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Qualitative Evaluation of Software Maintenance Services Integrated in a Virtual Learning Environment*

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Evaluation of virtual learning environments and integrated services provides valuable feedback to educators how to improve the quality of education and the provided services. Virtual laboratories are complex learning environments that include diverse hardware and software components. Due to the inherent complexity of these environments, their maintenance is a challenging and demanding task, but most often neglected. This article presents an approach to integration and qualitative evaluation of software change request services within a complex virtual learning environment based on a virtual network laboratory. The services were integrated with the aim to facilitate software maintenance activities in the learning environment. The evaluation of the services was conducted with the goal to discover their advantages, disadvantages, and based on them possible improvements. Based on the proposed research objective, qualitative research methods were selected. The evaluation was based on input from 22 final year undergraduates and nine graduate students at the Department of Information Technology. The collected data include participants' answers to open-ended questionnaire questions and field notes taken by the researchers. The detailed description of advantages provides the evidence of the services' usability, while discovered disadvantages form the basis for directing further improvements of the services and the learning environment. The detailed description of the research context, used methods, research process, as well as the research findings provides a guideline for conducting similar researches aimed at evaluating various types of services in learning environments.

Keywords: virtual learning environment; virtual network laboratory; software change request; software maintenance; qualitative evaluation

1. Introduction

Virtual Learning Environments (VLEs) have been widely adopted by educational institutions. VLEs are complex Web-based platforms that provide several features that support teaching and learning activities in educational institutions. A wide range of processes (educational, administrative and logistical) are integrated in these learning environments, making them very complex for using and maintaining [1]. Mueller and Strohmeier [2] pointed out that success of VLEs strongly depends on the appropriate development, implementation and continuous improvement (evaluation), while Hornik et al. [3] stressed the importance of meeting stakeholder expectations and the importance of surrounding service-related aspects for learning success in VLEs. Teachers using a VLE can customize its interface [4], integrate several different software tools [5], or provide additional services and functionality [6] in order to increase the students' benefits from the VLE. According to Varela-Candamio and García-Álvarez [7], the development of specific educational software and their integration in learning environments is essential for improving educational processes. Among other roles in VLEs, educators are responsible for operating the technological domain of VLEs, which assumes knowledge on supporting services, basic technology knowledge and software skills [8].

Maintenance of learning environments have not received adequate attention in literature [9–11]. Inevitable changes in these environments affect both the system and users, and may require considerable costs and efforts to manage and maintain them. According to Palmer and Tulloch [12], the key for establishing and maintaining successful learning environment is accommodation of changes in the content, technology and student needs. Alario-Hoyos et al. [13] stated that educational platforms include reduced set of tools for supporting variety of learning situations. Therefore, development of additional software tools and their integration in the existing platforms is necessary. Kara et al. [14] indicated that several remote and virtual laboratories were successfully developed, but majority of them failed after entering the maintenance phase. Furthermore, Papachristos et al. [15] stated that technical problems consume valuable class time in VLEs. Lehmann et al. [16] indicated that learning resources (texts, videos, software, and other materials that assist students in learning activities) undergo a multitude of processes in their life cycle, and in order to be reusable, they often should be changed or adapted for a new context of use. In addition, Kilgore et al. [17] pointed out that stu-

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dents (future engineers) often neglect the full life cycle of the products, which include interrelated stages such as design, implementation, operation, maintenance and disposal. Processes related to changes of learning resources should be managed as much as possible, while information emerged during these processes should be stored and managed in order to be usable for maintenance and possible improvements of learning resources and environments. Efficient maintenance of VLEs assumes careful and timely planning and implementation of software maintenance activities.

A significant number of research studies reported on the design, development and evaluation of different aspects of VLEs in variety of disciplines [18]. Since students are the main users of VLEs, their feedback have been recognized as one of the most important considerations in evaluating educational environments [19]. Students feedback is mostly collected by using questionnaires, interviews and observations. Crosier et al. [20] argued that gathering students' opinions about software parts of educational environments ensures that software is useful, enjoyable and usable for them. Qualitative studies are useful for empirical evaluation of systems when the focus is on the user experience, behavior and opinion in the real situations, without intentionally manipulating the environment [21].

Maintenance of VLEs is a challenging and demanding endeavor for the educators that are usually involved in educational processes and in administration of hardware and software resources in VLEs. Due to the dynamics of the educational processes and complexity of VLEs, software maintenance is a continuous endeavor that requires constant engagement. According to IEEE Std 1219–1998 [22], software maintenance is set of activities aimed at modifying a software product after delivery in order to correct faults, improve performance or to adapt to a modified environment. The essential process in software maintenance relates to modification, or change of a software product [23]. This process is initiated by issuing a change request or a maintenance request, which is a formal description of a required change. Different organizations provide different approaches for submitting change requests. These approaches include web based services, ticketing systems, emails, or documents with the predefined forms. In this line, this research aims to do the preliminary qualitative evaluation of software maintenance services integrated into the virtual learning environment. Having that in mind, the research was designed as an exploratory qualitative study. Since the research objective was to discover characteristics of the services, students that are users of the learning environment were selected as the study participants. This led to the following research question: *What are advantages and disadvantages of provided software maintenance services in the learning environment?* Based on the research findings, improvements of software maintenance services in the learning environment are proposed.

2. Background

Qualitative studies enable capturing the segments of the educational practice that cannot be investigated by using quantitative methods [24]. Qualitative research studies on VLEs address different aspects of VLEs, but their common characteristic is the use of qualitative research methods, qualitative data collected from stakeholders in educational processes, and purposeful selection of a small number of participants [25]. Since qualitative studies rely on relatively small number of participants, they use both students and educators as participants.

The majority of studies are performed with the goal to collect and analyze perceptions and experiences of using the learning environments. For example, Hanson and Asante [26] presented an exploratory phenomenological study intended to review personal experiences of students and lecturers in using a hybrid VLE based on Moodle. Research findings showed that hybrid learning environment helps in gaining significant amount of knowledge as well as technological skills, and enhances the teaching and learning styles of both the lecturers and learners. Richards and Kelaiah [27] presented a qualitative study with the aim to investigate students' opinions and suggestions about features that should be considered in the design, implementation and evaluation of VLEs. Based on the analysis of collected data and literature review, the authors suggested a set of usability attributes that should be considered in designing and evaluating VLEs. An exploratory case study of international students and their use of VLEs in a Scandinavian institution of Higher Education were presented by Habib et al. [28]. The authors identified the following factors in the educational experience of international students with VLEs: level of digital literacy, degree of understanding of academic and administrative language, and types of technology used in communication.

Some studies reported on using and evaluating different tools and services in VLEs. For example, Valtonen et al. [29] presented a study that provides an insight into the experiences of employing personal learning environments (PLEs) by students from vocational and polytechnic level schools in Eastern Finland, and based on students reflections concluded that building and using PLEs is challenging task that requires active teacher support. Costen

[30] explored the influence of using the discussion board tool in a course management system on student learning in hospitality courses, and based on students' comments about their likes and dislikes of the VLE, concluded that the use of introduced tools enables deeper learning in courses and facilitates sharing of views between students. Martınez-Arguelles et al. [31] investigated factors of service quality in e-Learning, and based on the specific critical incidents reported by students, established some recommendations for university managers regarding quality improvement of the services. Gibbings [32] presented a phenomenographical study aimed at discovering different ways in which students experience the use of remote access laboratory. The study involved eight students that use the laboratory for hardware-based experiments. The findings were presented in four categories representing the qualitatively different ways of experiences with the laboratory, which provide a platform for improving development and operational use of remote laboratories.

Several studies investigated different relationships between teachers and VLEs. For example, the qualitative results of two evaluations of LOCO-Analyst, a learning analytics tool, and discussion of lessons learned confirmed the usability of the tool involved in educational processes [33]. da Silveira Espindola and Silveira [4] presented a qualitative exploratory case study with the objective to discover how teachers express and represent themselves through the use of VLE interface, and research findings pointed out the importance of customizing interface, written language and content. Jackson and Fearon [34] presented an interpretative case study in order to explore the influence of expectations management in realizing benefit success when adopting a VLE. The authors developed a conceptual framework based on research findings, and pointed out the importance of avoiding unrealistic expectations, proactive user involvement and change control for developing efficient VLEs. Johannesen et al. [35] presented an interpretative ethno methodological case study with the aim to explore teaching practice as the mix of human actions and technological constraints in VLEs. The authors stressed the importance of sociomaterial approaches to technology-based and technology supported educational practices for advancements in the field. Fry and Love [36] conducted a qualitative phenomenological study with the objective to explore lecturers' use and perceptions of a VLE in a UK business school. On the basis of the research findings the authors called for redefining the role of lecturers to adopt the best of both the virtual and physical environments, and pointed out that development of learning, teaching and assessment strategies is necessary for enhancing the use of VLEs.

3. Methodology

Several difficult situations during the modifications of software applications in the laboratory and the need to provide better services to students have motivated the development and integration of software maintenance services in the laboratory. Initial virtual laboratory has been extended with several software applications and software maintenance services, which together comprise a complex VLE. After that, an exploratory research study with the objective to discover advantages and disadvantages of the software maintenance services was conducted. This study describes the initial phase of software maintenance improvement in the created VLE.

The starting point in this research is the identified need to explore the characteristics of software maintenance services from the students' perspectives. This leads to choosing exploratory study design and qualitative research methods, which assumes active participation of both researchers and research participants in the process of constructing knowledge about the services. On this basis, the research question is derived: *What are advantages and disadvantages of provided software maintenance services in the learning environment?* The research aims to discover advantages and disadvantages of the services, and to present them in a framework that is easy to understand. Discovered advantages and disadvantages form the basis for planning improvements in the learning environment.

3.1 Research context

Empirical research was carried out in the computer laboratories in a university setting. The research sessions were organized out of the regular schedule of the classes in computer laboratories with the access to Virtual Network Laboratory (VNLab) environment [37]. A virtual laboratory learning environment was implemented, because virtual laboratories are popular learning environments for learning and experimenting by using web-based simulations.

Several software applications have been developed since the introduction of VNLab in the university courses for teaching computer network concepts [38, 39]. Software applications have been integrated into VNLab with the aim to facilitate laboratory use. Due to the increased complexity of the laboratory, effective maintenance of these software applications, as well as the entire infrastructure, has become increasingly important. Since the process of software change is essential in the main-

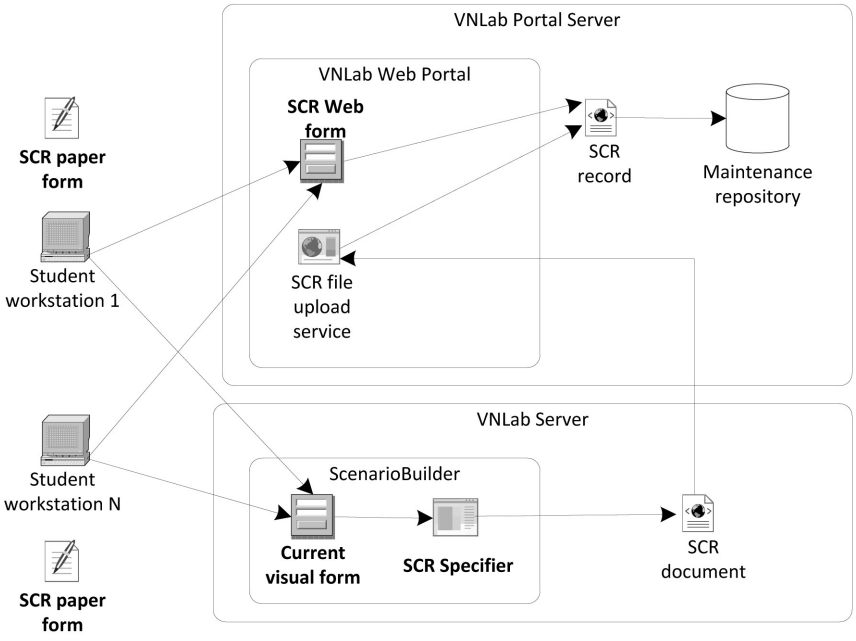

Fig. 1. Software change request services integrated into VLE based on VNLab.

tenance phase of software life cycle, we decided to implement software change request (SCR) services in order to facilitate submission of change requests by students [11]. Laboratory infrastructure was extended with SCR services, and together they form a complex VLE presented in Fig. 1.

Three services for submitting SCRs have been implemented in the laboratory:

- The service available as a web form. The web form is a part of *VNLab Portal Server*. This service can be used for reporting requests for all software applications deployed in VNLab.
- MS Word document with the form for request specification, which can be sent by an e-mail to the laboratory administrator. In addition, students can submit requests in the paper form to the laboratory administrator. This service is introduced in order to ensure the submission of requests when the students are not able to access the electronic services.
- The service for specifying requests in the context of a running software application is available only in software application *ScenarioBuilder*, which is used for specifying computer network scenarios based on Network Node Description Language (NNDL) [40]. This service is integrated into the software application and enables sending a request in the form of an XML file to *VNLab Portal Server*.

3.2 Participants

When deciding on the study participants, we considered the suggestion proposed by Morse et al. [41]: "*. . . the sample must be appropriate, consisting of participants who best represent or have knowledge of the research topic. This ensures efficient and effective saturation of categories, with optimal quality data and minimum dross.*" Therefore, students that are users of the presented services were selected as research participants. The only prerequisite was that the students finished courses related to software engineering and computer networks, which ensures homogeneity of focus groups organized during the research sessions [42].

The students were invited to participate in the research on voluntary basis. 22 students from the final year of undergraduate studies, and 9 students from the master studies at the Department of Information Technology participated in the study. It is worthwhile to note here that the number of participants is determined by the purposeful sampling technique, which is the common case in qualitative research [25].

3.3 Research process

The research process is based on three research sessions conducted with the students in the laboratory regularly used in the university courses. After each session, collected data were analyzed and merged into the research report. In the first session participated 12 students, in the second session participated 11 students, and 8 students participated in the third session. It is worthwhile to note, that both bachelor and master students participated in all sessions.

All research sessions had the same agenda and lasted between 120 and 150 minutes. Each session

started with the introductory part aimed at informing the students about the details of the research (purpose, topic, methods, publication of results, ethical issues). During this part of the sessions, the students and researchers signed the document Research Informed Consent, where all relevant information about the research was stated [43]. After the introductory section, participants were informed about the contemporary issues in software maintenance.

The third part of the research sessions was the experimental session, which lasted about 45 minutes. Students were supposed to detect errors intentionally inserted into software application *ScenarioBuilder*, and after that to submit an arbitrary number of change requests by using all services. The main idea of this part of the research sessions was to refresh students' feelings related to the SCR services.

Focus groups followed the experimental part of the research sessions. Focus groups were organized in order to enable discussions about the services and to collect large amounts of data suitable for qualitative analysis [42]. Focus group sessions lasted about 60 minutes. At the beginning of each session, questionnaires with open-ended questions were distributed to all participants. Questionnaires with open-ended questions are one of the common ways for collecting qualitative data [44]. The questionnaire contained 6 open-ended questions, two for each service. The form of questions was: "*Please state and describe advantages/disadvantages of the specific (paper form, web form, integrated) SCR service*". During the focus groups, the researchers facilitated the discussions between the participants and wrote short field notes about the participants, the discussion and the process of the research [45]. Field notes were amended immediately after each session with more detailed descriptions of the whole session. Field notes were included in the analysis together with collected answers. Students filled the questionnaire during the focus group session. Notes were mostly written during the time when the students wrote answers to the questions.

After each research session, collected empirical data were analyzed by using grounded theory coding techniques and memo writing proposed by Charmaz [46]. Every part of the collected data was analyzed and compared with the previously analyzed data. The analysis of the data collected during the third focus group revealed that the clear repetition of the collected data occurs, which means that saturation of emerged concepts (advantages and disadvantages of services) was achieved. This indicated that there is no need to collect new data (organize new research sessions).

3.4 Research methods

3.4.1 Methods for collecting data

Collected empirical data include: participants' answers to open-ended questions in the questionnaire and field notes taken by the researchers. Both types of data were collected during the organized focus groups. The focus groups were organized to facilitate discussions between the students about the topic of interest, while the researchers ensured that the discussions remained focused, but without influencing the types and the quality of the data provided by the students. The following reasons motivated organization of focus groups: (1) focus groups enable collecting a large amount of data provided by several participants, (2) data are collected as unstructured text suitable for an exploratory qualitative study, (3) the participants provide answers in their own words based on their own experience, and (4) the discussions in focus group may help in discovering problems and suggestions for improvement directions that cannot be revealed with other empirical methods. Open-ended questions were selected because they are suitable for collecting participants' responses that are unanticipated by the researcher, while they still remain rich and explanatory. The focus groups were not tape recorded. Instead, the group moderator facilitated discussions related to open-ended questions, and the participants wrote their answers on the paper. The number of participants had not been known before organizing focus group sessions because the participation was on the voluntary basis. The focus groups were conducted by two researchers. One researcher acted as the moderator of the discussion and the other acted as the note-taker.

3.4.2 Methods for analyzing data

The advantages and disadvantages of the services were identified through the process of coding empirical data and developing the explanations of identified concepts. The basic methods for analyzing data are coding and memoing, proposed in grounded theory approach, because they are strict and systematic, but still flexible. Coding of raw empirical data is based on initial and focused coding proposed by Charmaz [46]. Constant comparative method, based on simultaneous coding and analyzing of data, was used [47]. Initial and focused coding enabled iterative adjustment and classification of discovered concepts, while advanced coding enabled examination of the relations between the codes and derived concepts, and the transfer of meaning for developed concepts (identified characteristics of the services).

Initial coding refers to identifying important words or groups of words, in the data and then

assigning labels to them. In some cases, in vivo codes (words used by participants in their answers) were used as initial codes [46]. Initial coding started after collecting the first set of answers from the students participating in the first focus group. Identification of the initial set of codes is supported by writing the memos assigned to each initial code. In these memos, identified initial codes, as well as details about the research context, participants and research process were elaborated. After the second focus group, focused coding was introduced in the analysis, which included development of codes that are more direct, selective and conceptual. In this phase of coding, the most significant and frequent initial codes were extracted, compared, and used to analyze new and previously analyzed data. Developed focused codes and decisions that had contributed to this analytic process was elaborated in memos. After the third focus group, advanced coding technique, named theoretical coding [46], was used for developing relationships between the advantages and disadvantages developed during the focused coding. Data analysis techniques are presented in Fig. 2. Coding of data and conceptual memoing were conducted in conjunction as it is suggested in literature [46]. Advanced coding enabled development of clear and meaningful concepts that describe advantages and disadvantages of services, as well as their organization in the understandable framework.

A typical student's answer with applied coding techniques is presented in Table 1. Advanced coding, which is not presented in Table 1, enabled structured presentation and comparison of identified characteristics of services, as well as establishment of relationships between them.

4. Research findings

The characteristics of the services were classified as advantages or disadvantages based on the students' opinions. It is important to note that contradictory situations occurred several times during the data analysis. For example, for one student a specific service is fast, reliable and an excellent choice, while for others the same service is the worst solution. To address these situations, it was adopted that a specific characteristic will be considered only if it appears more than once in the collected answers.

According to Kearney [48], this type of findings fits well within initial exploratory work, where the objective is a rich description of an experience that will be used as the basis for improvement of the services. The research findings are organized in the natural way that presents the advantages and disadvantages of each service. The findings are supported by short illustrative verbatim quotations from research participants (translated by the researchers) in order to increase the evidential power and the validity of the findings [49]. A

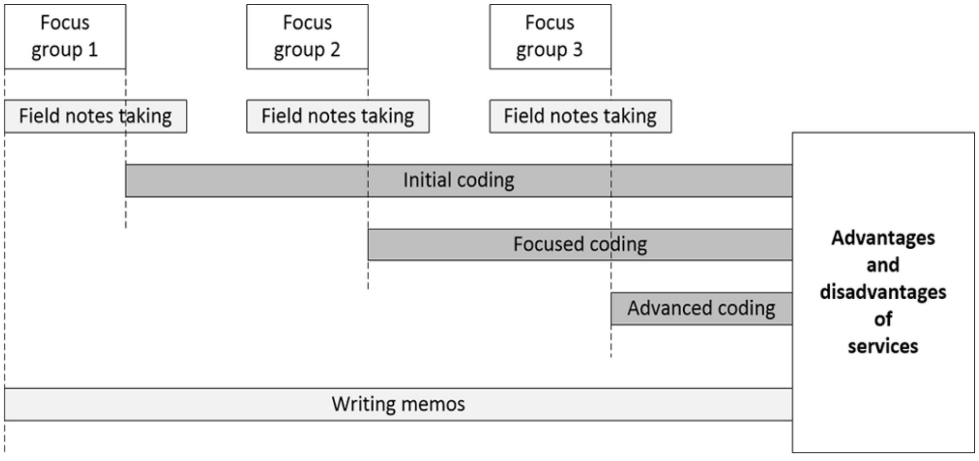

Fig. 2. Data collecting and analyzing techniques used in the study.

Table 1. An example of coding a typical answer from the questionnaire

Answer	Initial coding	Focused coding
Easy and **understandable** for users and for **developers (how to implement)**. If it is set to the **appropriate place on the form**, and if the **user is aware of its existence**, the service is **quick and easy to use**. The service is implemented as a **reliable** and **compact functionality**.	Easy, understandable, developers (how to implement)	Intuitiveness, knowledge and skills of programmer
	Appropriate place on the form, user is aware, quick, easy to use	Finding service, characteristics of user, duration, ease of use
	Reliable, compact functionality	Reliability, compactness

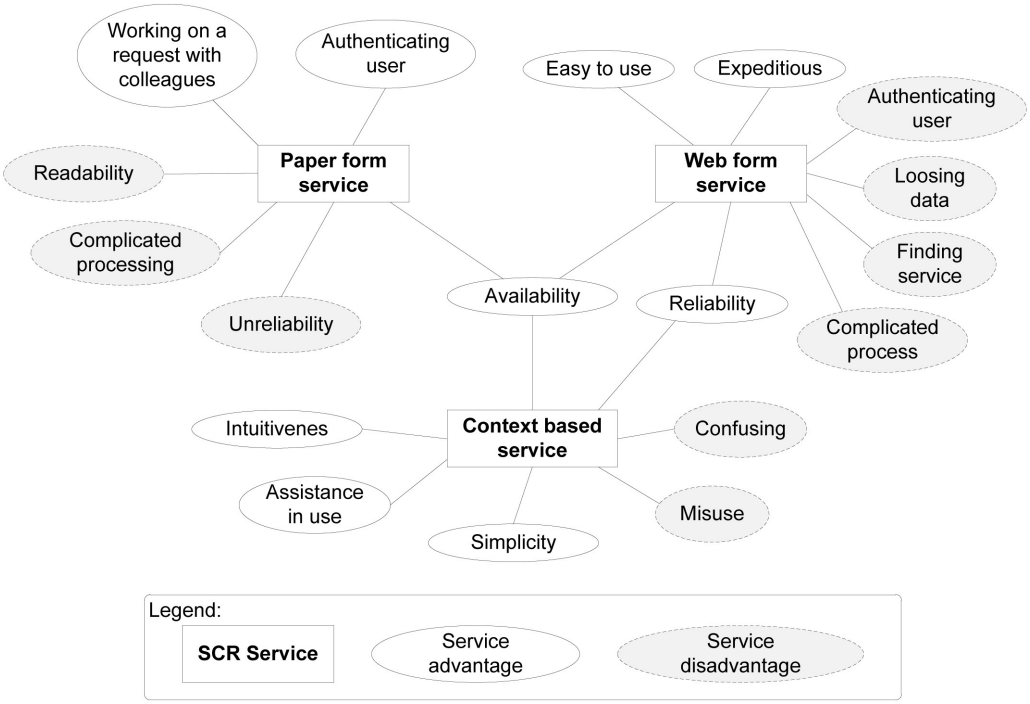

Fig. 3. Discovered advantages and disadvantages of software maintenance services.

comprehensive view of all identified characteristics of the services is presented in Fig. 3, which will be used for guiding the explanations in the rest of this section.

4.1 Specification of a request in the form of a document

4.1.1 Advantages

Availability: Almost all study participants agreed that the most important advantage of this service is the ability to specify and send a request when the electronic equipment does not work or is not available. This means that the service is always available to students. The following quotations illustrate the importance of the service availability:

> *In the case when a computer and Internet are not available this is the only way.*
>
> *If you do not have access to computer, you can take a paper form and fill the request.*

Authenticating user: The advantage of this service is that a request may be personally signed (and stamped), and stored in the archive, which is sometimes very important for both users and developers. The following quotations illustrate the importance of the user authentication:

> *The advantage is related to having a written history of your request. This includes a stamp, signing, the reference number, and following an internal procedure for submitting a request.*
>
> *After filling the form, you can save your copy of a document in your archive. In this way, you will have an official record of a request.*

Working on a request with colleagues: The ability to complete the request with the help of colleagues is also an important advantage of this service. In some cases students discover some issues during unofficial discussions (for example in the faculty hall while waiting for classes), and jointly prepare a request description. Collaborative work on a request specification enables students to exchange and consolidate ideas and reach the best specification. The following quotation illustrates the importance of joint work on specifying a request:

> *Several people can jointly work on one request and see more than only one person.*

However, two students stated that cannot anticipate any advantage of this service. This is not surprising since the investigation conducted by Chang et al. [50] revealed that students prefer electronic feedback compared to handwritten, which is illustrated with the following quotation:

> *There are no advantages, or I cannot see them.*

4.1.2 Disadvantages

Complicated processing: The most important disadvantage of this service is a complicated and time-consuming processing of requests. The main problem is related to entering data from a paper form into an electronic database that is more suitable for

searching and analyzing. The following quotations illustrate this disadvantage:

> *Additional processing of a paper form that includes entering data in an electronic database of requests. Additional work for programmers.*
>
> *Hard to classify and manage. The process of prioritizing cannot be automated. Needs an extra employee (work) to do data input in a database.*

The next issue related to the complicated processing is related to the *duration* of the process, because most of the participants think that this is the slowest solution for submitting a request.

Readability: The next identified disadvantage is readability of requests, which is associated with the handwriting of the users, and has significant influence on request interpretation by programmers. The following quotation points out this disadvantage:

> *The problem can be handwriting, which can be hard to read and understand. Handwriting is the most significant problem. The problem is with the additional free writing on the paper that would confuse developers.*

Readability can be distorted also by correcting errors while filling the request form, which is illustrated with the following excerpt from an answer:

> *The problem is with correcting errors while filling the paper form. In the case of a mistake, it takes a lot of time to correct it. The request can be unreadable because of handwriting and correcting mistakes during the writing.*

Unreliability: Several students think that this method for submitting a request is not reliable because the request (the paper) might be lost, and the identified problem will not be solved in that case. The next quotation illustrates this:

> *There is a possibility of losing the request, and the possible long period of delivery of paper with the request.*

4.2 Specification of a request in the Web form

4.2.1 Advantages

Availability: The main advantage of this service is its availability, which means that the service is available from any computer with the access to the faculty intranet. Therefore, the service is available not only in the laboratory, but students can send requests from any other location outside the laboratory. This is supported by short comments provided by the majority of participants, like:

> *High availability from various locations.*
>
> *. . . even if the software blocks the machine, you can go to the other, and the service is available on it.*

Easy to use: The web form service is equipped with standard functionalities available in web forms. Several easy to use controls (for example, drop down menus), clear and understandable layout, and several functionality (for example, caching of previously entered data) significantly contribute to the ease of use of the service. The following quotations account this advantage:

> *The web form can be easily filled because it is enough to select one of the offered values for some fields. Also, the advantage is caching of data in web browser, which helps in filling a web form.*
>
> *A standard appearance and the behavior of web forms. Several elements on the web form enable easy filling, like choosing a date. This helps and makes filling faster. Easy and fast correction of errors during the request specification.*

As an additional explanation for this advantage, several students said that "*people just feel comfortable while using the Internet*" or "*people are accustomed in using Internet technology*".

Expeditious: The service is characterized as quite fast regarding the process of specifying and delivering a request to the programmers, which is illustrated with the following excerpts from the answers:

> *Fast and easy filling of the web form, and fast delivery of the requests to developers.*
>
> *After sending the data, they become immediately available for further processing.*

Reliability: All participants in the study believed that the service is reliable because the requests are recorded directly on the server and the data are validated before sending. The following quotation illustrates this property:

> *Fast and reliable approach. Very important is that the user can add several attachments to a request for additional clarification of the request. The data can be checked before the submission of a request.*

4.2.2 Disadvantages

Finding service: The problem that is stressed by the most of the students is related to finding a web form, which is illustrated with the following quotation:

> *User should stop working in the current application, start a web browser, and find the address of a web form and after that can fill the data in the form.*

Authenticating user: The problem with the web service is also the authenticity of a user, since anybody with the access to the web service can submit a request. This may cause several requests that are not real requests related to the software. The following quotation illustrates this disadvantage:

> *The problem is the possibility that anybody with Internet access can fill the web form and submit something that is not the real request related to the laboratory.*

Complicated process: For a small number of students the problem is complicated processing that involves leaving the current application, launching the Internet browser and finding a web form. After

filling some data in the web form, a user should return to the software application to check the next issue to be included in the request, and that may be repeated several times. The following quotation illustrates this:

> *User should often switch to software application in order to collect data for filling the web form.*

Loosing data: The problem that exists with the web service is the possibility of losing the data because of technical problems with the Internet connection. It is more likely to happen if a student should enter more detailed description of a problem, which lasts longer. This is illustrated with the following quotation:

> *In some cases data in the web form can disappear without the possibility to recover them (for example a problem with connection). In these cases there is no trace that will lead to the previous specification.*

4.3 Specification of a request in the context of a running application

4.3.1 Advantages

Assistance in the use: The assistance during request specification is the most important advantage of this service. This advantage is reflected through the activation of the service in the same way as other operations in the visual forms in a software application, and the fact that the data about the application have already been entered into the visual form for specifying a request. This is illustrated with the following segments from the participants' answers:

> *The way in which the service is integrated in the application enables easy usage of the service. Some data, like data about a software application and version, are filled automatically, which makes filling the request much faster and easier.*
>
> *The assistance to a user is the most valuable advantage. Also, the user can add additional files to a request. If it is set to the appropriate place on the form, and if the user is aware of its existence, the service is quick and easy to use.*

Intuitiveness: Intuitive access to the service within the application is enabled through the full integration of the service and invoking it in the same way as any other functionality available in the application. The service is directly accessible in the software application, at the same position on each visual form. This is illustrated with the following quotations:

> *An excellent way that facilitates users to submit problems and bugs. Direct access to the service from the application where it is necessary. User is familiar with the environment—the same in the service and in the application.*
>
> *This is an intuitive approach that is easily accessible. The application context is organized to save the user time. After recognizing a problem, a user can easily start the service from the current form. Filling the request specification form is easy, and also the service is fast.*

Reliability: This service automates some steps in specifying requests, thus reducing the possibility of errors. The following quotation illustrates this service characteristic:

> *The service is available at the place where the problem is identified. This makes processing faster and more reliable.*

Simplicity: Several participants stated that this service is the most simple for using because it has the minimal number of straightforward steps. In addition, the request specification can be completed within the application visual form where the process is started. The following quotations illustrate this advantage:

> *Achieving the goal (a submitted request) with the minimum effort by the user. The most simplified process, with the minimal number of steps.*
>
> *There is no moving between applications, just start a request specification process and follow the steps.*

Availability: The service is directly available in visual forms in the software application for specifying network scenarios. This enables easy access to the service without leaving the current working context. This is illustrated by the following quotations:

> *The service is easy to find and available to users. Direct access to the service from the application where it is necessary. While working within the application the user can better see the problem.*
>
> *The service is available at the place where the problem is identified. This makes processing faster and more reliable.*

4.3.2 Disadvantages

Confusing: The first identified disadvantage is related to the users' confusion due to a new functionality added into the application. The users acquire some routines in interacting with software applications, and any new functionality should be carefully planned and introduced in order to achieve the best possible effects. The following quotations illustrate this:

> *Additional button in the interface of a software application may confuse a user. What if the user, by mistake, presses the button. It could be annoying for the user. A help about the service should be included in the application.*
>
> *This may introduce a disorientation of a user because of an additional functionality in the application. Perhaps it should be placed in the help menu.*

Misuse: This disadvantage relates to the misuse of the service by the students due to its availability. Some students stated that this might be even greater

problem with the service use in commercial applications. The following quotations illustrate this:

> *Possible overloading of developers with requests. If it is easy to submit a request, some users will use the service even when it is not necessary.*
>
> *In addition, with this service users can submit many useless requests because the service is easy accessible.*

5. Discussion

An insight into the advantages and disadvantages emerged through qualitative analysis indicates that implemented services are generally useful for the students. The advantages confirm the usefulness of the services, while the disadvantages suggest possible directions for improvements. Some characteristics of the services are self-descriptive, while others require additional discussions and clarifications.

It is interesting to note that the characteristic *availability* is discovered as an advantage for all services. This finding is very important for laboratory maintainers since it indicates that all services are provided in the right manner to the students. However, this advantage is closely connected to some other characteristics of the services and requires some clarifications. For example, for the service available in the context of a running application, two discovered disadvantages, *confusion* and *misuse*, could be discussed together with the availability. Although students think that the service integrated in the application context is highly available, it might cause excessive use of the service in the cases when there is no need to submit requests. This misuse might overload the maintainers of the laboratory with requests that are not real problems. In addition, the new functionality available in the user interface may cause confusion since the users acquire certain habits in the use of software.

Authentication of a user that submits a request appears as both advantage and disadvantage of different types of services. Submission of a request in the paper form enables signing the document with the request, which ensures that the requester submits the real request. However, the web based form for request submission is available on the internal server and does not require authentication of a requester. This is identified as a disadvantage of the web based service since anybody with access to the faculty computer network can submit a request even if he/she is not the user of the laboratory.

For the majority of students *reliability* of the services is identified as an important characteristic. However, students' answers revealed that paper form service is not considered as reliable because there is a possibility that a request will be lost, and the identified problem will not be solved. The problem with unreliability of the paper form service is closely related to the complicated processing of requests (the main issue is related to additional work required for entering request data in the maintenance repository), which is also identified as a disadvantage of the service. Web based service and the service integrated into the software application ensure automatic recording of requests in the maintenance repository, which contributed to the students' standpoint that these services are reliable.

Some contradictory situations appear during the analysis of the perceived characteristics of the services. For example, some characteristics of the web based service seem to be discrepant. The web based service is generally perceived as reliable, which is the obvious advantage, but students identified the possibility of losing data as a potential disadvantage (due to the problems with communication equipment). The next advantage of the web based service is its expeditiousness (the service is considered fast and reliable in delivering a request to the laboratory maintainers), which might be seen in the contrary with the problem of finding the service (identified as a disadvantage) and complicated process (identified as a disadvantage). In addition, the advantage related to ease of use, and disadvantages related to finding services and complicated process might seem to be opposite, but they are related to different steps in the request process. This advantage relates to filling the web form, while mentioned disadvantages relate to the need to stop the current work in software application, switching to a web browser and finding the web form for specifying requests. These findings will direct the improvement of the web based service towards automating the process of finding the web form for specifying requests.

The most important advantage of the service integrated in *ScenarioBuilder* is the *assistance in use*. The students prefer several technical details that assist in specifying requests (automatic detection of software elements initially affected by the request, or possibility to attach files with additional descriptions). The service is also characterized as intuitive and simple to use, because it is easy to comprehend how to invoke and use it. One of the main issues that contribute to the service simplicity is that student can specify a request while working in the context where the problem occurs. However, this advantage comes together with the disadvantages such as misuse and confusion because of adding a new functionality in the application.

5.1 Directions for improvements of the services

The research findings are used as the basis for initiating improvement activities in the learning environment. Qualitative research findings present an opportunity to see the more comprehensive

picture of the services, and to identify problems based on students' knowledge and experiences. Identification of problems helps in establishing improvement priorities before attempting with possible solutions. We adopted the approach for identifying the characteristics of the services based on students' opinions, with the aim to discover problems that have not been perceived during services' development and implementation. Possible improvements of software maintenance activities are based on identified disadvantages of the services, supported by some useful comments related to the advantages of the services.

Regarding the paper form service, the only direction for the improvement is to automate activities related to entering data from the paper form into the maintenance repository. This includes sending an email to the user who submitted the request with details extracted from the paper form. With this extra step the processing of the requests will not be less complicated, but this will improve reliability of the service and eliminate the problem with readability of the text because the submitter will validate the request before further processing.

The first improvement of the service implemented as the web form is directed towards increasing reliability of the service through mandatory identification of a user that submits a request. The user will be asked to provide an email address to which the request will be sent, and to reply to the message to confirm the validity of the provided data. This improvement is going to be implemented as an additional service that will be used by all other services in the environment. The second improvement of the web based service will enable invoking the service directly from the currently used software application, for example by pressing a button in a current visual form. This improvement will allow easier finding of the service and the transfer of some initial data from the application to the service. Indirectly, it will have the positive impact on the complicated processing of the requests.

The problem with the misuse of the service integrated in the software application is going to be solved with an additional check and validation of the data by the requester, as it was explained for the previous services. This additional step will be automated and will not introduce additional work of the personnel that maintain the laboratory. If a request is the consequence of the misuse of the service, it is expected that required additional verification by the requester will be missed, which will lead to the elimination of the request. A request without a confirmation from the requester will not be considered.

The problem with a confusion introduced with the new functionality in the software user interface is less important since the functionality use is similar to the use of other functionalities available in the software application. Practically, the service is invoked in the same way as other functionalities, and the user interface of the visual form of the service is with the same layout and functionality as other visual forms in the application. The improvement will also include the integration of a help support that will explain the purpose and the functioning of the service.

5.2 Threats to validity

Validity of research, as defined by Anney [51], was ensured by providing the detailed description of the research context, research methods and findings, and by strictly following the instructions for using coding and memoing techniques proposed by Charmaz [46]. However, the researchers are aware that the following threats to validity should be clarified in order to increase the reliability of the study.

The researchers are aware that encouraging and moderating discussions in the focus groups may influence the way of participants' thinking and their answers, but according to Wibeck et al. [52], this stimulated the students to explore a range of perspectives related to the characteristics of the services, and to provide unique experiential data. In addition, Kitzinger [53] argued that facilitation of interaction in focus groups can encourage people to engage with one another, to verbally formulate their ideas and to produce knowledge that previously had not been articulated. Having that in mind, the researchers decided to actively facilitate discussions, which led to more detailed answers (richer empirical data) that helped in evaluating the services.

The next problem that was faced during the analysis of collected data was related to the handwriting of the research participants. Some words were completely unreadable, and it was necessary to try to find the most appropriate substitutions that will not change the meaning of the participants' answers. Since the number of substituted words is very small, and these words are not crucial for the meaning of the collected answers, the substitution of words does not affect the accuracy of the interpretation. These decisions were grounded in the fact that a researcher produces research findings as a refined and rich description of experiences by drawing out from raw data [54], and that analysis of textual data is based on meaningful units composed of several words that convey an idea, rather than analyzing word by word [55].

5.3 Research benefits and implications

In order to investigate the perceived benefits for students that participated in the research, an additional questionnaire was distributed to them. This

questionnaire was distributed at the end of each session. 29 from 31 students stated that the research was useful for them, while two of them thought that the research was not useful for them. This is satisfactory, considering that the students participated in the study on voluntary basis, and that no one left the research sessions. The students stated that this research helped them to: (1) better comprehend software maintenance activities, (2) get insight how to organize a research for their own needs (projects and seminary works), and (3) feel useful due to the provided opportunity to actively participate in the improvement of the learning environment.

The researchers' benefits from the research are manifold. The first benefit is the increase of the knowledge about the services and students' expectations, leading to the improvement of the services and more reliable functioning of the whole educational environment. The next researchers' benefit is related to acquiring deeper knowledge of qualitative research methods, which has changed their understanding of the practice in information technology field, and has increased their consciousness about the importance of human factors for the practice.

This research contains useful lessons for educators who provide different services to their students. The study may be used as an example how to organize an evaluation of provided services in order to identify their characteristics, and potential improvements.

5.4 Limitations of the study

Although the research findings provide the evidence that the research objective has been achieved, this study has certain methodological limitations. The first limitation, which is common in qualitative studies, relates to the sampling technique and the sample size. The sampling technique used in the study is based on the saturation concept (clearly stated in the methodology section), which assumes that discovered advantages and disadvantages are saturated and completely identified. However, there is no guarantee that additionally collected data will not reveal new characteristics of the services. This limitation is going to motivate a continuous monitoring of the services usage, as well as conducting additional evaluations after implementing some of identified improvements.

A bias which occurs as a result of the researchers' active involvement in the research through moderating focus groups and interpreting collected qualitative data can also be viewed as a limitation of the study. This limitation is minimized through careful and systematic implementation of qualitative research methods as it is proposed in the literature.

Finally, a generalizability of the research findings is also a limitation of this study. The study is highly context dependant (students, researchers, a specific VLE and services), and therefore, the researchers do not claim that the research findings can be generalized to other VLEs. However, a detailed description of the research design and the research process allow other researchers and educators to conduct the evaluation of their VLEs by using methods described in this study.

6. Conclusion

This article presents a qualitative evaluation of software maintenance services integrated into a VLE designed for teaching computer and communication network courses at the university. The main findings of the study are identified advantages and disadvantages of the services, which are grounded in the students' answers to the open-ended questions. The identified advantages indicate positive attitude of the students towards the provided services, while disadvantages constitute the basis for the future improvements of the services and VLE. The contributions of this study are: (1) It presents a clear motivation for introducing software maintenance services in VLEs, which helps the educators in providing more reliable VLEs to students; (2) It provides detailed guidelines how to use qualitative research methods for evaluation, which is especially important in engineering education, where educators have clear preferences towards quantitative methods; (3) It provides guidelines how to use research findings of a qualitative study for identifying possible improvements.

Several future research directions arise from this research. The first one is the implementation of identified improvements and their evaluation. The second direction is the implementation of services for maintaining hardware and network infrastructure in the laboratory. Finally, development and implementation of similar maintenance services for other learning environments, such as wireless and distributed environments for computer based measurements in industrial and medical systems, is also a promising research direction.

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