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Implementation of adaptive learning at higher education institutions by means of Moodle LMS

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Abstract. E-learning courses have become popular means of delivering knowledge to students in higher education institutions. Most participants of learning process note that they benefit from the possibility to gain knowledge regardless of time, location and device they use. Among other advantages possibility to return to learnt material several times, divide material into parts, consume information through different types of educational materials (video, infographics, presentations, text, quizzes etc.) are mentioned. At the same time most of the surveyed students chose that they lack personalization both of materials and studying process, limited in terms of fulfillment and would like to have a choice of the level of study. The educational trend that is able to put into practice the above mentioned requirements is blended learning as it has a range of advantages such as usability, consideration of individual abilities, additional materials introduction, activities monitoring. Although it combines offline and online learning, effectiveness of e-learning courses designed for its implementation play a crucial role. To make a learning process correspondent to the students' needs adaptive learning can be introduced in higher education institutions. Adaptive learning is a methodology that allows to identify level of students' knowledge and their learning styles and transform materials, tasks and ways of their delivery according to the needs of learning process participants. LMS Moodle offers different solutions for adaptive learning. They provide administrators and teachers with tools to vary all stages of a learning process starting with delivery of information and ending with assessment.

1. Introduction

Utilization of digital instruments in educational process changed approach to learning of both teachers and students considerably. The concept of blended learning was developed which gave students more autonomy and requires increasing independency at the same time. Having implemented blended learning technology, its online part allows choosing place and time of performing tasks, planning own studying schedule, returning to studied material if needed, but that also requires from teacher's preparation of high quality learning materials and providing students with access to the materials. These changes correspond today's students' inquiry for digitalization of education and partly satisfies the needs in personalisation of educational process. However, most higher educational institutions still have unified learning materials which do not consider students' learning styles, knowledge level difference, needed depth of study, time frameworks for the course completion etc. Therefore, implementation of adaptive learning remains one of current HEI's tasks. Special attention from this perspective must be paid to electronic learning courses (ELC) as self-study process has rapidly been moving online during the recent decade, and electronic learning courses has become the basis for extracurricular work for both extramural and intramural programs. Thus, studying tools that allow adapting and personalizing ELCs



for students' individual needs is relevant today. That is why in Borys Grinchenko Kyiv University attention is paid to research on e-learning based on e-content utilization including e-learning courses and electronic collaboration (e-collaboration) of all educational process participants, particularly adaptivity in LMS Moodle and implementation of advanced digital technologies into educational process. Specialized solutions for adaptive learning such as Smart Sparrow, Alta, DreamBox, ScootPad are offered today for educational institutions, but they are only gaining their popularity and are not included into top 200 tools for learning in 2019 (<https://www.toptools4learning.com>). Moreover, their implementation in higher educational institution requires additional financing. Therefore, it is early to talk about wider usage of such solutions, and HEIs have to look for ways to implement adaptive learning with the systems they have already been using. One of such popular systems is Moodle LMS. That is why the task of this article is to analyze the ways of adaptive learning implementation using Moodle LMS.

2. Literature review

American psychologist and behaviorist B. F. Skinner who is considered to be a founder of personalized (adaptive) learning, stated in his book "The Technology of Teaching" that one of effective ways of teaching is dividing material into small parts and adapting learning tasks to current level of students' knowledge [40]. Elements of adaptive learning were reflected in works of Hermann Astleitner and John M. Keller [3], B. Bloom [4], Volodymyr I. Bondar and Iryna M. Shaposhnikova [6], Lee J. Cronbach [12], Harold E. Pashler [33] and others. With the development of informational technologies educational process has shifted online. That led to appearance of such notions as "blended learning" and "electronic adaptive learning". In particular, research on blended learning was conducted by scientists Nadiia M. Boliubash [5], Olga V. Bondarenko [7], Donald Clark [10], Charles Dziuban, Patsy Moskal, Constance Johnson and Duncan Evans [13], Charles R. Graham and Jared Stein [19], Volodymyr M. Kukhareno [23], Nataliia Morze and Liliia Varchenko-Trotsenko [27] Anthony G. Picciano [35], Kateryna V. Polhun [36], Natalya V. Rashevskaya [38], Heather Staker and Michael B. Horn [41], Kaye Thorne [43], and implementation of adaptive learning by digital means was studied by Peter Brusilovsky and Christoph Peylo [8], Vatcharaporn Esichaikul, Supaporn Lamnoi and Clemens Bechter [16], Pavlo I. Fedoruk [17], Meg Coffin Murray and Jorge Pérez [28], Ok-choon Park and Jung Lee [32], Pedro Paredes and Pilar Rodríguez [31], Serhii M. Pryima [37], Lex van Velsen, Thea van der Geest, Rob Klaassen and Michaël Steehouder [44], M. L. Zueva [45] and others. Among the tools for implementation of adaptive learning in HEIs a learning management system is noted. One of such systems that gained popularity in universities due to its flexibility and free distribution is Moodle LMS. That makes the question of implementation of adaptivity elements in Moodle relevant and many researchers have paid attention to this topic in recent decade among whom there are Gökhan Akçapınar [1], Valentina Caputi and Antonio Garrido [9], Deborah Couëdelo [11], Aleksejs Jurenoks [21], Vladislav Kukartsev, Ekaterina Chzhan, Vadim Tynchenko, Oleslav Antamoshkin and Alena Stupina [22], Linawati, NMAE Dewi Wirastuti and G. Sukadarmika [24], S. Nikitopoulou, E. Kalabokis, Z. Asimakopoulos and A. Apergi [29], Mark Rollins [39], Herman Dwi Surjono [42] and others.

3. Theoretical background

Prior to integration of any innovative tools and methodologies into educational process of a HEI the factors that influence the effectiveness of the process, satisfaction of all participants must be analysed as well as tendencies in educational technologies on international level. One of promising educational technologies according to "NMC Horizon Report: 2018 Higher Education Edition" [15] is adaptive learning – adaptation of content and choice of means for its implementation according to the needs of educational process participants to increase the effectiveness of activities. Personalization of the approach to learning cannot be made without understanding educational technologies implemented in HEIs as well as students' learning styles, habits and preferences. Thus, taking into consideration global tendency of shifting from a classroom learning to online learning many universities use blended learning to adapt a learning process to current educational process requirements.

Under such conditions a teacher is able to use innovative technologies such as mobile learning, gamification, storytelling, formative and peering assessment etc. This helps to vary the ways of delivery information to students and make learning process more flexible and corresponded to their needs.

According to the results of the survey of Borys Grinchenko Kyiv University students (<https://forms.gle/nZsjMtT6wEmvrSVk8>), where 119 students of 4 different fields of study took part, the respondents prefer the following sources of knowledge (fig. 1): electronic learning courses, mobile applications, video channels, social networks, googling, MOOCs, e-books.

What digital learning instruments do you prefer?

119 answers

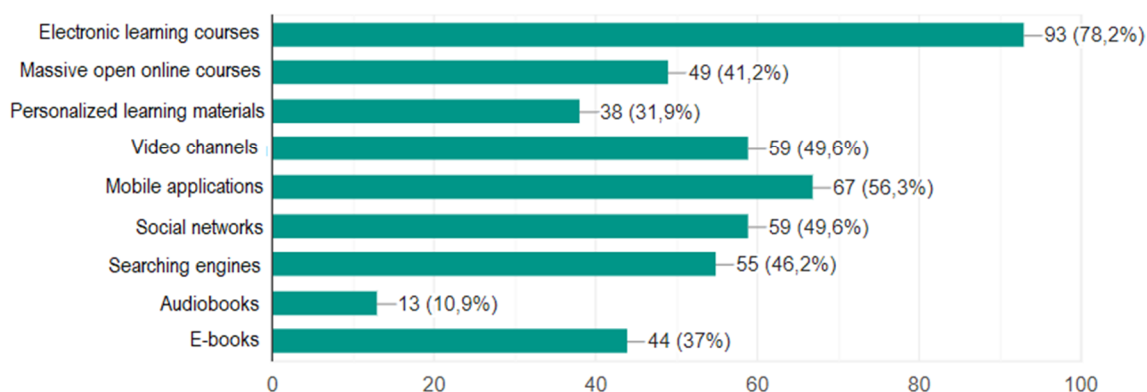


Figure 1. Students’ preferences of digital learning tools (own survey).

Thus, we can sum up that students prefer structured online resources. An effective solution is using e-learning and distant educational technologies; standardization in e-content and electronic learning environment development and global transition from Learning Management Systems (LMS) to Training Management System (TMS) [26]. The surveyed students noted the following advantages of e-learning as possibilities to choose time for learning, perform tasks online, separate tasks into parts for completing them, return to mastered material and availability of various formats of materials (figure 2).

At Borys Grinchenko Kyiv University e-learning system is used. Please mark advantages of using e-learning courses:

119 answers

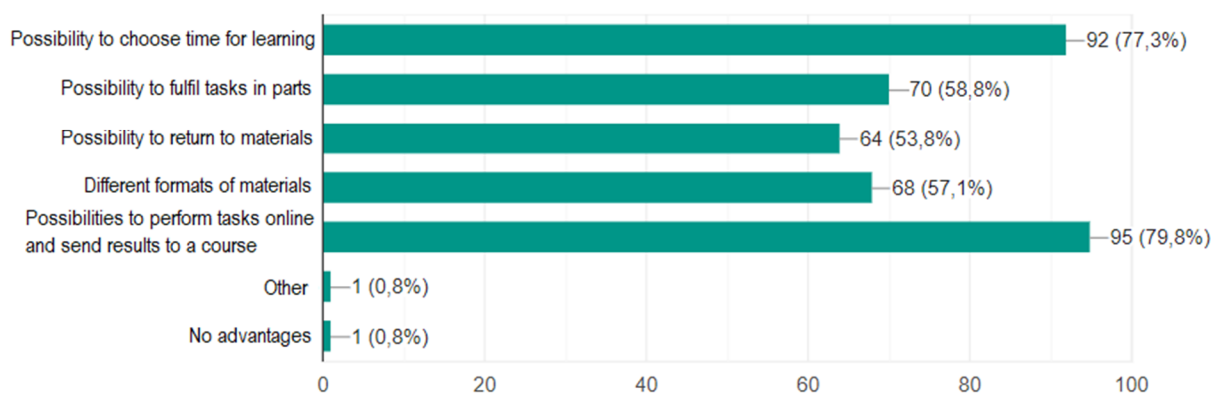


Figure 2. Advantages of e-learning courses (own survey).

Thus, e-learning courses (ELCs) provides adaptation of learning process to some level. However, unified ELCs do not fully cover students' request for individual approach to learning. In particular, the respondents of the survey noted among the main disadvantages of ELCs restrictions in time given for the course, lack of consideration of different learning styles in the choice of materials. A part of surveyed students also marked as negative factors lack of learning process personalization and unification of quizzes (figure 3).

Mark disadvantages in utilization of e-learning courses:

119 answers

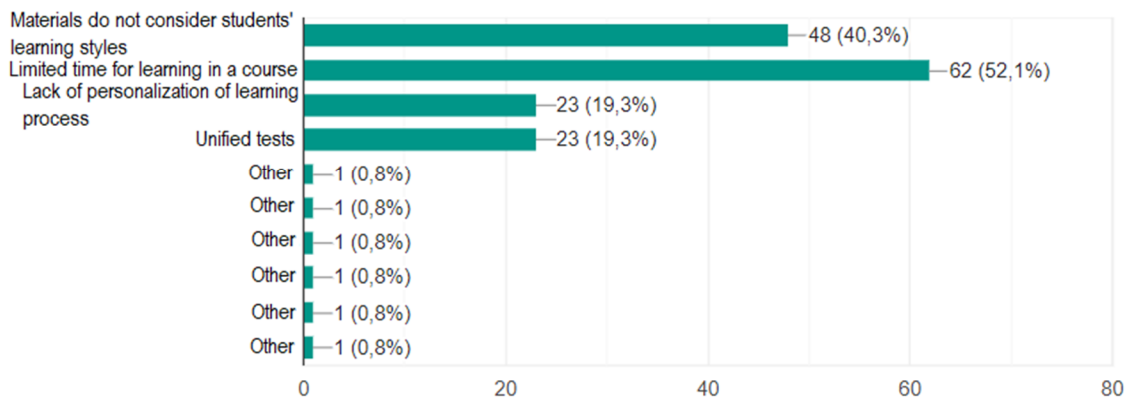


Figure 3. Disadvantages of e-learning courses (own survey).

Designers of e-learning courses face the need to consider users' requirements to provide better education results. The main challenges according to the results of the survey are providing various formats of materials delivery, offering terms of study choice, dividing quizzes and tasks into different levels of difficulty as well as providing courses at various difficulty levels in general, giving options of choosing sequence of study. Satisfaction of these needs is possible through implementation of adaptive learning (figure 4).

Mark what can improve quality of e-learning courses:

119 answers

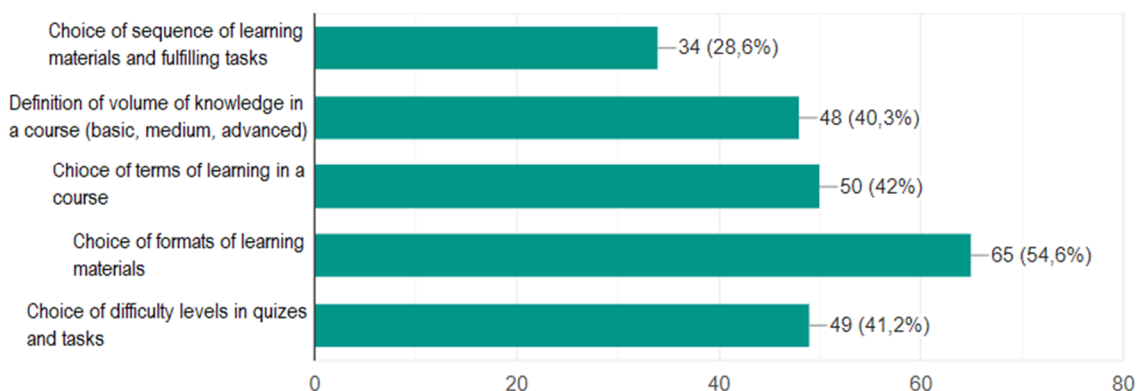


Figure 4. How ELCs can be improved (own survey).

Adaptive learning is a methodology that involves periodic information gain about knowledge level, learning styles of students and configuration of learning resources, tasks and assessment accordingly.

The aim of adaptive learning is to provide students with the means to acquire information according to their training needs and cognitive peculiarities. Requirements to adapted learning materials are formed considering aims of educational process. Current level of students' knowledge is to be taken into consideration as well as difference in learning styles and individual needs. One of the tasks of an educational institution is to provide the same effectiveness of educational process for the students who are new to the academic field and those who have prior academic experience.

Adaptive learning tools are technologies that are able to synchronize with learning process and being based on machine learning technologies can adapt to the progress of each student and change learning content in real time without outside help. Adaptivity can be displayed in one or several elements of technology: content, assessment, sequence [14].

Adaptive content means providing learning materials in the format that allows students to move their own educational trajectory. Adaptive content is fulfilled through contextual help, content splitting, separation of material into parts, possibility to choose volume and format of material. For example, in the process of an online lecture students' level of knowledge can be assessed with the help of questions and a student can be directed back to the part of information which is not mastered enough or they can be allowed to skip some part of information as mastered before.

Adaptive sequence involves automated choice of relevant content, difficulty level and order of studying the material on the basis of learning activities analysis. The tools with adaptive sequence are the most complicated ones as they analyse data, form and change individual trajectory of a student in real time simultaneously.

Collecting data is not limited to accumulation of information about right and wrong answers. To design an individual learning trajectory adaptive software considers many different indicators such as accuracy of answers, number of tries, use of additional tools, interests of a student (e.g., which subjects they prefer).

Adaptive sequence is implemented in three steps: collecting data, analyzing it and adjusting a sequence of the material layout to the needs of the student. The main advantage of a learning tool with adaptive sequence is filling existing gaps in knowledge. If a student missed a class or did not master it enough and now it complicates learning new material, the sequence of tasks and topics changes. A student initially fills the gap in his or her knowledge and afterwards moves to current topic.

Adaptive assessment means that any question depends on the answer to a previous one. The better it is, the more difficult tasks are given afterwards; and vice versa: if it is difficult for a student to answer a question, the tasks will become simpler until the student acquires the knowledge. Adaptive assessment tools are usually used for periodical monitoring once in a few months. students receive a relatively sizable quiz task to check the level of material acquisition during a module, a semester etc. After a monitoring data is analysed and the results are used for further correction of the program and of individual learning trajectory of each student. That is why one of the advantages of adaptive assessment is detailed statistics.

One of the ways to implement the above mentioned elements of adaptive learning is introduction of specializes complex solutions (systems, platforms, software) like Smart Sparrow, Alta (by Knewton), DreamBox, ScootPad and others.

Smart Sparrow (<https://www.smartsparrow.com>) is an educational platform which offers adaptive and interactive learning solutions. For implementation of **adaptive sequence** it uses designed adaptivity and algorithmic adaptivity. Designed adaptivity is a method that provides a teacher with tools to create a sequence to lead a student through the content with the best result. The model is programmed to react to a student's feedback and change a sequence according to their needs including offering advanced materials for well performing students and slower pace for those who cannot master materials in short terms. Algorithmic adaptivity is based on estimation of a student's current level of knowledge and definition of next required learning experience. The platform offers also options for **adaptive content** and **adaptive assessment**. The main idea behind Smart Sparrow solution is to provide students with as

much personalized learning experience as possible giving educators pedagogical freedom in planning their courses. Learning analytics is one more tool to evaluate students' performance and to customize courses to their needs and learning abilities.

Alta (<https://www.knewton.com/why-alta>) is adaptive learning courseware offered by Knewton company. The software strongly relies on real time analytics tools which help to **manage content and sequence** of a course. The main idea is to help student perform the best in their courses by revealing their gaps in the process of assignments completion and providing them with materials to fill in the gaps. Being concentrated on sequence and content, the solution claims that formal assessment is not required to direct learning process, as the software evaluates students' performance in the process of tasks completion. However, learning objectives have to be chosen to build a learning trajectory.

DreamBox (<https://www.dreambox.com>) is an example of an adaptive solution for a very specific market. It is focused on providing schoolchildren with math knowledge. Adaptation of learning trajectory is assured through constant formative assessment and adjusting instructions and offered materials according to the results of the assessment. In terms of **adaptive content** level of difficulty, number of hints, tempo and **sequence** of materials are chosen for each individual student on the basis of their previous performance.

ScootPad (<https://www.scootpad.com>) offers adaptivity at several levels: adaptive diagnostic, adaptive practice, just-in-time lessons, automatic remediation and automatic assessment. The platform allows to combine automated and teacher-driven activities. The main focus is on **adaptive sequence** that is aimed at mastering topics where gaps were detected in the assessment process.

The above mentioned solutions are able to cover an educational institution's needs in adaptivity of learning process. However, they require solid investments as well as integration with existing learning management systems. That is why HEIs might consider possibilities of implementation adaptive learning elements with the means already used at a particular university. One of such examples can be LMS Moodle which is popular among educational institutions as it is open source, can be customized and offers a lot of different solutions for various learning purposes.

LMS Moodle offers fragmentary solutions for all types of adaptive technology - sequence, content and assessment. However, we have to consider that adaptivity is not the only task of the system. Implementing different adaptive elements in an electronic learning course, we must take into account tasks of a particular course, ways it is delivered to students and students' needs in personalization. Utilization of blended learning makes it easier to structure an e-learning course and define how it can be adapted. The model below (figure 5) determines the stages of e-learning course design and implementation including those ones where adaptivity can be offered as well as highlights the resources of Moodle used to materials and tasks. These resources will be analyzed below in terms of adaptivity.

The important stage in the implementation of the model is determination of intended learning outcomes (ILO) that could be based on Bloom's taxonomy [4] modified by Lorin W. Anderson and David R. Krathwohl [2]. According to the taxonomy there are six levels of cognitive skills: remembering, understanding, applying, analyzing, evaluating and creating. In blended learning system remembering and understanding – lower levels of cognitive skills – are achieved through out-of-class activities which require only familiarization with the materials. Whereas analyzing, evaluating and creating – higher levels of cognitive skills – are mainly formed during in-class activities. This kind of determination might be helpful in defining learning levels and their further utilization in adaptation of content, sequence and assessment (figure 6).

At the stage of determining ILOs the criteria for evaluation of students' knowledge and skills initial level and of their learning styles are determined to be used for further choice and graduation of learning materials. In Moodle LMS that can be implemented with the help of Feedback, Quiz or Survey activities.

The **Feedback** resource provides an opportunity to create a survey with different types of questions including multiple choice, yes/no, short text answer, numeric and other types of questions which are suitable both for identifying learning styles, levels of knowledge and for level of satisfaction definition during the learning process. The resource allows reviewing statistics data in the form of diagrams, tables and downloading them for further working out.

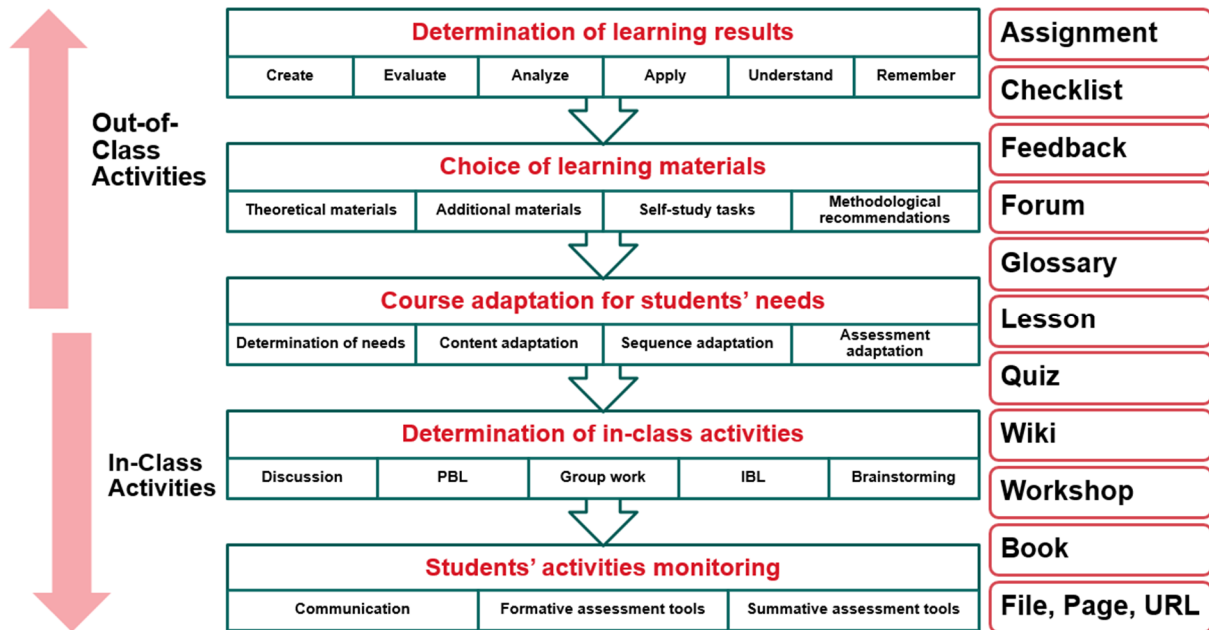


Figure 5. Model of blended learning implementation in e-course.

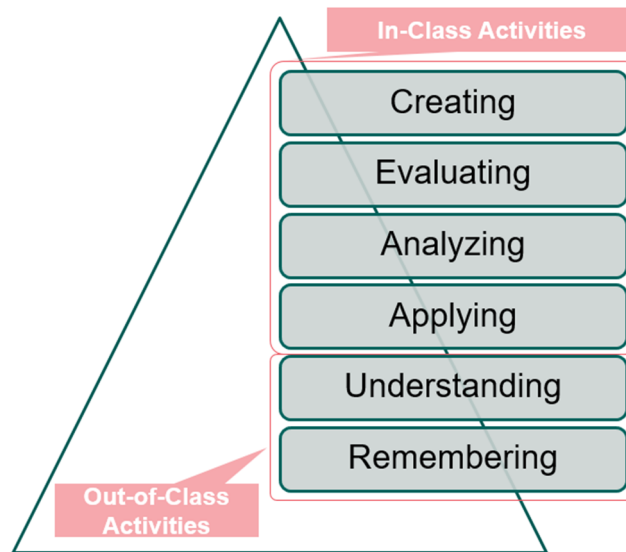


Figure 6. Utilization of flipped learning [20] and Bloom’s taxonomy [27].

The **Quiz** resource allows ranging students’ levels of knowledge using standard tests. With the option *Overall feedback* the borders for each level of knowledge are set up and a student receives a corresponding feedback after passing a quiz. For example, students with the results higher than 80% could be offered to take an advanced course, those who have their results between 60 and 80% get standard course, and the students whose achievements are under 60% will be offered a basic course.

The **Survey** resource can help to evaluate the collaborational level of a group using *Attitudes to Thinking and Learning Survey* (ALLTS) option. This allows estimating optimal ratio of individual and group work in a particular group.

At the second stage of implementation of the above mentioned model a teacher prepares learning materials according to the determined ILOs. At this stage adaptation of e-learning course is being fulfilled.

In the process of adaptation of learning materials students' learning styles ought to be considered, for example, using VARK model [18].

Activities of Moodle LMS allow simultaneous utilization of different types of materials to provide better information acquisition by students with different learning styles (figure 7).

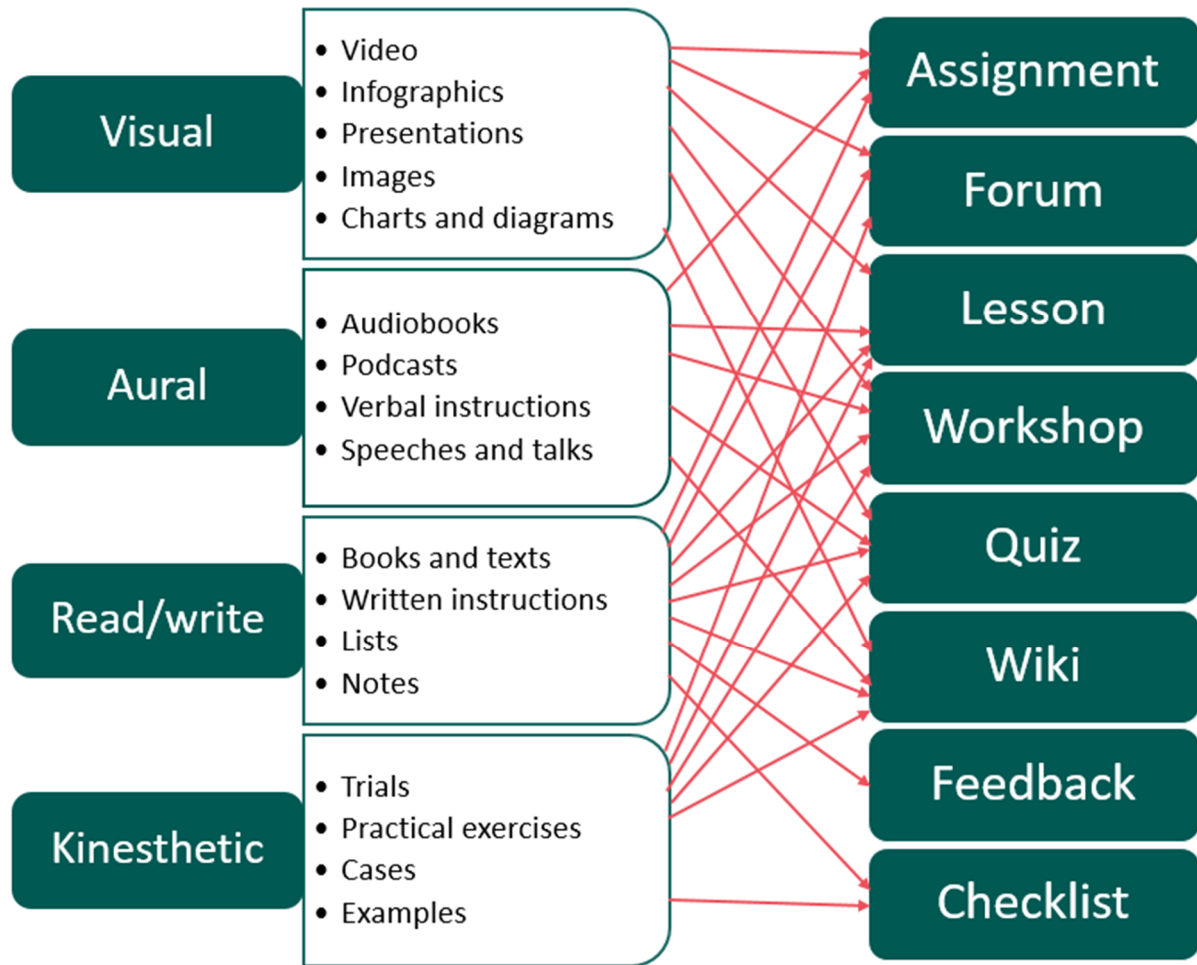


Figure 7. Utilization of Moodle activities for preparation of learning materials using VARK model.

A teacher can create groups of users in an ELC according to their learning styles if required, and then assign correspondent groups to different added activities. That means that every student will see individually assigned materials.

Let us have a look at the scheme of possible adaptive sequence in an ELC (figure 8).

A teacher can use **Lesson** activity to provide consequent theoretical materials (that is a set of pages with lecture materials) or to organize learning activities where different trajectories of a lesson are offered using transactions between pages, adding extra clusters and pages with questions (multichoice, matching, short answer questions, etc.) (figure 9). Depending on student's answers and the way a teacher uses Lesson activity, a student can either go to the next page or return to the previous page or be directed in other way that correspond student's needs.

If it is required, a Lesson can be assessed, designed in different difficulty levels, and can be a part of adaptive assessment.

Lesson	Assignment, Workshop	Quiz
<ul style="list-style-type: none"> Pages branching system design with different options of passing a lesson <ul style="list-style-type: none"> Minimal level Medium level High level Advanced level Additional materials 	<ul style="list-style-type: none"> Transmission to a task depends on the level of a lesson passing Limitation of passing score Depending on the gained score transmission to different level of a test 	<ul style="list-style-type: none"> Quiz passing depends on the score level for practical tasks Different quiz modes (using hints, etc.)

Figure 8. Scheme of adaptive sequence example.

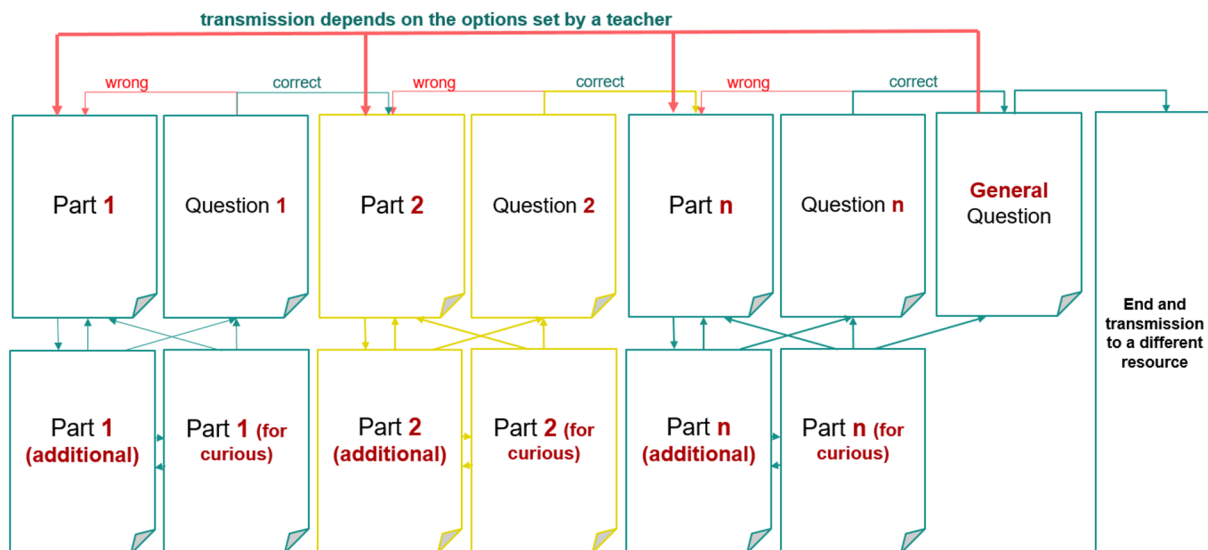


Figure 9. Logical scheme of an adaptive lesson.

A type of the lesson can be chosen by a lecturer depending on the educational needs and the way it will be used – for support of in-class activities or for self study.

One of the tools that can be helpful for implementation of adaptive materials, in particular, assessment is a **Quiz** as some options in the quiz resource allow students not only to answer questions, but also interact with the system, impact possible frameworks of getting a note.

Design of such questions is provided with the help of the option **Question behaviour** that is used to choose test passing mode by students. Let us go into details about the quiz modes.

The modes **Adaptive mode** and **Adaptive mode (no penalties)** allow students to make many tries before going to the next quiz task. That is if a student is not sure about the answer, it's possible to check it during the quiz and change the answer. However, during the second and following attempt a note will be calculated including penalties set up by a teacher. Adaptivity of assessment using these modes is in giving students choice whether they want to check correctness of an answer and change it, which will lead to decreasing of the overall score but at the same time lower the risk of failing a particular test.

Using the mode **Interactive with multiple tries** a teacher can provide students with hints to help them answer the questions. As soon as a student provides a correct answer, a hint is not offered. When a student used all available hints for a question, the latest answer is marked as either incorrect or correct including the penalty for using hints and feedback is provided. A student can have different feedback after each try. The number of attempts is limited to the number of hints plus one. Utilization of such

mode gives students choice whether to use hints for regulation of their results or not. Using hints increases the possibility of choosing correct answers but makes it impossible to gain maximum score.

In the mode **Deferred feedback with Certainty-based marking (CBM)** or **Immediate feedback with CBM** a student not only answers a question but also marks the level of certainty in percentage. The classification of the answers is adjusted depending on the level of students' certainty. That means if they answered correctly, but it was just a guess about the correctness of the answer, their score can vary from 1 to 0.33 points. If students answered wrong, but showed high level of confidence in their answers, their score can be adjusted from 0 to -2 points.

Adaptivity of assessment using this mode is in the fact that students can get different marks depending on their level of certainty in their knowledge. A student is able to decrease the percentage of confidence consciously which lowers the risk of receiving a negative score, but at the same time makes the highest possible score also lower. Utilization of the mode motivates students to estimate their level of knowledge objectively and stimulates to pay attention to problems and solve them unlike traditional testing.

The Quiz activity can also be a part of adaptive sequence of an e-learning course as with its help depending on the score of a student they can be offered different feedback and directed to different parts of the course if some materials require revision or deeper learning.

The assignment activity module allows teachers to design tasks, collect students' answers, assess them and provide feedback on them. With the help of this resource adaptive assessment can be implemented giving students tasks of different difficulty levels based on their previous answers.

That means the activity can be used for collecting and traditional assessment of students' activities at all stages of a learning process. Students are able to send any type of digital content (files) such as text documents, spreadsheets, pictures, audio and video files. In addition, students can be allowed to input answers in a text editor in an e-learning course. Tasks also might be used as a reminder for students about activities which must be done during in-class lessons.

At the stage of defining results of students' in-class activities attention should be paid to achieving ILOs aimed at developing higher levels of cognitive skills. While choosing tools for students' activities monitoring a teacher defines how different types of communication among students and between students and a teacher will be implemented.

Considering all above mentioned information, Moodle LMS provides teachers with possibilities to implement personalization and adaptation of educational process tasks.

4. Conclusion

Adaptive technologies have both advantages and disadvantages. Among the advantages there are productive learning and accurate recommendations for every student. The disadvantage is that they require much more time for implementation compared to traditional learning and adaptive technologies do not solve the problem of knowledge usage in real life.

To introduce adaptive learning in the learning process of higher educational institution specialized solutions can be used. However, Moodle LMS which is already implemented at many HEIs offers wide range of options for a teacher to plan and implement adaptivity in the process of an e-learning course design at all levels - adaptive content, adaptive sequence and adaptive assessment. In the centre of this process there is a teacher who can choose the ways of implementation understanding peculiarities of students and their educational needs and learning styles. That is why the main task in implementation of personalization and adaptive learning is training lecturers, as their role is no more limited to mechanical knowledge giving and testing, but requires design of practical and creative tasks, project supervision and help with time management. That is why educational process with implementation of adaptive technologies emphasises the role of teachers even more.

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