paper; however, some of their elements are incorporated in the competencies described above.

Conclusion. The research resulted in a new competence model of a teaching engineer in the sphere of light industry technology. The model is distinguished from other similar models by introducing such new parameters as prospects of innovative development of light industry. The model takes into account the review of publications related to competence-based approach, and meets the Ukraine education regulations and standards. It includes general and professional competencies. The general ones embrace instrumental, interpersonal, system, information, communicative, and legislative. Professional competencies are subdivided into pedagogical and those related to professional activity: engineering and production and technological. Further research will be focused on the competency development model for a teaching engineer in light industry.

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UDC 378

Analysis of the Curriculum Subjects Correlation

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The methodological foundation for the analysis of courses dependencies within the university curriculum has been studied. To build an effective curriculum, a model of disciplines correlation analysis based on Spearman's rank correlation using students' assessment as input information was proposed.

Key words: curriculum, discipline, correlation, model, analysis, prerequisites, co-requisites.

Introduction

One of the main goals of University control automation is to develop a curriculum. It provides initial data for dean's offices.

While implementing the new federal state educational standards of higher education (FSES HE) in the education system, it is necessary to take into account the relations between studied subjects to develop new curricula. These relations are reflected in the terms of "prerequisites" and "post-requisites".

Prerequisites are subjects that are required to be studied beforehand.

Post-requisites (co-requisites) are the subjects that should be studied after a particular subject.

In most cases, prerequisites and post-requisites are chosen by a faculty member without taking into consideration the interrelations between these disciplines. Thus, the curriculum can only partially reflect the relations between the subjects, which leads to inconsistent assessment and auditors' claims in the framework of education quality management system.

1. Approaches to curriculum development with regard to logical coordination and consistency of subjects

Let us consider some approaches to effective development of curriculum in higher education institutions with regard to logical coordination between subjects.

The aim of curriculum enhancement is to choose the most essential content for a particular professional activity and distribute it throughout the academic terms in an optimal manner.

It should be noted that curricula can be presented as directed graphs, tables, or matrix, which conditions the variety of approaches to curriculum design [1, pp. 16-28].

Works [2, pp. 90-97, 3, pp. 111-116, 4, pp. 134-143, 5, pp. 179-185] offer algorithms of curriculum design with regard to interrelations between studied subjects and developed competencies. While developing curricula, the value of a subject, faculty qualification, and sequence of subjects are taken into consideration. However, it is a user who determines the dependency between the subjects. Thus, the issue of adequacy of such relations remains open.

Mathematical models offered in [6, pp. 66-71] are based on automation of curriculum development by using a semantic net to arrange the sequence of the subjects. In this case, relation-associations reflect the subject dependency, which reveals all non-realized dependencies in the curriculum.

Studying the issues of material

preparation for study packs [7, pp. 35-38], the researcher suggests keeping the balance between the amount of training content and academic hours of a subject by defining the priority of each subject and choosing the content in descending order of priority. The priority is determined by attributing particular value to a subject, content material or task. The values are determined basing on students' skills and knowledge (entry test).

The authors of paper [8, pp. 136-143] offer a decision-making model for curriculum synthesis. It takes into consideration the subjects interaction in curriculum, since some knowledge is based on the content studied beforehand [9, pp. 14-17]. The intensity of the relations between the subjects was evaluated by the expert evaluation method based on the binary Cartesian product. Importance index of a training module is calculated by expert ranking method according to Saati's method (Method of analytic hierarchy) [10, pp. 80-83]. The importance indexes of secondary subjects are calculated through estimating the importance index of the major discipline in regard to the other subjects within the same course. It takes into account the contribution of a subject not only on related subjects but also on the subjects studied afterwards. To determine the importance index of a subject, a DxD matrix is made, with each element being equal to the intensity coefficient of relations between subjects i and j. The necessary coefficients are calculated by experts. It depends on what is more important for professional training: either logic and learning outcomes or summarized total significance of the training content.

In works [11, pp. 1013-1020, 12, pp. 203-215], the authors compare algorithms of curriculum formation: KBS, LS-Plan and IWT, a distance learning system taken as an example. One of the main adaptation methods is sequence of training programmes (curriculum). The curriculum implies the way to help students to find an optimal way "through the training content" [13, pp. 1-7]. The curriculum in this case is an algorithm or graph. The research showed that LS-Plan has the longest educational trajectory and the biggest number of errors, while IWT creates the shortest educational pathway. The correlation of the subjects was not studied in the research.

Interaction between curriculum modules was studied in [14, pp. 28-34]. A frame is regarded as a basic information unit of a training system. The paper describes main possibilities of frame combinations. To connect the training content between different frames, it is necessary to introduce information relation between them. The frame content is not mathematically formalized, however, each frame can be connected with its describer that distinguishes the main concepts and relations between the frames within one subject. The frame describer has a logical form, but it allows keeping order only on the highlighted subset of frames.

Analyzing the existing approaches to curriculum design with regard to logical sequence of subjects, it is possible to conclude that it is mostly experts who set the correlation between subjects in curriculum while determining the sequence of prerequisites and co-requisites. In other words, it is faculty staff's decision. There is no module analyzing subject correlation within a curriculum in the most modules. Thus, we took a decision to develop a model to analyze correlation between curriculum subjects based on Spearman's rank correlation coefficients.

2. Analysis of correlation between curriculum subjects based on Spearman's rank correlation coefficients

The results of course final assessment (in scores) are taken as input data to analyze the interaction between the subjects of the curriculum. However, it should be taken into consideration that a traditional mark, which is registered in the exam record list, depends on a particular scale chosen by a particular University.

We calculate nonparametric correlation coefficient since students marks are subjected to non-normal distribution, i.e., they are multimodal distribution. To fulfill it, it is necessary to rank the characteristic values (in our case these are students' scores of final exam in a subject) in descending or ascending order.

To evaluate the intensity of relations between different subjects of a course, let us use Spearman rank correlation [15, pp. 626-628]. It is calculated as follows:

$$\rho = 1 - \frac{6\sum_{i=1}^{n} d_i^2}{n(n^2-1)},$$

where d_i^2 – difference square of ranks;
n – number of observations (number of rank pairs).
The result will always be between 1 and minus1.
Student's T-test is used to test the significance of the coefficient. T-statistic is calculated while testing the hypothesis:

$$t_{pac} = \sqrt{\frac{\rho^2(n-2)}{1-\rho^2}}.$$

The calculated value is compared to the tabulated one $t_q(n-2)$. If the calculated value is bigger that the tabulated one, it indicates the significance of the correlation coefficient, and thus, it proves statistical significance of relations between sampling data. The task can be done with any mathematical software (for example, Mathcad).

3. Research results

Academic achievements of students of Urga State Technological Institute, National Research Tomsk Polytechnic University (USI TPU) were the base for the correlation research. The academic office provided sampling of final students' marks in all the curriculum subjects over three recent years (2013, 2014 and 2015), a Bachelor's degree course in "Applied Information Technology".

The structure of the main education programme was developed at the Department of Information Systems, USI TPU. There are prerequisites for each studied subject.

Basing on the model, a correlation matrix of interdisciplinary relation between the subjects was suggested. It has the size NxN, where N is the number of subjects, provided by the course. In this case, N = 55. The correlation coefficients with t-statistic less than t_q (28) = 2,05 can be considered to equal zero, since the correlation is insignificant.

While analyzing the general matrix of correlation coefficients, it can be concluded that:

a) Most subjects of the first academic term (Computer Science and Programming, History, Mathematics, Economics, Foreign language, Discrete Mathematics, Fundamentals of Information Society Development, Physics) are strongly correlated. It is explained by the fact that prerequisites for all these subjects are provided by the school education programme. Successful school study ensures good academic performance during the first term.

b) The subjects of the last (the 8th) term (Graphics in Information Systems, Production and Engineering Training, Information Systems Management, Research Work, Information System in Accounting and Audit) are also closely correlated. It accounts for the fact that all these subjects should ensure successful Bachelor's thesis defense or state examination pass. The content of these subjects are supposed to be applied in further professional activities of the graduates.

c) The prerequisites are not always correlated with the subject they are supposed to relate to. The reason for that was mentioned above: the faculty members responsible for the curriculum choose the prerequisites and co-requisites without studying interrelations between them.

d) Most of the subjects have a significant correlation with the English language, which is a characteristic feature of the specialty. Most programming languages are written in English. Thus, a good English level facilitates student's progress in computer programming.

Table 1. Intensity of relations between the subjects

Subject	Prerequisites according to the curriculum	Prerequisites revealed by the analysis
B3. Professional cycle (102 credits ECTS)		
Computer systems, nets and telecommunications	Computer science and programming; Discrete mathematics	*Computer Science and Programming; Discrete Mathematics;* Mathematics; English; Physics; Practical Course; Numerical Methods; Probability and Mathematics Statistics; Data Base; Management; Algorithm Theory; System Theory and System Analysis; Philosophy
Information systems and technologies	Fundamentals of information society development; Computer science and programming; Data base	*Fundamentals of Information Society Development;* English; Discrete Mathematics; Practical Course; Probability and Mathematics Statistics; Management; System Theory and System Analysis; Philosophy

The data obtained via analyzing the interrelations between some subjects are presented in Tab. 1.

Thus, the method described above reveals that faculty's or experts' choice of prerequisites in curriculum fail to correspond or at least only partially reflects the real correlation between the subjects.

4. Prospects for research and applications

The results obtained from the analysis of correlation between curriculum subjects based on Spearman's rank correlation coefficients can be applied in developing both basic curriculum and individual one that takes into account student's interests and abilities.

Study of correlation between curriculum subjects can be useful not only for general curriculum but also for individual education pathway development.

Petrova S.Yu., Gudzovskii A.A. and Kuz'min A.V. [16, pp. 39-50] offer an object-oriented model of individual curriculum development. It implies implementing a supporting system that provides optimal educational vectors basing on student's academic achievements. A student should have a choice of elective subjects that are closely related to the subjects that the student is good at. In most cases, a set of elective subjects is formed either basing on the Education Standard or on a set of available subjects related to a course. Such model contains neither an algorithm to select interrelated subjects, nor a mathematical model to analyze the intensity of correlation between curriculum subjects.

In earlier publications we developed a dynamic model to manage an individual education pathway of a student [17, pp. 77-81, 18, pp. 245-257]. The sequence of subjects, which is conditioned by the curriculum, is determined with the help of coefficients of correlation between the subjects (prerequisites and co-requisites). It is possible to overcome the restriction related to the sequence of subjects within an academic term and a whole course by using the results of correlation between curriculum subjects based on Spearman's rank correlation coefficients.

Conclusion

While analyzing the existing approaches to curriculum development we investigated the methodological base to study the intensity of relations between curriculum subjects.

We developed a model to analyze the subjects interaction for a particular course based on Spearman's rank correlation coefficients, using final scores of graduates for some previous years as input data.

The task can be completed by means of any Mathematical software (for example, Mathcad). The suggested model was tested on academic achievements of USI TPU students.

The method to calculate the coefficient intensity of relations between curriculum subjects (prerequisites and co-requisites) will be applied in the dynamic model related to management of student's individual education pathway. It can also be applied to develop an effective basic curriculum.

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Innovativeness in Future Engineers: Value and Motivational Characteristics

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The article presents the results of research concerning the peculiarities of value-motivational structure of engineering students with different levels of innovativeness manifestation. The obtained data allow introducing new practical technologies aiming at future engineers' motivational activity and innovativeness development.

Key words: innovativeness, innovative potential, value-motivational structure, engineering education.

Rapid changes in public consciousness developed under the influence of social-political and social-economic deformations are a problem sphere for modern psychology from the standpoint of theory and practice. Society is a community of people and if we want to build an advanced civilization, one has to start with a person's bringing-up and education.

One of the key factors of modern society's development and well-being is innovation. To support innovations, special financial and technical resources are allocated by the society and some organizations, since innovations are an important condition for viability, activity, and competitiveness of any company. Innovation provides intensive development of both economy and society, in particular. It contributes to the efficient solution of the problems faced by the government. However, when analyzing the problems of innovation support, they are, as a rule, considered in economic and managerial aspects, whereas psychological bases of developing personal innovational potential have not been adequately investigated

The issue of research in peculiarities of innovativeness development in modern society is conditioned by the necessity to develop new forms of personal development management. Searching for the boundaries among personal success, efficiency, and performance, new generations can apply their activity for boon or bane both for themselves and society. The perspectives of psychological trends in innovativeness are connected with not only revealing peculiarities of the quality in the activity, but also implementing the efficient social-psychological and psychological-pedagogical techniques of managing personal characteristics to develop social creativity.

Based on the analysis and generalization of numerous theoretical investigations dealing with analysis of personal potential of professional development and psychology-acmeologic potential of professional activity, one can suggest that personal innovative potential is an integral complex of activity resulting from involvement in innovative process and consisting of interconnected and interdependent components: creativity (cognitive-prognostic component), innovativeness (dynamic-managerial component), and constructiveness (value-motivational component) [2; 5].

In foreign research the interest in innovativeness as a personal quality is presented in different concepts and approaches that are concerned with innovative behaviour, innovative potential of management, and cognitive styles responsible for a person's inclination for innovation (R.A. Bruce, T. Amabile, R.M. Kanter, M. West, M. Basadur,