Decision Making Support System for Individual Educational Trajectory Choice in LMS

Yuriy Skorenkyy[a,b] , Nataliya Zagorodna[a] , Nataliia Kunanets[b] and Ihor Baran[a]

[a] *Ternopil Ivan Puluj National Technical University, 56 Ruska St, Ternopil, UA46001, Ukraine*
[b] *Lviv Polytechnic National University, 12 Bandery St, Lviv, UA79001, Ukraine*

Abstract
Models of individual educational trajectory selection by a student, assisted by the specialized module within a university learning management system, is designed in IDEF0 notation. A2 diagram of the elective components choice block is constructed. A methodological basis for the module of decision making is suggested. Structural and functional models of the subsystem of individual curriculum are developed in the paper.

Keywords 1
Decision making support, learning management system, individual educational trajectory

1 Introduction

The rapid social and economic changes make strategic planning an urgent need not only for large companies, but also for a university and even for an individual who seeks to leverage the opportunities offered by education to acquire new and much needed skills. Coherence of the strategic plans of various related institutions and individuals can ensure the synergy of their activities and become a factor of success for breakthrough industries and society as a whole. A university student has the legal right not only to choose the educational program, specialty and form of education, but also to design an individual educational trajectory by choosing disciplines within the relevant educational program. As this choice is the right of every student, a specific active environment emerges in which actions of each of the agents affect the long-term prospects of the university and the students. Learning Management System (LMS) is a mean of implementation of the educational program so far [1-3]. But LMS can also become the tool which facilitates a choice of an educational trajectory and ensure coherence of various trajectories based on personal preferences and external requirements. Legal background and regulations currently facilitate the implementation of an automated tool that able to support not only students' independent activities, but the educational trajectory tuning as well. The purpose of this study is to model a decision making support system for the educational process in a virtual learning environment. The components of the system, its inputs and outputs, relations between components should be defined. The models developed in this paper are to facilitate the development of appropriate subsystems and their integration into LMS and resource planning systems of universities.

2 Educational institution as an active environment

By choosing elective courses (at the micro-level) a student seeks to maximize his future benefits. However, given the limitations imposed by the collective nature of the educational program implementation (at the meso-level), it is practically complicated to achieve a satisfactory result. In classical theory a manager finds a satisfactory solution to the problem, based on the collected

ITTAP'2021: 1nd International Workshop on Information Technologies: Theoretical and Applied Problems, November 16–18, 2021, Ternopil, Ukraine
EMAIL: skorenkyy@tntu.edu.ua (A.1); zagorodna.n@gmail.com (A.2); nek.lviv@gmail.com (A.3); ihor.remm@gmail.com (A.4)
ORCID: 0000-0002-4809-9025 (A. 1); 0000-0002-1808-835X (A. 2); 0000-0003-3007-2462 (A. 3) 0000-0002-8153-2476 (A. 4)

information and his own experience. This approach is more realistic than a strictly rational one, because the decision-maker is forced to take into account random events and unpredictable circumstances that do not allow him to make the optimal decision [4, 5]. In this situation, the decision-maker seeks to identify only the most significant features of the situation and therefore he is forced to restrict rationality.

2.1 The structure of the system: the constituent subsystems

To supply all components of the distance learning process [6, 7], the information system of the educational institution should support not only the educational process itself, but also the formation of the student's curriculum (educational trajectory), acquisition of practical skills (during internships at enterprises) and various forms of assessment, preparation and defense of the final thesis. The components of the system are the following: the subsystem for acquiring general competencies, the subsystem of developing an individual curriculum (elective disciplines), the subsystem of acquiring professional knowledge (disciplines of the cycle of professional training), the subsystem of acquiring professional skills (training), subsystem for the final thesis preparation.

The subsystem of individual curriculum design is responsible for the selection of narrow specialization and special training courses based on market analysis and the results of assessment and testing on previous stages. At the output, the individual educational trajectory of the student must be formed, the topic of qualification final thesis is to be formulated and appropriately formalized.

The subsystem provides

- processing and storage of the information about students and their performance data;
- accumulation, updating and display of the market analysis results and employers' requirements;
- recommender system for choosing specialization and professional courses;
- information about elective disciplines, their content and role in the structure and logical scheme of training;
- selection, coordination and formal approval of the topics of qualification final thesis.

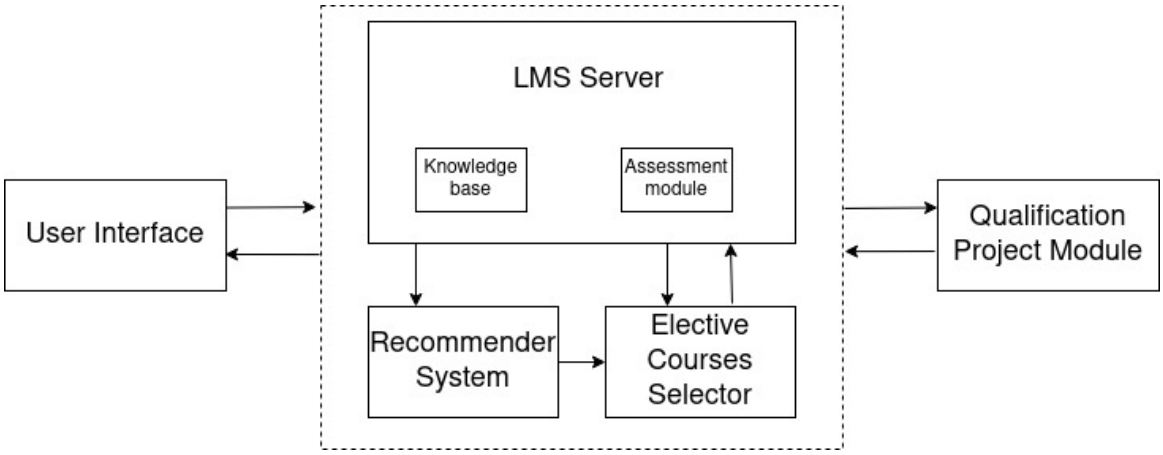

Figure 1: Modular structure of the subsystem for the development of an individual curriculum

The "User Interface" module provides authentication of system users according to their roles (student, instructor) and remote access to the services. The LMS Server module is the main one for communication between components, actors and processes, provides request processing and execution of basic functions, forms requests to the recommender system, keeps statistics and logs. The Recommender System module, based on evaluation data obtained through the LMS and market analysis data, provides individualized recommendations on the choice of specialization, special disciplines and the topic of the thesis. The qualification project module supports students' work on the final thesis and is to be coordinated with external modules of the third parties, such as CRM's, EPR's or software development platforms of the practical training bases.

2.2 Functional model of the system

For the system under consideration, the environment is the education system, including participants and stakeholders of the educational process [8]. The process has inputs and outputs, as well as activates mechanisms, is controlled from the outside and can initiate calls.

The functional model encompasses:

• processes, functions or tasks to be performed within the system;

• interactions of these processes, functions and tasks with the environment and with each other.

The inputs for the learning process are the knowledge acquired by students at previous educational levels and the results of external independent assessment. The output is an entity into which inputs are converted. In our case, the outputs are general and professional competencies. The guiding information for the educational process is the sectoral educational standards and educational programs, documented requirements of employers, as well as methodological support. In the proposed implementation, the controls are formalized in the framework of the educational scenarios. The learning management system, teaching staff and faculty as well as the professional training (internship) bases are the principal mechanisms in the proposed model.

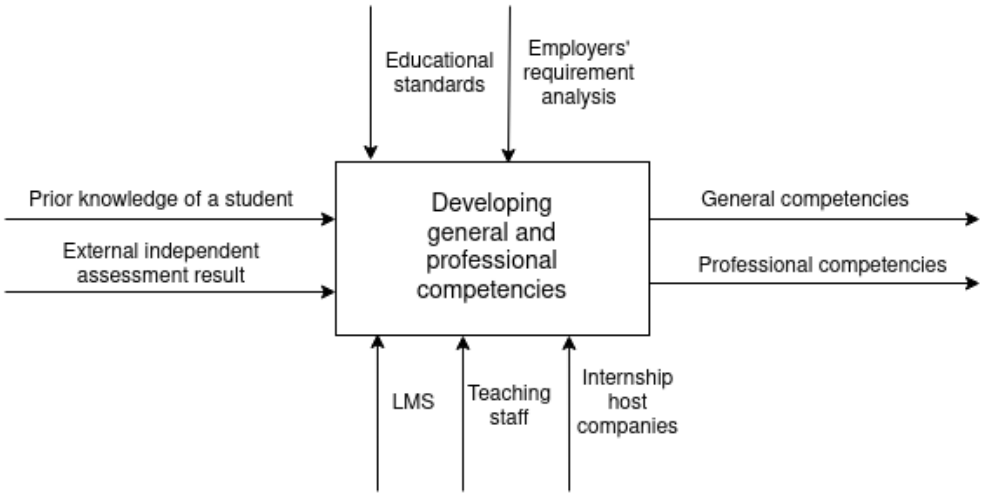

Figure 2: IDEF0 context diagram of the electronic educational system

In this model, the learning process is divided into five sub-processes:

• acquisition of general competencies (disciplines of the general training cycle),

• development of an individual curriculum (elective courses),

• acquisition of professional knowledge (disciplines of the professional training cycle),

• acquisition of professional skills (types of internships),

• qualification project.

In its turn, the development of an individual curriculum is divided into:

• choice of a narrow specialization,

• choice of special courses,

• choice of the qualification project subject and topic.

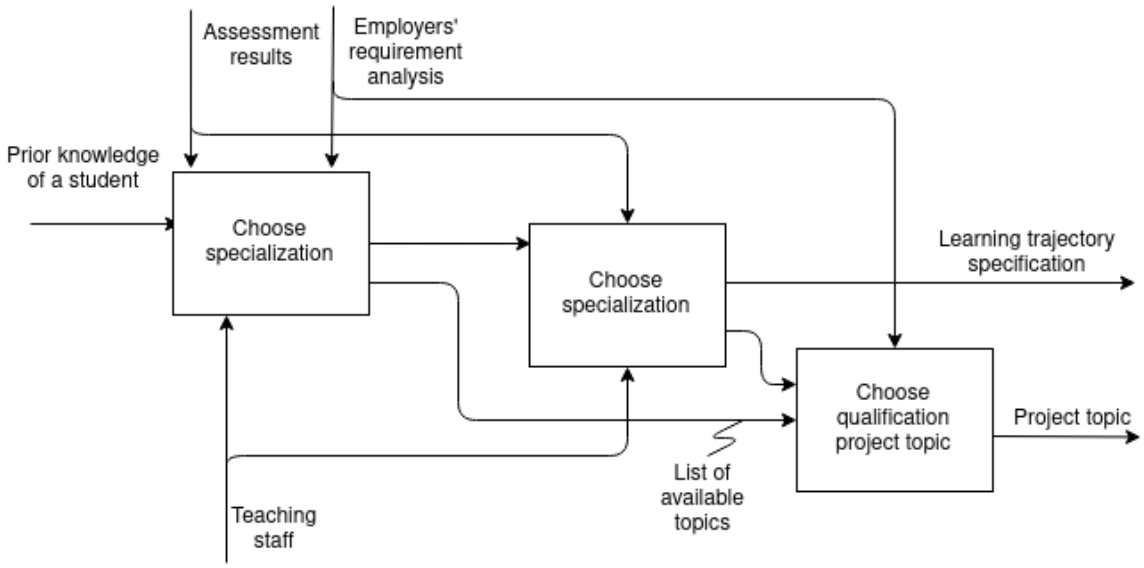

Figure 3: A2 diagram of the elective components choice block

Assessments may be carried out in various forms [9] and combinations, so the following structure is proposed for this unit:

- adaptive testing,
- problem-oriented assessment,
- professional certification.

The system is to support decision-making by students, teachers, administrators, and LMS server. The information on which the decisions are based is obtained both from the environment and the knowledge base of the system. Decisions are recorded in the database and determine the further behavior of the system.

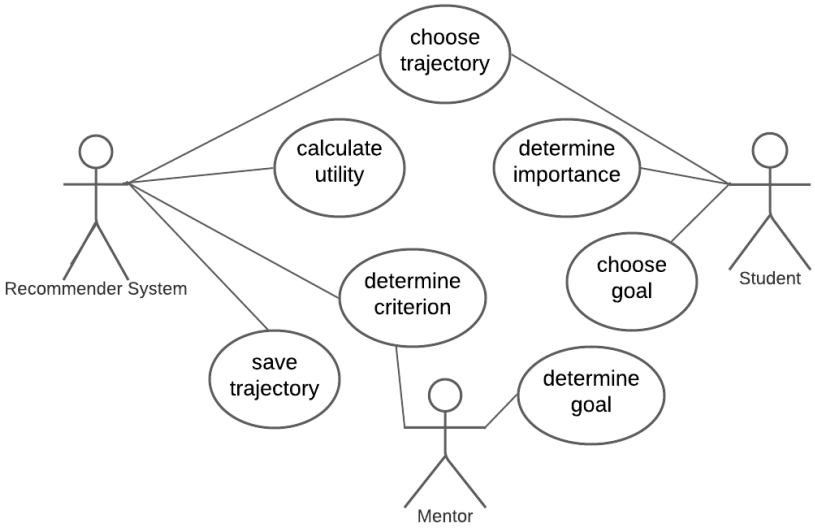

Figure 4: Use case diagram for the course selection module.

The actors in this model are the LMS, student and instructor. The system being designed integrates CRM functions (including database), IDE courses and tests, knowledge base and decision support systems.

3 Decision making processes in the system

Heuristic educational activity and, as a consequence, the individual educational trajectory, is characterized by such concepts as the learning pace and the educational output of the learner. The pace of learning determines one of the main parameters of education, namely educational output. Thus, within the same time slot set by the teacher to fulfill the learning task on some object, the amount of educational output may be greater for the student who studies at a higher pace. The teacher can and should urge the student to acquire different skills, both emotional and logical. This will allow following more than one general educational trajectory for all students, with some variability acceptible withregard to educational standard. Simultaneously, this will also produce individual trajectories that allow students to create personal educational outputs that differ in both size and content.

Let us illustrate the use of the modelled system for the case when optional levels (forces and policies) are not included. In our opinion, to support the decision-making regarding the variable components, the Analytic Hierarchy Process is the method of choice [5]. In the direct process, the criteria are determined by the mentor (teaching staff) and the weight of the criteria are set by the student. Generalized weights are calculated by the LMS. In the reverse process, the student identifies the desired scenarios and the teacher identifies problems and situations that may interfere, as well as the goals of other students that may affect the process.

The planning process in the forward direction begins with defining the planning purpose and building a hierarchy of the direct process, as shown in Figure 5.

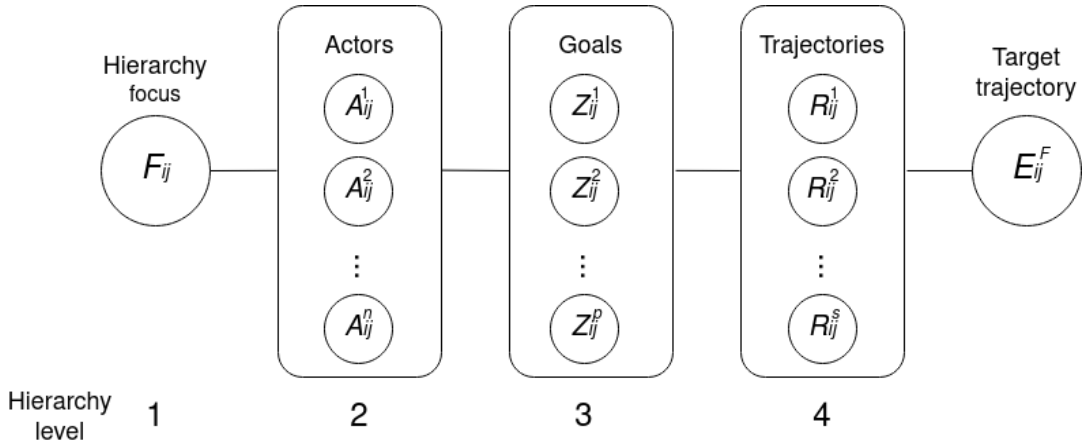

Figure 5: Scheme of the direct planning process

At the top of the hierarchy (level 1) there is the focus of the hierarchy, which determines the logical future. Level 2 of the hierarchy consists of actors. Level 3 is formed by the goals of each actor. At the fourth level there are possible trajectories, pursued by each actor. The last level of the hierarchy is defined as a generalized educational trajectory, which is the result of the implementation of all logical scenarios (the projected future). In the process of evaluating hierarchies in LMS, the vectors of goals priorities in the direct process and those for the reverse process relative to the elements of the hierarchy are calculated. Every single trajectory and the generalized educational trajectory can be quantitatively characterized by a set of criteria defined by the mentor. To determine the integral estimates of the generalized trajectory relative to the focus of the hierarchy and relative to the specific actor, a matrix for estimating scenarios is to be built.

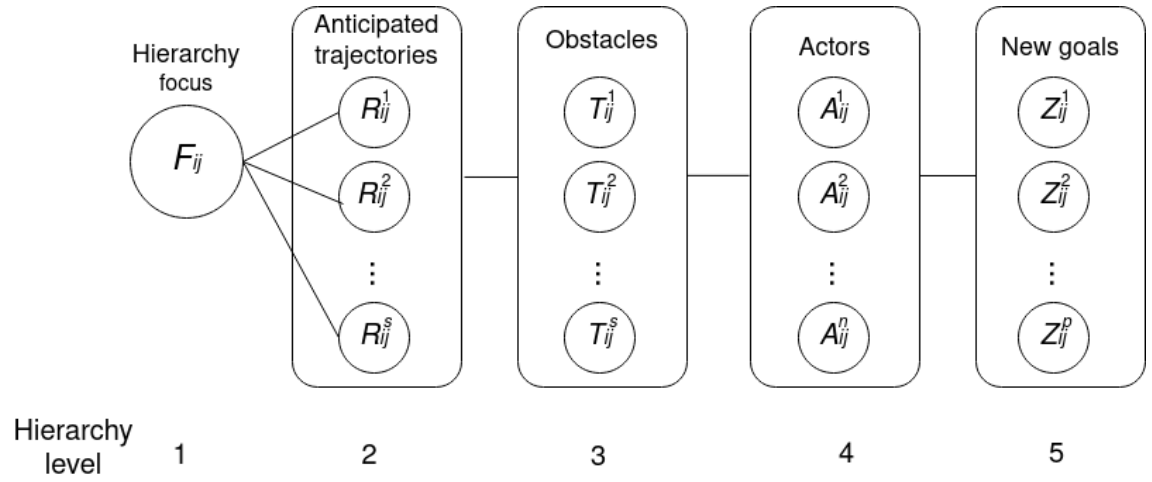

Figure 6: Scheme of the inverse planning process

In the reverse process, every student identifies one or more of the anticipated trajectories that he or she wishes to implement and prioritizes those trajectories in terms of their impact on the generalized version of the desired future. The mentor, using the knowledge base, identifies a list of problems and situations that may hinder the implementation of those trajectories. At the fourth level there are students who can influence the solution of problems, their new goals are described at the fifth level. After defining the goals in the reverse process, the direct process is repeated with use of the most important of the goals only. Priorities in the next direct process are corrected only at the goals level. The priorities of the generalized result of the repeated direct process are then compared with the priorities of the desired future states of the first inverse process to determine whether the logical future is approaching the desired one. If this is not the case, a second iteration of the reverse process is implemented, in which the priorities of the desired future states are changed and/or new goals are chosen. Those elements that are given higher priorities are used in the third iteration of the direct process. Trajectory priorities are calculated and compared with the priorities obtained in the second iteration of the inverse process. The procedure is repeated until the possibilities of finding ways to increase the probability of a logical planning result are completely exhausted.

Conclusions

Nowadays, the academic autonomy of universities, the legal background and both national regulations and international agreements, as those of the European Higher Education Area, all facilitate the implementation of the educational trajectory design by every student in correspondence with the market requirements. State-of-the-art learning management systems are like constructors which allow implementation of highly customizable specifically tuned modules into digital campuses platforms [10-12]. But most of known LMS are considered only as means of educational program implementation. We suggest a methodological basis as well as structural and functional models for the module of decision making support system within a digital learning platform of a university. Such module would enable a student to design an individual educational trajectory. The initial step of model design is done in terms of constructed IDEF0 context, A2 and User Case diagrams. Schemes of direct and inverse planning process are analyzed. For an implementation in a given LMS, the peculiarities of educational activities and profile of a particular university is to be taken into account. Implementation of such subsystems is the field of future research

References

[1] J. Underwood, S. Cavendish, S. Dowling, K. Fogelman, T. Lawson, Are integrated learning systems effective learning support tools?, in: Computers & Education, Volume 26, Issues 1–3, 1996, pp. 33-40, ISSN 0360-1315.

[2] H. F. Aldheleai, M. U. Bokhari, A. Alammari Overview of Cloud-based Learning Management System, International Journal of Computer Applications 162 (2017) 41-46.

[3] Yu. Skorenkyy, R. Kozak, N. Zagorodna, O. Kramar, I. Baran, Use of augmented reality-enabled prototyping of cyber-physical systems for improving cyber-security education, J. Phys.: Conf. Ser. 1840 (2021) 012026.

[4] A. C. B. Garcia, P. M. Maciel, M. A.C. Martins, An Active Environment to Assist Individual and Group Decision MakingProcess, ECIS 2000 Proceedings (2000), 70.

[5] J. Figueira, S. Greco, M. Ehrgott "Multiple Criteria Decision Analysis: State of the Art Surveys", International Series in Operations Research & Management Science, vol 78. Springer, New York, NY, 2005.

[6] D. Alpert, D.L. Bitzer. Advances in Computer-based Education. Science. 167(3925), (1970) 1582-90.

[7] N. Mlitwa J-P. Van Belle A proposed interpretivist framework to research the adoption of learning management systems in universities. Communications of the IBIMA, 2010.

[8] N. Mlitwa Technology for teaching and learning in higher education contexts: activity theory and actor network theory analytical perspectives, in: International Journal of Education and Development using ICT, 3(4), Open Campus, The University of the West Indies, West Indies. Retrieved June 6, 2021, 54-70.

[9] Yeonjeong Park & Il-Hyun Jo Using log variables in a learning management system to evaluate learning activity using the lens of activity theory, Assessment & Evaluation in Higher Education, 42:4, (2017) 531-547. doi: 10.1080/02602938.2016.1158236

[10] G. Gutiérrez-Carreón, T. Daradoumis, J. Jorba (2015). Integrating Learning Services in the Cloud. Journal of Educational Technology & Society 18 (1, 2015), pp. 145-157.

[11] C. K. Chen, M. N. Almunawar Cloud Learning Management System in Higher Education, in: P. Ordóñez de Pablos, M. Lytras, X. Zhang, & K. Chui (Ed.), Opening Up Education for Inclusivity Across Digital Economies and Societies, 2019, pp. 29-51.

[12] O. Kramar, Y. Drohobytskiy, Y. Skorenkyy, O. Rokitskyi, N. Kunanets, V. Pasichnyk, O. Matsiuk, Augmented Reality-assisted Cyber-Physical Systems of Smart University Campus , IEEE 15th International Conference on Computer Sciences and Information Technologies (CSIT) 2, 2020, 309-313.