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# Software Testing Course in IT Undergraduate Education in Serbia

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**Abstract:** *In the last two decade, with the establishment of Information Technology (IT) departments in Serbian universities, the need for having Software Testing courses has also emerged. In this paper Software Testing is considered as an important subject but is not widely offered in many IT programs. Some faculties have one or more software testing courses in undergraduate studies, but some of them not. The Faculty of Technical Science in Čačak has IT studies, but in old curriculum doesn't have Software Testing course. Here we proposed program for this course which will be elective course on last year of studies. Also, it is present the importance of this course for student to find job position in domain of software testing.*

**Keywords:** *software testing; student; education; information technology (IT)*

## 1. INTRODUCTION

At most faculties in Serbia, students usually learn theoretical concepts of software testing as a part of Software Engineering or Programming courses. In practice, it is very difficult to learn all aspects of software testing throughout these courses. But, employers expect that graduate students have the ability to write and test computer programs [1]. In academic institutions more emphasis is given to software development than ensuring its quality.

There are many organizations which provide certificates for software testing. Some of the most recognizable in Serbia are Knowledge academy BSC courses [2] and International Software Testing Qualification Board (ISTQB) [3]. ISTQB provides courses in three levels: basic, advanced and expert. Agile Software Testing, Agile Testing Trainer, Scrum Training, etc. are some of the software testing topics included in these certified courses.

In order to obtain necessary knowledge, students should attend some of the above-mentioned specialized courses or have Software Testing course in their study program.

In recent years, Software Testing course became a part of curriculum in many Information Technology (IT), Computer Science (CS) and Software Engineering (SE) undergraduate studies. The authors of this paper propose adding Software Testing course at the final year of undergraduate IT studies at the Faculty of Technical Sciences in Čačak, accredited in 2014. During this course, main theory concepts as well as the different tools for software testing should be introduced to students.

## 2. RELATED WORK

The importance of software testing is reflected in the fact that there are many scientific papers concerning software testing in education. In [4], authors identified attitude and economics as major obstacles to software testing. Students must face these issues in order to successfully complete the testing process.

The paper [5] describes how Software Testing was gradually taken into curricula at some IT faculties. That was inevitable due to the increased complexity of software which was developed. During this course, students are required to select a tool for testing of software depending on its type and to apply it for software quality assessment.

Author of paper [6] proposes a pedagogical model in software testing teaching at the undergraduate studies. In this paper, seven course modules for teaching software testing as well as relationships between them are described.

In paper [7] authors propose postgraduate program for software testing. This is recognized as important for acquiring necessary knowledge and competencies for software testing. Although there are many software testing specialized courses available at the market, it is beneficial to include this kind of program at faculties. By attending courses offered in the above-mentioned program, students can become competent software testing professionals.

In paper [8] the performance of students in testing, given the tendencies in the industry is investigated. The authors were motivated by the lack of similar studies in software testing field.

## 3. THE IMPORTANCE OF SOFTWARE TESTING

The experience with students learning process indicated that Software testing is one of the core courses. Programming, Data Structures, Object-Oriented Programming, Software Engineering and similar courses can be helpful in development of software testing skills, but insufficiently.

At first, skills in completing stages of Software Development Life Cycle (SDLC) other than software testing were gained at IT faculties. The main focus of IT engineer education has been software development. IT students usually attend the basic programming courses firstly, and their main goal is creating applications, without worrying about testing techniques [8]. Recently, there are many new questions arising such as: Who will use that software? Is it usable? Will it work on different operating systems? Is it reliable?

Software testing is important phase of SDLC and all complex projects must be tested. There is always a need for testing, whether software companies implement new technologies, improve the existing state or maintain it.

Today, software development is a complex task. In most large software companies there is a team of IT engineers which work on one project. Each team usually has one member who is responsible for software testing or a third party company specialized in this area is engaged. In smaller software companies developed software also needs to be tested, so there is always a need for employees with software testing skill, regardless of company size.

In the area of Internet, software testing is also of a great importance. The cost of failures is very high, especially if it includes reputational damages. Software testing is continuously adapting to the rapidly changing needs of dynamic business, so various development methodologies are created and used for testing [9].

## 4. SOFTWARE TESTING COURSE IN UNDERGRADUATE STUDIES IN SERBIA

IT, CS and SE are continuously developing, which leads to greater need of IT engineers. In order to meet the demand, number of IT students at Serbian colleges is rapidly increasing. These occurrences barely have an impact on Software Testing course, so in many faculties it remains aside. Most of courses are based on software development, while mistakes and bugs in code are not being properly handled. No matter how experienced the programmer is, mistakes can always occur. Software testing is crucial for software quality since costumer wants his product to be optimized and to work without errors.

In Table 1 list of all faculties with corresponding undergraduate studies which provide Software testing course is presented. In the column Semester is shown the number of semester in which students attend Software Testing. In column No. of Students, number of students who enrolled faculties in 2017 is presented [10]. It can be concluded that about 30% of all students who are studying undergraduate IT/SE/CS studies have Software Testing course. This course is mainly in the final years of the studies.

**Table 1.** *List of faculties which have Software testing course in IT/SE academic studies*

| No. | Faculty name and place | Undergraduate academic studies | Semester | No. of Students |
|---|---|---|---|---|
| 1. | Faculty of Electrical Engineering in Belgrade | Software Engineering | 5 | 180 |
| 2. | ICT in Belgrade | Internet Technology | 5 | 40 |
| 3. | FTN in Novi Sad | Engineering of Information Systems | 4 | 80 |
| | | Software Engineering and IT | 7 | 80 |
| 4. | PMF in Novi Sad | Information Technology | 4, 6, 8 | 80 |
| 5. | Technical Faculty "Mihajlo Pupin" in Zrenjanin | IT-Software Engineering | 7 | 40 |
| 6. | Faculty of Science in Kragujevac | Informatics | 8 | 100 |
| 7. | University of Novi Pazar | Software Engineering | 7 | 40 |
| 8. | Department of Economics of the State University in Novi Pazar | Business Informatics | 7 | 40 |
| 9. | Faculty of Information Technology in Belgrade, Metropolitan in Belgrade | Software Engineering | 5 | 84 |
| | | Game Development | 7 | 20 |
| 10. | RAF in Belgrade | Computer Science | 7 | 25 |
| 11. | Faculty of Informatics and Computing, University Singidunum in Belgrade | Computer Science and Informatics | 8 | 80 |
| | | Software and Information Engineering | 5 | 50 |
| 12. | FINTECH, University Educons in Belgrade | Information Technology | 5 | 60 |

During the past years, some of the colleges in Serbia noticed the importance of Software Testing course and included it into their curriculum. On the other hand, there are 18 faculties (with 27 different study programs in area of computing) which still have not integrated this course in their study programs. These faculties are displayed in Table 2. Therefore, most of the faculties cannot provide graduate students with knowledge in both software development and testing.

Larger companies usually make separate sectors for software testing, which are better known as Quality Assurance (QA) sectors. The need for QA engineers (software testers) still continues to increase since there is a lack of qualified people for that position. Consequently, including Software Testing course in as many as possible faculty programs will result in greater number of QA engineers, which is beneficial for both companies and graduate students.

**Table 2.** *List of faculties which do not have Software testing course in IT/SE academic studies*

| No. | Name and Place | Undergraduate academic studies | No. of Students |
|---|---|---|---|
| 1. | Faculty of Electrical Engineering in Belgrade | Computer Engineering and Information Theory | 250 |
| 2. | FON in Belgrade | Information Systems and Technology | 330 |
|  |  | Information Systems and Technology-Distance Learning | 100 |
| 3. | Faculty of Mathematics in Belgrade | Informatics | 160 |
| 4. | Faculty of Electronic Engineering in Nis | Computers and Information Technology | 250 |
| 5. | Faculty of Science and Mathematics in Nis | Computer Science | 55 |
| 6. | FTN in Novi Sad | Computing and Automatic | 240 |
|  |  | Information Engineering | 60 |
|  |  | Applied Software Engineering | 160 |
|  |  | Animation in Engineering | 60 |
|  |  | Information Technology | 35 |
| 7. | Technical Faculty "Mihajlo Pupin" in Zrenjanin | Information Technology | 80 |
|  |  | Information Technology Management | 25 |
| 8. | Faculty of Science in Kragujevac | Computer and Software Engineering | 60 |
| 9. | University of Novi Pazar | Computer Engineering | 109 |
| 10. | Faculty of Science in Kosovska Mitrovica | Informatics | 40 |
| 11. | Faculty of Technical Science in Kosovska Mitrovica | Electrical and Computer Engineering | 80 |
| 12. | **Faculty of Technical Science in Cacak** | **Information Technology (from 2014 accreditation)** | **80** |
|  |  | Electrical and Computer Engineering | 80 |
| 13. | Faculty of Information Technology in Belgrade, Metropolitan | Information Technology | 84 |
|  |  | Information Systems | 66 |
|  |  | Computer Engineering | 25 |
|  |  | Computer Design | 20 |
| 14. | Faculty of Informatics and Computing, University Singidunum in Belgrade | Information Technology | 50 |
| 15. | Faculty of Economics and Engineering Management in Novi Sad | Informatics | 50 |
| 16. | Faculty of Information technology –ALFA, University in Belgrade | Information Technology | 25 |
| 17. | Faculty of Mathematics and Computer Science –ALFA, University in Belgrade | Informatics | 25 |
| 18. | Faculty of Computer Science, Megatrend | Informatics | 75 |

## 4.1 Disadvantages of old curriculum in IT studies at the Faculty of Technical Sciences in Čačak

In 2006, IT undergraduate studies were founded at Faculty of Technical Sciences in Čačak. At first, Software Testing course had not been included in these studies, so software testing was learnt as a part of Software Engineering course. Therefore, graduate students will have to learn the principles of testing as well as the tools used to test the software independently, in order to get a job at software testing position.

In the old accreditation from 2014, it was suggested that Software Testing course could be one of the elective subjects, which can be attended at the VIII semester. At that point, students will already have all of the needed pre-knowledge to learn this subject. There will be more than 100 students who will choose this course. That will be students who are now students of 2nd and 3rd year of IT.

With establishment of new, improved program in 2017, Software Testing course was finally included in curriculum as an elective subject in VII semester.

## 4.2 Proposed structure of Software testing course program in IT studies

Software testing requires specific skills, including critical thinking, analytical abilities, and investigative skills. Good programming knowledge has a positive effect on testing, especially in structural testing, where testers need to understand the code to create test cases. Automated testing also requires a good background of programming. On the other hand, in functional testing, test cases are created using requirement specification. Even though programming is not necessary, there is a need to mentally visualize how the program satisfying given specifications will function in order to derive the test cases consisting of inputs and expected outputs. So it can be assumed that programming knowledge is a beneficial factor for successful software testing. The questions which arise are: Are better programmers, better testers as well? Do higher programming skills result in higher rates of success in testing? More specifically, do higher programming skills help in conducting testing in general, or is this more related to success in a specific testing technique, e.g. functional, structural, or automated testing [11].

Structure of Software testing course will be accomplished through Lectures and Laboratory sessions. The ST course lectures are composed of fifteen 2-hour lectures with midterm and final exam. Course should ensure that students understand the importance of ST activities and how much the good product relays on software testing phase.

In table 3, the sequence of lectures for ST course is presented.

**Table 3:** *List of Software testing lecture topics*

| Lecture | Course title |
|---|---|
| 1. | • The concept of testing<br>• Software testing in software development process |
| 2. | • Test Driven development<br>• Software analysis<br>• Software bugs |
| 3. | • Methods and levels of testing<br>• System testing |
| 4. | • Agile software development |
| 5. | • Fundamental agile testing principles, practices and processes |
| 6. | • Agile testing methods, techniques and tools |
| 7. | • Software components testing<br>• Bottom-up and top-down testing |
| 8. | • Midterm exam |
| 9. | • Testing goals<br>• Testing process management |
| 10. | • Test plan and implementation<br>• Testing process improvement |
| 11. | • Performance testing<br>• Security and penetration testing<br>• Functionality testing |
| 12. | • Team testing<br>• Testing automatization |
| 13. | • Defining user requirement management |
| 14. | • Graphical user interface testing<br>• Web applications testing |
| 15. | • Data base testing |
|  | • Final exam |

The ST laboratory sessions are composed of twelve 3-hour lectures and three terms of 3-hour project defending for all students who will finish their projects (Table 4). After attending these lessons, student will be competent to successfully test software parts or whole software. Students will learn how to analyze and choose corresponding testing tool, create test cases and efficiently accomplish software testing. In order to train students to do all of the above-mentioned on their own, they will be taught different methods, techniques and tools regarding testing. Good tester must also know how to create test cases based on tester or customer requests or complains. After that, all test cases are collected and sprint is made.

Team work is also an important part of software testing. Test cases should be properly assigned to team members, in order to have whole sprint finished in agreed time. Software testing laboratory class sessions should first cover scrum methodology, creation of test cases and sprints. After that, introduction to different software testing tools can begin. Since students have good knowledge of Java, it will be desirable that they also learn how to test applications made in that programming language. Projects made on Java course could be used as a material for testing, and on that example they could recognize software testing importance. Even students with best grades

could discover that those projects work only when used strict instructions.

**Table 4:** *List of laboratory sessions topics*

| Lecture | Course title |
|---|---|
| 1. | • Software testing introduction<br>• Different aspects of software construction process<br>• Software construction planning |
| 2. | • Scrum methodology<br>• Creation of sprints in agile software development<br>• Creation of test cases |
| 3. | • Types of tools for testing<br>• Introduction on tools which will be used in course |
| 4. | • Testing white, gray and black box |
| 5. | • Introduction to JUnit<br>• Basics tests with JUnit |
| 6. | • Intermediate testing with JUnit |
| 7. | • Test automatization with Junit |
| 8. | • Introduction to SeleniumHQ<br>• Basic tests with SeleniumHQ |
| 9. | • Intermediate web application testing with SeleniumHQ |
| 10. | • Introduction to AutoIt testing software<br>• Basic tests with AutoIt |
| 11. | • Connecting AutoIt with Selenium<br>• Intermediate automatization testing |
| 12. | • Database testing with Data Factory |
| 13. | • Project defend |
| 14. | • Project defend |
| 15. | • Project defend |

Testing will be accomplished with JUnit testing software, when their Java knowledge will be of great importance, since testing in JUnit requires knowledge of Java programming language. After desktop application testing, student will learn how to test web application with SeleniumHQ. Again, to write tests scripts, Java programming language is required. Students will be able to test whole web site or application automatically with their testing script.

Sometimes web testing requires user interaction. In that case, AutoIt software can be used for user interactions automation. Connecting AutoIt with SeleniumHQ provides possibility to make intermediate automated test scripts.

Besides of all the above-mentioned, students will also learn how to test databases. In IV semester, students are attending Introduction to information systems course, in which they are learning SQL language and database creation and manipulation. Bad database can easily lead to so called "dead lock" or performance issues. Software testing tool for databases called DataFactory can help in preventing those situations.

After lectures and laboratory sessions students will have enough knowledge to do different type of testing with different tools. Those tests will be automated and efficient and they can cover from tiny parts of software to whole software testing. To get final grade of their knowledge in software testing, they will need to make project which consists of preforming automated test of whole Java application. Students will also choose one web site or web application, which should be tested with AutoIt connected with SeleniumHQ. All that should be well documented. That project will be defended verbally before examination period. That way, students will prove their practical and theoretical knowledge learned in this course.

## 5. CAREER OPTIONS IN SOFTWARE TESTING

After finishing IT studies, there are different career paths in area of software testing. Some of the common job positions in this field are QA engineer, test manager, tester, etc. Testing career usually requires skills such as domain and analytical skills, technical knowledge, communication, soft skills, etc. Devotion, flexibility and learnability are also desirable skills for software testing professionals.

Software testing practitioners can come from a variety of backgrounds. In Figure 1, eight typical job roles in the area of software testing are shown. Below each job opportunity, main responsibilities regarding specific job are listed.

Software testing can be applied in many scopes, and some of them are following:
- Automation Testing
- Performance Testing
- Security Testing
- Cloud Testing
- Infrastructure Testing
- Information Management Testing
- Test Environment Management
- SAP Testing
- Mobile Apps and Devices Testing
- Database Testing
- Oracle Testing
- Package, product Testing
- Test Process TPI, QBP
- Agile Testing
- Test Data Management
- Web Testing
- Regression Testing
- User Acceptance Testing
- Chain Testing, E2E Testing.

Practitioners in testing services can advance in their careers by doing the following:

- Improving knowledge in various areas of testing solutions, tools, methods, processes, architectures, and disciplines.
- Applying industry expertise and specific knowledge.
- Promotion of engagement in activities which increase practical knowledge and training in order to progress to the executive level.
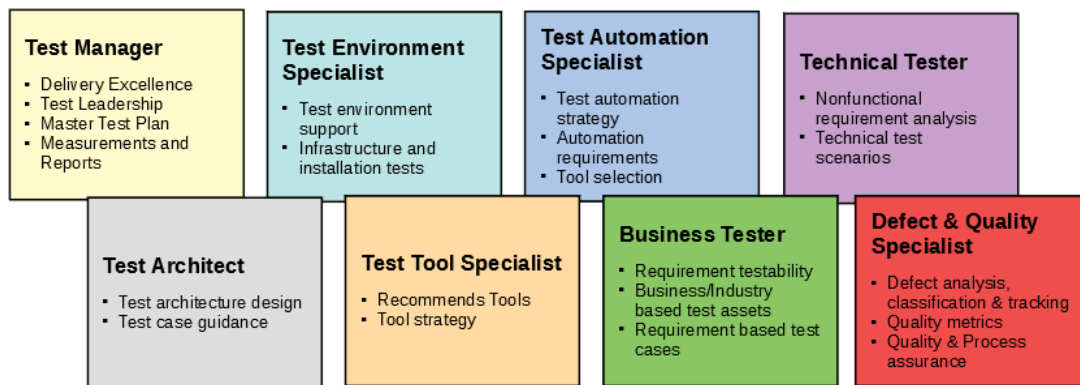
**Figure 1.** *Different job opportunities in software testing*

## 6. CONCLUSION

Due to the increasing demands of end users and complexity of applications created for them, the quality of software must be exceptional. Graduate students of IT, SE or CS studies must have abilities required for working at any stage of SDLC. Although software testing is a part of curriculum at many faculties in Serbia for more than 20 years, but there are still a lot of faculties where this area is not being studied as a separate course. This can be a big disadvantage of study program because proper knowledge of software testing cannot be achieved by learning it partly, throughout other courses. During the Software Testing course, basic theory concepts should be learnt, and some of the software testing tools should be applied.

Based on the [10] approximately 3700 students attend undergraduate IT studies in Serbia. About 50% of students are graduating within the program completion deadline. Out of the total number of IT students, about third of them have Software Testing included in their studies.

Authors of this paper propose that, due to the importance of this field, all IT study programs should have Software Testing course at least as an elective subject. Thus, graduate students would have the opportunity to apply for some of the before-mentioned job roles in area of software testing. This would be beneficial for both students and employers, because students would be able to find a job in the field of software testing without additional training, and employers could hire qualified engineers without difficulties.

## ACKNOWLEDGEMENTS

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