Adaptive Support of the Educational Process by the Automated Library Information System

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Abstract

The article examines the implementation of integrated data processing of adaptive support of the university's educational process with the library's information resources. The study aims to develop a mathematical model of interaction between the library and other participants of the educational process on the formation of the university database of educational literature. A mathematical model describing the process of forming a list of recommended literature for the discipline based on the curriculum, as well as a model of management of the acquisition process in the Scientific Library of Lviv Polytechnic National University based on the lists of recommended literature from the discipline working program, are developed. An algorithm for calculating the book supply considering electronic documents introduced in the Scientific Library is presented. The book supply index is calculated based on the list of recommended literature from working programs of disciplines. The presented results serve as an essential component for developing an adaptive information support system of the university by integrating an automated library information system with information systems of other structural units and forming a single virtual learning information environment.

Keywords 1

Curriculum, education database, working program, university library, university information system, list of recommended literature.

1. Introduction

Problems of information support of the university occupy an essential place among the priority areas of quality education. The challenges of the Covid-19 pandemic have had a profound effect on transformational processes in education and society as a whole. Universities will not fully return to the traditional education model, as it no longer meets the modern requirements of students. The widespread introduction of alternative and innovative approaches to providing educational activities with the help of the latest information and computer technologies has become a natural and integral component of the functioning of universities around the world. In the new conditions, we observe the formation of a new generation of the information society. Innovative approaches require the process of teaching disciplines and the formation of methodological support for these disciplines. That is, forming the university curriculum needs to be modernized through the development of specialized management systems for information support of the educational process.

The university library is an active agent in the scheme of information support management of the educational process. Due to the use of the automated library information system, it becomes possible to integrate it with the university's information system to implement high-quality information support of scientific and educational activities. It highlights the need to implement mechanisms for integrated data processing of adaptive support of the university's educational process with information materials of the library.

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2. Analysis of recent research and publications

An analysis of recent publications in the development of information support systems for the education process has revealed that, in general, there are two main areas of research. The first direction concerns the actual search for ways to modernize the principles and approaches to forming a curriculum of individual discipline. The second area covers the practical results of implementing hybrid training programs using a wide range of digital learning tools (digital games, virtual reality, virtual learning environment). The obtained results reflect the features of the educational process in certain disciplines and consider the specifics and needs of a particular field of knowledge or educational level (school, college, university).

2.1. Innovative approaches to the formation of curriculum

An essential factor in effective teaching and learning is the formation of a quality curriculum of the discipline [17]. De Gagne J. C. and co-authors emphasize the importance of a careful approach to developing the curriculum of disciplines and ensuring their content, particularly in the field of cybercivility in health professions education. Authors indicate a comprehensive study of modern theories, models, and conceptual and theoretical foundations as an essential factor for implementing this task. It is a basis for integrating new knowledge and skills into existing professional practice and education. In addition, a wide collection of literature in English and national languages will provide a global perspective and global skills for students [9].

Chike K. E. and co-authors examine the integration of the latest research results in telemedicine into the medical training curriculum. Researchers found a lack of unity of approaches to the formation of training programs. They summarize the need to develop common national standardized principles of curriculum development based on a comprehensive analysis of the latest research results in the field [11]. The need to standardize curriculum is dictated by the problems in determining the list of basic competencies of students and evaluating the effectiveness of learning. In addition, qualitative formation of the curriculum requires constructive coordination between teaching and assessment methods with learning goals and outcomes [12]. In support of this position, Hoxhaj I. and co-authors propose using such a comprehensive analysis of the latest research results in the field to standardize the content of the curriculum and form a list of competencies of future professionals [7].

Vachkova S. N. and co-authors point to the significant impact of new technologies on the education sector. Researchers propose to analyze and transform school curriculum to improve their quality using big data technology [15]. Zhao Yu. and Liu H also address the use of big data technology. The authors emphasize that traditional curricula with the rapid development of online education, artificial intelligence technologies no longer meet the growing demands of participants in the educational process. Therefore, they offer their Hadoop-based cloud computing platform that operates big data analysis and application curriculum resource management [20].

Viana J. and Peralta H. study the curriculum as a form of organization of the learning process from the learner's perspective in the context of online learning. The authors emphasize that the formal context in which institutionalized education takes place and the curriculum operating in it is central to developing a personal curriculum [10]. In line with the individual approach in the formation of educational programs, Pinilla S. and co-authors offer a study of the learning management systems in the aspect of educational design research (EDR). Researchers provide data that indicate the usefulness of using the EDR approach to systematically implement a quality management system in the curriculum by supporting self-regulated learning [16]. Alt D. and Naamati-Schneider L. point to the need to consider self-regulation as a key component and learning outcome when designing an online course curriculum. The authors emphasize that the combination of self-regulation technologies with advanced technologies in online courses helps to encourage active learning, allows to develop and acquire abilities for independent learning among students [4]. Ibañez P., Villalonga C. and Nuere L. offer to ensure the holistic development of students in the process of learning and building knowledge to constantly monitor student activity in a virtual environment of the university. In particular, students' activity in the content areas and forums were analyzed [13].

Thus, the development of alternative non-traditional approaches and searching for sources for forming a quality curriculum is an urgent theoretical and applied problem.

2.2. Introduction of digital learning as a component of innovative educational programs

The digital learning mode provides independent and innovative student learning that easily implements the digital virtualization of the learning environment and provides students with more creative space and practical freedom. Exploring the benefits of digital teaching, developing multimedia learning programs, and innovating a database of multimedia learning materials have become effective learning tools [18].

Kim D. and Li M. investigated the impact of digital storytelling techniques in the digital learning curriculum on attracting students with a wide range of expressive resources, increasing their motivation, creativity, identity development, and communication with others [5].

Delgado F. focused on developing online skills-based courses. The digital strategy proposed by the researchers in combination with digital delivery during quarantine restrictions showed positive dynamics in the evaluation of learning outcomes [6].

Pasalidou C. and Fachantidis N. consider mobile augmented reality (MAR) in the learning process. According to the school curriculum, additional information and digital functions were imposed on the real world of the user through the use of mobile devices. The experience of using this mobile application is defined as positive [C. Pasalidou, N. Fachantidis,Teachers' Perceptions Towards the Use of Mobile Augmented Reality: The Case of Greek Educators, in: Proceedings of the13th International Conference on Interactive Mobile Communication, Technologies and Learning, IMCL 2019, Thessaloniki, Greece, 2019, Advances in Intelligent Systems and Computing 1192 (2021) pp. 1039–1050. doi: https://doi.org/10.1007/978-3-030-49932-7_97]. Poronnik P. and Sellwood M. J. also point to the significant potential of virtual reality platforms in curriculum development [14].

Hébert C., Jenson J. and Terzopoulos T. also focused on the study of digital learning in the implementation of digital games [3]. The research results by Dai, Y. and co-authors support the introduction of a digital game-based learning system in educational programs and its application to various fields to increase motivation [19].

Research by Hao C. and co-authors offer research findings on the formation of hybrid curricula. The authors point to the significant potential for introducing virtual laboratories as an effective training model to address the shortcomings of existing physical laboratories. The virtual system of experiments itself provides students with a rich, practical, and expansive experimental experience [2]. Widiaty I. and co-authors also offer the results of designing an alternative resource as part of an innovative curriculum. The developed digital library consists of a digital book room, an audiobook room, and a video book room, each of which has virtual facilities, such as a shared library, but in digital platform settings [8].

Thus, it is evident that the traditional curriculum no longer satisfies the modern realities of the educational process. Active implementation of a hybrid curriculum that combines digital learning tools and traditional approaches gives positive results in providing quality and creative learning.

3. Hypothesis of research

The creation of an integrated system that combines the library's information systems and other structural units of the university is a prerequisite for forming a united educational information space (UEIS). The primary purpose of UEIS is to ensure adequate information interaction of all participants in the educational process. This purpose can be realized in an information environment distributed by function and level of access based on a single university data warehouse. The university library is an active participant in the educational process. Effective information support of the educational process in the conditions of UEIS should provide for the implementation of technological processes through the joint use of information from the information systems (IS) of the university and the automated library information system (ALIS). That is, information interaction occurs by organizing the mutual

integration of data. Data sharing allows to development of special information products for different categories of users. Therefore, the urgent problem is the formation of an appropriate mathematical model, which will describe the relationship of structural units of the university with ALIS to provide users with the necessary educational and scientific sources of information. The basis for the organization of the educational process is the curriculum, which forms the base of working programs of disciplines. Determinant for high-quality book supply of disciplines by educational literature is the compliance of the library's collection with the lists of recommended literature [1].

The basis for forming a list of recommended literature (basic and additional) to the discipline is a working program within the curriculum. Consider this process in more detail and develop a mathematical model.

4. Results

4.1. Working programs of disciplines as a plan of acquisition of education literature collection

Let the curriculum be a lesson

$$Curriculum_i = \langle Sp_i, \{EMCD_{ij}\}_{j=1}^{DN} \rangle, \quad (1)$$

where

$Curriculum_i$ – university curriculum, where $i = (1, \dots, CurN)$;

$CurN$ – the number of university curricula;

Sp_i – i-th speciality of student training;

$\{EMCD_{ij}\}_{j=1}^{DN}$ – educational and methodical complex of the discipline $Discp_{ij}$ for students of the speciality Sp_i, where $j = (1, \dots, DN)$, DN – the number of disciplines of the speciality.

Each educational and methodical complex of the discipline $EMCD_{ij}$ will be presented in the form:

$$EMCD_{ij} = \langle WorkProg_{ij}, LecNotes_{ij}, Dydaction_{ij} \rangle, \quad (2)$$

where

$WorkProg_{ij}$ – working program of the discipline;

$LecNotes_{ij}$ – main lecture notes of the pedagogical worker who is responsible for teaching the discipline;

$Dydaction_{ij}$ – didactic support of independent work of students, individual educational and research tasks and methodical recommendations for their performance.

The working program of the discipline will be presented in the form:

$$WorkProg_{ij} = \langle DispTitle_{ij}, ContentModule_{ij}, \langle RecLit_{ij}, AddLit_{ij} \rangle, InfRes_{ij}, AcadHours_{ij} \rangle, \quad (3)$$

where

$DispTitle_{ij}$ – title of the discipline;

$ContentModule_{ij}$ – content module of the discipline $Discp_{ij}$;

$\langle RecLit_{ij}, AddLit_{ij} \rangle$ – recommended literature, where $RecLit_{ij}$ – list of basic recommended literature; $AddLit_{ij}$ – list of additional recommended literature;

$InfRes_{ij}$ – information resources;

$AcadHours_{ij}$ – the number of academic hours provided for the study of the discipline $Discp_{ij}$.

The primary source of information for the library on what literature can be used in the educational process are the working programs of academic disciplines. With a certain frequency, the work programs (or parts of them) of all university disciplines are directing to the library to update the catalog of book supply. To do this, responsible employees (usually from the department's staff) analyze the literature lists of work programs of academic disciplines. The bibliography of the work program is represented by two lists:

1. $RecLit_{ij}$ – list of main (basic) recommended literature. The literature presented in this list is mandatory for the student to study for mastering the discipline successfully.

2. $AddLit_{ij}$ – list of additional (supplement) recommended literature. The literature presented in this list is not mandatory for the student and is used for the in-depth (more detailed) study of the discipline.

The university library's acquisition is the priority direction of completing the educational literature collection ($EduLitCol$), as this collection is used by students, who make up almost 90% of all library users.

The cyclical nature of the learning process allows organizing effective procedures for copying existing data from the book supply to the curricula of the next year with minor modifications.

The collection of educational literature $EduLitCol$ is presented as a set of bibliographic records of books $bibRec_k$:

$$EduLitCol = \{bibRec_k\}_{k=1}^{N^{(bibRec)}}, \quad (4)$$

where

k – sequencel number of the book in the collection of educational literature;

$N^{(bibRec)}$ – the total number of books in the collection of educational literature.

The bibliographic record $bibRec_k$ will be presented in the form:

$$bibRec_k = \langle Authors_k, BookTitles_k, UDC_k, PubYear_k, PageNum_k \rangle \quad (5)$$

where

$Authors_k = \{authors_{km}\}_{m=0}^{N^{(authors)}}$ – the set of all book's authors, and $N^{(authors)}$ – the number of authors;

$BookTitles_k = \{bookTitles_{kp}\}_{p=1}^{N^{(bookTitles)}}$ – the set of all titles of the book (for example, in different languages), and $N^{(bookTitles)}$ – the number of books' titles;

$UDC_k = \{udc_{kr}\}_{r=1}^{N^{(udc)}}$ – set of UDC values (Universal Decimal Classification), and $N^{(udc)}$ – number of UDC values;

$PubYear_k$ – year of publication of the book;

$PageNum_k$– the number of publishing sheets of the book.

4.2. List of recommended literature of the discipline as a source of forming a database of educational literature

The typical university library's acquisition involves the following processes:

- receiving documents (from teachers, institutes, deans, etc.);
- ordering documents;
- distribution and transfer of documents;
- analysis of university information support;
- other ancillary processes.

Figure 1 presents a model of management of the acquisition process, which is carried out after analyzing the lists of recommended literature of the working program of the discipline.

The results of the analysis of information support of the university are reflected in the thematic-typological plan (TTP). TTP is part of an ALIS or a separate part. However, in both cases, all TTP data are stored and processed at the database level. The central units of universities that use TTP data are:

- a library that purchases literature (including electronic documents) for the needs of the educational process;
- the department, which needs an accurate indicator of information support of disciplines to pass accreditation;
- a lecturer of the discipline who is interested in the qualitative content of the academic discipline;
- a student who needs literature to master the material of the discipline.

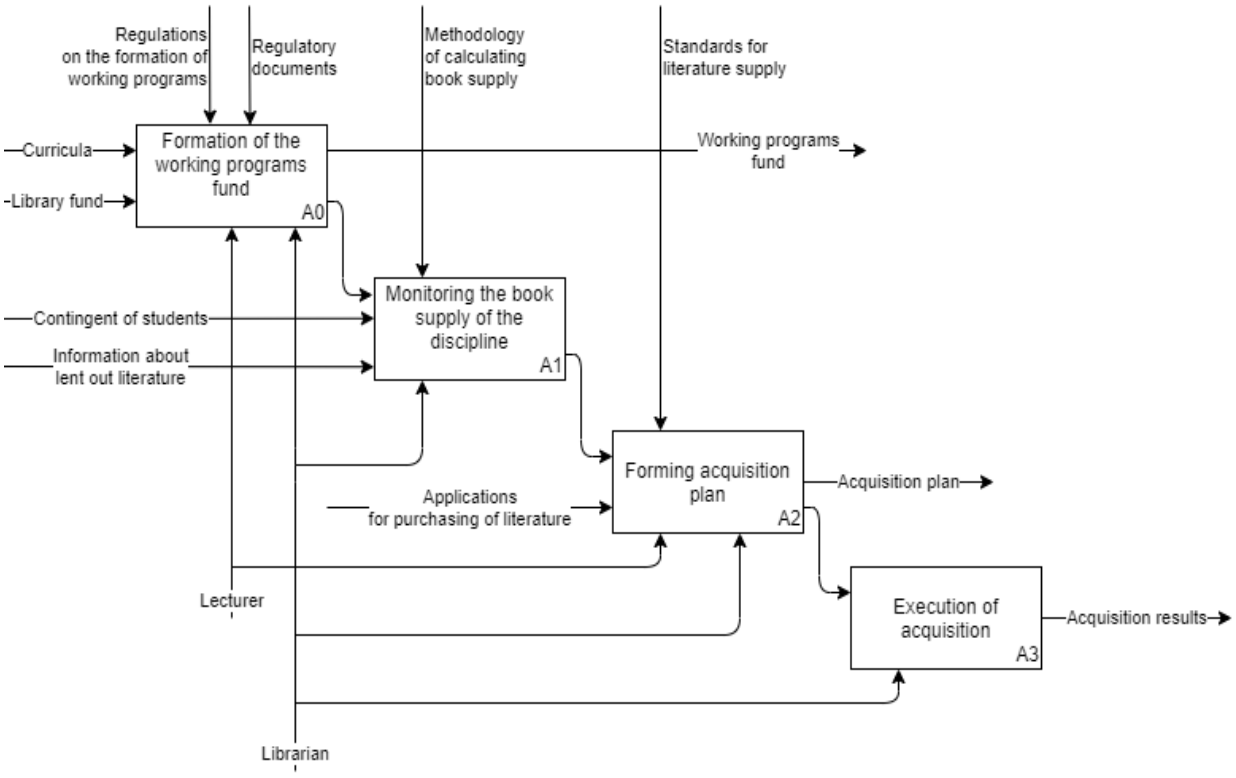

Figure 1: University library acquisition management model

One of the indicators of TTP is the book supply index. It is the ratio of the number of students to the number of copies of literature. The book supply index is essential for the accreditation of departments and the university. Traditionally, when calculating this indicator, libraries consider the physical literature and literature from the collection of electronic publications.

An algorithm for calculating the book supply index taking into account electronic documents was introduced in the Scientific Library of the Lviv Polytechnic National University. The algorithm for the calculation of the book supply index is presented in Figure 2.

The book supply index is calculated based on the list of recommended literature and can be used in two cases:

- formal verification of the requirements for the literature supply of academic disciplines during accreditation;
- analysis of information support of the educational process.

The analysis of the information support of the educational process allows adjusting the plans of the library acquisition - starting from the purchase of literature and ending with the involvement of new lists of information sources.

The list of recommended literature $RecLit_{ij}$ for the discipline $Discp_{ij}$ of speciality Sp_i from the working program $WorkProg_{ij}$ is in the form of a set of bibliographic record of books:

$$RecLit_{ij} = \left\{recLit_{ij}^{(a)}\right\}_{a=1}^{N^{recLit}}, \quad (6)$$

where

N^{recLit} – the number of items in the list of references.

Each bibliographic record will be presented in a tuple:

$$recLit_{ij}^{(a)} = \langle Authors_{ij}^{(a)}, BookTitles_{ij}^{(a)}, UDC_{ij}^{(a)}, PubYear_{ij}^{(a)}, PageNum_{ij}^{(a)} \rangle, \quad (7)$$

where

$Authors_{ij}^{(a)} = \left\{authors_{ijb}^{(a)}\right\}_{b=0}^{N^{(authors^{(a)})}}$ – the set of all authors of the book from the list of basic recommended literature $RecLit_{ij}$ for the discipline $Discp_{ij}$ of the speciality Sp_i, and $N^{(authors^{(a)})}$ – the number of all authors of the book;

$BookTitles_{ij}^{(a)} = \left\{bookTitles_{ijc}^{(a)}\right\}_{c=0}^{N^{(bookTitles^{(a)})}}$ – the set of all titles of the book, and - the number of all possible titles;

$UDC_{ij}^{(a)} = \left\{udc_{ijd}^{(a)}\right\}_{d=0}^{N^{(udc^{(a)})}}$ – the set of UDC values, and - the number of possible UDC values.

$PubYear_{ij}^{(a)}$ – year of publication of the book;

$PageNum_{ij}^{(a)}$ – the number of publishing sheets of the book.

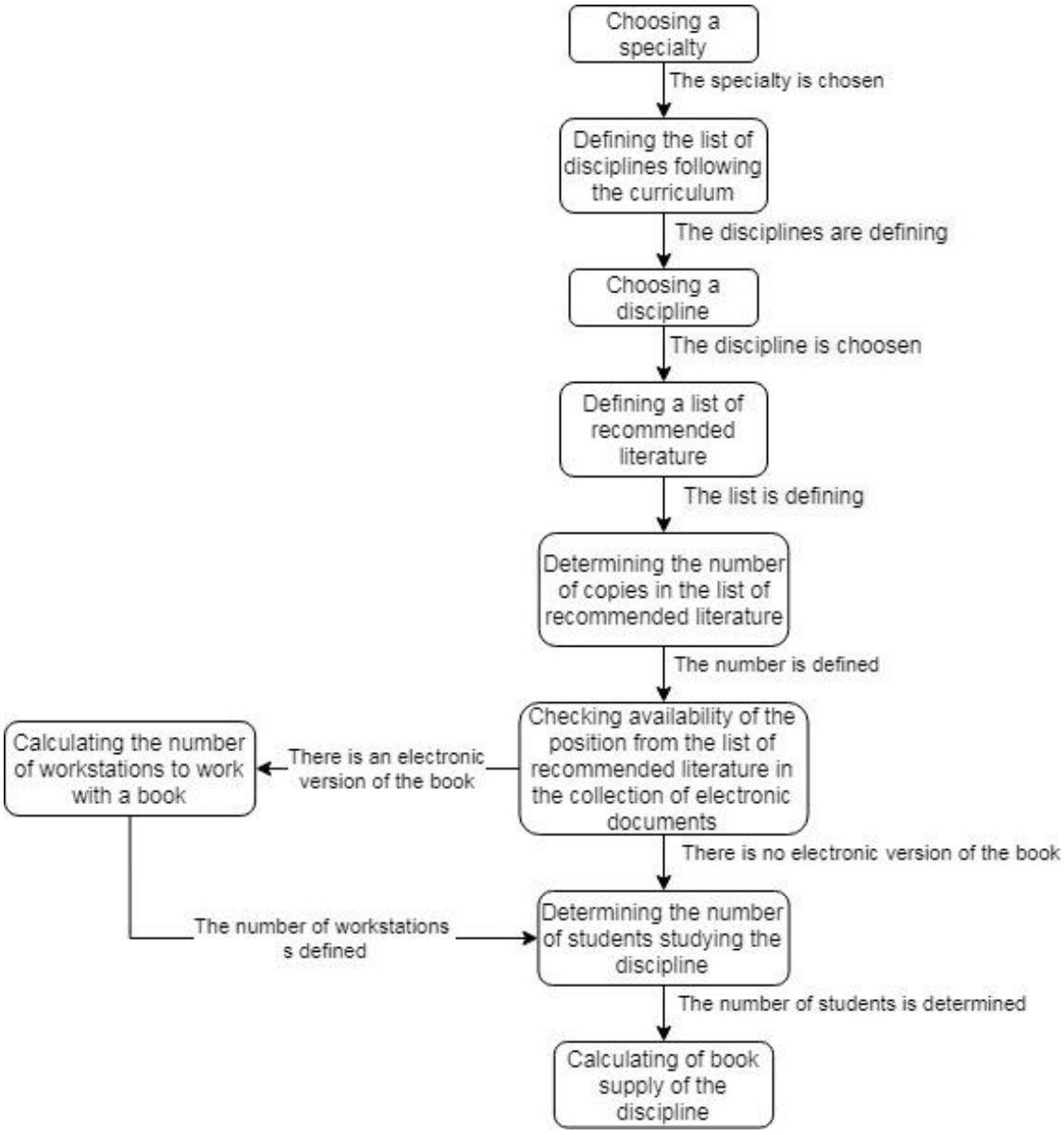

Figure 2: The algorithm for the calculation of the book supply

An essential element of the information system (IS) of the university is the electronic catalog (EC). The library's EC is a rather specific search engine, as the search is performed in clearly structured data. For example, a field in the EC interface to search for literature by a known author is used only to search for books with a given author. The same applies to other fields. Therefore, each search box must have a specific template.

The task of information retrieval in the EC by keywords (for example - the author, title of the book, year of publication) compares these keywords with bibliographic records of documents entered into the database ALIS. Thus, forming a list of literature for the discipline, the search will be performed in the database of educational literature collection $EduLitCol$.

The main search fields of the EC are Author and Title of the document. Other fields (Year of publication, Publisher, UDC, Type of document) are additional, and they refine the search query, not form it.

Suppose we have a set of search queries:

$$Query = \{query_s\}_{s=0}^{N^{(query)}}, \quad (8)$$

where

$N^{(query)}$ – the number of lecturer's inquiries to the EC to form a list of recommended literature $RecLit_{ij}$. Each request will be submitted as:

$$query_s = \langle qAuthor_s, q_s, qBookTitle_s, qAdditional_s \rangle, \quad (9)$$

where

$qAuthor_s$ – part of the search query that identifies the author of the document;

$qBookTitle_s$ – part of the search query that determines the title of the document;

$qAdditional_s$ – part of the search query, which determines additional search parameters (UDC, year of publication, type of document).

Then the search function will look like this:

$$Resoult = Search(Query, EduLitCol), \quad (10)$$

where

$Resoult$ – a set of metadata of books obtained as a result of searching in the database of the educational literature collection $EduLitCol$ on search query $Query$.

When forming the list of literature for the discipline, considered that the lecturer relies on his own expert experience. Forming such a list can take a long time because of the ignorance of the teacher with the collections of the library in a particular area or other circumstances (limited or incomprehensible functionality of the library's EC interface, lack of EC, poorly developed reference and search apparatus of the library).

If the lecturer knows the authors of the books that should be included in the list $RecLit_{ij}$, the search function will take the form:

$$Res_s = Search(qAuthor_s, Authors_k), \quad (11)$$

where

Res_s – a set of metadata of books obtained due to a search among all authors of the collection of educational literature.

If the lecturer knows the title of the book, the search function will look like this:

$$R_s = Search(qBookTitle_s, BookTitles_k), \quad (12)$$

where

R_s – a set of metadata of books obtained as a result of searching among all the titles of the collection of educational literature.

The peculiarity of selecting literature for the discipline using equitations (11) and (12) is that the lecturer must clearly formulate a search query $Query$. He must know the author or title of the book and only then search. However, he cannot always know all the literature in the library, which belongs to his subject area. It would be much easier for him to choose from the list those books that he thinks will be the best, based on his expertise. Moreover, this list can be formed by the library. It is clear that with a large number of disciplines forming such lists is a time-consuming task. So it is essential to develop adaptive methods of forming a list of literature for disciplines with subsequent selection of the literature that the lecturer considers the best.

5. Conclusions

The following interrelated aspects determine the formation of quality information support of the educational process:

- development of working programs of disciplines that contain the most relevant lists of recommended literature (main and additional), which will most fully allow the student to master the material;
- acquisition of the library's educational literature collection (print and electronic), which corresponds to the lists of recommended literature from the working programs of disciplines.

Establishing effective interaction between the library and the university to create an electronic educational database involves implementing integrated data processing of adaptive support of the university's educational process with the library's information resources.

In order to form a general university system of information support of the educational process, a mathematical model of forming a list of recommended literature for the discipline based on the curriculum and a model of library support based on a list of recommended literature were developed.

The primary source of the database of educational literature is the working programs of disciplines that contain the most relevant lists of recommended literature. Working programs are the basis of the educational and methodical complexity of the discipline and the university's curriculum in general. Therefore, the lists of recommended literature from the working programs of disciplines should determine acquiring the university library's educational literature collection.

An algorithm for calculating the library's book supply index is proposed. It can be used when planning the acquisition of educational literature and accreditation of the university's educational departments.

The presented results serve as an essential component for developing an adaptive information support system of the university by integrating an automated library information system with information systems of other structural units and forming a single virtual learning information environment.

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