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## DECISION-MAKING SUPPORT INFORMATION SYSTEM FOR EVALUATION OF MASTER'S THESIS

*Digital transformation involves utilizing information technologies and digital tools to restructure the business processes and increase their efficiency. During the COVID-19 lockdown, this topic becomes even more relevant. This paper covers the digitalization of such processes as preparing the master's research work and presenting the results. We modeled a system for supporting decision-making when evaluating master's thesis based on the results of expert assessment and automated text verification for plagiarism following the regulatory documents of a higher education institution and general recommendations for observing academic integrity. This paper suggests system implementation via LMS Moodle, determines the resources for loading the master's thesis and accompanying documents, conducting peer review, organizing consulting undergraduates, and communication per the distribution of the roles. To verify texts for plagiarism, the Unichек module can be integrated with LMS Moodle. The availability of an educational environment in the universities along with the creation of a single user base will allow for implementing the proposed information system with minimal costs.*

*Keywords: information system, master's thesis, evaluation, plagiarism verification software, modeling, LMS Moodle*

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## ІНФОРМАЦІЙНА СИСТЕМА ПІДТРИМКИ ПРИЙНЯТТЯ РІШЕНЬ ПРИ ОЦІНЮВАННІ МАГІСТЕРСЬКИХ РОБІТ

*Цифрова трансформація передбачає використання інформаційних технологій і цифрових засобів для перебудови й збільшення ефективності реалізації бізнес-процесів виробництва та сфери надання послуг, що значно актуалізується в умовах COVID-19. Цифровізації окремих процесів підготовки та представлення результатів магістерського дослідження присвячено матеріали цієї статті. Нами змодельовано інформаційну систему підтримки прийняття рішень при оцінюванні магістерських робіт за результатами експертного оцінювання та автоматизованої перевірки тексту на наявність плагіату відповідно до нормативних документів закладу вищої освіти та загальних рекомендацій щодо дотримання академічної доброчесності. Визначено основні бізнес-процеси, а саме: управління користувачами, управління оцінюванням магістерської роботи, поширення результатів досліджень магістрів; здійснено їх декомпозицію за стандартами структурно-функціонального аналізу і проектування та рольовий розподіл потенційних користувачів системи. Запропоновано варіант реалізації цієї системи засобами LMS Moodle: визначено ресурси для завантаження тексту магістерської роботи та супровідних документів, здійснення рецензування, організації консультування магістрантів та комунікації суб'єктів освітнього процесу відповідно до визначеного рольового розподілу. Для перевірки текстів на наявність плагіату до LMS Moodle інтегровано відповідний модуль компанії Unichек. Технологію Learning Tools Interoperability (LTI), що підтримується LMS Moodle, застосовано для інтеграції електронних освітніх ресурсів з навчально-інформаційного порталу університету до репозитарію магістерських робіт. Зазначено, що наявність інформаційно-освітнього середовища закладу вищої освіти та створення єдиної бази користувачів дозволить як організаційно, так і технологічно реалізувати проектовану інформаційну систему з мінімальними затратами.*

*Ключові слова: інформаційна система, магістерська робота, оцінювання, програмне забезпечення перевірки на плагіат, моделювання, LMS Moodle*

### Introduction

The large-scale implementation of digital technologies is one of the conditions for higher education to reach the level of international standards. However, strengthening the university position seems challenging today due to the closed educational systems and institutions. According to the Webometrics rating [1], the attention to the universities' scientific activities and research results dissemination according to the open science and communication regulations [2] is continuously growing. The institutional repositories are among the tools for scholarly communication actively utilized by modern universities to disseminate the results of the scientific activities of both experienced scientists (teachers) [3] and beginners (masters) [4].

Placing the research works in master's thesis repositories (e.g. <https://repository.usfca.edu/thes>, <http://academysps.edu.ua/biblioteka/repozitarij-magisterskih-robot/>) ensures that the results of master's research are open in the external environment and complies with the recommendations of the Association of European Universities on open access to scientific information [5]. Also, we should emphasize the importance of undergraduates following the rules and ethical standards of academic integrity [6], since modern technologies provide for many opportunities not only for research but also plagiarism, fabrication, falsification, and other violations of academic ethics. Accordingly, the placement of master's thesis in repositories is preceded by the performance quality and design assessment, and the observance of academic integrity.

Under the conditions of COVID-19 pandemic and switching to online mode, the problem of designing an information system to support decision-making when evaluating master's thesis for plagiarism becomes even more relevant. Though developing a system that belongs to the intelligent decision-making segment [7] is a part of the digital transformation of modern universities.

#### Related Works

Quality assurance of master's training, the support and evaluation of the master's thesis are important tasks of universities and are the subjects of scientists' and teachers-practitioners' research.

The work [8] presents the experience of using ICT to improve the quality of the master's thesis. In particular, the advantages of using ICT for the implementation of basic processes are identified as:

- management: selection of supervisors, the appointment of reviewers, scheduling of master's thesis presentation and other organizational activities, plagiarism verification, reporting and evaluation of the master's thesis;
- supervision: planning and conducting meetings (consultations), exchange of information, receiving feedback;
- cooperation: self-assessment of work, interaction with the head, other masters, reviewer, administration of the university, etc.

Some aspects of students' cooperation with diploma supervisors are presented in [9]. Given the important role of feedback in master's dissertation projects, the attitude of students from the Netherlands to supervisor feedback in the context of the master's thesis can be used to improve the interaction between masters and their supervisors.

The approach which was proposed in [10] to develop institutional PDS can be used to check the text master's theses and protect copyrights because in the age of digital technology plagiarism detection services (PDS) have become an obligatory component of the Learning Management System (LMS).

Understanding the role of motivation and involvement of students in the process of preparing and presenting the results of master's research is very important. It is interesting the experience of Stockholm University in developing and implementing a specially designed network review system Peer Portal [11] in this direction. This system is fully student-control and provides direct interaction between students without the intervention of supervisors. Using this system helps students and teachers to optimize the work with the master's thesis: to improve the quality of checking; to save a supervisor time; to increase students' involvement and responsibility, to give constructive suggestions.

There are also complex solutions for providing support for the preparation and evaluation of the master's thesis. The Department of Computer and Systems Sciences (DSV) at Stockholm University has developed a SciPro learning support system to overcome problems and improve the quality of diploma project results. The authors of the study [12] identified the actual problems (dissertation initiation, supervision, presentation and evaluation of results, technical problems) and proposed a model for organization and delivering useful electronic resources in order to reduce problems in master's thesis preparation. Another example is the use of ICTSS (ICT-based support system) to support the interaction of students at different stages of master's thesis preparation to ensure the quality of thesis manuscripts, supervision, and evaluation, as well as strengthening the motivation and responsibility of masters [13]. Proposals from both pedagogical and technical aspects were developed as part of this study. The results can be scaled in different universities.

At the same time, the design of an information system to support the preparation and evaluation of master's theses is considered as a complex project containing three main components: management, technology, and education. Its implementation in a particular university depends on the available resources and competence of the participants in the educational process. In accordance with this one, the functionality and limitations of the system, as well as prospects for development are determined.

#### Purpose

This article aims to model and select software to implement the decision-support information system for evaluating master's thesis based on the expert assessment results and automated text verification for plagiarism following the regulatory documents of a higher education institution and general recommendations for observing academic integrity.

Upon the results of related works analysis and user needs, the purpose of information system for decision-making when evaluating the masters' thesis includes:

1. Organizing a digital environment to support the preparation and presentation of the research results;
2. Providing access to the university educational environment for both undergraduates, managers, scientists, and professors;
3. Outlining roles required to support the process of preparing and issuing master's papers, expert evaluation and obtaining permissions to protect their authors, and also administrating these roles;
4. Providing the educational component for undergraduate research (elective training courses and modules, MOOC recommendations, etc.);
5. Organizing knowledge sharing and communication of system users in accordance with their roles and rights;
6. Providing for automatic review of works uploaded into the system for text matches (plagiarism) and generating the reports and (if necessary) expert reviews;
7. Organizing the review process and relevant results delivery;

8. Developing the decision-making procedure to grant undergraduates admission to protection and organization of placement of protected works in the general repository.

**Proposed technique**

At the level of system functional decomposition, we outlined the main business processes:

*User management* that provides for user registration and rights distribution; creating the organizational structure of the system data and providing the users with access to certain elements of the user system per roles distribution; providing for accompanying documents for the master's thesis preparation (regulations, guidelines, etc.); organization of additional training (subject of student's choice, webinar recordings, etc.); organization of communication of all participants;

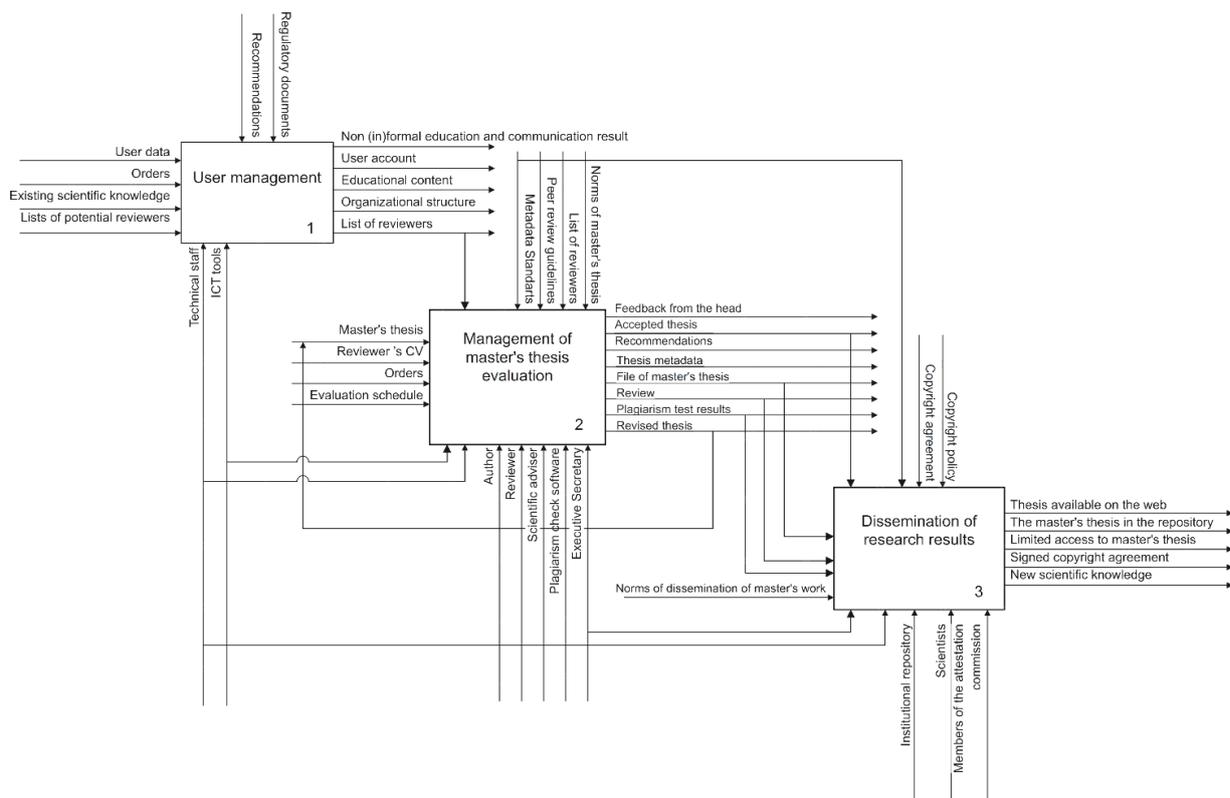
*Management of master's thesis evaluation*, which includes: loading of the thesis to the system and categorizing works by structural subdivision, educational program, year of graduation, etc.; providing for accompanying documents (regulated by the provision on the preparation and presentation of master's work in the institution), in particular, supervisor's feedback; control and submitting the review results; appointing reviewers and providing them with information on the timing and deadlines for thesis examination; monitoring of thesis assessment process; the ability to update a file following reviewer's recommendations or the control regulations;

*Reviewing thesis for plagiarism* that includes utilizing the certain service to automatically check the master's work for text matches; generating a report on review results; conducting an additional expert assessment (if necessary) - providing an expert opinion on compliance with the author's academic integrity, and recommendations for amendments and the following review;

*Review includes evaluation* of the submitted work, preparing the review template; performing peer review (in open or anonymous mode), and uploading the review results to the system;

*Dissemination of research results* preceded by: the results of the master's thesis assessment review, identifying the work status (admission to defense, the recommendation for a public review or limited access, e.g. only for members of the examination commission); archiving the thesis works; preparing metadata to upload to the master's thesis repository.

According to the SADT (Structural Analysis and Design Methodology), we chose the IDEF0 methodology (Fig. 1) to simulate the process of master's work assessment. IDEF0 and similar modeling methods that are often used to reengineer the processes - clarify the process implementation and change management [14].



**Fig.1. Model SADT walk-through of the information system for decision making when evaluating the master's thesis**

The model includes the activities of all participants involved in the decision-making process while evaluating master's thesis:

*Author* (master) upload their thesis to the system, receive alerts and recommendations on the results of the standard control and the plagiarism review; communicate with other reviewers, in particular, with the supervisor;

*Scientific adviser* upload feedback to the system, "recommend" reviewers, monitor the status of the thesis (according to the stages of checking regulatory control, plagiarism, reviews), advise masters, communicate with other participants;

*Reviewers* conduct reviews according to the proposed templates and upload them to the system;

*Executive secretary* consult undergraduates, in particular, upload the regulatory documents and methodological recommendations into the system; perform standard control (in accordance with the rules for master's thesis registration), in case of detection of text matches, perform additional reading and provide for an expert opinion; appoint peer reviewers; decide on master's admission to defense and create the orders;

*Representatives of dean's office* responsible for posting orders, master's works evaluation schedules, managing instructional materials; certification committees, etc.;

*Technical staff (admin)* responsible for managing organizational structure and databases, registering users and granting them rights supposed for their roles and positions; and also managing thesis within the repository and the accesses to viewing those works;

*Members of the attestation commission* can review all the supporting documents of the master's study, as well as reviews and test results for text matches.

The main concepts of the IDEF0 methodology are activity (implementation of main business processes) and flow. The term ICOM (inputs, controls, outputs, mechanisms) is often used to refer to flows. The examples of input in the proposed model can be the master's thesis text file, lists of potential reviewers, evaluation schedules, etc. These outputs can be reused as inputs for further activity and future feedback. Thus, the master's thesis text file approved as a result of the realization of the Management of master's thesis evaluation process relate to inputs to the Dissemination of research results process the implementation. The plagiarisms review report can be a reason to return the thesis for rework. The mentioned activities are guided and controlled. For example, the List of reviewers identified during implementation of the User management process can be used as controls for the Management of master's thesis evaluation process. However, the elements of control also include regulatory documents, the research methodology and academic ethics, licenses and copyright agreements on the research results publication, etc. Figure 1 demonstrates the diagram of the zero level, however the IDEF0 diagrams are shown in hierarchy where the actions split down into new sections providing for the structural-functional decomposition.

The main goal of modeling an information system was to understand the process of supporting decision-making while evaluating the master's thesis works and to provide a ground for the analysis of expenses and efficiency of alternative ways of organization. Concerning the process of selecting tools for the system development, we suggest that rapid deployment and configuring can be implemented based on the open-source CMS system. Also, this would significantly reduce the project expenses.

### Results

Deciding upon the tooling to build the project one should consider the software products and approaches already used in the information and educational environment of the university [15]. This allows for rapid deployment (due to available software familiar to developers), easy onboarding (users are familiar with the interface) and no need to re-enter data once uploaded to the environment (for example, students' and teachers' accounts).

For example, the National University of Life and Environmental Sciences (NULES) of Ukraine implemented an educational environment that includes a single user base (built on the basis of open LDAP), and a knowledge portal (implemented on LMS Moodle). This is why, the Moodle electronic training courses was selected to be tool for development of a decision-making information system to support access the master's thesis. This system is a free open source software that can be modified according to the development needs that is important for Ukrainian educational institution. The wide functionality and availability of third-party modules allows for effectively setting the required environment. NULES as well as many other universities in Ukraine, already utilize LMS Moodle for teaching. Also, according to an international survey 2020, this system ranks 16 among the most popular tools for teaching and studying [16].

As the basic unit of cataloging master's thesis we suggest an educational program that would require creating a separate course in LMS Moodle. The programs and courses should be combined into catalogs-faculties, where the departments can also attach documents with general information for students of the particular course. The courses would include tasks for each year. Also, these courses would allow for configuring access rights for different system users.

To avoid duplication, the key regulations, such as master's degree training and defense document, should be posted on the home page or as active links to relevant documents presented on the university's official website or institutional repositories. The documents and methodological recommendations related to research should be included in the relevant Moodle course.

Besides, undergraduates can be offered (for self-study or additional course) electronic training courses by professors of higher education institutions, mass open online courses (MOOC), recorded webinars, etc., which topics are relevant for the master's research work. An example of such a course at the NULES of Ukraine is the elective course "Scientific communications in master's studies" (<https://elearn.nubip.edu.ua/course/view.php?id=4090>), or MOOC on academic integrity (<https://mooc.uit.no/courses/course-v1:UiT+Plagiarism+English/course/>), academic writing (<https://www.classcentral.com/subject/academic-writing>), etc. To upload research works for expert evaluation

and plagiarisms review, students should use the Moodle Tasks module. This module allows each student to download their master's work in the desired format, with utilized specific terms, following the academic integrity regulations. However, to ensure the academic integrity regulations the additional plagiarism check module is integrated into the system.

The standard configuration of the LMS Moodle system doesn't include ready-made plagiarism check modules. However, this option can be provided by integrating third-party software. The official Moodle repository contains 19 modules for plagiarism check. These modules are free and open, however, their use is regulated by the subscription policy of the providers.

In our research, we use the Unicheck module for integrating text verification for plagiarism with the Moodle system produced by Ukrainian company Unicheck. This module can be installed from the official additional repository ([https://moodle.org/plugins/plagiarism\\_unicheck](https://moodle.org/plugins/plagiarism_unicheck)).

The plagiarism test from Unicheck can be performed for texts and files uploaded to Tasks, Forums, Workshops, as well as by answering the open test questions (Essays). However, the Tasks module is the most appropriate way to check master's thesis for text matches. Besides, the Tasks module allows for setting up clear deadlines for downloading work both for a specific group and for individuals. The Tasks module allows to specify how many files you want to download if the qualification work includes additional files (for example, specific schemas, charts, or, for example, loading modules with a single file). Besides, you can clearly define the preferred file formats or limit the allowed formats for a particular task. For example, you can set limitations for uploading graphics files instead of models or charts created via the appropriate tools.

To automatically check the downloaded files for the text matches, the university, should create a corporate account at [unicheck.com](https://unicheck.com). The personal account is available for any user, though it does not allow integration with third-party software.

To configure the integration with the individual Moodle server, the user must specify the addresses of the servers they want to integrate and obtain the Client key and Client secret (Fig. 2a), which, in turn, must be specified in the settings of the plug-in module in Moodle.

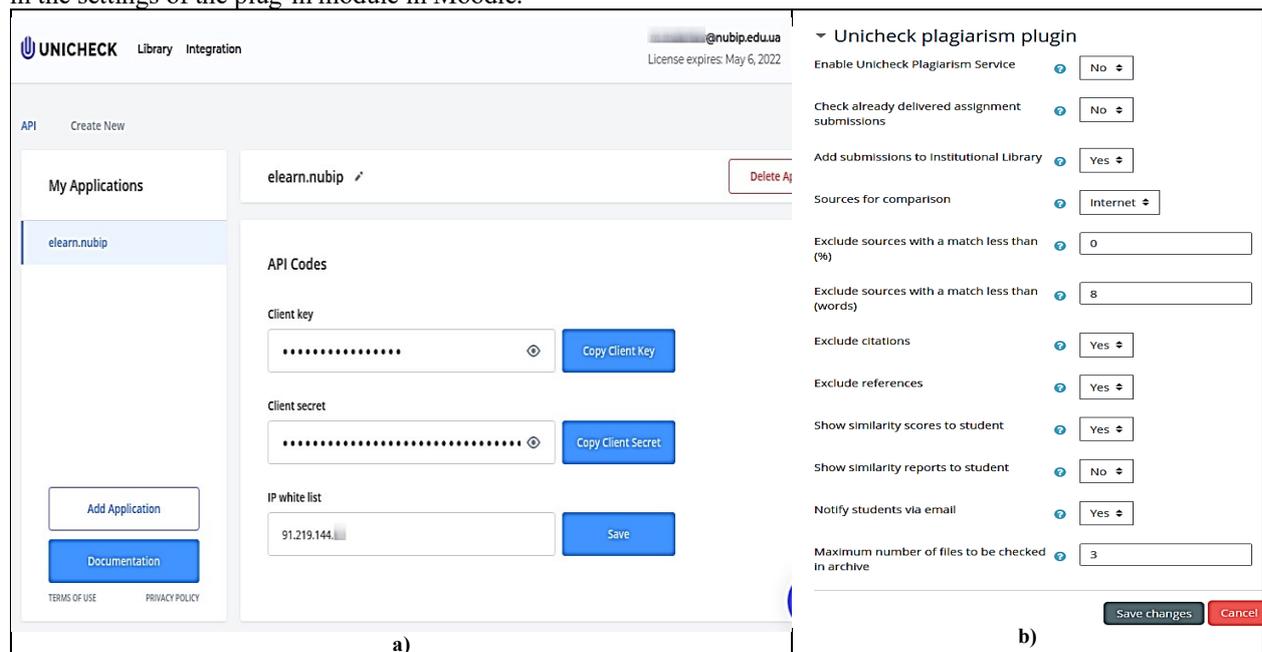


Fig. 2. Setting Unicheck and verification rules Moodle

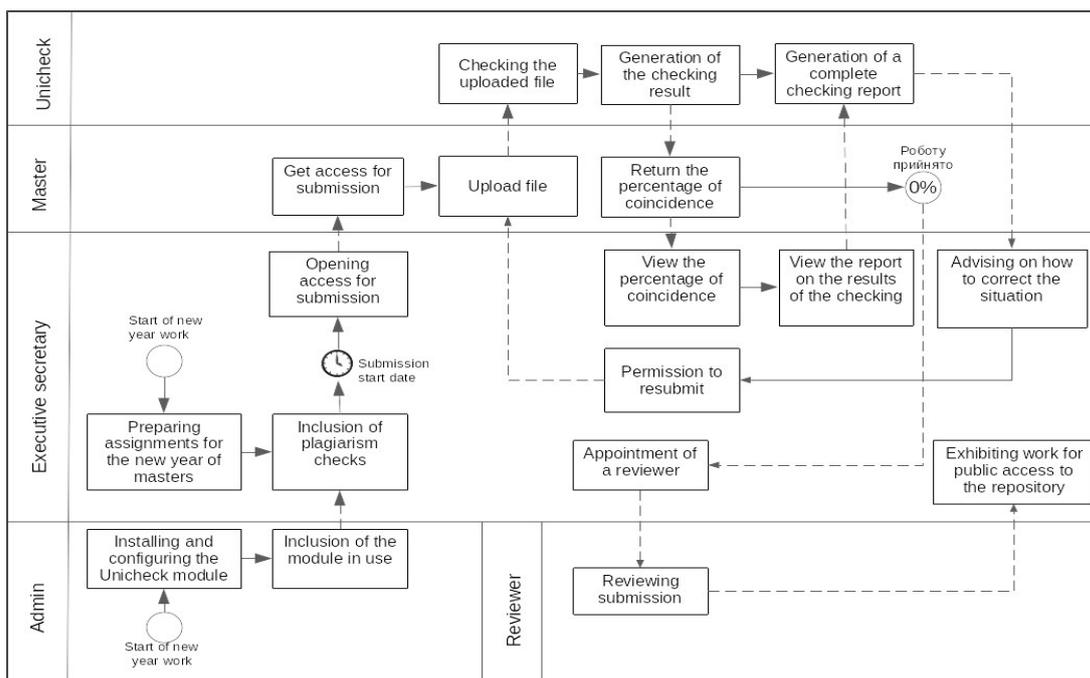
Thus, the LMS Moodle administrator has many items to fine-tune the text-match module behavior. In particular, you can define the source of the verification: search all Internet documents or create your university database in Unicheck. You can also change standard Unicheck settings and set the elements that should not be considered plagiarism or set a limit (% of text matches) for admission to master's thesis defense (for instance the requirements to describe the standard methodology or labor protection provisions) (Fig. 2b)

The Unicheck plagiarism check allows for rapidly verifying the file uploaded to Moodle, comparing it to texts on the Internet and previous thesis published in university. The verification results are available for the author (Fig. 3) and people with relevant access rights, for example a scientific adviser. The executive secretary can access the audit results and generate relevant reports. If the downloaded work requires amendments and re-check for plagiarism, the executive secretary can provide the user an additional opportunity to download the thesis. The new file will also be checked for plagiarism over time.

Unicheck Assignment									
Grading action: Choose...									
Reset table preferences									
Select	User picture	First name / Surname	Email address	Status	Grade	Edit	Last modified (submission)	File submissions	Submission comments
<input type="checkbox"/>		Nicole Betts	n.betts643@mailinator.com	Submitted for grading 74 days 11 hours late	Grade	Edit	Tuesday, 3 December 2019, 10:24 AM	Zapata_rail.docx UNICHECK ID:15000654 79.83% Report	Comments (0)
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<input type="checkbox"/>		Audrey Jones	a.jones@mailinator.com	Submitted for grading Graded	50.00 / 100.00	Edit	Friday, 13 September 2019, 4:45 PM	assignment (styles+links).docx UNICHECK ID:12080751 29.61% Report Attention	Comments (0)
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**Fig. 3. The results of verification for plagiarism**

The LMS Moodle allows assigning a reviewer in the special module in Tasks. The executive secretary of the defense commission can appoint a reviewer from the list of reviewers formed by the university order. The reviewer will receive an email with an invitation to assess the individual works. Navigating to the Downloaded Files list page, the reviewer will only see the theses assigned for their review. To review thesis according to certain criteria, the standard evaluation module of LMS Moodle is recommended. We also recommend including the Instructions. Thus, the evaluation criteria that the reviewer uses to assess the thesis and draw conclusions are prepared in advance. After the review (in case of a positive decision on the assessment and passed check for plagiarism), the executive secretary approves thesis for defense and provides the permissions for master's thesis in the repository (in the Tasks module). The general model of such work is shown in Fig. 4.



**Fig. 4. Verification of plagiarism and uploading master's thesis into repository after review**

The LMS Moodle flexible system allows for assigning the user's roles in the process be it a master, a supervisor, a reviewer, an executive secretary, a representative of the dean's office, a member of the certification group, and managing access rights. Moodle 3.9 provides 700 settings to specify access rights for different roles. Except for the default roles, the system allows for creating new roles and set required access rights. The default integration modules allow for easily embedding Moodle in the existing university educational environment. LMS Moodle supports the latest learning technology Learning Tools Interoperability (LTI) (version 1.3), which allows you to integrate into the e-course learning resources from third-party services, as well as we can act as a provider of such resources. We will use this functionality to integrate ready-made learning resources from the university's educational and information portal into the Master repository (Fig. 5). This allows you to reduce the redundancy of data in the environment, concentrate the necessary data in one place and strengthen the integration of the Master repository in

the information and educational environment of the university. Accordingly, Moodle can access the university's database that eliminates the need to re-register participants on a new resource.

In the National University of Life and Environmental Sciences of Ukraine, the user base is built on LDAP technology and connects to the internal university's educational environment: the training portal, the web-conferences portal, the portal for applicants for admission, virtual laboratories, etc. To access to user bases is encrypted with the TLS protocol, and the server is located in the university's internal private network and receives requests only from the secured servers (Fig. 5).

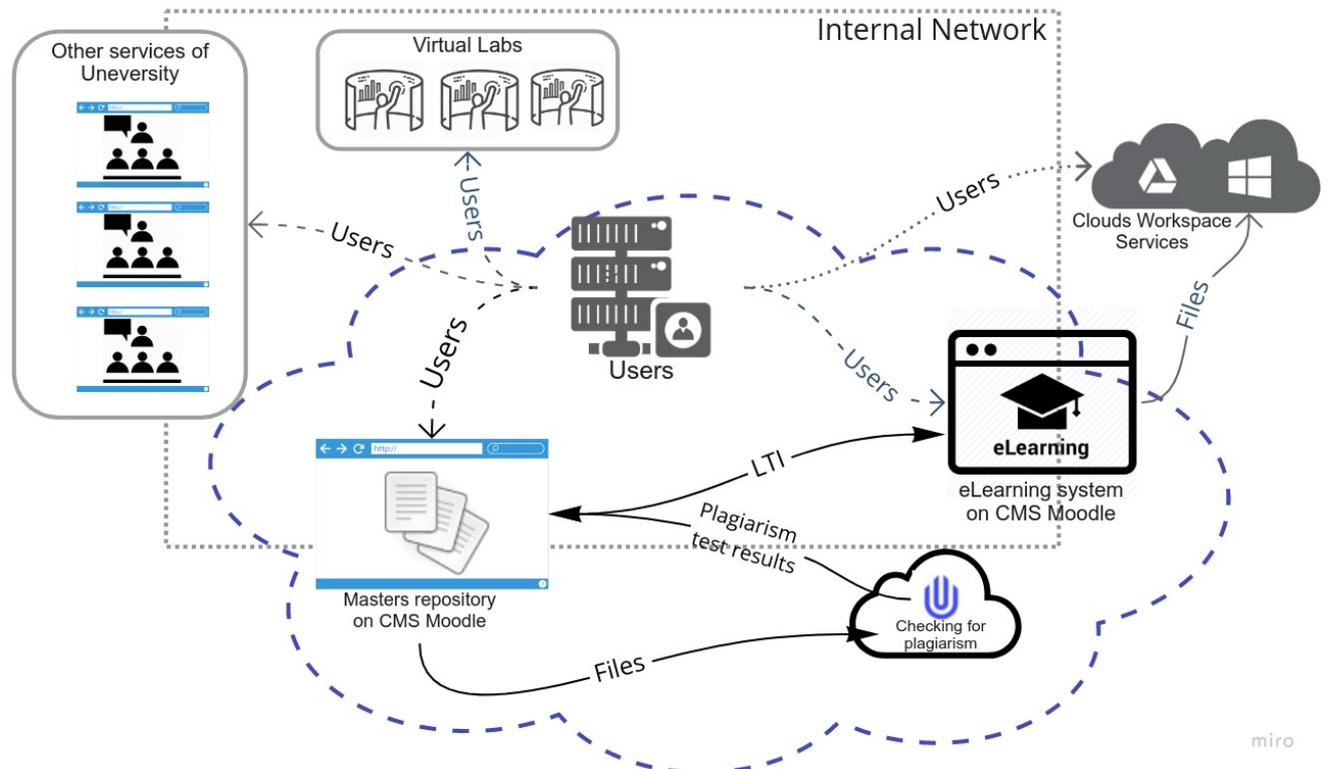


Fig.5. The architecture of the university educational environment

Currently, the National University of Life and Environmental Sciences of Ukraine user base stores has 17,667 students and 1378 teachers. This allows for designing an information system for supporting decision-making when evaluating master's thesis in 2021, and thus to expand the existing educational environment of the university.

### Conclusions

Since digital transformation involves the use of information technologies and digital tools to restructure and increase the efficiency of business processes in the industry, the development of an information system supporting decision-making when evaluating master's thesis can be considered a component of the digital transformation of modern universities.

Decisions about the functionalities, constraints, and technologies used to design, deploy, and implement such systems in a particular higher education institution depend on the resources available and the competence of the staff. With sufficient funding, universities create their own systems to support master's training, but such corporate systems are difficult to scale.

Since the higher education institutions already operate the information and educational environment with a single user base, it is easy to develop and integrate new subsystems and modules to enhance this environment. One of these subsystems is a decision support system for evaluating master's work. To implement this solution, the university chose to utilize an open-source software LMS Moodle. Since this teaching management solution is actively used in the educational process of the National University of Life and Environmental Sciences of Ukraine, it is possible to use both the electronic training courses developed by the university's scientific and pedagogical staff and third-party resources integrated into the university's educational environment.

The further development of the designed system is supposed to contribute to the digitalization of the master's thesis protection process, and the development of new modules for the Moodle platform. Considering that LMS Moodle is open-source software, this task can be completed by any programmer of the required level of qualification, who may even do that in terms of their graduation work.

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