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Design and Application of a Testing Framework of Online Course Based on Agile

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Abstract. On the basis of the feature analysis on development of online course from the perspective of software engineering, a testing framework of online course based on agile is designed firstly. The framework consists of four test cycles with iteration by test stages on preparing for testing, pre-testing, functionality testing and regression testing, and with a test process of acceptance testing at the end of four test cycles before product delivery. The evaluation on organization of the contents of chapter-section structure is also embodied in this framework. Secondly, the framework is fully applied to the agile testing project for an actual online course of "Software Engineering", experimental result shows that more bugs for types of structure of contents, usability, compatibility, installing, security, and navigability of the online course are detected in time and test result is noticeable. Finally, putting forward that some features and aspects on non-functionality testing through test automation together with effective exploratory testing method, and constructing an automated testing environment on cloud computing for big data processing will be the future research.

1. Introduction

Online course refers to the sum of the teaching contents of a course subject and the teaching activities which are implemented through the internet, it is a new manifestation of the course on information era. As a type of instructional software, the implementation on its functions of online course should be under the guidance of curriculum theory, teaching theory and learning theory through the internet, and the designing of course and teaching are the core of the online course for designing [1]. From the initial static form of textbook on website to information period recently, the online course needs a teaching platform to support. On one hand, it focuses on the dynamic designing of the contents of the course with diversified media elements (text, image, animation and sound), emphasizing the analysis on teaching targets and teaching contents. On the other hand, online course focus on functions of self-learning and collaborative learning for learners, providing learners with more personalized learning services. With the development of network and information technology, online course has become a kind of effective learning approach which is accepted by the majority of learners from high schools or universities. For the functionality testing and learning evaluation of teaching effectiveness of online course, it has been focused by both software development engineers and educational experts. As the same with other types of instructional software which are used on web, online course embodies the development of software functional modules on the surface, which essentially include the analysis and
design of teaching targets, the design of learning process, and the organization of teaching contents according with the learning habits and learning needs for learners [2]. With the continuous application of online course now, concerns on quality of software products have been also come with effective testing and evaluation activities, which have become the research hotspot both in education field and software engineering field at present.

However, testing and evaluation of online course are often confused by some researchers. Research works on evaluation of online course are relatively perfect and more mature evaluation systems or specifications are also formed in recent years. For example, from the perspective of educational services or analysis for learners to construction of online course evaluation system [3-4], from the perspective of user experience to construction of online course evaluation system [5-6], implementation of online course multi-evaluation based on the Moodle [7], and so on. But, the research results above are all based on learning experience to discuss the diversified evaluation system of online course almost, ignoring the perspective of using the software by common users form software engineering to testing of online course indeed, lacking of relevant research results now. From the view of operation, it is proposed by Prof. S.Q. Yu in [1] that black-box testing method is more suitable for testing of instructional software, and testing contents involve navigation testing, interactive testing, functionality testing, content testing stability testing, installing/uninstalling testing, and security testing. From the view of software engineering, a series of test models are put forward in [2] and [8-9]. But, for one of the categories of instructional software, how to design and carry out validity test activities on online course within a relatively short development period or in agile circumstance, further research work still needs to be explored.

In this paper, we design a testing framework of online course in agile circumstance from the perspective of software engineering. And as an agile testing case, the research on this testing framework that based on agile is fully applied to agile testing process for an actual online course of "Software Engineering" which is running on web. This is of great importance on validity test for users' requirements of online course in agile environment and also promoting in construction of educational software engineering.

2. Design of the Testing Framework Based on Agile

2.1. Agile Testing
Agile testing is a rapid testing practice that follows the Agile Manifesto, emphasizing testing systems from the user's perspective, focusing on the newly developed capabilities of iterative testing instead of emphasizing the rigorous testing phase of traditional testing [10]. Agile testing is inherited from agile development also. Test speed and test adaptability are high emphasized. By the change and adjustment on test indicators constantly, to achieve the goal on requirements for users effectively, and final software product could be released in time. Agile testing overcomes the problems of the traditional testing, such as the user's requirements, which are not adapted to the frequent changes, shorten software cycles and complicated flow control [11].

In recent years, with the rapid development of software industry either in domestic or abroad, agile testing has been widely used in various test practice. Additionally, a series of testing models which are based on theory in agile are also come into being. At present, the general framework of Scrum [12] is also widely used to instruct the whole execution process for most of the agile testing projects.

2.2. Features on Development of Online Course
As it is mentioned above, online course is a type of instructional software for learners. In addition to the main functions and performance are required to be achieve on the web, but it is also necessary to reflect the characteristics of modern distance education fully and increase the interests of users.

From the perspective of learning, online courses are very different from the common web sites in terms of content presentation, learning interaction, integration of information resources, and teaching methods. Generally, the design of the organization structure and the displaying on learning contents
are needed to be carefully designed by educational experts and teachers. Organization structure of online course is the structure of chapter-section indeed, that is the learning objects or learning units are collected at different levels of the course for learners. The typical structure template of chapter and section for online course are shown as Table 1 below. The design of the displaying on learning contents refers to the way when the learner takes learning activities by browsing the web page of the online course. It needs to be selected the best presentation pattern for displaying the information according to the content of the course and provide a clear learning resource space for learners. The design of the displaying include the design of course interface, course navigation, arrangement of content, medium presentation, human-computer interaction, and so on. These designing elements are both important and unique, which are different from other traditional web applications and they should be well designed in the process of development of online course.

But, from another perspective of software engineering, application on online course is a kind of web application, and testing activities belong to web testing either. Test objects involve content, function, structure, usability, navigability, performance, compatibility, interoperability, security and configuration [13]. Additionally, each functional module and its interface of online course must be completed by unit test to detect bugs on navigation, and user graphical interface (GUI) should be tested too. In the actual learning environment, web applications on online courses usually have a large number of end users. Usability testing, reliability testing, compatibility testing, security testing are also important aspects of performance testing.

| Chapter | Overview | Brief introduction to this chapter |
|---------|----------|-----------------------------------|
|         |          | Learning object on this chapter   |
|         |          | Emphasis on this chapter          |
|         |          | Concept diagram of this chapter    |
| Lead-in | Overview | Brief introduction to this section |
|         |          | Learning object on this section    |
|         |          | Emphasis on this section           |
|         |          | Concept Diagram of this section    |
| Section*| Overview | Lead-in/Practice/Evaluation/Summary |
| Practice|          |                                   |
| Evaluation|        |                                   |
| Summary |          |                                   |

### 2.3. Testing Framework Based on Agile
The idea on designing of the framework is based on agile Scrum which is widely used recently. Firstly, each testing work in each phase of iteration cycle is adapted to agile development features. Secondly, the amount of code for submitting in one iteration cycle is more than traditional testing phase [14]. So in addition to complete the functionality testing and performance testing, verification on software development process of online course is also included. In this framework, four test cycles with iteration by test stages of preparing for testing, pre-testing, functionality testing and regression testing are designed, the duration of each iteration period is no longer than 10 days, and each test stage include some test activities.

However, online course is a unique system for web application, although the testing method is similar to the common web testing method. Not only should the testers are participated in the whole process of Scrum, but also teachers, experts on education, students are participated the whole test process of test preparation, pre-testing, functionality testing and regression testing. These test activities should be executed in one iterative cycle in agile environment.
Acceptance testing is also an important part of the framework. The purpose of acceptance testing is to ensure that the software is ready to verified, to make the functionality and performance on the software as expected by users [15]. The acceptance testing of performance and stability can be done by some of the automated testing tools. From the user's view, installation and validation on software are still needed to design the test scenario manually. In acceptance testing of this framework, installation testing and validity testing are additionally designed. The testing framework of online course based on agile is shown as Table 2.

2.3.1. Preparing for testing. In agile testing environment, a test team should be set up first and is responsible for testing, including developers, testers, full-time course teachers, educational experts, et al. Test speed and adaptability should be adapted to changes on requirements for users, time is not allowed to be wasting on clarifying requirements and design changes, and static testing by developers is essential in this phase. In addition, the structure of overall contents for online course which is referenced in Table 1 should be reviewed by the whole team, a preliminary test plan in agile is developed. In this test stage, requirements will be not known up usually, and it's difficult to imagine every detail by users, especially by learners. So, test tasks only for major functions and acceptance criteria are confirmed by test team.

2.3.2. Pre-testing. In pre-testing stage of the framework, continuous testing and the feedback on features on quality on testing are obvious. Within a version iteration cycle, a pre-test is required before functionality testing, to ensure that test activities are performed only for a software version which has a relatively stable user's requirement [16]. Pre-testing is composed of test driven development of new modules and unit testing, continuous integration testing of daily new code-build verification test (BVT) and basic functionality testing by automated testing in general. The purpose is to ensure that the addition of code components or a set of code daily is testable for users. Moreover, these test activities will be executed in next test stage to form testing iteration. Modules for development will be changed rapidly, to cause the continuous testing in agile environment. By the way, educational experts, full-time course teachers with some students should review the structure of chapter- contents for online course, and test tasks for secondary functions and acceptance criteria are confirmed by test team.

2.3.3. Functionality testing. The period of agile testing is much short. During the process of iterative testing, whether the new features are adapted to requirements for users, and whether there are no bugs in iterative process of testing or not are very important [17].

Three layers (unit testing and components testing on bottom layer/API testing for business in middle layer/Graphical User Interface testing at the top layer) of test automation framework [18], which is looked like a pyramid (as shown in Figure 1) is suggested to guiding functionality testing. But requirements for web pages of online course are often changed rapidly in a short period of time, so it is not suitable to implement automated testing fully. Coding for top layer on GUI is also changed rapidly, the testing method on automated testing with some exploratory testing is more suitable [19].

![Figure 1. Framework of test automation.](image-url)
Besides, unit testing, continuous integration testing of daily new code-build verification test (BVT) for new modules or code changes on existed modules are also tested, and the structure of section-contents for online course should be continued to review by full-time course teachers with some students, constantly modifying or promoting the content of structure of online course. Some test tasks for secondary sub-functions and acceptance criteria could be confirmed by test team if they are existed.

2.3.4. Regression testing. In regression testing stage of the framework, when most of the development work of the online course was completed, some test activities for optimization and the reviewing the structure of contents of online course for optimization are the main tasks. Exploratory testing for some new functions which are changed can be attempted to detect more abnormal bugs. Some detailed introduction on exploratory testing method and applications are listed in [18] [20-21] for readers who are interested in them.

![Table 2. Testing framework based on agile.](#)

| Test Cycle | Test Stage in Agile | Test Activities |
|------------|---------------------|-----------------|
| Iteration 1 | Preparing for testing | Set up a test team |
| | | Define the major test requirements |
| | | Static testing |
| | | Review the structure of overall contents for online course |
| | | Develop a preliminary test plan |
| | | Confirm test tasks for major functions and acceptance criteria |
| | | Team communication |
| Iteration 2 | Pre-testing | Confirm test tasks for secondary functions and acceptance criteria |
| | | Test driven development of new modules |
| | | Unit testing |
| | | Continuous integration testing (Build verification testing/Basic functionality testing) |
| | | Review the structure of chapter-contents for online course |
| | | Team communication |
| Iteration 3 | Functionality testing | Confirm test tasks for secondary sub-functions and acceptance criteria |
| | | Test driven development of new modules |
| | | Unit testing |
| | | Continuous integration testing (Build verification testing) |
| | | Review the structure of section-contents for online course |
| | | Team communication |
| Iteration 4 | Regression testing | Review the structure of contents of online course for optimization |
| | | Unit testing for optimization |
| | | Integration testing for optimization |
| | | Exploratory Testing for functions changing |
| | | Team communication and summary |
| Before delivery | Acceptance testing | Validity testing |
| | | Evaluation on online course |

2.3.5. Acceptance testing. Acceptance testing is the verification on definition of test requirements before delivery. To makes the functionality and performance on the software as expected by users [15] [22]. Acceptance testing of performance and stability can be done by some of the automated testing tools. But, usability testing, compatibility testing, installing/uninstalling testing security testing, navigability testing can be selected to execute by manual testing. Evaluation on online course should be completed by course teachers, educational experts, and some users of actual learners. Researches on evaluation of online course are relatively perfect recently, and some methods of evaluation could be referenced in [3-7].
3. Application of Testing Framework

3.1. Background of the Project
The background of this project is to test an online course of "Software Engineering" of a university which is based on agile testing circumstance. Most of the users are local undergraduate students who are interested in this course. The essential functions of online course is to provide with learning resource to registered learners for self-learning, self-examination and online discussion, registered teachers have authority on course management and exam management. The time for the first released version of online course is no more than one month. Additionally, the requirements for users may be changed from time to time according to the changes with application environment during the development, and some features after finished in developing will be released on Android platform.

3.2. Application of the Framework
To verify the validity on the application of testing framework in this paper, a small test team is set up which includes five numbers (one coder, two testers, one course teacher, and one student). Test iterations are four cycles and the time for each test cycle is seven days, the following is a brief introduction to testing application.

In preparing for testing stage, a project meeting is held. Requirements tasks for testing should be summarized to user case by testers, and test priority (L/M/H) should be assigned. A test plan for agile testing is also designed, and a high-level of functionality test case is completed to develop. After the meeting, use case is further refined and assigned to the specific tester in the form of sub tasks, and completion time (usually the completion time of sub task for a sub-use case is 0.5-2.0 days) is also specified, and it is shown as Table3. Of course, reviewing the adaptability, integrity, and structure of overall contents for online course are also completed by course teachers and students in this stage.

In stage of pre-testing and functionality testing, firstly, using the daily building code and build verification tests as a continuous integration test script because of rapid changes on development daily. QTP (Unified Functional Testing) is used to add written scripts which were passed unit testing scripts to complete the continuous integration of basic module functionality testing. Secondly, the framework of three layers on test automation is used for functionality testing, unit testing, integration testing, and application programming interface layer (API) of code components at the bottom and middle of the framework are performed by tool of QTP. Thirdly, reviewing the structure of chapter and section contents from cognition for online course should be done by course teacher and student. Additionally, some educational experts and art designers are invented to evaluate the interface for aesthetics and art of the course, and feedback to developers for modification and improvements timely.

In stage of regression testing, in accordance with the iterative increase of the system functionality, in the regression testing practice of each cycle of iteration, test case (suite) is still executed by test automation for the newly-added functionality in regression testing. For example, during the iterative development of the online course, as the new functions, use cases: "1.4 Resource evaluation/2.4 Blog communication/4.3 Score statistics" are added to development, automated test in regression testing on newly code should be executed as soon as possible. So, the mainly functions for regression testing after system integration, because the time of version release is much short some exploratory testing method is widely used by mutual testing. After the last test cycle of iteration, acceptance testing needs to be organized to ensure that the functions and performance on this software version have been satisfied the requirements for users.

On one hand, performance on acceptance testing has been completed by an automated testing tool, such as the load testing and response time for simulating multi-client concurrent operation. On the other hand, from the view of using of the actual users, usability testing, compatibility testing, installing/uninstalling testing, security testing, navigability testing, and so on should be put into application on changes for testing scenario by exploratory test method through black-box mode. For example, in terms of installation testing, we change the original test scenario on PC and install the
online course client system on Android phones with different brands and hardware configurations, such as "Xiaomi", "Huawei", to test the same terminal system for different hardware compatibility.

Table 3. Use case and test priority.

| User Authorization       | Use Case             | No./Sub-Use Case/Priority |
|-------------------------|----------------------|---------------------------|
| Registered learner      | Course learning      | 1.1 H Resource inquiry    |
|                         |                      | 1.2 H Resource download   |
|                         |                      | 1.3 M Resource collection |
|                         | Course Discussion    | 2.1 H Course forum        |
|                         |                      | 2.2 L QQ communication    |
|                         |                      | 2.3 L WeChat communication|
| Registered teacher      | Course manage        | 3.1 H Resource upload     |
|                         |                      | 3.2 M learning topics lunch |
|                         |                      | 3.3 H Online Q & A        |
|                         |                      | 3.4 M Exercise reviewing  |
| Exam manage             | 4.1 H Question bank construction |
|                         | 4.2 M Online exam    |
| System administrator    | System manage        | 5.1 M User management     |
|                         |                      | 5.2 L System help         |

3.3. Analysis on Test Result

According to the application on this testing framework based on agile in this paper, the whole test process is better focused on the software product itself and the user’s value that delivered rapidly. Here, as a case for a module of "Course Discussion", total seventeen bugs (static testing: 1/BVT: 2/functionality testing: 3/regression testing: 5/acceptance testing: 6) that detecting in the whole stages of the framework. But, more bugs are defected in stage of regression testing and acceptance testing. The proportions of the major types of bugs are structure of content on the online course, usability, compatibility, installing, security, and navigability. The result shows that using the testing framework based on agile in this paper, an active role in defecting bugs in agile environment and improving the software quality is positive.

4. Future Research

In acceptance testing phase on performance testing of the framework of the actual online course, through system performance testing could be done by certain performance testing tools, considering the online course will be installed or deployed on different system terminal in a large area for operation, so it is necessary to avoid response time and data access delay when a large number of end-users who are going to login or browse the website in a limited time. Testers, course teachers and developers must think more about the some features and aspects on non-functionality testing through test automation together with effective exploratory testing method, such as performance, load, stability, stress, compatibility, data conversion, user interface, and upgrade, backup, and so on, especially in big data background. Additionally, constructing an automated testing environment based on cloud environment to satisfy the test requirements on cloud computing for big data processing, matching the capabilities of the client environment with the requirements of the server, and explore new approaches to software testing under large-scale concurrent environments are also future research work.

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