The Model of Curriculum Constructor

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Abstract. The curriculum constructor model based on ontology that allows establishing connection between curriculum objectives, learning outcomes, expertise and disciplines is introduced in this paper. Thus, it makes possible to consider the compliance of the Education Programme with the learning outcomes and expertise, as well as, it helps check the curriculum goal achievements, the learning outcome development and mastering the competences. The constructor lets create different subsets with different properties and set various individual trajectories.

Keywords: e-learning · Ontological model · Artificial intelligence · Curriculum development · Learning outcomes · Competences · Curriculum goal

1 Introduction

The main issue of this research is to create an estimation model of achievement of curriculum objectives. Curriculum design consists of several stages. The Education Programme goal achievement is carried out through the Education Progamme learning outcomes. Each learning outcome is associated with one or more expertise, while the expertise are associated with a set of disciplines. To achieve the curriculum goal in the context of programme disciplines is ensured by the student's competency mastery. However, each stage requires the verification of the goal achievement, learning outcome, and expertise. Frequently, it happens that not all learning outcomes or achievements are achieved resulting the lack of achievement formal verification at each stage that leads to the difficulties of assessing the Education Programme goal achievement. Besides, in case of the errors in the Education Programme design it is impossible to check them at the design stage. A different approach to design the Education Programme that allows all verifications and checks incorporate into the Education Programme model is required in that regard. That is why the development of the curriculum goal achievement model estimation with the verification is the foundation for the Intellectual Learning Management System.

2 Related Works

There are various work dedicated to the development and assessment of the Academic programme. Thus, in the paper [1] researchers have introduced a new way of executing intellectual data analysis for the development instructions and the academic programme

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assessment. Authors propose the association rules of the analysis technique in order to identify a set of rules that manage the relationship between two main elements: an academic education programme and student outcomes.

The result-based training is considered as a learning model in the paper [2] that creates an emphasis in assessing student performance according to the outcomes that lie in knowledge, skills and behavior. The study revealed that this teaching form is widely used in technical higher institutions around the world. At the time of the study the authors have emphasizes that the outcome lies in what learners can do rather than what they know.

It is shown that the MOOC provides an opportunity to assess student learning in a technically mediated online environment in the papers [3, 4]. An analysis has been carried out from MOOC or from several MOOCs with different numbers of students to carry out the research in the paper [3]. The study has found that MOOC course design can have a significant impact on course student engagement rates. The model of intelligent MOOC presented in the paper [4] blended and any e-learning at its designing, using the knowledge base, ontological model of discipline, and their relevant question-answer system and intelligent search. The separate important part of each MOOC is the intelligent assessment of knowledge and achievement of announced training results. The suggested MOOC model is more effective for distance, blended and any e-learning.

Perspectives of artificial intelligence influence on teaching technologies have been considered in the paper [5]. Four different categories of education landscape have been considered in the study course. They are: individual learning content, modern teaching methods, score multiplying technology, and relationship among students, as well as teachers. The researchers have presented the research outcome stating that Artificial Intelligence (AI) is able to change the learning trajectory. The knowledge assessment is an important artificial intelligence task that is often based on natural language processing. In the paper [6] empirical research is studied with the aim of assessing knowledge that can be applied without human participation.

The authors of the paper [7] have created an intelligent assessment system that is considered a collective and joint project designed for the construction intensive, heuristic and adaptive part that is considered a subsystem in the concept of teaching students. This study assumes a three-part structure based on standard training flows, and explains the function and construction of each part. The researchers have analyzed the use of the electronic assessment in the field of computer teaching, and identified factors that contribute to effective electronic knowledge assessment in the paper [8]. The authors of the paper [9] have provided the research overview through the systematic analysis that considers the use of AI in the higher education.

They have reviewed over 2,656 publications from 2007 to 2018. 146 papers have been used for final generalization according to the exact aspects of introduction and exclusion. The research results introduced in the AIEd publications show that they belong to informatics and STEM, as well as point out the fact that quantitative methods are more often used in empirical research. In the paper [10] the research authors studied and discovered the methods and ways of dynamic generating the test tasks that are based on the student knowledge examination using methods grounded in neural networks. These methods can help ensure flexibility in the controlling alternative adaptation that adjusts to personal knowledge level. As a result, this procedure will enable the teacher to acquire the most representative assessment of the student knowledge. In the paper [11] authors have presented a tool for Assessing Infrastructure Service Level Environment (AISLE).

The purpose of this tool is to improve the application of artificial intelligence methods in assessing student's understanding of a specific teaching topic with the concept map support. They have used the XML parsing method to perform the required evaluation. A two-layer feedback neural network has been used in order to construct the analyzer.

The authors of the paper [12] have studied the intelligent software system introduction for e-learning that is focused on increasing the student motivation and academic achievements in computer programming courses. The created intellectual approach seeks to provide students with appropriate materials based on teaching degree.

The authors have provided the efficient scheme of fuzzy automatons for the intelligent recognition of students' textual responses in the paper [13]. The recommended system adapts to unintentional mistakes made by learners, as well as simulates a benevolent human evaluator. The authors of the paper [14] have analyzed the latest neural network scheme in order to intelligently analyze the student interaction in the field of study. The model is used for a typed one-word text solution at the end of the teaching. The authors have considered an approach in the paper [15] that is based on k-variable fuzzy finite state automation for the implementation of a scoring system for short answers. The presented method attempts to imitate student behavior in the context of made mistakes that may be knowledge-based or unintentional in nature. The developed methodology has been described using sample assessments from a test conducted on a group of students.

The authors on the paper [16] have developed a technology that allows integrating existing partially effective tools with general learning management systems (LMS) in accordance with the standard. The designed and developed system can be used as modules for existing systems or LMS. Universities interested in the system can use this tool as a module.

The scholars of the paper [17] have also presented an improved assessment system technology that can be used both for teaching skills and knowledge. A general technologically advanced grading system for online logic courses has been developed taking into account the e-learning standards and specifications.

The scholars in the paper [18] have focused on the triangular membership function, where the two inputs have been two different system results, namely the finance and business statistics principles, while the output has been the performance value. The authors have applied the method to a sample of twenty-two first-year students at the University of Malaysia.

The authors [19] have reviewed the student performance on two separate tests on the same subject "Electrical Control" to measure student performance. Then they have used the classical methods to compare the assessment results with the obtained results. Their sample consists of twenty students of laboratory courses in control methodology in Turkey.

The authors of the paper [20] have sought to assess collectively the student group knowledge and skills. They have created a fuzzy model in order to assess the student group knowledge and abilities, in which the evaluated student characteristics have presented in fuzzy subsets variant of a set of linguistic meanings determining their work. Student profiles have been for quantitative/qualitative study results of student performance in groups.

The authors of the paper [21] have applied the fuzzy logic to determine the student knowledge level in a certain knowledge area using the response time to test questions and the student's score as metrics.

The authors have presented a fuzzy neutral inference system for modeling a student in the context of a web-based intelligent learning system in the paper [22]. The proposed model has been implemented and tested on simulated student data.

The authors of the paper [23] have considered an approach to student knowledge assessment that is based on fuzzy modeling neural network. A fuzzy neural diagnostic process model has been proposed in order to establish the student data. The model can be simply adapted to the individual teacher judgment. This approach can be applied in order to implement the disclosed student model that will be interactively corrected by the teacher. Scientists [24] suggest an integrated approach to fuzzy sets in order to assess the learning outcomes aimed at learners. They apply the fuzzy set foundations in order to find out the fuzzy concept for an individual proposal, and also use the fuzzy set method to establish the evaluation criteria for their corresponding values.

The authors [25] have created the Cogito software package, in which they have used the neural network to search for patterns in "noisy" data from paper and pencil, and also connected them with Perry models and Reflexive intellectual development judgments.

The researchers [26] have given the latest strategy for assessing education achievements during the teaching process of students, in which each question is assigned by the linguistic variables of a fuzzy set depending on its importance, difficulties and problems through the membership functions.

The scientists have presented a fuzzy logical diagnostic model that is called the profile of teaching students in the paper [27]. In the process of research, the authors of the current paper [28] considered and researched different ways and methods, which where, as a result, utilized for the evaluation of capstone projects.

The authors [29] gave an example of an educational domain model. During the development of the current paper, the authors [30] suggested a variety of methods which would analyze and calculate the students' activity with the intent of improving the students' performance. As a result of the research it was determined that the most effective and at the same time practical method happens to be the analysis of study, meaning the constant analysis and comparison of the results using algorithms.

During the research of the educational methods, the author of the current paper, [31] opened a course for future engineers which had a participation of 27 students. By analyzing the completed course in question, the students were satisfied with the high quality educational material, and in addition, were able to give feedback for improving the course. The author of this article [32], as a result of his research, came to the conclusion that the theoretical educational part of the programs not only develops the development of educational programs, but also simultaneously allows expanding the possibilities of the learning process. In the course of the study, the authors of this scientific work [33] consider the concepts of educational programs that are formed on the basis of the results. The authors [34] of the article gave an example of curriculum development using the artificial intelligence (AI) backpropagation method. In the work [35] for the design of curricula, the design of the PLM course was considered. The article [36] considered the use of aggregated profile clustering to assess the curriculum of a higher educational institution. The authors [37] conducted a study in the field of the educational process. And also the structure of the analysis of the curriculum is proposed for the study to test the proposed approach. In the article [38], the authors gave an example for developing a computer science curriculum at a secondary liberal arts university in the context of cybersecurity. This article [39] is dedicated to modulating a new curriculum for integration into the existing curriculum. This article [40] aims to redesign the curriculum for Industry 4.0.

3 Curriculum Constructor

The Curriculum is being developed by the Academic Committee members. Furthermore the curriculum is being approved by the administration undergoing the examination and the review and approval procedure at the University collegiate bodies.

Currently, the constructor functions are as follows (Fig. 1).

Users of the system:

1) the Academic Committee members.
2) Administration staff.
3) External expert.
4) Internal expert.

1. A member of the academic committee develops CURRICULUM, enters general data: task, type, degree (bachelor, master, doctor), time period of study, distinctive characteristics, language of study, date of approval by the academic council, availability of accreditation, formed results of research.
2. The composition of the index of disciplines by a member of the academic committee.
3. The creation of the CURRICULUM template by a member of the academic committee: enters mandatory subjects to the educational program.
4. After the creation of the CURRICULUM template by am employee, a member of the academic council chooses the subjects and fills out CURRICULUM.
5. A employee reviews the created CURRICULUM. In case everything is correct, it is sent for examination. In case of the opposite, the CURRICULUM is sent for revision.
6. A roster of experts is available, an employee assigns these experts to particular CURRICULUM. The experts review the CURRICULUM. Examination is done according to a particular template. If the CURRICULUM is correct, it is sent for confirmation, if not, it is sent for revision.
7. An employee downloads the CURRICULUM, prints it, and announces at the academic council.

An employee creates necessary reports for CURRICULUM. The staff generates the necessary reports in the CURRICULUM.

The disadvantage of this constructor is that it is impossible to consider the compliance of the Education Programme with the learning outcomes and expertise, as well as to check the curriculum objective achievements, the learning outcome development and mastering the expertise.

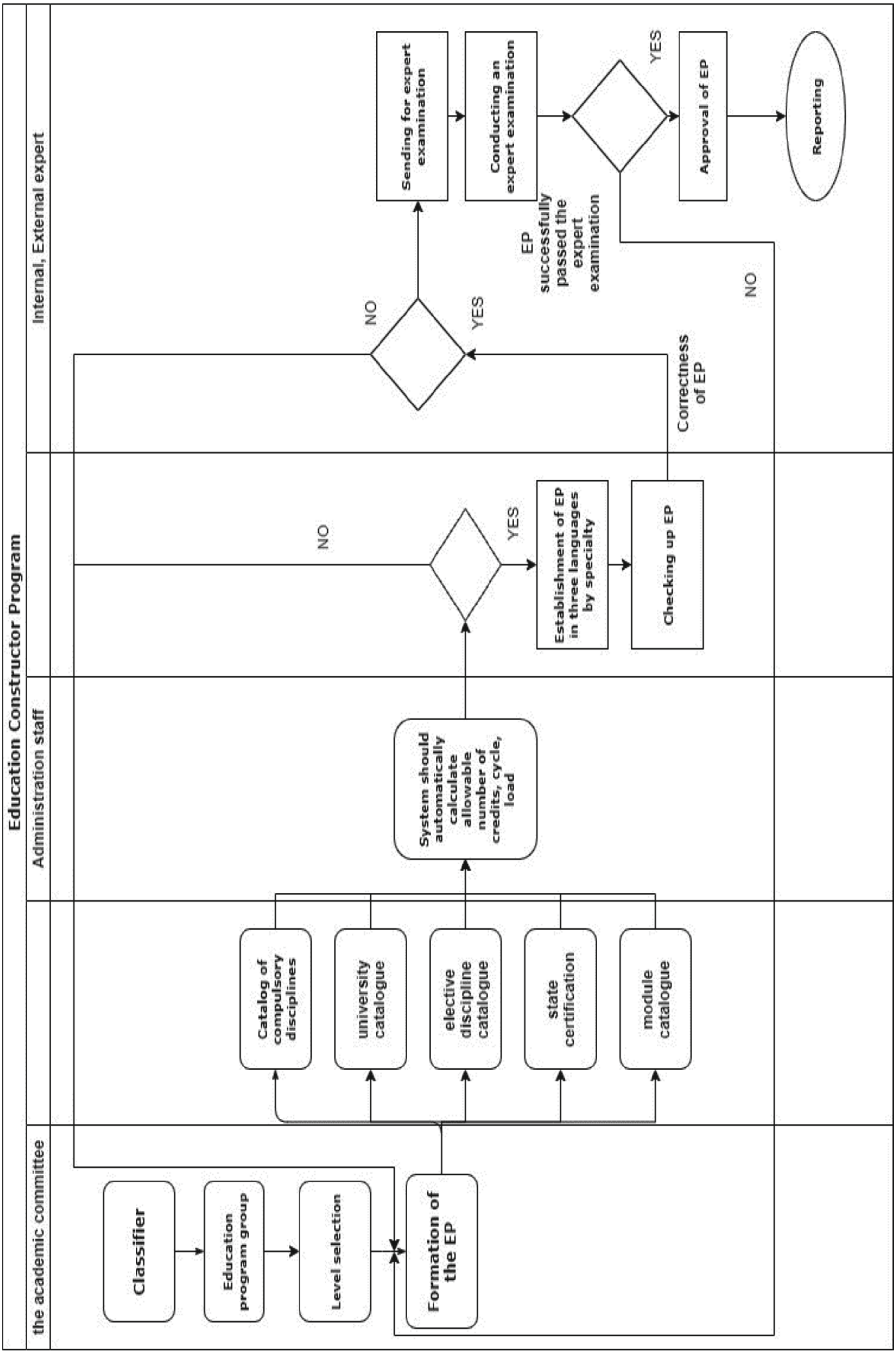

Fig. 1. Current curriculum constructor's model

4 Development of Curriculum with Using Ontological Model

Development of curriculum consists of several stages that are described in Fig. 2.

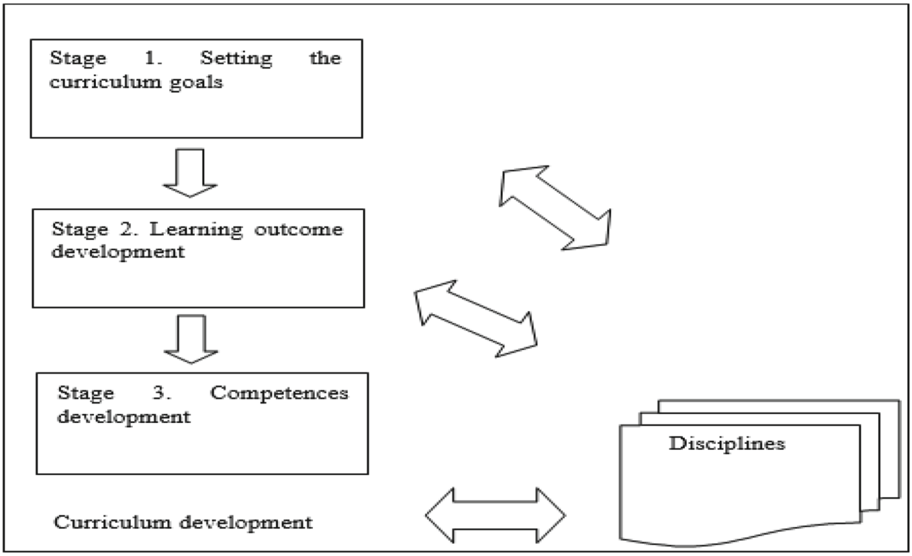

Fig. 2. Curriculum development stages

It is crucial to correlate the competences with the learning outcomes, and the learning outcomes with the programme objectives.

Stage 1. Setting the curriculum objectives:

Curriculum objectives are aimed at training specialists of high qualification level without a category, the second category and the first category. It is necessary to complete a number of tasks including the targeted creation of students' contingent, the specialized theoretical and practical training of the students during the learning process focused on the modern employer requirements. Hence, the Programme goal is designated as GDP, the learning outcomes as R, and the expertise as C.

The requirements for the goal are as follows: brevity, comprehensibility, connection with the learning outcomes.

Stage 2. Curriculum learning outcomes:

The learning outcomes are created both at the Curriculum level of higher education and at the individual module or academic discipline level.

The learning outcome requirements:

1. Demonstrating the attained knowledge in the field of research;
2. Implementing the attained knowledge, being able to form theses and arguments, being able to solve problems in the field of research on a professional level;
3. Perform data collection on the bases of social, ethical, and scientific reasonings;

4. Being able to implement theoretical and practical skills into solving problems in the field of research;
5. Independence for further training in the field of research;
6. Using the methods of scientific researches and academic writings in the field of research;
7. Utilizing the attained knowledge and understanding of facts, theories, and phenomena in the field of research;
8. Following the principles and customs of academic integrity.

The results should be achievable, measurable and related to the competences.

Stage 3. Curriculum competences:

Competence is the ability to put into practice the knowledge, skills and abilities acquired in the learning process in professional activities.

Competences must be short, achievable, measurable and related to the disciplines.

The learning achievements can only be verified if the learning process, learning validation and student's knowledge evaluation are fully formalized.

The curriculum goal can be understood in general terms as the combination of all learning outcomes of the programme.

$$\mathrm{G_{DP}} = R_1 \& R_2 \& R_3 \& \ldots \& R_n \tag{1}$$

where $R = \{R_1, R_2, R_3, \ldots, R_n\}$ a set of learning outcomes.

However, in a particular case, these learning outcomes can be divided into mandatory learning outcomes of the Education Programme, and they can be variable.

Mandatory core learning outcomes, as the name suggests, are mandatory and included in full. Thus, the subset of the mandatory learning outcomes can be represented as $R = \{R_{c1}, R_{c2}, R_{c}3, \ldots R_{cn}\}$.

Varieties of the learning outcomes can be represented as $Rv = \{R_{v1}, R_{v2}, R_{v}3, \ldots R_{vn}\}$. However, there is a formal need to impose restrictions on minimum necessary and sufficient variable learning outcomes for obtaining a degree. But, it is impossible at this stage, the restrictions are introduced at the stage of formulating competences while verifying the compliance with the disciplines. Then the formula (1) can be rewritten as (2):

$$\mathrm{GDP} = R \& R_v \tag{2}$$

Many of the competences can be described as (3):

$$C = \{C_1, C_2, \ldots, C_n\} \tag{3}$$

Many of the competences can be represented as (4):

$$D = \{D_1, D_2, \ldots, D_n\} \tag{4}$$

The example of ontology illustrating the relationship between objectives, learning outcomes, competences and disciplines is represented in Fig. 3.

The term "ontology" (the word "ontology" comes from the Greek "ontos" - existing and "logos" - concept, teaching, reason), proposed by R. Goklenius, appeared in 1613.

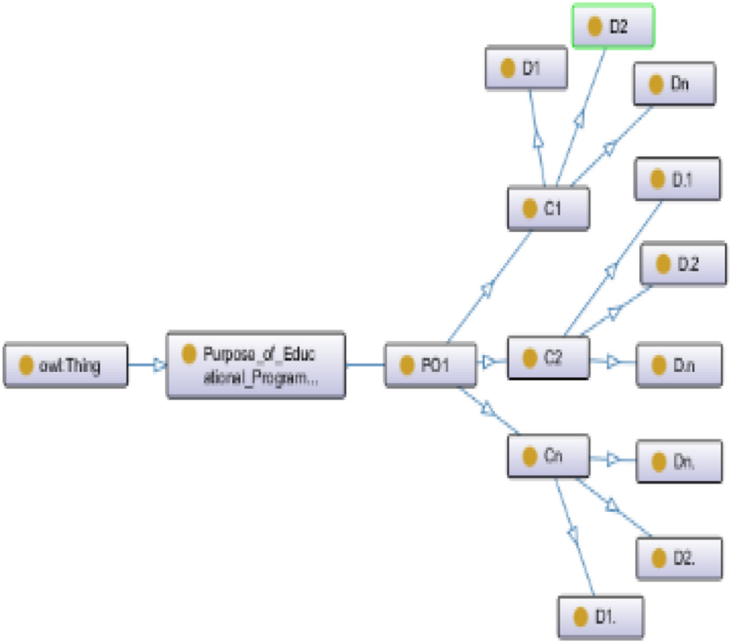

Fig. 3. Example of curriculum ontological model

At present, the methods of knowledge engineering, the young science of the extraction, structuring, presentation and processing of knowledge are becoming more and more popular [41]. The ontological model is built in Protégé tool [42].

This use of ontology to create the Curriculum model makes it possible to establish a connection between the curriculum goal, learning outcomes, competences, and disciplines. It allows creating different subsets with different properties and defining various individual trajectories.

There are 15 options for developing curriculum using the ontological modeling through various combinations of possible options.

1. Formulating the Curriculum objectives;
2. Formulation/choice (among existing numbers) of the relevant objectives of the learning outcomes and linking them to the goal;
3. Formulation/ choice (among existing numbers) of the competences and linking them to the learning outcomes;
4. Creation/ selection of existing disciplines with descriptions and keywords, and linking disciplines to the competences.

5 Conclusion

In this paper, an attempt is made to create the Curriculum constructor model based on the ontological modeling. The links between the curriculum goal, learning outcomes, competences and disciplines are considered while developing the Curriculum Model. The existing curriculum constructor does not provide an opportunity to check the compliance of the Education Programme with the goal, learning outcomes and competences, as well as to verify the goal achievement, the learning outcome development and mastering the competences. The lack of linkages subsequently precludes analysis and assessment of the learning outcomes and results of competence mastering.

6 Further Work

Further work prospects, in our opinion, lie in creating a kernel of a new knowledge-based learning management system. The Curriculum as the basic document of the educational process and its correct design plays a major role in providing high-quality education. The next modules of the system are the intelligent knowledge assessment module and the module of MOOC. Connection of these modules will significantly expand the traditional LMS services for students and professors.

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