Methodology for Evaluation of Internal Quality of the Study Programme

R. Čevere, S. Sproge

Abstract—Quality improvement of the study process and study programmes has been a topic of great interest of late years in the European Higher Education Area. The methodology for evaluation of internal and external quality of the study programmes is being developed at the Faculty of Information Technologies, Latvia University of Agriculture. The methodology is developed based on the analogy with quality model of the software products, and it can be applied to the defined study programme. Evaluation of the quality attributes included in it answers such questions: are the necessary elements of knowledge and skills included in the programme; is it easy to teach and to learn the programme; how efficient is the programme; how easy it is to modify the programme. The main attention in the present paper is paid to two aspects of the quality assurance. One of them is evaluation of the quality characteristics of the content of the study programme, and the second one is holding the peer reviews for quality assurance.

Index Terms—curriculum development, software quality

I. INTRODUCTION

Considering the great topicality of quality assurance in the sphere of higher education, a lot of publications dedicated to this subject can be found in the international space of information. Most of them deal with definitions of the quality concept and approaches of quality assurance and quality improvement as well as with understanding and managing quality [1]-[5].

Activation of quality assurance problems in software development has started considerably earlier, therefore gaining great experience in quality assurance of development processes and quality of the end product. Development and maintenance of quality systems of a company have proved themselves as an effective tool for quality assurance of processes in the sphere of software product development. The next stage where significant results have been achieved is the development of quality model and method of quality evaluation of the software product described in the international standards ISO 9126 and ISO/IEC 14598 [6], [7]. The model and the methodic are widely discussed in the new version of software product quality and evaluation standards ISO/IEC 25030 [8]. The authors of the present paper describe how the method of software product quality evaluation can be used in the development of method for quality evaluation of the study programme. The method is based on two aspects: one of them is regular evaluation of the external quality of acquired study courses done by the students using the metrics defined by the authors, while the second one is holding the peer reviews for the evaluation of internal quality of the study courses.

II. GENERAL EVALUATION OF THE STUDY PROGRAMME

In the previous papers the authors have described the studies of information technologies specialists as the first stage of the software development project staff training, and they have proposed a common study quality model based on the analogy with the software quality model [9]. International experience related to the implementation of certified quality systems in the sphere of education has demonstrated not so good results compared with the software development [10]. Nevertheless the software evidentiary has a great similarity with the results of education process as the product. First of all, both of them have an abstract nature, and wide circle of clients interested in these products. The interests of these clients usually are very different and contradictory. Long-term experience in the implementation of quality requirements in the software development projects allows applying this experience in the development and quality evaluation of the study programmes of information technologies.

Higher education institutions have problems defining criteria and procedures for the evaluation of a study programme during its development and implementation. The implementation of study programme requires a continuous following its quality, and application of proper quality assurance systems [11]. The European Commission recommends developing quality assurance systems based on several essential principles, including evaluation of programmes and/or education institutions, using internal evaluation, external review and involvement of the students. The evaluation results should be published, and international cooperation in evaluation process should be organised [12]. The quality evaluation results play a significant role, assisting higher education institutions to improve results of their operation.
Accreditation of the study programme encompasses its external evaluation, and at the same time serves as the state warranty to the study quality [13], [14].

In Latvia during the accreditation study programmes are evaluated in accordance with the following criteria [15]:
(a) the aim and tasks of the study programme;
(b) content and organisation of the study programme;
(c) presentation and knowledge evaluation;
(d) assurance and control of the studies;
(e) research work of the staff and the students;
(f) quality assurance and warranty.

The main task of these criteria is to facilitate evolution of the study programme and to achieve improvements. The accreditation of the study programme means an external evaluation of the quality, during which an external accreditation commission determines the conformity of the programme with the previously defined minimum quality standards [16]. The main difference between the accreditation and quality evaluation is that the first one defines the conformity of the programme with the minimum standards, while the second one determines the level of academic quality [17]. Hence, the quality evaluation should be regularly carried out by the education institutions themselves.

Therefore accreditation relates to the external valuation of the study programme, but today the internal activities of an education institution have especially significant meaning in quality assurance. Self-assessment report which is annually prepared during the period of accreditation is one of them. The self-assessment report includes the following information:
(a) practical implementation of the study programme – presentation method, analysis of delivery resources, involvement of the students in the research work, cooperation with the employers;
(b) evaluation system;
(c) the students – number of students studying in the particular study programme, number of graduates, evaluation of the study programme from the viewpoint of the students and of the graduates, participation of the students in the improvement process of the study programme;
(d) qualification of the academic staff;
(e) sources of funding and infrastructure support;
(f) proposals for the improvement of work quality;
(g) plan of the study programme progress.

Even though this information is rather detailed, basically it has a descriptive character and does not contain estimation of quality of the content of study programme. Each higher education institution may chose its criteria used for the quality of the programme content. Higher education institutions should develop and maintain internal quality system which provides possibility to ensure qualitative study process by managing internal and external evaluation of the study programmes.

The present paper describes the organisation of quality evaluation of study courses and the study programme in total based on the analogy with the software development, and the activities well known for software quality assurance are used already for the study programme. From the viewpoint of quality assurance of education it is the ground level of the education institution for the internal quality assurance (task of the faculty and the departments). The methods are being approbated for quality assurance and evaluation of the study programme “Programming” at the Faculty of Information Technologies, Latvia University of Agriculture (LUA).

III. EVALUATION OF THE INTERNAL QUALITY OF STUDY PROGRAMME

In software development the evaluation of the internal quality of a product is carried out based on the analysis of software and/or system requirements specification, design description, and source code. Evaluation can be done using the sequence of the steps described in software quality standards ISO 9126 [18], the procedure of planning and implementation of the evaluation process described in software evaluation standards ISO/IEC 14598-2, and the recommendations of software measurement process standard ISO/IEC 15939 [19]. The evaluation activities are carried out in accordance with the recommendations described in the Standard of Software Reviews and Audits [20]. The same approach is used both during the development of individual study courses and the whole study programme.

The documents being an intermediate product are analysed during the software development.

Software requirements specification “is a document that specifies the requirements for a system or component. Typically it includes functional requirements, performance requirements, interface requirements, quality requirements, design requirements, and development standards”. Software design description “is a document that describes the design of a system or component. Typical contents include system or component architecture, control logic, data structures, input/output formats, interface descriptions, and algorithms” [21]. Design description is a draft of the system or a model.

In the sphere of software development theoretical methods, standards and practical recommendations have been developed for preparing and assessment of such documents. The main attention is paid exactly on the quality assurance of the content.

Regarding the study process, the study programme, the study plan and descriptions of the study courses are the basic documents on which the quality of the results is build on.

Study programme covers all the requirements necessary for obtaining an academic degree or professional qualification. The study programme is regulated by a special document – description of the study content and delivery. Depending on the type and level of education it defines the aim of the particular programme; tasks and the planned results; the content of education; scope of compulsory courses, restricted elective courses and elective courses of the programme;
schedule of mastering; criteria for evaluation of the proposed education; forms and procedures of control [22].

Study plan is a part of description of the study programme which contains information on the courses to be mastered, their scope, control forms, sequence of studying, and breakdown by terms.

Study course is on a defined level, scope and time specially organised outline of the study subject or a part of it which has a defined results [23]. Study course is a separate unit of the plan of the study programme.

Preparation, drawing up and approval of these documents are defined in various regulatory enactments of higher education, and the internal and external institutions of the university control their implementation. Although practically no recommendations for quality assurance of the content of study programme and study courses are available [24].

Developers should think about the quality of the study programme from the very beginning of its development. Similarly with the software product development the process of constructing the study programme can be divided into several phases (see Table 1).

<table>
<thead>
<tr>
<th>Phase</th>
<th>Software product</th>
<th>Study programme</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Requirements analysis</td>
<td>Requirements analysis</td>
</tr>
<tr>
<td>2.</td>
<td>Architectural design</td>
<td>Development of the content of the programme</td>
</tr>
<tr>
<td>3.</td>
<td>Detailed design of software product – (software and system architecture)</td>
<td>Development of the study plan of the programme</td>
</tr>
<tr>
<td>4.</td>
<td>Coding and testing of software product</td>
<td>Development of the content of study courses and study materials</td>
</tr>
<tr>
<td>5.</td>
<td>Integration and testing of software product</td>
<td>Development of the plan of lectures and practical task</td>
</tr>
<tr>
<td>6.</td>
<td>Integration and testing of the system</td>
<td>Planning the total study work</td>
</tr>
<tr>
<td>7.</td>
<td>Installing the software product</td>
<td>Preparing the timetable</td>
</tr>
<tr>
<td>8.</td>
<td>Operation and maintenance of the software product</td>
<td>Delivery and improvement of study courses</td>
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</table>

The present paper mainly deals with the methods of evaluation of the internal quality of study courses. The total evaluation process is organised similar with the software development. The first stage of the software testing is unit testing, during which the smallest units of software are checked. It is followed by the integration testing, which pays main attention to interconnection of the units during their integration into system. The testing process ends with the system testing. Evaluation of the study programme is planned similarly, starting from the smallest units – the study courses. The following documents of the study courses, prepared in LUA for each course of the study programme serve as the evaluated objects:

(a) the programme of the course (detailed description of the course) – kept in the department;
(b) the description of the course (entry to the register of all courses of LUA);
(c) study materials (LUA e-study system – http://estudijas.llu.lv);
(d) sources of literature (main catalogue of the Fundamental Library of LUA - http://llufb.llu.lv/).

Using the model defined for the internal quality of software products, adapted for education sphere, the following quality characteristics are being evaluated:
(a) functionality (F);
(b) usability (U);
(c) efficiency (E);
(d) maintainability (M);
(e) portability (P).

The team of peer review will be organised for the evaluation of internal quality of study courses, including the representatives of academic staff of relative study directions, representatives of graduates (currently students of master or PhD study programmes), and at least one representative from an external organisation (representative from employers or other university).

In accordance with Standard ISO 9126-3 the quality evaluation consists of 5 steps:
1) identification of quality requirements: during this step the weight is defined for each quality characteristic and sub-characteristic;
2) specification of evaluation: during this step metrics are chosen to be used for evaluation of each quality characteristic and sub-characteristic;
3) planning of evaluation – development of evaluation plan;
4) evaluation;
5) feedback to the organisation.

The objects of the current evaluation result from the study programme which is being prepared for the reaccreditation.

The reviewers have received for the evaluation of study courses the following documents: programme of the course; course description, previous programmes of corresponding courses (in order to evaluate changes in the content), the plan of the study programme and electronic catalogue of the Fundamental Library of LUA.

During the first step the weights of quality sub-characteristics are defined, then reviewers use the defined weights during the evaluation process (see Table II). The weights are defined from the viewpoint of a user’s needs, and it is done by the personnel of the department.

<table>
<thead>
<tr>
<th>Quality characteristics</th>
<th>Quality sub-characteristics</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Functionality <em>(Are all the required topics included into the study course?)</em></td>
<td>Suitability</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Accuracy</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Interoperability</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Functionality compliance</td>
<td>M</td>
</tr>
<tr>
<td>Usability <em>(Is the study course easy to teach and to learn?)</em></td>
<td>Understandability</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Learnability</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Deliverability</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Attractiveness</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Usability compliance</td>
<td>H</td>
</tr>
<tr>
<td>Efficiently <em>(Is the study course efficient?)</em></td>
<td>Time behaviour</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Resource application</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Efficiently compliance</td>
<td>M</td>
</tr>
<tr>
<td>Maintainability <em>(Is it easy to maintain the study course?)</em></td>
<td>Analysability</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Changeability</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Stability</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Verifiability</td>
<td>H</td>
</tr>
<tr>
<td></td>
<td>Maintainability compliance</td>
<td>M</td>
</tr>
<tr>
<td>Portability <em>(Is it easy to transfer the course?)</em></td>
<td>Co-existence</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Adaptability</td>
<td>M</td>
</tr>
<tr>
<td></td>
<td>Replaceability</td>
<td>L</td>
</tr>
<tr>
<td></td>
<td>Portability compliance</td>
<td>M</td>
</tr>
</tbody>
</table>

The second step is selection of metrics for the evaluation of quality characteristics. Table III shows an example of metrics selected for quality evaluation of the study courses. The metrics defined based on the modification of the recommendations from Standards ISO 9126-3 and ISO 9126-4 are marked with a symbol "*". The metrics without "*" are additionally defined by the authors.

<table>
<thead>
<tr>
<th>Sub-characteristics</th>
<th>Descriptions of metric</th>
<th>Input to measurement</th>
</tr>
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<tbody>
<tr>
<td>F- Suitability *</td>
<td>Functional suitability</td>
<td>Detailed programme of the study course</td>
</tr>
<tr>
<td>F- Suitability *</td>
<td>Completeness</td>
<td>Detailed programme of the study course</td>
</tr>
</tbody>
</table>

The third step includes the planning of evaluation process of the study course. The evaluation process is organised in accordance with the recommendations of Standard for software reviews. In order to facilitate the reviewer’s work and to obtain the information which can be better compared and treated, the checklists have been prepared reminding the questions to be reviewed (see example below):

**Status of course documents:**
- Existence of the programme of the course
- Entry to the register of courses
- Existence of study materials

**Topicality of course documents:**
- Conformance of the programme to the information in register of courses
- Conformance of study materials to the programme
- Existence of references for all topics

**Assessment of the content of course:**
- Topics of the course are described in referenced sources
- Branch topicalities have been included into the content of course
- Practical (laboratory) work is necessary for mastering the course

Number (amount) of planned practical work is adequate

Description of the course is:
- a) correct;
- b) unambiguous;
- c) complete;
- d) consistent;
- e) ranked for importance;
- f) verifiable;
- g) modifiable;
- h) traceable.

Relationships of the course with other courses are clearly described

The content of the course gives necessary grounding for
relevant courses
The course does not repeat the relevant courses
Additional unassisted work of students is planned for mastering the course
Amount of planned additional unassisted work is proportional to the scope of course

IV. DISCUSSION

Recommended evaluation and measurement procedures in software development include definition of the goal at the beginning, and processing, assessment and application of the obtained results at the end as mandatory steps. Application simultaneously includes feedback to the previous processes, stages or steps in order to perform the possible improvements. The same approach will be used in the development of study programme.

The initiated work of quality evaluation is long lasting. First of all evaluation will be done during the full period of study programme, and it lasts 4 years. Therefore full processing of the obtained results of a questionnaire using well known methods will be possible only after some years. Meanwhile the first results are already being used on the basis of qualitative assessment. Each lecturer has been introduced with the questionnaire results on relative courses of the previous term. This allows drawing the first conclusions and making improvements which are in the competency of the lecturer, and improves mutual understanding between the students and the lecturers.

The initial processing which is planned for the evaluation of a full study programme predicts methodical analysis and evaluation of the results (it can be started after the end of the study year 2012/2013). For individual selected metrics it is planned to count the values which will be used as a “ground value” for determination of the direction of further evolution. One of the planned assessments is to use the following equation (1):

\[ X = 1 - \frac{A}{B} \]

where
\[ A \] – number of negative events;
\[ B \] – total number of events.

This formula allows interpreting the results according to the principle “the closer to 1 the better” or, depending on the metrics nature, “the closer to 0 the better”.

V. CONCLUSION

Software development is one of the spheres in which long-lasting and in many cases successful experience is gathered in the development of quality systems, and in the development of product quality models and quality evaluation rules. Experience for more than 10 years in the development and implementation of quality system in the TickIt certified company of information technologies allows defining the most significant ways for the introduction of quality requirements into everyday work. Annual successful assessment of international surveillance and recertification audits gives the approval to correctness of these solutions. Close contact of training information technologies specialists with the qualification of the staff of development projects, and, therefore, its impact on the quality of the end product allows setting a target to develop a unified quality model and unified approach to quality evaluation.

Trial to solve quality improvement problems in education institutions by creating and introducing certified quality systems is not a useful approach. If in the sphere of software development a certificate in many cases ensures an advantage and improves competitiveness of the company, then in the sphere of education it is not a significant aspect. Education institutions are placed under strong and varied regulations of control and accreditation, and certificate of ISO 9000 has no practical influence on them.

Nevertheless fundamental investment can be taken from the experience of the software quality requirements implementation and quality evaluation. Usage of this experience in education sphere allows creating a common view on quality assurance totally. The main goal should always be clear in individual quality assurance activities and quality evaluations on different levels, and it is the quality of the end product. Such approach perceives the quality assurance as a continued process which has a beginning, but which never ends. This process should be maintained and continued always until the basic processes exist.

This paper describes only one activity from the set of multiform actions. It is the quality evaluation of the study programme and study courses, using the concept of the internal and external quality evaluation methods defined in the sphere of software development. Generally the evaluation is being organised like the stages of software testing. The first one is evaluation of the units, which is followed by integration, and then evaluation of the system (in this case the whole study programme).

The initiated work is long lasting. Different activities, including organisational events and solving subjective problems should be done before achieving substantial results. For example, in order to obtain assessment from satisfactory wide and valid group of users, i.e., students, first of all it is necessary to achieve wide and interested participation of them in this process, yet it requires additional educational work. At the same time participation in such process for former specialists of information technologies can be considered as a direct part of education process since it allows the students in practice to acquire participation in such activities as reviews of the results and intermediate results, which are very necessary in software development.

Currently reading of many publications which nowadays are devoted to quality problems of education process does not succeed in finding the ones describing practical or methodically organised approach to quality assurance and evaluation of the content of study courses. The work described
in the present paper was initiated some years ago, and it is planned to be continued until all components of study quality models are tested. For the time being work is carried out prevailing in one department of the Faculty of Information Technologies. Developed recommendations and tested methods are introduced as a persistent part of work.

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REFERENCES


