Conceptual Modeling in E-Learning and its Impact on Content Quality

Ján Lang, Peter Kyseľ

Abstract: *Current e-Learning does not provide standards, metrics, processes, methods and other techniques that would allow defining what falls under quality educational content and what does not. Regarding to this we can find certain inspiration or potential analogy in the field of software engineering. Software developers and others involved have already solved some domain similar problems. The document addresses the question whether the issue of quality educational content is similar to the issue of quality in software engineering. This could be very helpful in identifying of standards, metrics, processes, methods for the development of educational content. We think about certain kind of content engineering. The paper examines the extent to which the selected metrics from software engineering are applicable in the identification of the educational content for e-Learning. Conceptual modeling successfully used in software engineering is not domain-dependent. Therefore, we see potential for its application in the field of e-learning. Under the relevant metrics, we confront several conceptual models. We explore the impact of such a representation of the educational content components on content quality.*

Key words: *Conceptual Modeling, e-Learning, Educational Content, Educational Content Engineering, Quality, Standards, Metrics.*

INTRODUCTION

The question of life quality engaged a relatively important community e.g. [3] indicates the quality of life as a measure of fulfillment of objectives stated by the individual. Man's determined objectives reflect the demands he faces. The objectives are thus an expression or internalization of requirements. A man decides on the basis of its experience, assessment and value metrics how the external requirements are being transformed into goals. Procedures and methods for transforming problems into the domain of solutions in terms of clearly defined criteria or metrics are usual in architecture, electrical engineering, software engineering and so on. Interpretation of models is a platform for constructive debate affecting the overall quality of the result. There is no doubt that the confrontation of different views over the model is in mentioned disciplines widely applied. The problem of e-learning is the absence of such metrics, processes, methods and other techniques, making it possible to formalize the required content in the form of knowledge, skills and competences. Conceptual modeling has this potential. Education is a sectional most important area, which is a prerequisite for sustainable development. Formalism - supporting the existence of an explicit statement of the educational content - can be for the purpose of education the same as for electricians' circuit diagrams or for mechanical engineers technical drawing or for software engineers' physical data model expressed in UML. So current e-Learning does not provide standards, metrics, processes, methods and other techniques that would allow defining what falls under quality educational content and what does not. We see this as a problem suitable for solution.

RELATED WORKS, ANALOGY BETWEEN SOFTWARE AND CONTENT

Regarding to this we can find certain inspiration or potential analogy in the field of software engineering. Software developers and others involved have already solved some similar problems. The document addresses the question whether the issue of quality educational content is similar to the issue of quality in software engineering. This could be very helpful in identifying of standards, metrics, processes, methods for the development of educational content. We think about certain kind of content engineering. We perceive several serious similarities between software and educational content, For example both of them are intended to be presented in a memory. They can be interpreted as a sequence of steps for carrying out certain tasks. Software can be human readable as well as the educational content. Both of them may result as a team product etc. For each software can

be decide whether it is good or not. It is thus possible on the basis of the metrics that determines its quality. The metric in this context stands for determining the degree of the quality. It represents a mathematical function by which a particular variable can express the extent to which the software is good or poor. Among the main features of quality software product must be concerned the following: r*eliability* - this attribute determines whether a software loss occurs could cause the physical or economic damage. There are several definitions of reliability. Reliability is the likelihood of a software system to behave according to the specifications given time, it represents the time between two software failure is the failure rate [5], c*orrectness* - this attribute is a measure of the fact that the software is programmed according to specification. Requirements specification is most commonly expressed by detailed description of use cases in Cockburn's notation [1] etc., f*lexibility* - this attribute is a measure of adaptation to change. If something changes, the software must be adaptable [4], r*eusability* - This attribute expresses the ability to use software - its part in other applications [8], c*ompatibility* - This attribute expresses the ability to use the product with other products [2], e*ffectiveness* - this attribute is trying to minimize hardware requirements, meet the criteria linked to development. Effectiveness can be expressed using a pricing model [7], p*ortability* - this attribute is a measure of the complexity of deployment - to translate the software into another software or hardware platform [6] and e*ase of use* - This attribute is a measure of performance to installation, training, management and use.

PROPOSAL OF METRICS FOR CONCEPTUAL MODELS QUALITY TESTING

Given the relatively strong analogy between software and educational content it is supposed to apply selected metrics in order to calculate the level of the quality of any educational content. From the identified metrics applied in software engineering and after examining the available standards from the family issued by the International Organization for Standardization (ISO) and the International Electro technical Commission (IEC) registered by numbers ISO/IEC 9126 including its updates as well as IEEE, AENOR etc. we have proposed the following metrics for conceptual models quality testing: correctness, integrity, interoperability, reliability, maintainability, testability and efficiency. Individual metrics have their weight. This is determined by the number of occurrences of a given metric in the reviewed quality metrics of software engineering. From software engineering quality metrics we did not use metrics that directly depend on the individual by his behavior, psychological profile of education and factors that influence educational content.

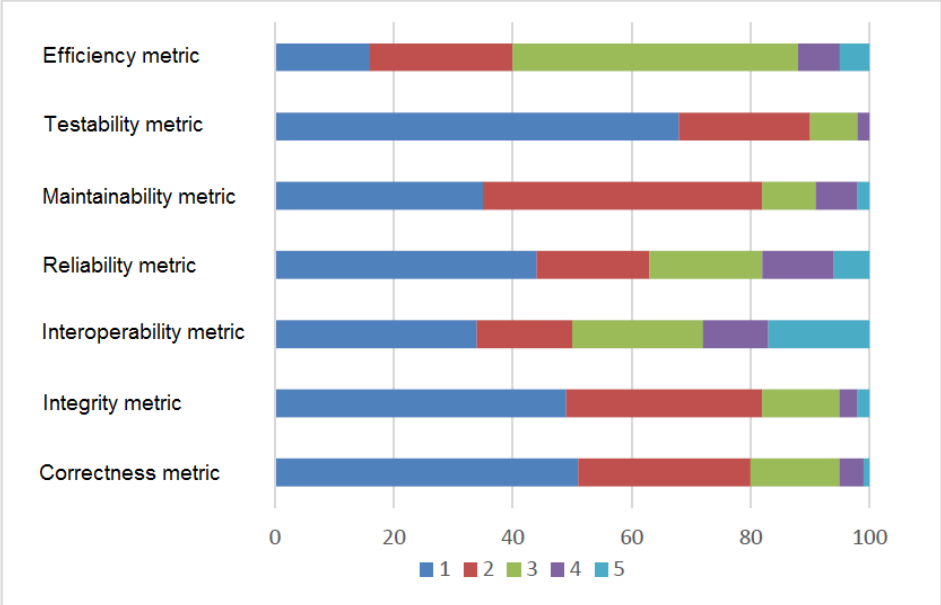

Figure 1. Matrix suitability in context of an educational content

EVALUATION AND DISCUSSION OF RESULTS

A) Validation of educational content quality metrics

We have performed this by questionnaire with eleven questions. Respondents were students, teachers and the practitioners. 70 respondents took part in the questionnaire. As we can see from the Figure 1 there are seven selected metrics: testability, efficiency, maintainability, integrity, interoperability, reliability and correctness. Figure XX shows the adequacy of our proposed quality metrics. This evaluation shows five kinds of responses. These are numbers from one to five. Number one means that the metric is suitable for determining the quality of the educational content and number five means that the metric is not satisfactory. As we see most satisfactory metric for educational content evaluation is the metric testability. Then there are maintainability, integrity, correctness and reliability. Below results achieved interoperability and efficiency metrics.

B) The use of conceptual modeling for educational content representation suitability validation

We have evaluated this using the use case represented by simple recipe of traditional Slovak dumplings topped with soft sheep cheese poured by roasted bacon. We can consider this functionality as a certain obligatory ability of a Cook according to international ISCO1, ESCO2, DISCO3 etc. or Slovak national NSP4 and NSK5. To formalize this we used simple Use Case UML diagram. But this served just to show an overview of the interaction of the user with the system expressed in the language of software engineering as is shown in Figure 2.

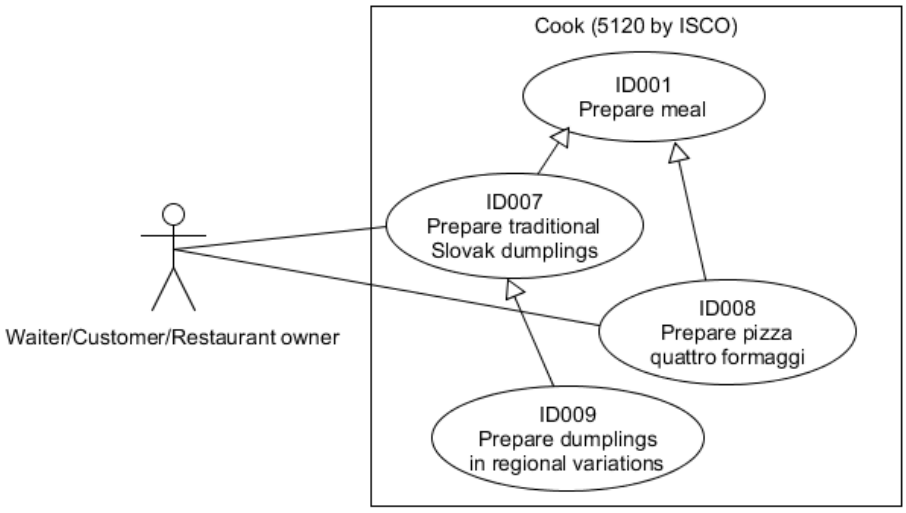

Figure 2. UML Use Case diagram - view of the model of an occupation Cook[6]

Use Case UML diagram is not the most important. The most essential is its written form. For this purpose, we offer a detailed description of the use case in Coburn's notation in its fully dressed use case template.

Use Case: ID007 Prepare traditional Slovak dumplings.
Goal in Context: Waiter used to order the meal in the kitchen of the restaurant based on the request of a customer.

[1] International Standard Clasification of Occupations http://www.ilo.org/public/english/bureau/stat/isco/isco08/
[2] European skils, Competences, Qualifications and Ossupations https://ec.europa.eu/esco/portal/home
[3] European Dictionary of Skills and Competences http://disco-tools.eu/disco2_portal/index.php
[4] The National System of Occupations http://www.sustavapovolani.sk/vz_domov
[5] National system of qualifications http://www.kvalifikacie.sk/
[6] European skils, Competences, Qualifications and Ossupations: http://data.europa.eu/esco/isco2008/Concept/C5120,

The preparation of this dish is one of the mandatory skills of a cook in Slovak restaurants. Employer or owner of a restaurant requires this skill from an employee (cook). This is because customers in such a restaurant may order this meal.
Scope: Restaurants.
Level: Primary task.
Preconditions: We can identify the waiter, the customer and the table in our restaurant where the customer seats.
Success End Condition: Waiter can serve the meal and we can have the money for the meal, customer can enjoy the meal and can be satisfied.
Failed End Condition: Waiter cannot serve the meal and we cannot have the money for the meal, customer cannot enjoy the meal and cannot be satisfied.
Primary Actor: Waiter, any agent (or computer if online booking) acting for the customer
Trigger: An order request comes in.

MAIN SUCCESS SCENARIO

1. *Waiter makes the meal order (n = number of servings)*
2. *Cook calculates the quantity of potatoes, sheep cheese and other ingredients. He asks for their supply.*
3. *Warehouseman gives the cook required the foodstuff.*
4. *Cook asks for inventory to prepare the meal.*
5. *Warehouseman gives the cook required inventory.*
6. *Cook grates potatoes, adds flavor and makes dough. He poaches the dough into the boiled water. He decants the dumplings and spills them on n plates (according to number of servings). Finally he pours them by roasted bacon.*
7. *Cook gives the servings to the waiter.*
8. *Waiter is ready to serve the servings (customer can enjoy the meal and can be satisfied also can pay for it).*

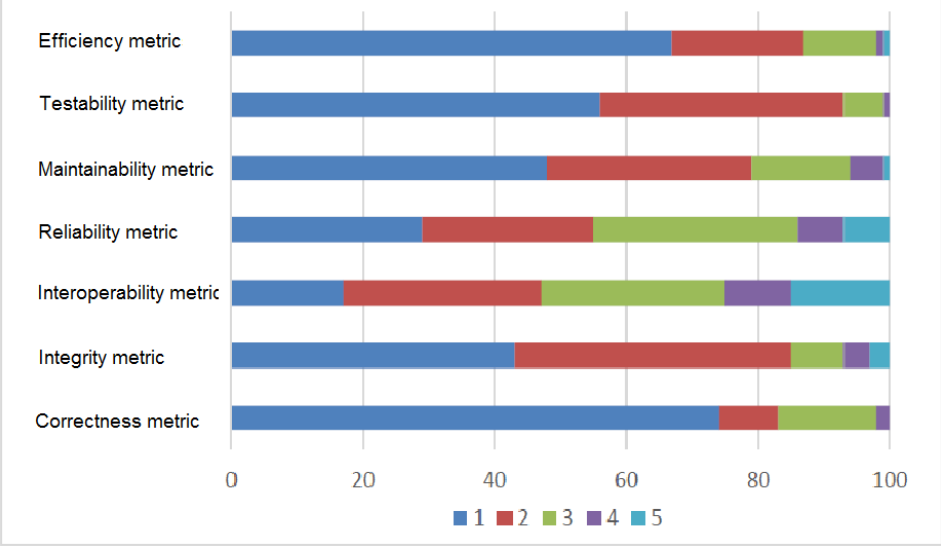

Figure 3. Fragment of the educational content from the domain of gastronomy represented in vocabulary descriptive way and assessed by proposed quality metrics

EXTENSIONS

3a. Restaurant (his food storeroom) is out of one of the foodstuff.
3a1. Renegotiate order.

SUB-VARIATIONS

1. *Waiter may use web order form*

RELATED INFORMATION (optional)

Priority: always top (hungry customer = bad customer)
Performance Target: 1 minute for order, 10 for preparation
Frequency: 200 per working day
Superordinate Use Case: Prepare meal
Subordinate Use Cases: Prepare dumplings in regional variations
Channel to primary actor: may be phone, web application or interactive
Secondary Actors: Warehouseman
Channel to Secondary Actors: may be phone, web application or interactive

We have performed this evaluation by two other questionnaires with just eight questions. The aim was to use quality metrics designed to evaluate the real content of education. Respondents were students and the UML practitioners. We had quite a large number of respondents from the domain of catering so we decided to check the quality of the educational content in the form of a recipe of a traditional food. 87 respondents took part in the questionnaire. The recipe was written in two ways without using elements of conceptual modeling and by using them - namely in the form of a use case.

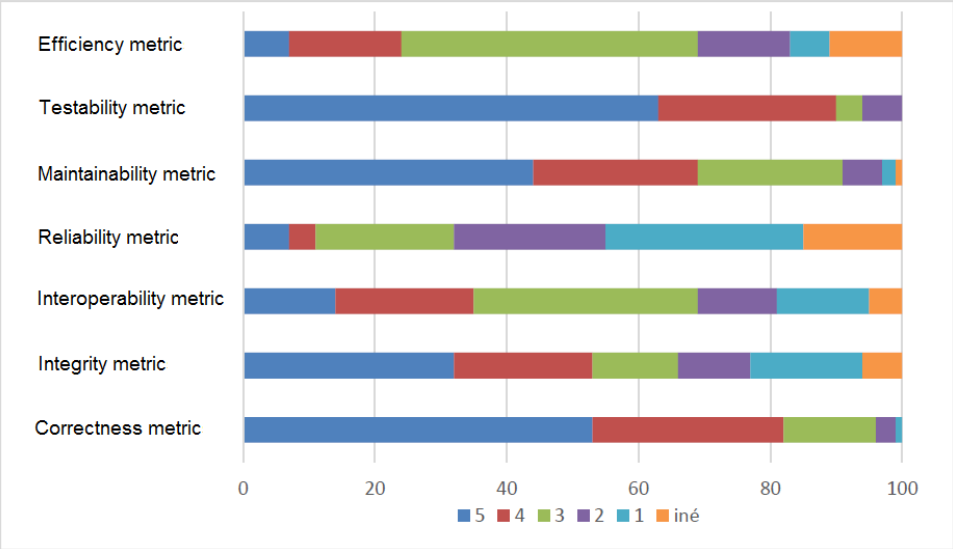

Figure 4. Fragment of the educational content from the domain of gastronomy represented by a detailed description of the use case and assessed by proposed quality metrics.

The outcome of the evaluation process of representation without using elements of conceptual modeling is shown in Figure 3. The outcome of the evaluation process formalization representation in UML - expressed by use cases is shown in Figure 4. As shown in Figure 3 most of the respondents were able to use metrics to evaluate the quality of the recipe. For example, in metric correctness respondents who scored less said that they lack the bacon in recipe. In case of testability they asked reduce the granularity and specify inventory more detailed. By this feedback from our respondents we have realized that proposed metrics are not only valid but also directly usable in real conditions. As we can see from the Figure 4 metrics correctness, maintainability and testability were evaluated without further comments. In case of interoperability respondents complained on the lack of possibility to cooperation between people during creating the recipe. The same problem they reflected also in case of reliability. They complained of the lack of alternative flows (lack of certain inventory or foodstuff etc.) Effectiveness was probably the biggest problem as we can see. Many respondents said that option 3 is a sort of neutral option. The reactions we have learned could not determine whether the procedure is effective or not.

CONCLUSIONS

In our research we have dealt with using the elements of conceptual modeling in e-learning to study the impact of their use on the quality of the educational content. We have compared the determinants of the educational content quality in the context of the software systems quality attributes. We have analyzed the quality according to the standards ISO, IEEE. We have investigated the role of conceptual modeling in relation to quality metrics. By the method of analogy to attributes defining software quality we have proposed selected attributes of educational content quality and opportunities to evaluate the quality of educational content. We have checked selected quality metrics as well as the possibility to write educational content as a detailed description of the use case. The use of conceptual modeling in e-learning we are confronted by use case diagrams. Finally, we evaluate our proposed solution by two questionnaires. The first was devoted to the adequacy of the proposed metrics including examples of their application. The second example was aimed at using conceptual modeling for writing educational content. He was subsequently evaluated by the proposed metrics. In general we can only advice this approach in designing of the educational content for existing and arising content management systems CMS.

ACKNOWLEDGMENT

This work was supported by 539461-LLP-1-2013-1-BG-ERASMUS-ENW ERASMUS - Contract between Slovak University of Technology and Angel Kanchev University of Rousse, Future Education and Training in Computing: How to support learning at anytime anywhere, 01/2013 - 09/2016.

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The paper has been reviewed.