Educational Technology Quarterly, Vol. **2021**, Iss. 2, pp. 257-273 https://doi.org/10.55056/etq.17

Structural model of a cloud-based learning environment for bachelors in software engineering

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Abstract. The article summarizes the essence of the category "model", presents the main types of models used in pedagogical research: structural, functional, structural-functional models. The basic requirements for the construction of these types of models are also given. The experience in building a model and designing a cloud-based learning environment of educational institutions (both higher and secondary) is analyzed. A structural model of a cloud-based learning environment for bachelors in software engineering is presented. Each component of the cloud-based learning environment model for bachelors in software engineering is described: target, management, organizational, content and methodical, communication, technological and effective. The model of interaction of participants of the educational process in the cloud-based learning environment is developed. Forms, methods, and tools (both traditional and cloud-based) of content and methodological components of the cloud-based learning environment's structural model that can be implemented in this cloud-based LMS are described. Forms of an educational activity (classes, practical training, independent work, control measures, as well as research work of students) are considered. The types of lectures that can be conducted in a cloud-based learning support system are described: lecture-conversation, lecture-discussion, video lecture, lecture-consultation, and lecture-presentation. The types of practical training offered in the cloud-based learning support system are described: laboratory work, workshop, seminar, and webinar. Different types of independent work and assessment are considered. The research work of students as a form of educational activity provided by the curriculum of bachelors in software engineering is singled out. The main teaching methods that can be implemented using a cloud-based LMS to support the training of bachelors in software engineering are considered. It is generalized that the cloud-based learning environment should solve all the main tasks facing higher education institutions.

Keywords: model, structural model, cloud-based learning environment, bachelors in software engineering

1. Introduction

Information and communication technologies play a significant role in the educational process because they not only fulfill the roles of the tools used to address specific pedagogical issues, but also because they offer qualitatively new learning opportunities, encourage the advancement of methodology and didactics, and support new educational paradigms. Cloud technologies are one of the most important trends in contemporary information technology.

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With the use of cloud technology, higher education institutions may manage distance learning, create libraries of books, instructional aids, textbooks, media files, keep electronic journals, use online services for the educational process, assess knowledge online, set up video conferencing, and more.

The issue of training highly skilled professionals in a variety of specialities, including bachelor's degree holders in software engineering, becomes crucial in the context of modernizing the higher education system. A bachelor in software engineering studies various programming languages, programming technologies, software development technologies, software testing technologies, learns to design collaborative projects and work on them in a team, etc. as part of their professional training. As a result, it's crucial for software engineering bachelor's students to interact effectively when using cloud technologies.

2. Related work

When theoretical approaches to the design of cloud-based learning environments (CBLE) were considered [32], it was discovered that the design and usage of cloud-based learning environments paid attention by Bajwa and Wu [1], Belahcen, Abik and Ajhoun [2], Hernández Rizzardini, Amado-Salvatierra and Guetl [8], Hinon [10], Lin et al. [18], Masud and Huang [22], Popel and Shyshkina [25], Wolfschwenger et al. [33]. Analyzing the approaches to the creation of the CBLE model, it is investigated that the issues of creating a model of the cloud-based learning environment are considered by Hinon [9], Jeong and Hong [12], Kim and Yoon [14], Lytvynova [21], Moreira and Ferreira [24], Shyshkina [30], Striuk and Rassovytska [31], Zhang et al. [34].

In particular, Striuk and Rassovytska [31] offers model of cloud-based learning environment, where it is considered as a set of educational, communication, and learning environments, based on traditional and cloud-based structural components. The researchers considers the communication environment as a set of such structural components: students, teachers, traditional and cloud-based learning tools. According to Striuk and Rassovytska [31], the learning environment contains a communication environment, together with the content, goals, methods, and forms of the learning organization. This model of CBLE provides for the use of traditional and cloud-based tools, methods, and forms of learning that complement each other. Striuk and Rassovytska [31] emphasizes cloud-based learning technologies such as Wiki, e-learning resources, social networks, and learning management systems.

Lytvynova [21, p. 100] takes into account the four primary components of the CBLE component model for a secondary school: spatial-semantic, semantic-methodological, communication-organizational, and target.

According to Bykov [5], innovative pedagogical technologies should be developed and integrated into the educational process, along with electronic courses, e-learning materials, computer-based systems for evaluating students' progress, a social network for educational purposes, etc.

The following components of the educational environment are defined in [4]:

- A study group or numerous groups that interact directly with students and in collective (group) forms of learning and extra educational activities carried out by students comprise

the *student-group component*.

- The *teaching component* regulates the educational process, which is aimed at achieving educational objectives.
- The *system of teaching aids* includes a set of information and material objects that can be used effectively and securely in the learning process.
- The *educational institution component* comprises of the funding and equipment system.

According to Lytvynova [20], the components of a cloud-based learning environment should have a flexible structure that allows them to adapt to the particular of the setting as well as the demands of teachers and students. Each teacher has the option of designing an educational environment for a given course or module, taking into account students' skills and academic accomplishment levels.

Rassovytska and Striuk [26] consider CBLE to be a component of the educational and scientific environment of higher education institutions, and they propose a general CBLE model of teaching computer science courses that is based on traditional and cloud-based structural components and is viewed as a collection of educational, communication, and learning environments. Teachers, students, and traditional and cloud-based learning tools are structural components of the communication environment. The communication environment, as well as the content and goals, methods, and forms of learning, are all part of the learning environment. The educational environment consists of a collection of learning environments (including all of their components) and educational industry standards.

Lytvynova [21, p. 100] also examines the CBLE secondary school component model, which is organized into four primary components: spatial-semantic, semantic-methodological, communication-organizational, and target. Furthermore, all components determine the content of CBLE and should ensure the activities of all educational institution participants in the educational process.

3. Results

The *purpose* of this paper is to provide a structural model of a cloud-based learning environment for software engineering bachelors. To build the structural model, it is necessary to define the concept of "model".

Modeling is an essential component of educational research since it is used to explain and study numerous processes such as patterns of development of the education system, learning environments, and so on [19, p. 52].

According to Kremen and Bykov [16, p. 7], designing a learning environment entails theoretically exploring the essential target and content-technological (methodological) aspects of the educational process that should be carried out in the learning environment, and then describing the composition and structure of the learning environment required for this (its statics and dynamics, including foreseeing and taking into account the development of the educational environment's structure, and the influence of the educational environment's structure).

It could be argued that the purpose of the theoretical study of the educational environment is to develop a model that will provide an idea of the educational environment in which all participants in the educational process will cooperate and communicate.

Gumenuk [7] understands the model as an "artificial object in the form of a scheme, physical structures, symbolic forms, or formulas that, while similar to the studied object (or phenomenon), reflects and reproduces it in a simpler and more generalized form in terms of structure, properties, and relationships between its elements" [7, p. 55].

Thus, *building a model of a cloud-based learning environment for bachelors in software engineering* entails simulating this process by developing a plan that reflects the goal, structure, circumstances, and operating principles of the system as a whole.

It is important to note that the same processes or phenomena might have multiple models. As a result, we present the characteristics of the many models utilized in educational research.

A *structural model* graphically depicts all of an object's structural properties [19, p. 53].

A *functional model* is a model that provides an opportunity to examine the functional aspects of a certain process and to assess its significance in relation to all internal and external components [19, p. 53].

Given that the model must be understandable, thorough, accurate, and applicable to all situations [19, p. 54], as well as after examining the key scientific papers on the subject, we generalized and presented the following structural model of a cloud-based learning environment for bachelors in software engineering (figure 1).

The learning environment is a system that was purposefully created, and its components and structure work together to create the conditions needed to accomplish the objectives of the educational process. The learning environment's structure also governs how its components are arranged internally and how they interact with one another [16, p. 10]. The proposed model (figure 1) is focused on achieving learning objectives (*target component*), which are reflected in the industry standards of higher education.

The CBLE for bachelors in software engineering must perform the following functions in order to meet the learning objectives:

- *management* over the educational process for training bachelors in software engineering;
- *organizational* – the organizing of the actual learning process through the sharing of access privileges and the sharing of subject communities;
- *teaching* – submission of training materials, as well as practical and laboratory work;
- *advisory* – delivering online consultations to students and student groups;
- *communication* – the possibility of communication between subjects, the presence of subject-subject interaction, and the use of the feedback mechanism;
- *controlling* – the availability of an electronic journal and the capability of online work assessment;
- *developing* – development of information and communication competencies of students;
- *systematizing* – systematization of the content.

These functions are made possible by the management component, organizational component, content and methodological component, communication component, and effective component of the CBLE for bachelors in software engineering.

3.1. Management component of CBLE for bachelors in software engineering

In the higher education educational process, the management component offers the use of cloud-based learning management systems and cloud-based learning assessment tools. The

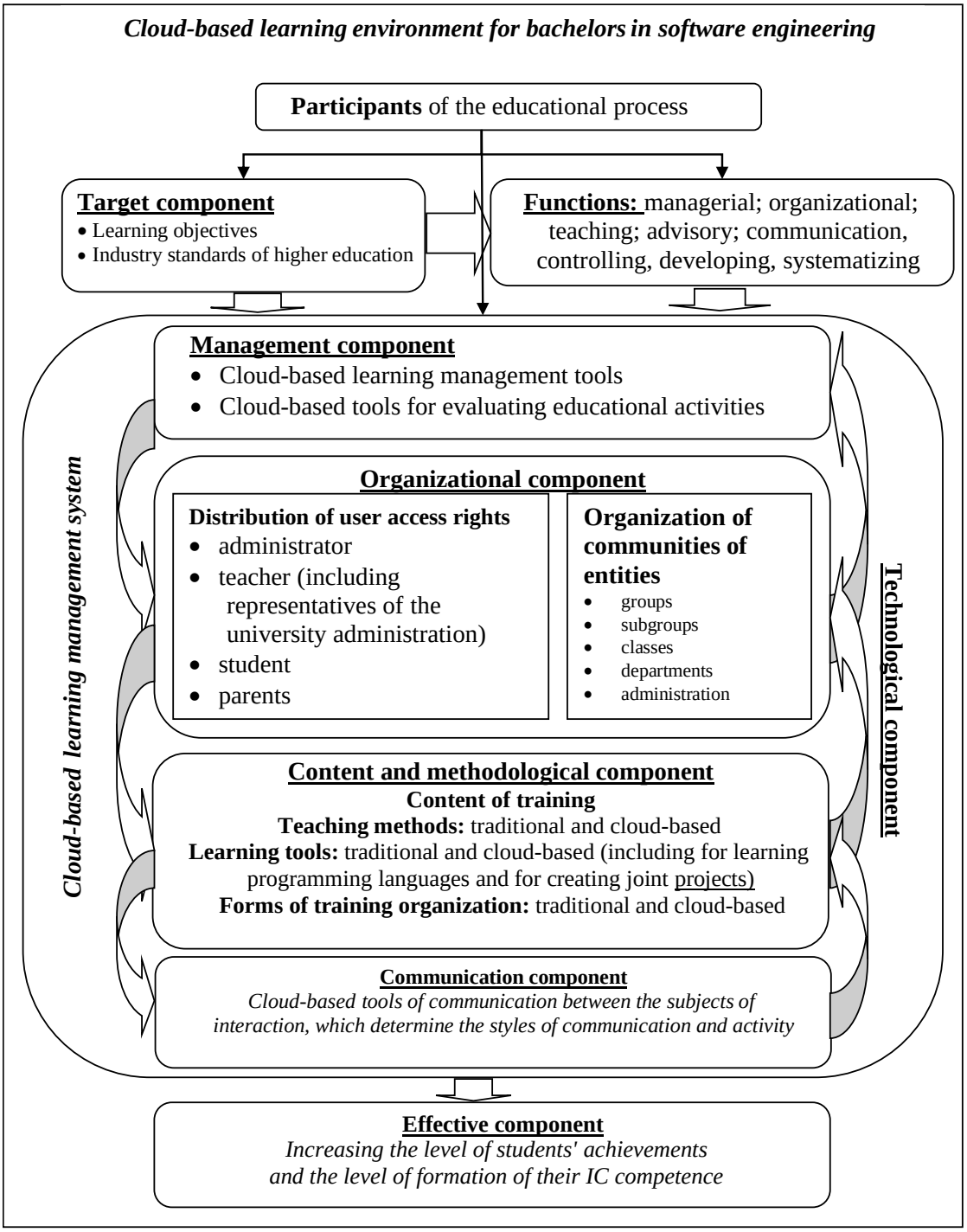

Figure 1: Structural model of a cloud-based learning environment for bachelors in software engineering.

courses included in the curriculum for bachelor's degrees in software engineering should also be defined under this component.

The CBLE for bachelors in software engineering provides opportunities to manage the learning activities of the students, including tests, lab work, group projects, and independent work.

3.2. Organizational component of CBLE for bachelors in software engineering

The allocation of user access permissions is necessary for the CBLE for bachelors in software engineering to operate successfully. Administrators, teachers (including those from the HEI administration), students, and parents are examples of such users.

It should be noted that each user group only has restricted access to the CBLE itself. Only the administrator has the most access rights. Parents and students may be permitted to read or download a range of instructional resources.

The CBLE for bachelors in software engineering provides each instructor with a personal cloud-based office where he can store all the resources required for effective and high-quality instruction, including curricula and work programs, textbooks, manuals, lecture materials, instructions for laboratory work, prerequisites for tests and exams, guidelines for the course and diploma theses, etc.

Because of its cutting-edge capabilities, instructors may give students access to all the materials they need to complete group assignments, individual tasks, research projects, etc.

Communities of CBLE participants should be organized for the sake of the educational process' quality level. Groups, subgroups, courses, departments, and administration are examples of such communities.

Keep in mind that each subgroup of students must be present for specific sorts of classes to be conducted as part of the educational process at higher education institutions (either class in computer classes, where limited equipment, or foreign language classes, which involves the division of students into smaller subgroups).

Students who are enrolled in a single course make up the course community. Even students from various groups could be included.

There should be a separate community of teachers of one department in the created CBLE bachelors in software engineering because the department's administration should tell instructors working in one department of a higher education institution about important news.

The following types of documentation must to be created, organized, and made accessible to the department's instructors in the CBLE for bachelors in software engineering:

- both at the national level and in university-level *normative-legal papers*;
- *curricula* for bachelors in software engineering;
- *recommendations on how to construct* the educational and methodical complexes of the course.

All the relevant elements should be considered while building this component, including the class calendar, deadlines, departmental work plan, announcements, discussions, contacts, etc. Additionally, it is recommended that the CBLE have internal communication tools (a sort of own social network), a forum (to involve in the discussion of all participants in the educational

process) and other features given the cloud technology. The construction of photo albums for groups and departments, which would include materials from all events occurring at the HEI, is another positive development.

The administration must be present in order to supervise instructors' productive and effective activities during the educational process. The administration oversees the conformity of the educational materials placed in the CBLE with the curriculum for all courses, as well as the compliance of the available courses in the CBLE to the bachelor's in software engineering curricula.

3.3. Content and methodological component of CBLE for bachelors in software engineering

Learning objectives influence educational material, which in turn influences the methods, technologies, and organizational forms used in higher education.

The content of the CBLE for bachelors in software engineering complies with all educational theories, higher education industry standards, and bachelor's degree software engineering curricula.

Each element of the methodological system is split into traditional and cloud-based components in this instance. It is crucial to get software engineering bachelors ready for their future careers by teaching them how to construct collaborative projects and study various programming languages.

It should be emphasized that in the higher education educational process, teaching aids supplement traditional ones. We shall comprehend the learning tools implemented with the aid of cloud technologies by the term "cloud-based tools".

The balance of traditional and cloud-based learning methods and organizational structures is influenced by the adoption of cloud-based learning tools. We shall comprehend such techniques and structures under the heading of "cloud-based methods and forms of training organization". These techniques and structures are implemented in the educational process using a cloud infrastructure.

As was already discussed, it's critical to develop collaborative projects to train software engineering bachelor's students. The planned CBLE for bachelors in software engineering offers this kind of activity in its entirety.

The proper selection of methods, forms, and learning tools (cloud-based and traditional) in accordance with the objectives of a specific course promotes the development of students' cognitive abilities, creative and logical thinking, skills to apply acquired knowledge in practice, and the formation of necessary professional competencies, including information and communication (IC) competence for the use of CBLE as a component of the professional competence of bachelors in software engineering.

3.4. Communication component of CBLE for bachelors in software engineering

Participants in the CBLE communicate with one another both directly and through cloud-based communication tools.

The diversity of communication channels is crucial to the communication component. They are both synchronous and asynchronous, according to Kienle [13]. Synchronous communication entails simultaneous interaction of participants at the same time, whereas asynchronous communication entails independence from the time of interaction.

Designing a cloud-based learning environment is impossible without building a model of interaction between students and teachers in a cloud-based learning environment.

Lytvynova [21] considers the component model of CBLE for secondary school. Shirehjini et al. [29], Zheng and Louie [35] discussed the student-professor and student-student online interaction with cloud-based technology.

Figure 2 illustrates the model we suggest for how learners interact with one another while learning in a cloud-based learning environment.

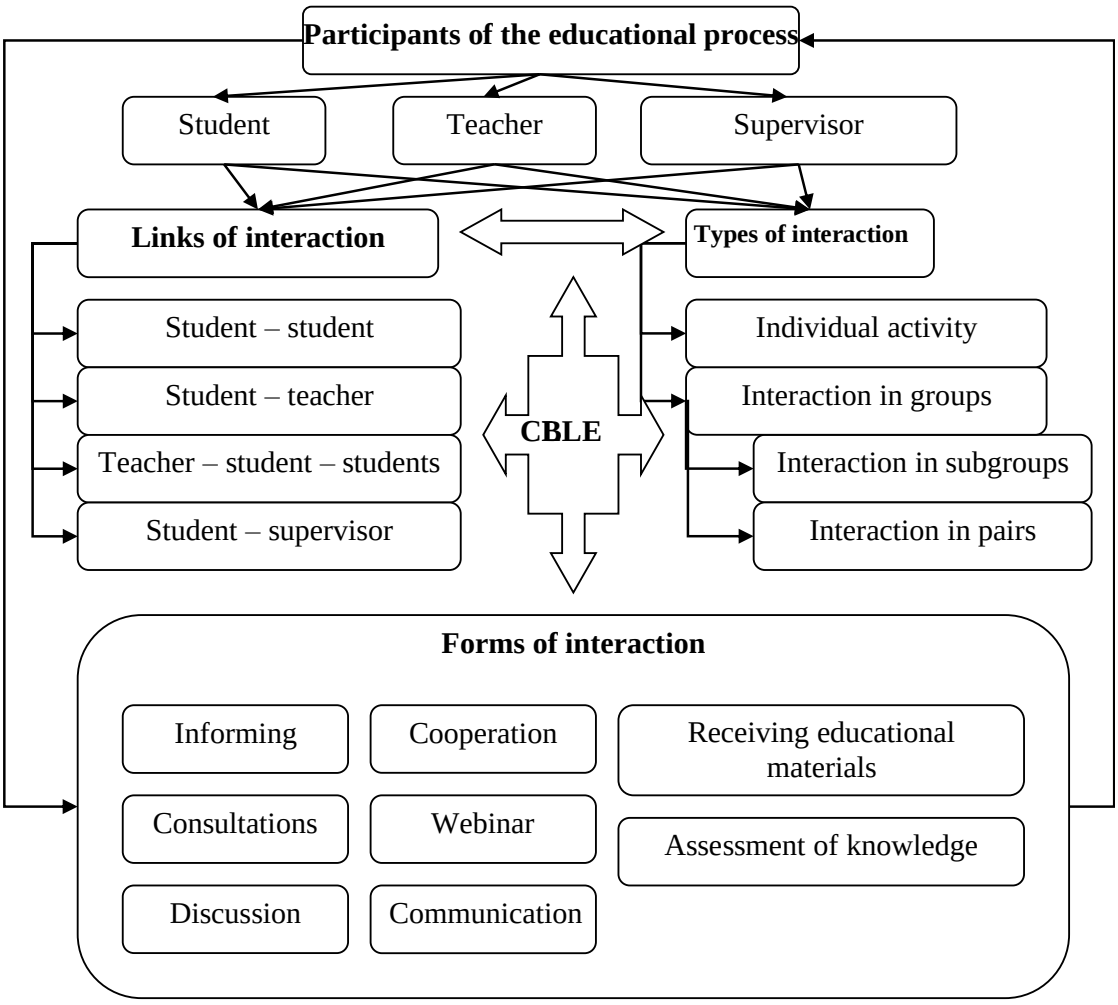

Figure 2: Model of interaction between students and teachers in a cloud-based learning environment.

It is important to first decide the subjects of interaction before thinking about how learners

would interact in a cloud-based learning environment. The student, the teacher, and the supervisor are the subjects of interaction in our case.

Since the curriculum of higher education institutions includes tasks like writing term papers and thesis, in which the supervisor assumes the major role, it should be highlighted right away that the supervisor is chosen.

Since the curriculum of higher education institutions includes tasks like writing term papers and dissertations (papers), in which the supervisor assumes the major role, it should be highlighted right away that the supervisor is chosen by a distinct organization.

The connections in the CBLE — student-student, student-teacher, teacher-student-student, and student-supervisor — are determined by the subjects of interaction. Keep in mind that one of the factors influencing the educational process is the contact between the teacher and students, student and students. In the end, everything depends on the interpersonal interactions with both the teacher and the students.

Different links of interaction cover different types and forms of interaction. In particular, the following types of interaction are distinguished: individual activity, interaction in groups, which is divided into interaction in subgroups, and interaction in pairs.

In the CBLE, students work individually on tasks (individual work), collaborate on projects, interact with other students in pairs or smaller groups to debate issues, and engage in mutual learning. They also interact with other CBLE participants who have registered for the course (interaction in groups).

Information, consultation, discussion, cooperation, webinars, getting training materials, knowledge assessment, and group communication are the key ways that subjects of the educational process interact in the CBLE. Interactional forms and types are closely related.

As a result, a teacher using the CBLE has the opportunity to let students know about a specific event through the addition of news and calendar events, respectively. Students can use the calendar events to plan their schedules, and they will be informed of breaking news that the teacher posts for a specific subgroup or group of students. The supervisor can specifically let the students in the problem group know about the exceptional meeting and other things.

A teacher in a particular subject or a supervisor for writing an article or course (diploma) project may be consulted for clarification on any questions the student has.

Another important form of interaction is discussion, where students and the teacher (supervisor) are equal subjects of learning. With the help of discussion, a discussion generates the formation of one's own opinion and the opportunity to defend it in a subgroup, group, or team. This is closely related to the form of group communication. Students can communicate through correspondence, chats.

Students frequently require assistance from their peers and teachers when conducting laboratory work. Collaboration is a wise course of action in this situation. Students gain personal attributes like camaraderie and the capacity to work as a team when they cooperate.

The CBLE uses a type of communication like a webinar for its online workshops for challenge groups. This is a very useful opportunity during the holidays, quarantine, etc.

There is an opportunity to get educational materials for effectively studying the subject (lectures, theoretical information, literature, etc.). Additionally, it is a type of instructional contact, which is essential to the overall success of education.

The learning process cannot take place without interaction between CBLE participants, which takes the form of knowledge assessment. Because of this, the CBLE offers this type of interaction for adding to the electronic journal and assigning a grade for a particular topic.

Noting that dialogue, brainstorming, discussion, and debate are the primary ways of communication, it should be noted that their utilization transforms the CBLE learning process into mutual learning, where students and teachers are equal partners in learning

3.5. Technological component of CBLE for bachelors in software engineering

The technological component contains interrelated management, organizational, content and methodological, and communication components and is realized via a cloud-based learning management system.

A cloud-based learning management system (cloud-based LMS) is a platform that enables shared access to educational activities and group communication between teachers and students while also developing, managing, and disseminating learning materials.

Any methodological system of learning involves the use of forms, methods, and learning tools in addition to taking learning objectives and content into account [28]. We outline the forms, methods, and tools (both traditional and cloud-based) of the content and methodological component of the structural model of the cloud-based learning environment (figure 3), which can be used in this cloud-based system to support a bachelors in software engineering.

The curriculum for a bachelor's degree in software engineering is included in the content component, which also takes into account how normative courses are taught in a cloud-based learning environment.

Classes, hands-on instruction, individual work, control activities, and student research projects are all examples of educational activity types included in the suggested model.

According to [23], one way that the educational process is organized in a higher education institution is through lectures. The CBLE conducts lectures as part of training program. In particular, CBLE for software engineering bachelors offers the ability to use cloud technologies to conduct a lecture-conversation, lecture-discussion, video lecture, lecture-consultation, and lecture-presentation:

- During the lectures-conversation, the teacher communicates with students, discussing a certain topic in the form of dialogue. In particular, when taking the courses "Programming basics" and "Object-oriented programming", which are required for bachelor's degrees in software engineering, students gain a better understanding of the types of errors that can occur, the stages of the testing process, as well as what to look out for when testing programs, etc.
- A teacher plans the student opinion exchange during the *lecture-discussion* at predetermined times in between finished logical portions [15].
- A *video lecture* is a lecture delivered through a cloud-based LMS in the form of prerecorded, edited video material that is available for students to study at any time. Students who study independently or miss class due to illness can benefit greatly from this style of lecture.

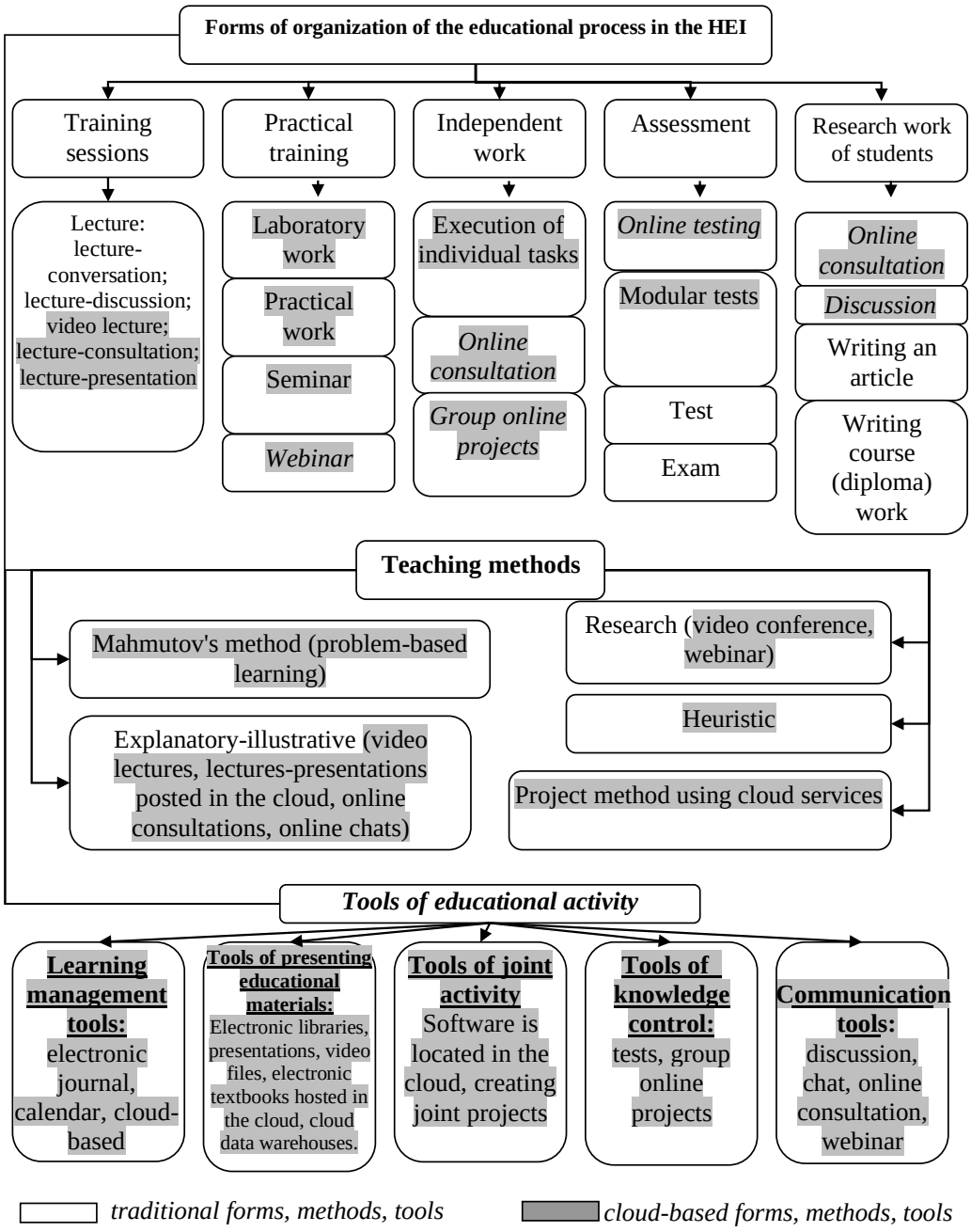

Figure 3: Forms of organization of the educational process, methods and learning tools in CBLE.

- A *lecture-consultation* is when the teacher presents information, focusing solely on the most important topics, and the students ask questions. The teacher then responds to each question fully [17]. This style of lecture is offered by cloud-based LMSs because to the ability to process theoretical material during downtime utilizing cloud technology and to

hold discussions with students about the material they have been studying.

- The instructor creates a *lecture-presentation* and uploads it to a cloud-based LMS. A lecture-discussion, lecture-conversation, or lecture-consultation can be combined with this kind of lecture. Multiple lecture formats combined together improve student learning.

Practical training includes such types of educational activities as laboratory work, practical work, seminars, and webinars. All of these types are supported by the CBLE for bachelor of software engineering. Additionally, this approach makes it possible to communicate with the teacher about laboratory and practical assignments without the use of additional tools. The enclosed report is available for the teacher to see and comment on. Naturally, this is very helpful for students who study independently, and for those who attend courses, there is also a form called the defense of laboratory work, where students must defend their report and respond to teacher inquiries. The defense of laboratory work is conducted online for students who are following a customized study schedule. The time and date for the defense of laboratory work are determined by the instructor.

A webinar is a method for holding conferences and other events online. The fact that CBLE can interface with cloud services like ClickMeeting, which offered services training for this kind of educational activity, is important to note.

It is possible to implement many types of control measures in cloud-based LMS. In instance, online testing gives students the chance to demonstrate intermediate control of a subject by taking an online test and receiving a mark. The cloud-based LMS for bachelors in software engineering enables the creation and administration of assessments both inside and outside of the teacher-designated classroom time. As a result, the estimation for the previous exam is instantly presented in cloud-based LMS.

You can ask questions with the following types of answers in a cloud-based LMS: correct/incorrect, one correct answer, multiple correct answers, fill in the blanks, free answer, answer as a number, and to determine compliance.

When taking the course over several semesters, intermediate control is implemented. The cloud-based LMS shows the average student grade for the whole course of study, which, if the right number of points are earned, counts as a grade point average.

Exam is a kind of final control. If the student is satisfied with the received rating (the arithmetic mean of all course grades), the exam can be taken and the grade for the exam automatically calculated. The student's grade is also automatically shown in the cloud-based LMS, and if it meets the highest value allowed, the student may be exempt from the exam.

The university's curriculum for bachelor's degrees in software engineering includes additional instructional activities like student research projects and term paper authoring (thesis). As previously indicated, a cloud-based LMS gives students and the supervisor the opportunity to communicate online.

Within the cloud-based LMS, the supervisor has the option to form a problem group with his students, where he may post updates and assign various tasks to them.

Writing a scientific paper is specifically required at the Zhytomyr Polytechnic State University for students in order to receive the highest score for a course (diploma) project. For this reason, the instructor offers tips to students on how to write articles and assists with writing by leveraging communication via a cloud-based LMS.

The following teaching methods are usable in CBLE for bachelors in software engineering:

- The utilization of video lectures, lectures-presentations, additional illustrative materials uploaded to the cloud, online consultations, and conversations in online chats enable by *explanatory-illustrative* method.
- In *problem-based learning* (Mahmutov's method), the teacher creates a challenging situation to encourage students' independent work. [3]. Situations when collaborative problems must be solved are provided with the opportunity to do so in cloud-based LMS.
- In *research-based learning*, the instructor plans the students' exploring and creative attempts to solve new, unusual situations [27]. A cloud-based LMS offers video conferences and webinars to adopt this strategy.
- The goal of *project-based learning utilizing cloud services* is to help students improve their cognitive and creative abilities, as well as their capacity to use cloud services to navigate the information space, autonomously build their knowledge, and think critically [11]. This approach works effectively when combined with problem- and research-based learning to help students develop their creative skills more fully.
- In a *heuristic method*, the instructor proposes to resolve an unusual problem. Students gain new knowledge and skills through reasoning [6].

The forms of organization of educational activities are closely related to both teaching methods and tools of educational activities.

The following cloud-based tools are provided as tools of educational activity in CBLE: learning management tools, tools of presenting educational materials, tools of joint activity for creating collaborative projects, tools of knowledge control, and communication tools.

3.6. Effective component of CBLE for bachelors in software engineering

The effective component envisages high-quality and uninterrupted operation of the CBLE, increasing the level of knowledge, skills, and abilities of students, as well as the formation of information and communication competence of bachelors in software engineering.

According to the suggested model, the created cloud-based learning environment for bachelors in software engineering should best address the challenges facing higher education institutions: planning the educational process in accordance with various curricula and educational models (full-time, part-time), organizing the educational process, organizing research projects, submitting educational and methodical materials, ensuring interaction between all stakeholders involved in the educational process in the HEI, giving information to teachers and students in various fields, ensuring the distribution of user access rights, community organization, and providing management of the educational process of training bachelors in software engineering.

4. Conclusions

As a result, we have broadened the definition of the category "model". There are three basic categories of models discussed: structural, functional, and structural-functional models. The fundamental prerequisites for building such models are listed. The cloud-based learning

environment's structural model is offered, and each of its elements — target, management, organizational, content and methodical, communication, technological and effective — is discussed.

The use of the CBLE in the educational process, which offers communication, educational interaction, cooperation, etc., is important for a better and more successful outcome of students' educational activities.

Future plans include developing a process for creating a cloud-based learning environment for bachelors in software engineering as well as a methodological framework for doing so.

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