2	44	4.02	0.115	0.762
Q3	44	4.11	0.143	0.945

Table 6. Satisfaction with WLS system

Question	Yes	No
Does WLS content help you to prepare labs exercises more easily?	97.7%	2.3%
Is WLS easy to use?	50%	50%
Does WLS help you to find information and literature about course topics?	75%	25%
Do you like the idea that your contributions to the WLS help other students?	100%	0%
Did the contributions of other students help you in learning and preparing labs exercises?	95.5%	4.5%
Would you suggest WLS to be used on other courses as well?	70.5%	29.5%

corresponding response scales. Table 5 shows the results for the questions from Table 4, indicating a high satisfaction level among students regarding using WLS. High marks on questions Q2 and Q3 confirm the effectiveness of using the WLS as a teaching tool. Lower marks on the Q1 question, relative to the marks on questions Q2 and Q3, is considered to be an indicator of further potential for improvement in the teaching and course management methodology. Exploitation of the potential for improvement will be the topic of our future research.

Table 6 shows the second part of the questionnaire, which holds double-choice questions. Students' answers are very positive based on the given results. They think that the WLS system helps them to prepare lab exercises, to work and to find information on course topics, literature etc. more easily. In summary, we obtain strong positive results on wiki usage from the students.

5.3 The third instrument: faculty archive analysis

As an indicator of student motivation to learn we analyse the number of students taking the final exam in the first term of the course. We collected research data at the third year of academic studies about how many students take the final exam in the first term for all courses. The collected data are shown in Table 7. Courses are labelled C1–C9, where C8 is the course that adopted the WLS based approach.

Data from Table 7 show that C8 (the WLS based course) comes first among all the courses in the number of students that took the final exam in the first term in both the 2006/2007 and 2007/2008 academic years. We conclude that the students' willingness to learn, measured by the number of students that took the final exam in the first term, is higher for the WLS based course than for other courses in the same year and in the same Department.

Table 7. Number of students that took the final exam in the first term for courses from academic studies in the third year of the computer science module (given in percent based on the total number of students that attend the third year of the computer science module for a given academic year)

Course	Academic year: 2006/2007	Academic year: 2007/2008
C1	18%	11%
C2	16%	43%
C3	45%	76%
C4	19%	32%
C5	42%	55%
C6	62%	76%
C7	44%	75%
C8	**95%**	**88%**
C9	70%	52%

5.4 Discussion

Data given in this section clearly indicate the growth of the WLS in terms of the number of new users, the number of pages created, the number of attached files and the number of revisions per page. Most of the students that attended the course registered with the WLS. The total number of pages created also shows significant growth. The number of new pages is nearly doubled between years 2007 and 2008, while the number of WLS users in 2007 was approxi-

mately the same as in 2008, indicating a much higher level of readiness for contribution in 2008. Students became more interested in using the wiki to publish their work. Data about the number of page views and page edits show that wiki pages are viewed more often than edited. It is not surprising that the number of wiki page views increases over time. At the same time, the number of attachments has grown. Based on the WLS log files data, it can be concluded that year 2007 students preferred to attach their content in formats other then wiki pages, while the year 2008 students, on the contrary, preferred to contribute their work in the form of a wiki page. Regardless of the fact that both groups of students had the same WLS introductory course presented in the same way, their work pattern was different, the general behaviour of generations of students was different. Taking into consideration the constant increase over the years in new contributions and attachments, we conclude that the adoption of the wiki-based teaching and learning model is reflected in the growing accumulation of knowledge within the WLS over the years, as well as an increase in student engagement and motivation to learn throughout the semester. Thus, the positive response on research questions RQ.1 and RQ.2 is confirmed (see Section 4.1.).

We have noticed that the students' work improved after they became aware that the results of their work would be used as complementary content to help future generation of students. After that, students started to contribute more actively, much beyond our expectations. Their extra work was not as a result of any immediate incentive. They contributed to the WLS with the following attitude: 'I write projects or labs documents, and someone else will use it'. Their wiki pages were more readable, attached files were in more usable formats with nice names and linked to somewhere else on the page. Additionally, we noted a significant reduction in plagiarism as a sort of system's self-regulation mechanism as the publishing students' work was available to a wide and public audience. Additionally, we noticed an improvement in the quality of content generated as well as an increase in the students' sense of responsibility for what they write, since their work is available to a wide audience. The process of knowledge sharing becomes a basic part of the learning process as students learn to use materials created in previous academic years and learn from other's experiences.

The students assess the usability of material used in the course highly and 97.7% of students assess content that they find on WLS as being helpful in preparing labs exercises. Further, 75% of students find that the wiki-based teaching and learning model help them to find information on course topics more easily, and 95.5% of students assessed the contributions of the previous generations of students' as helpful for learning and preparing lab exercises and projects. Thus, the accumulated knowledge of previous years has a positive influence on student learning, which answers the research question RQ.2 (see Section 4.1). We noticed from the several years of practice that progressive generations of students need less time to prepare their lab exercises and reports than previous student generations. Consequently, teachers can proceed with more advanced assignments for students. The experience indicates that wiki-based teaching and learning support a continuous improvement in learning effectiveness over multiple generations of students, and their behaviour changes with the level of knowledge accumulated in the WLS (see RQ.3 and RQ.4 from Section 4.1.). Further, students' perception of wiki learning after several academic years has resulted in positive satisfaction with the WLS and the wiki-based teaching and learning model, and students assess the wiki approach for general use in education as being a very good idea.

Results about the students' motivation to take the exam at the first term are very encouraging and show that the WLS based course gets the highest score among all other courses. Based on those results, we conclude that the adopted wiki-based teaching and learning model supported by the appropriate WLS design resulted in an increase in learning motivation among several generations of students (see RQ.2 from Section 4.1).

Wiki software is available as a service or as a stand-alone application either as a commercial or a free open-source software tools. Wiki as a service is a software application hosted on the service provider's server while a stand alone application is managed and hosted internally by the user's organization. In this way, the hosted solution offers a more user friendly and easy to use approach while the stand-alone application enables full customization at the expense of additional programming and system administration effort. Since we have all the necessary software development available within our group, we are able to adopt continuous development of the stand alone WLS hosted internally. We follow the principles of agile software development and we have implemented a number of plugins with different features on an as-needed base. The technical environment for the WLS consists of the software development environment Eclipse and a Java based wiki engine. Specialized plugin development can be a limitation for educators without software development skills, but there are many developed plugins available for use. There are plugins for forums, blogs, chat, tagging, etc. Also, individual internet access is necessary, one of the

basic pre-requisites for the use of any online learning environment. The approach is applicable to all academic courses domain independent. Students should posses basic computer skills and be familiar with basic online applications and tools. Also, a lab with computers with internet access is needed, which may be a barrier is some cases. It is very important that the WLS is up and running online all the time to support the students' continuous activities.

6. Conclusions and future work

We distinguish wiki from other teaching and learning environments with respect to the fact that other tools are built around a given predefined structure, while the wiki starts with the minimum possible structure and naturally grows an emergent custom structure based on how users use it. Each wiki is unique and customized to the requirements of its users' community as well as to the given application domain. A comparison of the success factors of the wiki based approach to education and learning with respect to other learning management systems in general is interesting research problem on its own, but is beyond the scope of this paper.

In this paper, we described wiki integration in the teaching and learning processes by means of the WLS design and wiki-based teaching and learning model with the aim of increasing students' motivation to learn. We based our research on the experience in integrating the WLS into teaching five academic courses. The activities lead to a total number of 2545 wiki pages created in the period between 2005 and 2008. We found that the practice improved student–teacher interaction, student(s)–student(s) interaction, collaboration skills, higher level thinking skills, teamwork, attitude towards the topics and motivation to learn. Statistics based on the WLS log files data collected since year 2006 are reported. There was a total number of registered students of 480, total number of created pages of 2545, total number of page views of 202357, total number of revisions of 17237, and total number of attached files of 2759. The documented continuous growth of WLS indicates a rise in the knowledge accumulation rate, the system adoption level by the students, and students' continuous engagements within course activities. By means of the research data presented in this paper we have proved that multi-semesters usage of wiki-based learning has yielded strong positive outcomes in the students' learning processes and a high motivation to learn. The increased motivation to learn and students who are highly satisfied with the teaching and learning methods are reflected in the high percentage of students who take the final exam in the first term. It is important to note that the results reported are not due to the new pedagogical approach or the tool alone, but are due to the appropriate mixture of the two. Our future research will focus on the still open questions: 'Can the model of changes in students' learning behaviour be identified?' and 'Does causality between the wiki-based learning process that induces higher student motivation and better final exam results exist or not?'.

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