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INTEGRATIVE TECHNOLOGY OF ACADEMIC SUBJECTS STRUCTURING AND ITS APPLICATIONS TO PRACTICAL DIDACTIC ISSUES

The paper is devoted to author's technology of the projecting academic subjects modular structure which is based on scientific knowledge integration. The bases of scientific knowledge integration are determined basing on the retrospective investigation of influence of integration tendencies in science on the formation of the professional education content. Forms of revealing scientific knowledge integration in education content are clarified what allows to elaborate the projecting technology of structure of an academic subject: special didactic and technological procedures to be done on each stage of the projecting in order to get as a result the modular structure of a subject keeping and spreading links between knowledge both inside a module and between modules and subjects of curriculum. The paper also considers possible ways of this technology application to the various didactic issues, in particular, in using in the systems of intelligent adaptive learning.

Key words: *academic subject, subject modular structure, knowledge integration, technology of structuring, content of education, systems of intelligent adaptive learning.*

Ref*. 10.*

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ІНТЕГРАТИВНА ТЕХНОЛОГІЯ СТРУКТУРУВАННЯ НАВЧАЛЬНИХ ДИСЦИПЛІН ТА ЇЇ ЗАСТОСУВАННЯ ДО РОЗВ'ЯЗАННЯ ПРАКТИЧНИХ ПРОБЛЕМ ДИДАКТИКИ

В роботі розкрито авторську технологію проектування модульної структури навчальної дисципліни на основі інтеграції наукових знань. Розроблено конкретні дидактичні та технологічні процедури, що мають бути виконані на кожному з його етапів з метою одержання в результаті модульної структури дисципліни із збереженням та розповсюдженням зв'язків між елементами знань. Технологію та результат її застосування проілюстровано на прикладі конкретної дисципліни одного з циклів підготовки майбутніх вчителів математики та інформатики. Визначено шляхи залучення запропонованої технології до найбільш актуальних проблем дидактики, зокрема до створення систем адаптивного навчання.

Ключові слова: *навчальна дисципліна, модульна структура дисципліни, інтеграція знань, технологія структурування, зміст освіти, системи адаптивного навчання.*

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ИНТЕГРАТИВНАЯ ТЕХНОЛОГИЯ СТРУКТУРИРОВАНИЯ УЧЕБНЫХ ДИСЦИПЛИН И ЕЕ ПРИМЕНЕНИЕ К РЕШЕНИЮ ПРАКТИЧЕСКИХ ПРОБЛЕМ ДИДАКТИКИ

Работа раскрывает авторскую технологию проектирования модульной структуры учебной дисциплины на основе интеграции знаний. Разработаны конкретные дидактические и технологические процедуры, выполнение которых позволяет получить в результате модульную структуру дисциплины, сохраняющую и распространяющую интеграционные связи между элементами знаний. Данная технология и результат ее применения проиллюстрированы на примере конкретной учебной дисциплины. Рассмотрены пути приложения технологии к решению актуальних проблем дидактики, в частности, к созданию систем адаптивного обучения.

Ключевые слова: *учебная дисциплина, модульная структура дисциплины, интеграция знаний, технология структурирования, содержание образования, системы адаптивного обучения.*

Лит. *10.*

Problem statement and research analysis. Nowadays evidence testifies that world is currently experiencing the age of deep changes concerning all branches of our life. It is displayed in quickly renewing technologies, incredible mobility of social life, new forms of communication, new means of world vision and world realizing. Indeterminacy and non-linear character of these objective processes are reflected in modern science whose leading tendencies nowadays are knowledge synthesis, mutual enrichment of sciences both inside separate branches and between other scientific areas. It is developing conversion to really interdisciplinary research under which interpenetration of knowledge and cognitive methods is taking place. Under the circumstances requirements to modern education are getting tougher. It is clear that global science needs researchers capable to solve integrative problems, and global labour market demands qualified employees who have flexible and operative knowledge system to be used in related branches, who are able to adapt quickly to technological changes, who are ready for renewing their educational level [1; 2; 9].

Under such conditions it is natural that education on all its levels and in all forms of provision undergoes considerable changes. It has to response with appropriate and relevant improvements, and, first of all, with formation of adequate content of education reflecting integrative processes in different branches of science [9]. As the content of education is realized via curriculum subjects, it is a paramount problem to build the coordinated system of academic subjects structured with preserved links between elements of knowledge [9; 10].

As it was mentioned above problems of curriculum development for all forms and levels of learning are crucial and cause necessity of deep investigations. It can be explained by increasing demands to contemporary graduators from universities, to their formed abilities of professional mobility and knowledge flexibility. Credit-modular system of students' training is based on the system of modular structured curriculum subjects. It is necessary to emphasize that approaches to modular structuring of a subject and their results play an important role in subsequent process of learning and mastering material accepting by students, in formation of students' knowledge and skills system. An academic subject is considered to be a mean of implementation of certain education content, and relevant modular structure of the subject can facilitate and improve these processes [3; 4].

On the other hand, any academic subject, especially in higher professional education, is an embodiment of some scientific branch adapted to teaching and learning. Hence, it is to reflect correctly and adequately the branch's structure preserving main links between notions, concepts, facts, theories that really exist both inside the scientific branch and between sciences

in a whole. It will promote and contribute to creation holistic and flexible system of students' knowledge. Such system of knowledge can be characterized by optimal information capacity, by readiness for implying in related areas, for mobile rising of students' educational level in their future lives.

However, very often the modular structuring of curriculum subjects does not preserve or does not convey necessary essential links between scientific knowledge what can cause negative consequences for trainees'. According to pedagogical studies, among such consequences there are forming of separate and uncoordinated system of trainees' knowledge, acquisition of purely specific skills instead of generalized ones, breaking of general wholeness and logic of a subject as well as destroying of links between related subjects etc. Therefore investigating of knowledge integration mechanisms in scientific branches as well as searching of ways of these mechanisms embodiment at modular structuring of curriculum subjects is really urgent for higher education development, and was one of the major tasks of our investigation.

The aim of the paper is to represent the author's technology of the projecting a curriculum subject modular structure which is based on scientific knowledge integration as well as to outline the possible ways of this technology application to the various didactic issues.

The basis of scientific knowledge integration were determined in our research basing on the retrospective investigation of influence of integration tendencies in science on the formation of the professional education content in general and on a curriculum subject in particular [4]. It was theoretically grounded that didactic component of an academic subject (in order to reflect scientific knowledge integration) besides traditional functions has to realize such didactic procedures:

- revealing a subject specific characteristics, measures of implementation of its conceptual and methodological arsenal;
- forming of fundamental all-over-scientific notion potential;
- detecting integration potential of a subject, learning cross-discipline methods of research;
- providing adequate types and mechanisms of knowledge arrangement which are able to reflect variety and complication of cross-discipline links;
- carrying out three-aspect mutual penetration of academic subjects via formed fundamental notion apparatus, cross-discipline means of cognitive activity, and information content of subjects.

Forms of revealing scientific knowledge integration in education content were clarified. Logical sequence and stage-by-stage fulfilling of above didactic procedures were grounded and determined, what in total composed the integration basis of the subject modular structure projecting.

Using this knowledge integration basis we elaborated the projecting technology of structure of an academic subject: we developed special didactic and technological procedures (based on the ideas of the 1) different levels of the education content formation; 2) different levels of knowledge generalization; 3) models of knowledge representation of the Artificial Intelligence theory) to be done on each stage of the projecting in order to get as a result the modular structure of a subject keeping and spreading links between knowledge both inside a module and between modules and subjects of curriculum [4–7].

To represent these procedures in brief we would like to emphasize the following. There are some levels of education content formation, and correspondently – some levels of knowledge generalization, which actually correspond to cybernetic approaches to the creating of meta-model of knowledge system.

The highest level of knowledge generalization contains «over-discipline» general system of knowledge, skills, abilities, ways of activity. This «over-discipline» content is concentrated as a network of «key-points» which are to be learnt in order to provide for a student unified image of reality. These «key-points» are defined basing on the analysis of a) the system of professional functions of a pre-service specialist; b) the structure of his activity; c) essence of his typical professional tasks. As a result we obtain on this step a semantic network which reflects «over-discipline» system of knowledge, skills, abilities, ways of activity. It is important to emphasize the dependence of the obtained network (and, consequently, the whole structure of the subject) on the target trainees' professional goals and tasks.

The next, following levels of knowledge generalization (the level of the specific discipline, the level of learning material and types of learning activity) provide comprehensive analysis of the discipline (author's procedure of the analysis and revealing didactic characteristics of academic disciplines is developed [4]) and technical procedures of building its frame-based structure and content. Frames as one of the classical models of knowledge representation has embedded properties of knowledge elements connections and spreading. As a result the modular structure of the subject designed as frame-based structure provides keeping and spreading links between knowledge both inside a module and between modules and subjects of curriculum in a whole. More over such a structure is sensitive to the changes of the curriculum and to the social demand.

To visualize the idea of our technology we would like to give a specific example. In the Fig. 1-2 there is a fragment of the modular structure of the discipline «Discrete mathematics» obtained on the base of described technology. Let us assume that this discipline is taught for pre-service Mathematics teachers. So, key-points of the highest level of knowledge generalization (and content of education respectively) must reflect and cover different professional functions of a Math teacher, the structure of his activity, essence of his typical professional tasks. Thus, the network (Fig. 1) is made of linked certain key-points $\mathbf{KP_{1,\dots,}KP_n}$:

KP1- system of mathematical facts, notions and their properties
KP2 – methods of mathematical problems solutions
KP3 – essence and methods of mathematical modeling
KP4 – IT instruments of mathematical modeling and investigation
KP5 – applied aspects of mathematics to various branches of science and life
KP6 – historical facts
KP7 – IT instruments of abstract notions visualizations
…
KPn – methodological knowledge and skills

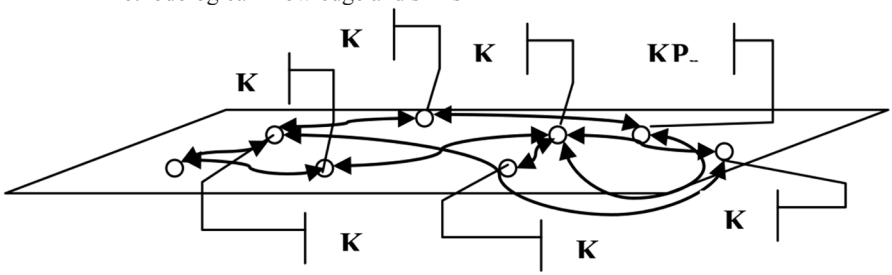

Fig.1. Fragment of the network, which represents «over-discipline» general system of knowledge, skills, abilities, ways of activity of a pre-service Mathematics teacher

After step-by-step knowledge generalization on the level of the discipline, on the level of learning material and types of learning activity, and using rules and methods of frame-based knowledge representation we obtain the modular structure of the discipline «Discrete mathematics» which is capable to realize knowledge links and integration. In the Fig. 2 you can see the place of the discipline among other subjects of different cycles of professional training as well as a structure of its modules. Due to frames structure, their Inheritance pointers automatically provide links between knowledge (or learning elements – LE) and their spreading inside each module, between modules of this specific subject and other subjects. These Learning Elements (LEs) and links between them were determined as a result of didactic procedures on different levels of knowledge generalization.

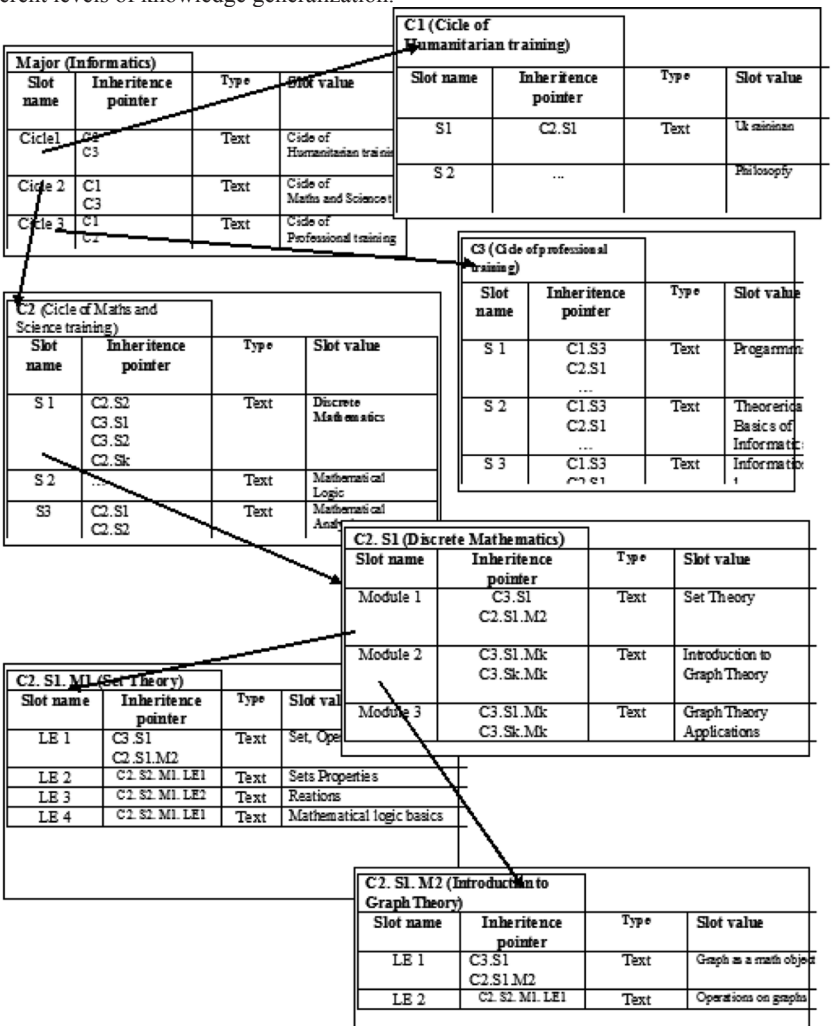

Fig. 2. Fragment of the modular structure of the discipline «Discrete mathematics» obtained on the base of described technology

More over almost all LEs correspond to certain key-points (KPs) of the «over-discipline» level (Fig. 1): LE1-LE4 of the Module1 are grouped around the KP_1 and KP_7; LE1 of the Module2 corresponds to KP_1 and KP_3 etc. So, if KPs of the highest level are changed (for example, due to social demand or professional requirements), these changes flexibly and naturally will be reflected in the structures of the academic disciplines.

It is clear that using the same procedures we can obtain coherent, coordinated system of all disciplines of all cycles of professional training.

In order to automatize realization and spreading of determined links it is possible to build this structure of the subject using some software. The most available one seems to be database systems. Using their built-in facilities we can realise mechanisms of knowledge integration in the curricula subjects, immediately detect links between learning elements, calculate degree of infiltration, optimise sequence and coherence of learning etc. Such attempts were undertaken in MS Access environment.

Our projecting technology also includes determination of the kind and type of expertise for the subject modular structure designed on the basis of scientific knowledge integration: internal scientific-methodical expertise of the pedagogical project by the models of estimate and diagnostic types. Appropriate criteria system was developed for the expertise of each model practical realization. With the aim of verification of the designed projecting technology on the basis of scientific knowledge integration empirical investigation was carried out which proved high quality of the ready-made project as well as its positive influence on the planning and results of academic process [4].

As long as we used at the subject modular structure projecting models of knowledge representation (in particular, semantic networks and frames) taken from the Artificial Intelligence theory to realize integration mechanisms among knowledge, our technology has practical application for coordinated and consistent projecting of modular structure of subjects on all levels of formation of education content. Such an approach might help to solve some important didactic problems of education like: forming students' integral knowledge system of optimal information capacity capable to be used flexibly in related branches; automatic control of cognitive processes in education; creating optimal educational trajectory from the standpoint both of a student and the situation on labour-market; determination of equivalence degree of related specialities and others. Solving these problems seem to be beneficial from the prospects of facilitating public professional and social mobility; education services delivery arrangements; developing optimal hybrid forms of education provision and governance and others.

Nowadays one of the most practical and urgent applications of the described technology of subjects structuring seems to be its using in the systems of Intelligent Adaptive Learning (IAL). Intelligent adaptive learning is defined as digital learning that immerses students in modular learning environments where every decision a student makes is saved, considered in the context of learning theory, and then used:

to guide the student's learning experiences; to adjust the student's path and pace within and between lessons; to provide formative and summative data to the student's teacher. According to the researchers, main components of the adaptive learning system includes Modular Curriculum, Learning activities, Continuous Assessment, designed pedagogically to engage students, and Database of student data. All these components together provide adaptive learning and data analysis necessary for both a teacher and a student [8].

It is obvious that one of the most important tasks of adaptive learning implementation is development and provision of all these components among which crucial role belongs to Modular Curriculum. As long as it is built according to our integrative technology of subjects

structuring, it is really beneficial for adaptive learning implementation as it helps students to obtain flexible structure of integrated knowledge depending on their previous level and experience, and give them a basis for their future education trajectory.

The system of knowledge obtained as a result of our modular structuring of the subject can be used as a basis for the development of didactic-methodical complex for adaptive learning activity. This didactic-methodic complex must include the chain of tasks which expects students' activity which is directed on using their system of knowledge in order to obtain integrated system of skills.

The elements of adaptive learning system supported by the author's integrative technology of subjects structuring were created and used in learning of some subjects of professional training of pre-service Mathematics and Informatics teachers at Kharkiv national pedagogical university named after G. S. Skovoroda.

Conclusions. The paper is devoted to author's technology of the projecting academic subjects modular structure which is based on scientific knowledge integration. The bases of scientific knowledge integration were determined basing on the retrospective investigation of influence of integration tendencies in science on the formation of the professional education content. Forms of revealing scientific knowledge integration in education content were clarified what allowed to elaborate the integrative technology of structure of an academic subject. Possible ways of this technology application to the various didactic issues were offered. In particular, it was determined the mean of the technology application in the systems of intelligent adaptive learning.

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