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Enhancing adaptive learning with Moodle's machine learning

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Abstract. This review explores how Moodle's machine learning capabilities enhance adaptive learning. We analyze five studies using Moodle for predictive and prescriptive support in education. These studies cover topics like learner classification, early risk detection, predictor comparison, reliability analysis, and custom indicators. We extract key findings, and address challenges while suggesting future research directions. This review offers insights for educators and researchers aiming to personalize education with Moodle.

Keywords: Moodle, machine learning, adaptive learning, personalized education, learning analytics, education technology.

1 Introduction

Law of Ukraine "On Education" defines education as the fundament of the intellectual, moral, physical and cultural development of an individual, his/her successful socialisation, economic wellbeing, a guarantee of development of the society and of the state. The education is aimed, e.g., at comprehensive development of a human being as a personality and as the supreme value of the society, raising responsible citizens capable to make a conscious social choice and channelling their activities for the good of other people and the society, and enriching the intellectual, economic, creative, cultural potential of the Ukrainian people on this basis, upgrading an educational level in order to ensure Ukraine's sustainable development and its European choice [10].

The main provider by systematic quality education is competent teaching stuff (educational – academic and research – worker). One of the purposes of higher education is to ensuring high-quality educational and scientific activity, competitive higher education, which is accessible to different segments of the population. Achieving this purpose involves providing special support in access to higher education through equipping

laboratories at the institutions of higher education with equipment for digital infrastructure, promoting the use of innovative technologies and the latest teaching aids in the educational process.

Attractiveness of higher education of Ukraine is important factor for concurrency of Ukraine at the international world market. Therefore, another important strategic purpose of the higher education development is attractiveness of higher education institutions for study and academic career, which can be realized through an implementation of student-centered learning, which is the basis for organizing the educational process using innovative technologies.

Law of Ukraine "On Higher Education" defines 4 types of higher education institutions for teacher's training and retraining: branch-oriented (pedagogical) university, academy, institute, and college [9]. According to the "Concept of development of pedagogical education", there is exists "an imbalance between the public demand for highly qualified teaching stuff, the prospects for the development of society, global technological changes and the contemporary system of pedagogical education, as well as the level of readiness/ability of modern teaching stuff to perceive and implement educational reforms in Ukraine as one of the important issues" [8], which need to be solved. The Concept emphasizes "the mismatch of critical professional competencies of graduates of pedagogical education institutions to the challenges of the digital society" [8, p. 4] and proposes a number of ways to solve it, among them are [8, p. 20]:

- To ensure own continuous professional development the teaching staff should acquire the competencies and skills in e-learning, media literacy, computer security, as well in the basics of androgogy.
- The methods for building pedagogical professionals' digital competence should be consistent with the applicable standard.

Since Ukraine's policy is aimed at integration into the European Union (EU), we should also take into account the strategic directions for the digitalization of higher education in the EU represented in the Digital Education Action Plan for 2021–2027. It offers a strategy for European education, which includes improved quality and quantity of teaching concerning digital technologies, support for the digitalisation of teaching methods and pedagogies. The Action Plan emphasys to [2]:

- digitally competent and confident teachers and education and training staff;

- high-quality learning content, user-friendly tools and secure platforms which respect e-privacy rules and ethical standards;
- digital literacy, including tackling disinformation;
- good knowledge and understanding of data-intensive technologies, such as artificial intelligence (AI).

Since 2020 (wide spread of the novel coronavirus), the Ukrainian teaching staff challenges in performing and managing emergency distance education. This rise a lot of issues both technical and organizing which made a drastic changes in the Ukrainian educators' digital competence. For the first time, the educational community has been self-organized to prevent a disruption of education on the all levels, from pre-school to tertiary. There is a growing interest in more flexible, innovative and sustained models of professional development, in particular where educators learn from their peers.

In addition, the emergence of new technologies such as AI, virtual or augmented reality and social robotics, challenge educators and requires them to take a more active role in the design and implementation of these tools to ensure their use is effective, desirable and inclusive [1].

Overall, there is a need to develop and test new pedagogies and techniques, also by investigating how emerging technologies can be smoothly integrated in existing teaching and learning practices. One of the prominent application of AI in education is a technology supported adaptive learning.

Moodle is a popular open-source learning management system (LMS) that supports online learning and teaching. Moodle provides various features and functionalities to create and manage courses, activities, resources, and assessments. Moodle also collects and stores a large amount of data from learners' interactions with the system, such as logs, grades, feedback, and profiles. These data can be used for learning analytics, which is the measurement, analysis, and reporting of data about learners and their contexts, for the purpose of understanding and optimizing learning and the environments in which it occurs.

One of the applications of learning analytics is to use machine learning models to make predictions and recommendations for learners and instructors. Machine learning is a branch of artificial intelligence that enables computers to learn from data and perform tasks without explicit programming. Machine learning models can be trained on Moodle data to identify patterns, relationships, and trends that are not easily observable by humans. For example, machine learning models can predict learners' performance, engagement, retention, satisfaction, and dropout.

Adaptive learning is another application of learning analytics that aims to provide personalized and optimized learning experiences for learners based on their individual needs, preferences, goals, and feedback. Adaptive learning can use machine learning models to tailor the content, pace, sequence, difficulty, and support of learning activities according to learners' characteristics and progress. For example, adaptive learning can recommend the most suitable resources, tasks, or strategies for learners to achieve their desired outcomes.

The *purpose* of this review is to examine how Moodle machine learning models can be used for adaptive learning.

2 Method

The first step was to select the papers that are relevant to the topic of Moodle machine learning models for adaptive learning. The selection criteria were as follows: (1) the papers should be published in peer-reviewed journals or conferences; (2) the papers should use Moodle as the main platform for data collection and analysis; (3) the papers should apply machine learning techniques to make predictions or recommendations for learners or instructors; (4) the papers should address the issue of adaptive learning or personalization in some way.

The second step was to search for the papers that meet the selection criteria in Scopus database and IEEE Xplore. The search titles were combinations of terms related to Moodle and machine learning.

The third step was to screen the papers that were retrieved from the search based on their titles and abstracts. The screening process was done manually by reading and evaluating each paper according to the selection criteria. The screening process resulted in five papers [3–7] that were included in this review.

3 Results

Hassan and El Fattah Hegazy [7] proposes a model that recommends the best machine learning algorithm to classify learners into four categories based on their interactivity with Moodle: active, passive, dropout, and irregular. The model uses Moodle logs to extract features and labels for learners, and compares six machine learning algorithms: decision tree, k-nearest neighbor, naive Bayes, support vector machine, artificial neural network, and random forest. The results show that random forest has the

highest accuracy and precision among the six algorithms. The paper also discusses the implications of the model for adaptive learning.

Cechinel et al. [5] describes the development and evaluation of a learning analytics dashboard for Moodle that displays predictions and insights from Moodle machine learning models. The dashboard uses Moodle machine learning models to early detect students at risk of failure in a course based on their grades, activities, and feedback. The dashboard also provides recommendations and interventions for students and instructors to improve their performance. The results show that the dashboard is useful and effective for supporting adaptive learning.

Bognár and Fauszt [3] compares different types of predictors for Moodle machine learning models, such as indicators, targets, analysis intervals, and prediction processors. Indicators are the features that are used to train the machine learning models. Targets are the outcomes that are predicted by the machine learning models. Analysis intervals are the time periods that are used to collect data for training and testing the machine learning models. Prediction processors are the methods that are used to generate predictions from the machine Prediction processors are the methods that are used to generate predictions from the machine learning models. The paper analyzes how these predictors affect the accuracy and reliability of Moodle machine learning models for different courses and scenarios. The results show that the choice of predictors depends on the context and purpose of the prediction, and that there is no single best predictor for all cases. The paper also highlights the challenges and limitations of Moodle machine learning models, such as data availability, quality, and privacy.

Bognár et al. [4] analyzes the conditions that affect the reliability of predictions by Moodle machine learning models, such as data quality, model training, and model evaluation. The paper uses a case study of a course to illustrate how these conditions influence the prediction accuracy and validity. The paper also proposes some guidelines and recommendations for improving the reliability of predictions by Moodle machine learning models, such as data preprocessing, model selection, model tuning, and model testing.

Fauszt et al. [6] proposes a method to create custom indicators for Moodle machine learning models based on course-specific data. The paper argues that the default indicators provided by Moodle may not capture the essential features of a course, and that creating self-defined indicators can improve the prediction power of Moodle machine learning models. The paper demonstrates how to use Moodle plugins and scripts to create and use self-defined indicators for predicting students' grades in a course.

The results show that the self-defined indicators outperform the default indicators in terms of prediction accuracy and precision.

4 Conclusion and future work

The main findings and implications:

1. Moodle machine learning models can provide valuable insights and support for adaptive learning by predicting learners' outcomes and behaviors, such as performance, engagement, retention, satisfaction, and dropout.
2. Moodle machine learning models can also provide recommendations and interventions for learners and instructors to improve their learning outcomes and experiences, such as resources, tasks, strategies, feedback, and guidance.
3. Moodle machine learning models can be customized and optimized according to different courses, scenarios, and purposes by using various predictors, such as indicators, targets, analysis intervals, prediction processors, and self-defined indicators.
4. Moodle machine learning models face some challenges and limitations in terms of data availability, quality, privacy, model training, evaluation, testing, reliability, validity, interpretability, usability, and scalability.

Future work on Moodle machine learning models for adaptive learning should focus on four areas: (1) empirical studies to evaluate effectiveness and impact in different contexts; (2) integration with other adaptive learning systems; (3) enhancement of user interface and user experience; and (4) addressing ethical and social issues. These studies are important to ensure that Moodle machine learning models are effective, efficient, and fair, and that they do not violate the rights and interests of learners.

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