Lukman, R. & Krajnc, M. (2012). Exploring non-traditional learning methods in virtual and real-world environments. *Educ. Technology & Society*, *15*, 237 – 247.

Mandler, D., Mamlok-Naaman, R., Blonder, R., Yayon, M. & Hofstein, A. (2012). High-school chemistry teaching through environmentally oriented curricula. *Chem. Educ. Res. Pract., 13*, 80 – 92.

Mc Goldrick, N.B., Marzec, B., Scully, P.N. & Draper, S.M. (2013). Implementing a multidisciplinary program for developing learning, communication, and team-working skills in second-year undergraduate chemistry students. *J. Chem. Educ., 90,* 338 – 344.

Pant, L.P. (2014). Critical systems of learning and innovation competence for addressing complexity in transformations to agricultural sustainability. *Agroecology & Sustainable Food Systems, 38*, 336 – 365.

Parchmann, I., Gräsel, C., Baer, A., Nentwig, P., Demuth, R. & Ralle, B. (2006). "Chemie im Kontext": a symbiotic implementation of a context-based teaching and learning approach. *Intern. J. Sci. Educ.*, *28*, 1041 – 1062.

Peterman, K.E. (2008). Field trips put chemistry in context for non-science majors. *J. Chem. Educ.*, *85*, 645 – 649.

Peteva, Z., Makedonski, L. & Stancheva, M. (2014). Increasing students' interest in chemistry with context-based approaches for control and assessment in the English language program at Medical University in Varna. C*hemistry, 23*, 73 – 87.

Piunno, P.A.E., Boyd, C., Barzda, V., Gradinaru, C.C., Krull, U.J., Stefanovic, S. & Stewart, B. (2014). The advanced interdisciplinary research laboratory: a student team approach to the fourth-year research thesis project experience. *J. Chem. Educ.*, *91*, 655 – 661.

Stozhko, N. Y., Tchernysheva, A. V. & Mironova, L.I. (2014). Computer assisted learning system for studying analytical chemistry. *Chemistry, 23*, 607 – 613.

Toshev, B.V. (2012). Science education in the science of education. *Chemistry*, *21*, 7 – 18 [In Bulgarian].

Toshev, B.V. (2014). Science illiteracy-constructivism-misconceptions-historical sensitivity. *Chemistry*, *23*, 9 – 17 [In Bulgarian].

Yngve, A., Tseng, M., Haapala, I. & Hodge, A. (2012). A robust and knowledgeable workforce is essential for public health nutrition policy implementation. *Public Health Nutrition*, *15*, 1979 – 1980.

✉ **Prof. Dr. Natalia Stozhko (corresponding author)**
Department of Physics and Chemistry
Ural State University of Economics
Yekaterinburg, Russia
E-mail: sny@usue.ru

Chemistry: Bulgarian Journal of Science Education | Volume 25 Number 2, 2016 | Природните науки в образованието

VARIATION DEGREE IN E-LEARNING COURSES: ASSESSMENT THROUGH FEATURE MODELS

Ivo Damyanov, Nikolay Tsankov
South-West University, Blagoevgrad

Abstract. The current paper presents a model for assessing e-learning courses through the application of quantitative methods based on feature oriented domain analysis. The approach gives an opportunity to assess: 1) the variation degree of electronic courses specified in university standards through invariant feature diagrams which can be modified for the specific purpose; 2) the quality and design of e-learning platforms. The assessment can be conducted at two levels: in relation to the structure and organization of the platform and as regards the relations among the courses it offers. This in turn can be used as a technique for comparing distance learning standards of different universities and for improving courses. The paper presents a sample feature model of the elements of an electronic course with a calculated variation degree.

Keywords: e-learning courses, variation degree, functional models

Introduction

Contemporary requirements to educational environment guarantee a high level of individualization in education based on the construction of pedagogical situations. In the context of e-learning platforms, these requirements are closely connected to the learner-centered approach in education. Despite the diversity of contexts in the construction of *learning objects* (Wiley, 2000), it is of utmost importance to establish a procedure for the design of Learning Context Models (hereafter LCM) (Tankeleviciene & Damasevicius, 2009) of electronic courses with different degrees of variation.

The design of such models facilitates the achievement of the immediate necessity of variation and diversity of the electronic educational content and meets the long-term demand of flexibility, adaptability, personalization and reiteration of that content.

Electronic platforms employing the embedded features of Learning Content Management Systems (hereafter LCMS), which additionally make use of learning objects and LCM as a basic criterion of quality assessment, have two major advantages in terms of their degree of variation: (1) it can be explicated within a specific university standard for electronic courses (i.e., as regards its components); (2) it can be specified within the whole platform (i.e., among the separate electronic courses).

The functional features of BlackboardLearn™ as an e-learning system have been presented in earlier studies (Plachkov et al., 2014; Tsankov & Damyanov, 2014).

The concept *learning object* occupies an important place in contemporary electronic education research. So far however, its meaning has been an issue of controversy (Damaševičius & Štuikys, 2008). In its most general, the concept *learning object* is defined as a relatively self-sustained unit of the educational content or as a feature which can be employed in a specific module, lecture, and seminar with a certain degree of adaptability depending on its capacity for structural and functional re-modeling.

The analysis, design and goal orientation of the learning objects within an electronic educational platform are part and parcel of the whole process of the conceptual modeling of both the educational content and its functional interpretations. As such, they serve as a solid foundation for the construction of feature diagrams resulting from this process.

Feature models and feature diagrams

In essence, a feature model is a hierarchical arrangement of a set of features. Table 1 presents the relations between the parent feature and its child features within a feature model, as well as the dependencies among features regardless of their direct subordination.

Any standard for electronic educational courses can be modeled and described in the language of functional diagrams. Fig. 1 offers a general illustration of the learning objects and their relations in electronic courses.

Table 1. The language of functional diagrams

Symbol	Type of relationship	Description
∧	And-relation	All child-features must be included
	Alternative	Only one child-feature can be included
	Or-relation	One or more than one child-features can be included
	Mandatory	Mandatory functionality
	Optional	Optional functionality
←---→	Mutual exclusion	Mutually exclusive functionalities
----→	Inclusion	The selection of one functionality implies the selection of another

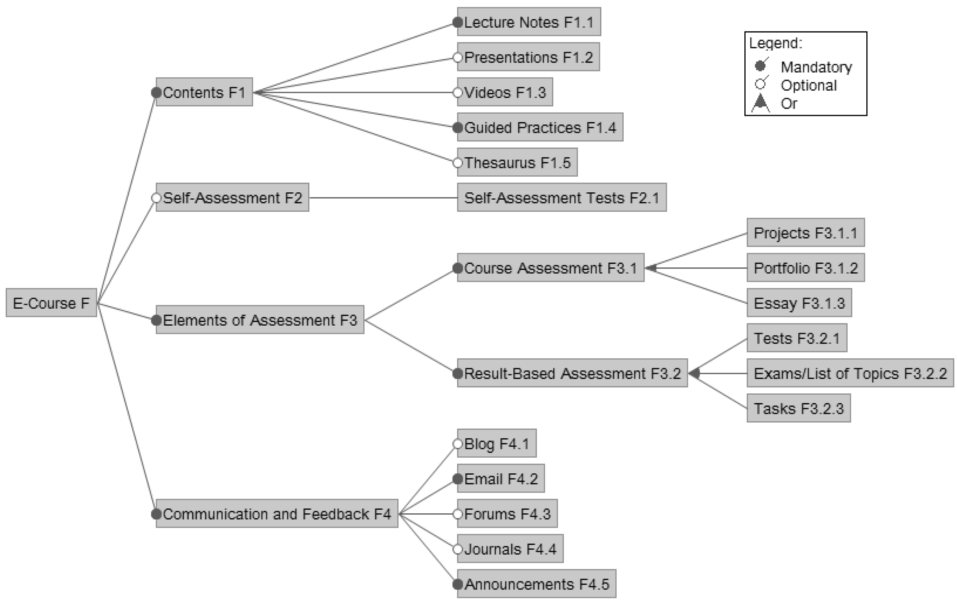

Fig. 1. Feature model of a standard for electronic course: illustration

Degree of variation and opportunities for its assessment through feature models

Feature based domain modeling is a well-known technique in the engineering of product lines. Von der Maßen & Lichter (2005) analyze the variation degree with respect to different domain relationship types based on Feature Oriented Domain Analysis (FODA) (Kang et al., 1990). Variation degree reveals the scope of the opportunities presented within a feature model and provides information in terms of flexibility, complexity and adaptability.

Two options for calculating variation degree in the context of product lines are proposed by Von der Maßen & Lichter (2005).

The first (basic) option considers the functional model as pure hierarchical dependencies and takes into account the level of variation in terms of subordination only – mandatory and optional elements, as well as alternative items.

The second option proposed examines the feature model as a network, including the dependencies of components that are not directly or indirectly subordinate. This includes both single and multiple dependencies between elements.

We suggest that these methods can successfully be transferred and applied to assess the variability of e-learning courses. We will limit our study to the first (basic) option in the consideration of the feature model of e-learning courses.

To calculate the variation degree of e-learning courses we first construct a diagram of the course features. The variation degree of the parent feature *F* (hereafter *var (F)*) depends on the variation degree of its child features (namely F_1, F_2, ...F_n), as well as on the parent-child dependency types.

Mandatory relationship

In this relationship, the selection of a parent feature requires a selection of a child feature as well. The variation degree of feature *F* ith *n* mandatory child features F_1, F_2, ...F_n is the product of the variation degrees of all mandatory child features, i.e.

$$var(F) = \prod_{i=1}^{n} var(F_i).$$

Optional relationship

In this relationship, if parent feature *F* is selected, the child feature F_i can but needs not be selected.The variation degree of feature *F* with *n*optionalchild features F_1, F_2,...F_n is the product of thevariation degrees of all optional child features, i.e.

$$var(F) = \prod_{i=1}^{n} (var(F_i) + 1).$$

Since the optional child feature can be either selected or not, we increase its variation degree by 1.

Alternative relationship

Alternative-relationship selection of parent feature *F* forces the selection of exactly one feature of the alternative child features. The variation degree of feature *F* with *n*alternativechild features F_1, F_2,...F_n is the sum of the variation degrees of all alternative child features, i.e.

$$var(F) = \sum_{i=1}^{n} var(F_i).$$

Or-relationship

An or-relationship between parent *F* feature and child feature F_i means that if the parent feature is selected, at least one of the or-child features must be selected. The variation degree of feature *F* with *n*or-child features F_1, F_2,...F_n is equal to the variation degree of a feature FF with optional child features decreased by 1 because at least one or-child feature has to be selected. The case when no child feature is selected must be subtracted, i.e.

$$var(F) = \left(\prod_{i=1}^{n}(var(F_i) + 1)\right) - 1.$$

Variation degree – case studies

Each functional model based on specific requirements and standards concerning the design of curricula, the organization of education, the interaction and communication between subjects and the various functionalities of LCMS, enable a comprehensive quantitative and qualitative evaluation of variations with respect to the established standards in the university.

The degree of variation makes it possible to compare the standards for the electronic courses between universities by transforming them into functional diagrams and using the method described above.

The calculation below gives the variation degree of the illustrative feature model in it completeness (Fig. 1).

var (*F*) = *var* (*F*1).(*var(F*2) +1).*var* (*F*3).*var*(*F*4);

var (*F*1) = *var* (*F*1.1).(*var* (*F*1.2) + 1).(*var* (*F*1.3) +1).*var* (*F*1.4).(*var (F*1.5) + 1) = 2^3 = 8;

var (*F*2) = *var* (*F*2.1) = 1;

var (*F*3) = *var* (*F*3.1). *var* (*F*3.2);

var (*F*3.1) = (*var* (*F*3.1.1) + 1) (*var*(*F*3.1.2) + 1) (*var*(*F*3.1.3) + 1) – 1 = 2^3 – 1 = 7;

var (*F*3.2) = (*var* (*F*3.2.1) + 1) (*var*(*F*3.2.2) + 1) (*var*(*F*3.2.3) + 1) – 1 = 2^3 – 1 = 7;

var (*F*3) = 49;

var(*F*4) = (*var* (*F*4.1) + 1).*var*(*F*4.2).(*var* (*F*4.3) + 1)(*var*(*F*4.4) + 1). *var* (*F*4.5) = 2^3 = 8;

Thus the intrinsic variation degree of the illustrated model amounts to: *var*(*F*) = 8.(1 + 1).49.8 = 6272.

Once articulated as educational content meeting a certain standard, an electronic course can be assessed regarding the degree to which it complies with that standard. Naturally, the mandatory elements (Learning Objects) will be part of it. The realization of each mandatory element, as well as the realization of the actual part of the variations can be subject to quantitative assessment showing the number of specific elements in the course that belong to one and the same Learning Object type. In this manner, any electronic course can be assessed against the variation degree of the model giving grounds for its comparison with other courses established on the basis of the same functional model. In order to account for the mandatory character of certain elements that have been articulated, it is possible that their quotient be doubled.

Table 2. Course assessment

Course	Students	Variation degree
Education science (Theory of education and didactics)	Students majoring in Education science	The e-course includes: **Content:** Lecture Notes (15), Guided Practices (8) **Element of Assessment:** Tasks (40) **Feedback:** E-mail, Journals, Announcements **Evaluation:** (15*2+8*2)+(40)+(1+1+1)= 89
Object-oriented programming	Students majoring in Computer science, Mathematics and Computer science, Information technology in environmental science	The e-course includes: **Content:** Lecture Notes (12), Presentations (13), Guided Practices (13) **Self-Assessment:** Tests (13) **Element of Assessment:** Essay (3), Tests (3), Exam (3), Tasks (3) **Feedback:** Email and Announcements **Evaluation:** (12*2+13+13*2)+(13)+[(3)+(3+3+3)]+(1+1) = 90

Table 2 presents the results of the assessment of the variation degree of two actual courses designed in the Blackboard platform after they have been conducted.

Conclusion

The application of conceptual modeling based on feature diagrams in the design of e-learning courses facilitates the quantitative assessment of the variation degree of course standards in different universities as well as its intra-systemic variability. These quantitative indicators enable a comparisons of the standards adopted by different universities in order to guarantee the quality of the e-learning content. The quantitative assessment of the variation degree presented in the present paper can be employed both in the accreditation of DL and in the comparative analysis preceding the choice of different platforms managing the educational process.