TransLeader: Models of Adaptive Learning in the Area of High Education in Ukraine (A3.5)

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Abstract: This paper explores the implementation of adaptive learning models in Ukraine's higher education institutions, emphasizing the central role of mentors—tutors or teachers—in tailoring educational experiences to meet diverse student expectations, needs, and learning styles. The study demonstrates how adaptive learning can be effectively integrated into existing learning management systems (LMS) like Moodle. The research outlines the stages of adaptive learning implementation, including the initial stage, pre-test stage, path generation stage, learning stage, and post-test stage, showcasing Moodle's functionality in facilitating these processes. A key element of adaptive learning highlighted is microlearning, where content is divided into smaller, easily navigable units that address individual educational requirements while allowing for flexible updates. Components such as Moodle's Lesson and Quiz tools exemplify how student knowledge can be developed and assessed dynamically within this framework. The work was conducted as part of the TransLeader project (2023-2-PL01-KA220-HED-000179445), namely, activity A3.5, which integrates technical expertise in AI and IoT with leadership training to create an innovative curriculum. The findings underscore the feasibility and effectiveness of adaptive learning approaches in enhancing personalized education through widely adopted LMS platforms.

Keywords: Adaptive Learning; Higher Education in Ukraine; Moodle LMS; Micro-learning; TransLeader Project

TransLeader: Modele adaptacyjnego uczenia się w obszarze szkolnictwa wyższego w Ukrainie (A3.5)

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Streszczenie: Niniejszy artykuł analizuje wdrażanie modeli uczenia się adaptacyjnego w instytucjach szkolnictwa wyższego w Ukrainie, podkreślając centralną rolę mentorów – tutorów lub nauczycieli – w dostosowywaniu doświadczeń edukacyjnych do zróżnicowanych oczekiwań, potrzeb i stylów uczenia się studentów. Badanie pokazuje, w jaki sposób uczenie się adaptacyjne może być skutecznie zintegrowane z istniejącymi systemami zarządzania nauczaniem (LMS), takimi jak Moodle. W pracy przedstawiono etapy wdrażania uczenia się adaptacyjnego, w tym etap początkowy, etap testu wstępnego, etap generowania ścieżki, etap nauki i etap testu końcowego, ukazując funkcjonalność Moodle w ułatwianiu tych procesów. Kluczowym elementem uczenia się adaptacyjnego jest mikro-nauczanie, w którym treści są dzielone na mniejsze, łatwe do nawigacji jednostki, które odpowiadają na indywidualne potrzeby edukacyjne, jednocześnie umożliwiając ich elastyczne aktualizowanie. Takie komponenty, jak Lekcja czy Quiz w Moodle, ilustrują, jak wiedza studentów może być dynamicznie rozwijana i oceniana w tym modelu. Praca została przeprowadzona w ramach projektu TransLeader (2023-2-PL01-KA220-HED-000179445), a konkretnie działania A3.5, który łączy techniczną wiedzę z zakresu AI i IoT z szkoleniami z zakresu przywództwa, tworząc innowacyjny program nauczania. Wyniki podkreślają wykonalność i skuteczność podejść adaptacyjnych w rozwijaniu spersonalizowanej edukacji za pomocą powszechnie stosowanych platform LMS.

1. Introduction

In the contemporary era, marked by constant technological progress, higher education emerges as a fundamental pillar for social development and national success. Education becomes the foundation for social progress, improvement of the world order and improvement of the quality of life. Modern educational models must take into account the socio-economic requirements of society and provide [1]:

Personality development: education should contribute to the harmonious development of the personality, supporting the reproduction of social, national and world cultural values. The educational system should form in young people a system of values based on general human and general cultural principles.

Professional training: education should prepare students to compete in the labor market, developing the necessary skills and competencies for effective participation in the socio-economic life of society.

Integration with global trends: Education systems must adapt to global changes by integrating the latest technologies and approaches in teaching and learning to remain relevant and effective.

Supporting lifelong learning: In a world of rapid change and innovation, education systems must foster a culture of lifelong learning by providing opportunities for ongoing professional development.

Equal access to education: an important aspect of modern education is ensuring equal access to educational resources for all categories of the population, which will promote social justice and inclusiveness.

Obviously, that education is regarded as a fundamental keystone in Ukraine, encompassing intellectual, moral, physical, and cultural development, as well as fostering social integration, economic well-being, and national progress. In the area of higher education, competent teaching staff plays a vital role. The Strategy for Higher Education Development in Ukraine emphasizes the enduring relevance of professions related to healthcare, education, creativity, and personalized services, as they remain irreplaceable by automated systems, even with the advent of artificial intelligence. [2].

With Ukraine's intention to be integrated into the European Union, it is essential to align with the EU's strategic direction for digitalization in higher education. Thus, a country striving to improve its educational standards, innovation in higher education takes on crucial relevance. The Digital Education Action Plan for 2021-2027 emphasizes digitally competent teachers and staff, high-quality learning content and platforms, digital literacy, and knowledge of data-intensive technologies, including artificial intelligence [3].

The recent challenges faced by Ukrainian educators during the COVID-19 pandemic and Russia's invasion of Ukraine have highlighted the urgency for digital competence and emergency distance education. This dramatic experience has sparked interest in flexible and innovative professional development models, where educators learn from one another. Moreover, the emergence of technologies like Artificial Intelligence (AI), Virtual and Augmented Reality, and Social Robotics poses new challenges and opportunities for educators [4].2. Methodology

2.1 Adaptive learning in the individualisation and the personalisation of education

One of promising educational technologies according to NMC Horizon Report 2018 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. Adaptive learning could be defined as "a technique that involves periodically gathering information about students' level of knowledge and learning styles, and configuring learning resources, tasks, and assessment accordingly" [5]. Another way to describe the term adaptive learning (or adaptive teaching) is "the delivery of custom learning experiences that address the unique needs of an individual through just-in-time feedback, pathways, and resources (rather than providing a one-size-fits-all learning experience" (Smart Sparrow Platform https://www.smartsparrow.com/).

The aims of adaptive learning include firstly, providing appropriate knowledge resources: focus on issues the participant of the educational process/course finds problematic and appropriate revision planning; secondly,

eliminating fatigue with the material – the point is to give the participant new, interesting content not studied before; thirdly, fully personalising the learning process [6].

Given above definition of adaptive learning led us to considering microlearning as a means of adaptive learning implementation. Microlearning has got a lot of attention from scientists recently. According to Leong et al. [7] hundreds of relevant publications have been identified during 2006–2019. In particular, the question of adaptive microlearning was addressed by Gherman et al., Sun et al. [8, 9]

It became obvious, that adaptive learning offers undoubted benefits: the educational process/e-learning project/training course is fully adapted to the learner, their individual needs, predispositions, capabilities, and the learning process is individualised and personalised on an ongoing basis. However, a negative aspect could be identified as well: the student is cared for by the implemented elements of AI. It is important that this care should not turn into dominance and the student should always be given priority, so that they can make appropriate decisions at all times.

2.2 Adaptive learning and ICT tools

Contemporary century marks the beginning of the so-called Intelligent Adaptive Learning (IAL) systems, which are aimed at the individualisation and, to a certain degree, personalisation of learning. Intelligent Adaptive Learning being re-defined as digital learning which is based on students working in modular learning environments where every decision they make is captured and considered within a sound learning theory. Those decisions are then used to guide their learning experiences, to adjust their path and pace within and between classes, and to provide their teachers with formative and summative data. The IAL systems are designed to: a) be the student's personal tutor, b) individualise the learning pace, c) regulate the student's cognitive load, d) adapt the sequence of the curriculum and associated learning experiences and, e) engage students in learning through games (Dreambox Learning, https://www.dreambox.com/).

Personalization of the approach to learning cannot be made without understanding educational technologies implemented in higher education institutions (HEI). Adaptive learning is applied, at first, in the educational process with the use of Information and Communication Technology (ICT) and Artificial Intelligence (AI) supported learning management systems (LMS). Many HEIs use e-learning systems for provision of distant learning, blended learning and independent study [10].

3. The designing of AL-compliant courses in Moodle LMS

Moodle LMS (Modular Object Oriented Dynamic Learning Environment) is a widely used e-learning system as it is open source and can be adapted to HEIs' needs. The newest version of Moodle LMS (v. 4.5) offers a variety of different activities and new options for teachers and learners (https://docs.moodle.org/405/en/New_features).

The main Moodle activities available and permanently updated include among others, e.g.: Assignment, Book, Chart, Choice, File, Folder, Forum, Game, Glossary, Hotpot, label, Lesson, Page, Questionnaire, Quiz, Survey, URL (Uniform Resource Locator), Wiki, Videoplayer, Workshop. Among the new activities available in recent Moodle versions is the H5P (HTML5 (HyperText Markup Language 5) Package) interactive content (which engages with interactive content in Pages, Labels, Books and more).

The Moodle LMS activities mode allows for the simultaneous utilization of different types of materials to provide better information acquisition by students with different learning styles (Fig. 1). The VARK (Visual, Aural/Auditory, Reading, Kinaesthetic Styles concept) proposed and identified by the acronym as: Visualizing modality; Auditory modality; Kinaesthetic modality and Verbal (Read / Write) style [11]. In the Moodle system, teachers can prepare and use different types of content depending on, e.g. a VAKR defined style and thus, suggested for students with adequate preferences and an individual learning approach. Specifically, Infographics, Animations, Maps, Photos, Presentations, Videos, Images for the Visual mode; Audio narrations, Audiobooks, Podcasts, Verbal instructions could be used for the Aural mode; iBooks, and texts, Encyclopedias, Forums, Blogs could be used for the Verbal (Read / Write) mode and Practical exercises; Tasks, Examples, Tests, Quizzes could be used for the Kinaesthetic mode. As shown in Figure 1 all these activities are successfully supported via Moodle system components [10].
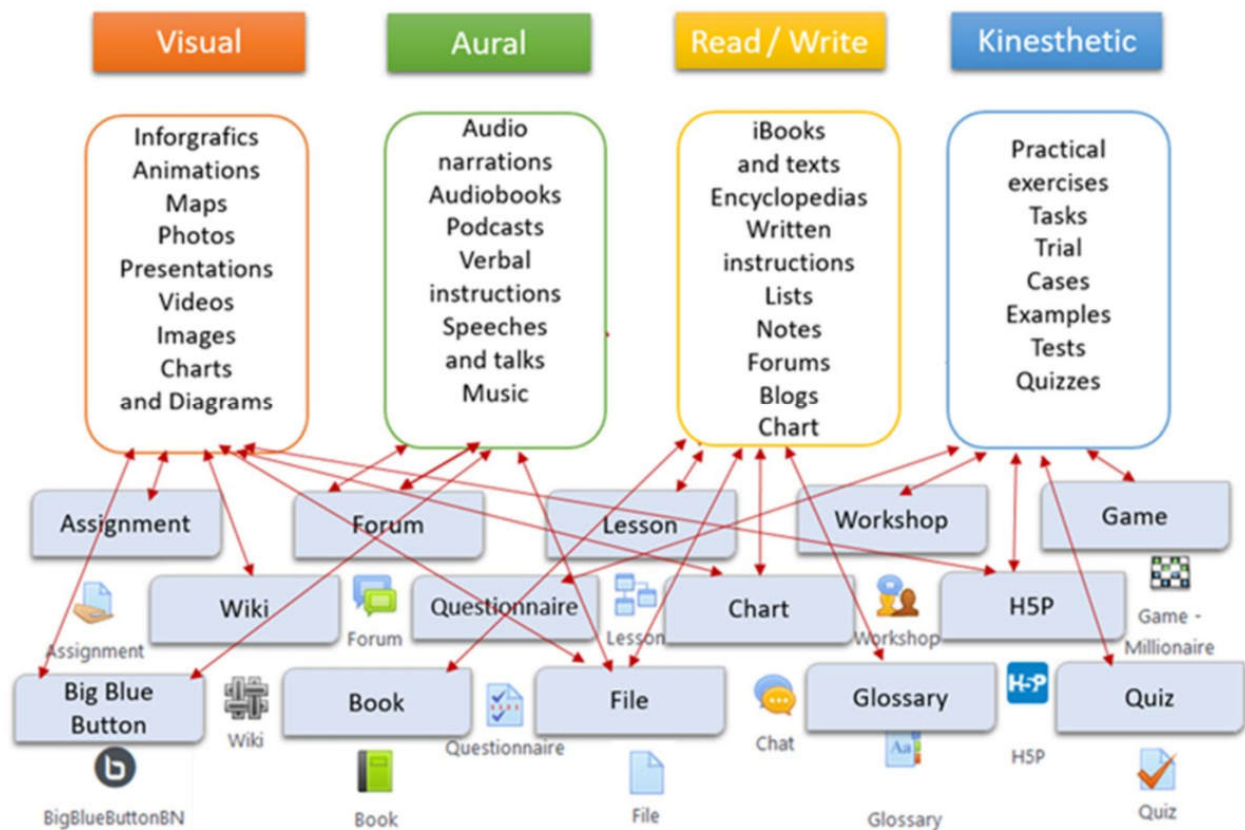
Figure 1. Utilization of Moodle activities for the preparation of learning materials using the VARK model
(https://doi.org/10.1007/S10639-021-10830-7/FIGURES/8)

The adaptive learning implementation process can be classified into the following stages: initial stage, pre-test stage, path generation stage, learning stage, post-test stage [12].

Initial stage. Learners login to the e-learning system and select a course to study. Usually, in universities this stage is organised by integration of academic curriculums in the e-learning system. Every student is enrolled in all the courses of their educational program and each course is bound to a specific semester(s). For this stage such activities a Subcourse, Assignment and Page are used to provide students with information on all disciplines, their forms of control in each semester and students' progress in each discipline and in general.

Pre-test stage. Learners are provided with a pretest and/or a survey to determine their level of knowledge, learning styles, intended learning outcomes. The testing results become the basis for learning path generation. At this stage gaps in students' knowledge are identified as well. In Moodle the stage can be implemented by such activities as Quiz, Survey, Questionnaire.

For example, the activity Survey is pre-populated with questions and a teacher cannot create own questions there. But the Attitudes to Thinking and Learning Survey (ALLTS) Survey resource allows teachers to assess the level of collaboration of a learning community (group). This helps to determine the optimum balance of individual and group work in the course.

The Questionnaire module is aimed at collecting data from users. Unlike the Survey activity, it allows teachers to create a wide range of questions and modify them to the needs of the course. It can be used to determine learning styles for further selection and gradation of materials.

The Quiz resource lets teachers to rank students' level of knowledge through standard testing. With the Overall feedback setting, boundaries are set for each level of knowledge and the student receives a corresponding feedback. For example, students with a score of 80% and above may be offered an advanced course, with results of 60-80% a standard course, and a basic course for those who scored less than 60%

Path generation stage. At this stage a student has to receive an individual learning path based on the results of the pre-test stage. By now, Moodle LMS contain very little automated mechanisms to provide this stage being a learning management system rather than fully adaptive learning platform. Therefore, alternative ways of the stage implementation have to be found to provide students with their own learning trajectory.

By the simplest approach, the Moodle's Topics being used to separate materials for students with different knowledge levels. By changing course layout to the section per page format and placing all materials of the corresponding level into the relevant section navigation in the course could be simplified.

Another option used by different HIEs in Ukraine, is to use the Checklist module to form lists of themes or tasks that have to be fulfilled to finish the course. The items can be added to the list from the current section, from the whole course or manually created. The status of the items in the list is updated automatically as students complete the related activity. A checklist can be edited so that only activities or resources that contain tasks were listed as obligatory ones. Thus, a teacher can customise checklists to the needs of a group and create them either for the whole course or for each module/theme separately. If different items can be completed by students with different levels of knowledge or learning styles, a teacher can set up an amount of items to be checked off to complete the Checklist [6, 10]. An individual learning path in Moodle LMS can be provided to a student as a list of to-do items to complete the course based on the pre-test results. It might require individual teachers recommendations or be partly unified for a specified level of knowledge.

Finally, Moodle's Learning Plans and Competence Framework have been used to provide groups or specific students with individualized learning trajectories (Fig. 2). A learning plan template defines a set of competencies which you can assign to a group of Moodle users. Competencies describe the level of understanding or proficiency of a learner in certain subject-related skills. Competency-based education (CBE), also known as Competency-based learning or Skills-based learning, refers to systems of assessment and grading where students demonstrate these competencies. Competency rule can be used to automatically mark as complete a parent competency when all children of it are complete. Linking the child competencies to course activities combined with the competency rule 'Mark as complete when all children are complete' will award the parent competency to a student when he has successfully completed the course activities. This way teacher get ability to semi-automate process of completion of individualized learning path along with gathering all evidences of achievement (activity and resource completion marks, quiz grades, etc).
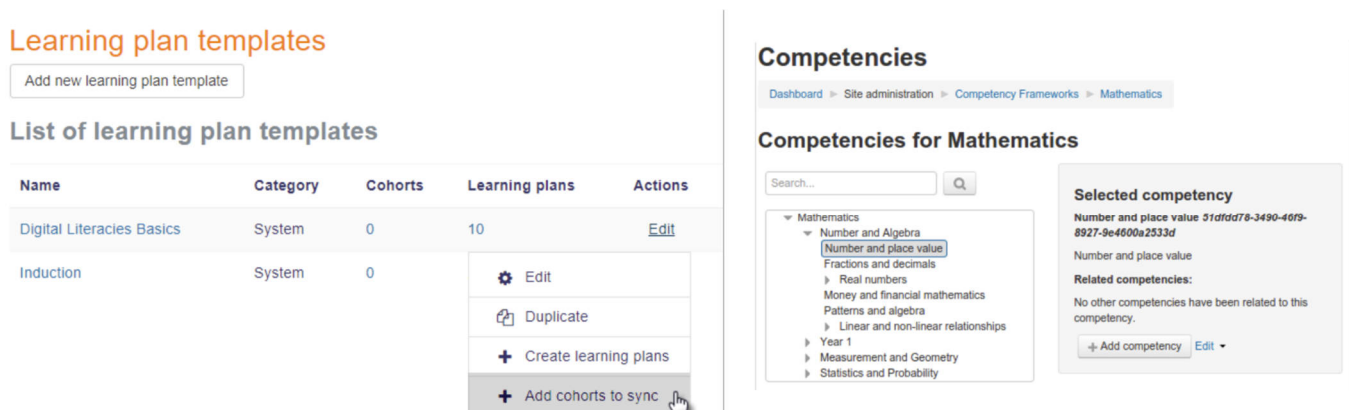

Figure 2. Learning plans and Competence Framework management in Moodle 4.x (https://moodle.org)

Learning stage. At this stage, recommended material is identified and a student deals with the learning content of a course. To provide flexibility of the content microlearning is used. The material separated into small logically complete parts can be easily used in any activity or resource used at the learning stage. Microlearning has a variety of advantages including better implementation of students' needs, wider diversity of materials for different knowledge levels, lower time expenses for material consumption, a possibility for knowledge gaps filling, increased motivation etc., [13]. According to the results of the survey [10] they also correspond better to students' needs who indicated materials divided into micro modules, short videos, visual materials and presentations as the most effective formats for theoretical materials.

Among the activities used at the learning stage the most popular are Assignment, Book, Chat, File, Forum, Glossary, Lesson, Page, Quiz, Wiki and Workshop. In our work we are going to pay attention to the activities which are the most beneficial from the perspective of adaptivity implementation, i.e. Lesson and Quiz modules.

A teacher can use Lesson activity to provide consequent theoretical materials (that is a set of pages with lecture materials) or to organise 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.) as shown on the Fig. 3.

Depending on the given answer 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 another way that corresponds to the 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. 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 [10].
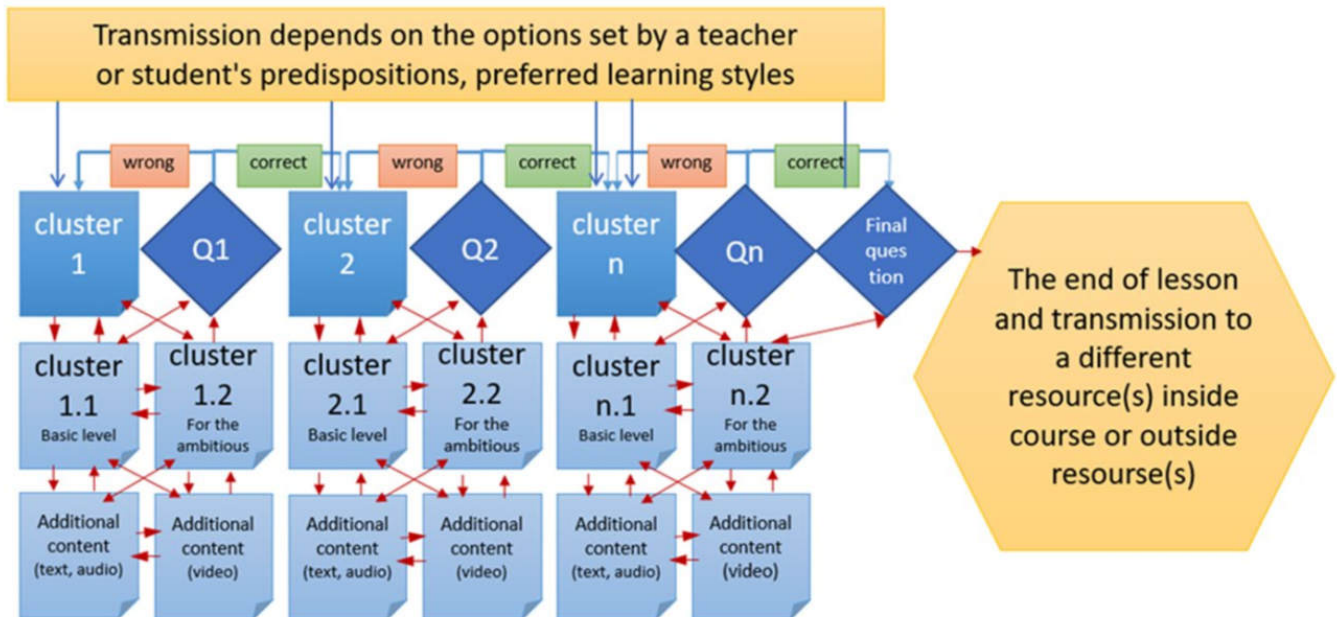
Figure 3. Proposal of a lesson structure with adaptive components
(https://doi.org/10.1007/S10639-021-10830-7/FIGURES/8)

Main type activities through which an assessment is being organised is Quiz, its filling and display for students depends on the setting of different parameters. Moodle provides Adaptive mode and Adaptive mode (no penalties) allows students to make multiple attempts before moving on to the next question. That is, if students are unsure of their answers, they can check it directly during the attempt and change their answers, but the repeated answer is indicated by taking into account the appropriate penalty indicated by the teacher in the parameters of the question. For example, a test for formative assessment might have multiple tries and hints, whereas for a summative assessment test Deferred feedback mode can be chosen. In Interactive with multiple tries mode after submitting one answer and reading the feedback, the student must click the "Try Again" button before attempting a new answer.

Deferred feedback or Immediate feedback mode with Certainty-based marking (CBM) are the modes where a student not only answers the question but also indicates how confident they are: not very sure (less than 67%); average confidence (between 67% and 80%) or very confident (more than 80%). When the answer is assessed, both accuracy and the level of certainty are considered by the system. For example, if the answer is correct, but only guessed, the score is adjusted from 1 to 0.33. If the answer is incorrect and high level of confidence was indicated, the score can be from 0 to -2 points (Fig. 4).

Using this mode provides the following benefits for students:
- they have to evaluate the correctness of our own answer;
- encouraging a solution to a problem, as opposed to answering questions immediately;
- adds confidence in their knowledge;
- get a more objective rating.

To encourage students to fill the gaps in their knowledge, Combined feedback option is recommended to be used in questions for Quiz. For each incorrect or partly correct answer a teacher indicates a related topic to study or/and give links to the corresponding activities and resources in the course.

Оберіть навички мислення високого рівня за вдосконаленою таксономією Блума.

Select one or more:

☑ a. Аналіз ✔

☐ b. Розуміння

☑ c. Оцінювання ✔

☑ d. Створення ✔

☐ e. Застосування

☐ f. Знання

Certainty ⓘ : ○ C=1 (Unsure: <67%)   ● C=2 (Mid: >67%)   ○ C=3 (Quite sure: >80%)

Ваша відповідь правильна

a)

Results for the whole quiz (1 questions)

Average CBM mark	2.00
Accuracy	100.0%
CBM bonus	-10.0%
Accuracy + Bonus	90.0%

Break-down by certainty

C=3	No responses
C=2	Responses: 1. Accuracy: **100%**. (Optimal range 67% to 80%). You were **a bit under-confident** using this certainty level.
C=1	No responses

b)

Figure 4. An example of answered question in a mode with CBM a) along with feedback for CBM quiz b)
(https://moodle.tdmu.edu.ua)

Finally, it is important to show the "Adaptive Quiz" (https://moodle.org/plugins/mod_adaptivequiz) – a very powerful Moodle extension that implements CAT (Computer-Adaptive Testing) approach for evaluation of students' knowledge. The Adaptive Quiz activity enables a teacher to create tests that efficiently measure the takers' abilities. Adaptive tests are comprised of questions selected from the question bank that are tagged with a score of their difficulty. The questions are chosen to match the estimated ability level of the current test-taker. If the test-taker succeeds on a question, a more challenging question is presented next. If the test-taker answers a question incorrectly, a less-challenging question is presented next. This technique will develop into a sequence of questions converging on the test-taker's effective ability level. The test stops when the test-taker's ability is determined to the required accuracy [14, 15].

To begin with, questions to be used with this activity are added or imported into Moodle's question bank. Only questions that can automatically be graded may be used. As well, questions should not award partial credit. The questions can be placed in one or more categories. Questions must be tagged with a "difficulty score" using the format "adpq_**n**" where **n** is a positive integer, e.g. 'adpq_1' or 'adpq_57'. The range of the scale is arbitrary (e.g. 1-10, 0-99, 1-1000), but should have enough levels to distinguish between question difficulties.

The Adaptive Test activity is configured with a fixed starting level. The test will begin by presenting the test-taker with a random question from that starting level. As described in [15], it better to have the starting level be in the lower part of the difficulty range so that most students get to answer at least one of the first few questions correctly, helping their moral.

After the student submits their answer, the system calculates the target question difficulty it will select next. If the last question was answered correctly, the next question will be harder; if the last question was answered incorrectly, the next question will be easier. The system also calculates a measure of the student's ability and the standard error for that measure. A next random question at or near the target difficulty is selected and presented to the user (Fig. 5).

This process of alternating harder questions following correct answers and easier questions following wrong answers continues until one of the stopping conditions is met. The possible stopping conditions are as follows:

- there are no remaining easier questions to ask after a wrong answer,
- there are no remaining harder questions to ask after a correct answer,
- the standard error in the measure has become precise enough to stop,
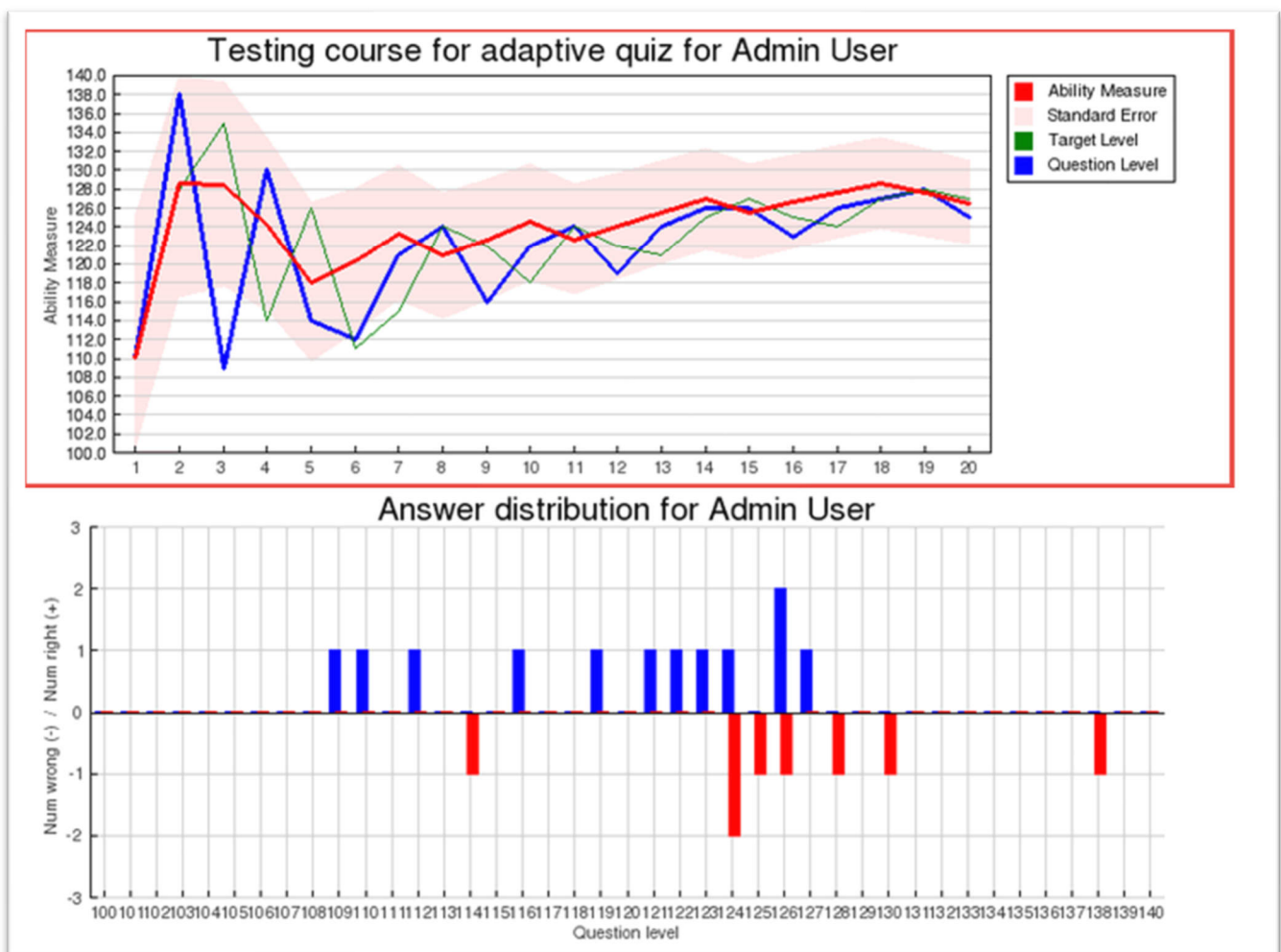- the maximum number of questions has been exceeded.

Figure 5. An example of report on the adaptive quiz attempt submitted by student (https://moodle.tdmu.edu.ua)

Post-test stage. After the learner has finished the entire learning path, it has to be checked whether the learning process was successful or not and needs some changes to be made. The summative assessment typically arranged in the form of a test, a project (individual or group), a speech etc. Thus, such activities as Quiz, Workshop, Wiki or Assignment are prevailing at this stage. The results of summative assessment must be analysed to find out strengths and weaknesses of the e-learning course and plan improvements for its next PDCA cycle. It is also essential to get feedback from students on the course to see whether there was enough material on each topic and whether it was understandable, diverse and easy to use. The feedback collection usually arranged with activities Questionnaire, Feedback, Forum.

4. Conclusions

In the centre of the adaptive learning design process there is a mentor: tutor or teacher who can choose the ways of implementing the expectations of students and their educational needs and learning styles. As shown in this work, the adaptive options are available in the setup of the Moodle system. Composition of Moodle LMS activities and resources presented above has shown that adaptive learning can be implemented in HEIs with the help of already used learning management systems like LMS Moodle. Each stage of adaptive learning implementation (initial stage, pre-test stage, path generation stage, learning stage and post-test stage) is possible to be arranged by means of Moodle LMS. Microlearning plays an essential role in adaptive learning implementation as learning materials divided into small parts are easier to meet individual educational needs of a learner, to navigate in an ELC and to update when required. The best examples are components such as Lesson or Quiz that expound upon the creation of students' knowledge and evaluating that knowledge.

Disclaimer

References

1. Herman, V., Vesolovskyi, O., Pysmenna, I., Kolodyazhna, A., & Mnozhynska, R. (2024). Educação A Distância: Uma Abordagem Adaptativa À Aprendizagem Na Era Da Informação E Do Conhecimento. Conhecimento & Diversidade, 16(41), 492–506. https://doi.org/10.18316/RCD.V16I41.11521

2. Cabinet of Ministers of Ukraine, (2022). Stratehiia rozvytku vyshchoi osvity v Ukraini na 2022-2032 roky [On approval of the Strategy of higher education development in Ukraine for 2022–2032]. Available from: https://zakon.rada.gov.ua/laws/show/286-2022-%D1%80#

3. Digital Education Action Plan (2021–2027), (2020). Available from: https://education.ec. europa.eu/focus-topics/digital-education/digital-education-action-plan

4. Fadieieva, L. O., & Fadieieva, L. O. (2023). Adaptive learning: a cluster-based literature review (2011-2022). Educational Technology Quarterly, 2023(3), 319–366. https://doi.org/10.55056/etq.613

5. Edmonds, E. (1987). Adaptation, response and knowledge. Knowledge-Based Systems, 1(1):3–10. https://doi.org/10.1016/0950-7051(87)90002-5

6. Smyrnova-Trybulska, E., Morze, N., & Varchenko-Trotsenko, L. (2022). Adaptive learning in university students' opinions: Cross-border research. Education and Information Technologies, 27(5), 6787–6818. https://doi.org/10.1007/S10639-021-10830-7/FIGURES/8

7. Leong, K., Sung, A., Au, D., & Blanchard, C. (2020). A review of the trend of microlearning. Journal of Work-Applied Management, 13(1):88–102. https://doi.org/10.1108/JWAM-10-2020-0044

8. Gherman, O., Turcu, C. E., & Turcu, C. O. (2021). An approach to adaptive microlearning in higher education. In INTED2021 Proceedings, 15th International Technology, Education and Development Conference, pages 7049–7056. IATED. https://doi.org/10.21125/inted.2021.1405

9. Sun, G., Cui, T., Beydoun, G., Shen, J., &Chen, S.(2016). Profiling and Supporting Adaptive Micro Learning on Open Education Resources. In 2016 International Conference on Advanced Cloud and Big Data (CBD) pages 158–163. https://doi.org/10.1109/CBD.2016.037

10. Morze, N., Varchenko-Trotsenko, L., & Terletska, T. (2023). Stages of Adaptive Learning Implementation by Means of Moodle LMS. In Proceedings of the 2nd Myroslav I. Zhaldak Symposium on Advances in Educational Technology, November 11-12, 2021, in Kyiv, Ukraine, 476–487. https://doi.org/10.5220/0012065500003431

11. Fleming, N., & Baume, D. (2006). Learning styles again: VARKing up the right free Educational Developments, SEDA Ltd, 2006. 7.4, Nov. 2006, pp. 4–7. Available from https://www.vark-learn.com/ wp-content/uploads/2014/08/Educational-Developments.pdf

12. Huang, S.-L. & Shiu, J.-H. (2012). A User-Centric Adaptive Learning System for E-Learning 2.0. Journal of Educational Technology & Society, 15(3):214–225. https://www.learntechlib.org/p/74952/

13. Varchenko-Trotsenko, L., Vember, V., & Terletska, T. (2019). Main aspects of educational video materials design for use in educational process of higher educational institutions. Electronic Scientific Professional Journal "OPEN

EDUCATIONAL E-ENVIRONMENT OF MODERN UNIVERSITY", (7):119–126. https://doi.org/10.28925/2414-0325.2019.7.12

14. Wright, B. D. (1988). Practical adaptive testing. Rasch Measurement Transactions, (2:2) p.24
15. Linacre, J. M. (2000). Computer-Adaptive Testing: A Methodology Whose Time Has Come (No. 69, p. 58). MESA Memorandum. https://www.cehd.umn.edu/EdPsych/C-Bas-R/Docs/Linacre2000_CAT.pdf