# CHAPTER- 2

# LITERATURE REVIEW

*Chapter 2 provides a synthesis of the literature on the use of ML and DL in predicting student academic adaptability. This chapter introduces and discusses the theoretical foundations of the research, reviews prior findings, and identifies the state of development, and future directions in this intellectual area.*

## Background

The idea of adaptability has roots in number of theories one of which is the “self-regulation framework” and its associated “three-dimensional model of adaptability”. In this model, thinking, behaving, and emotion are managed and manipulated in a way for an individual to respond adequately to pressures from environment. It is this aspect of self-organisation and self-regulation that allow people to (Sheriston, Holliman and Payne, 2019).

The ability to composite different adjustments, learning, and general wellbeing within multiple learning environments is encompassed into the construct of student adaptability. The factors considered are mental attitude learning, technical skills, social-economic status, and environmental factors as well. The nature of the data which reflects adaptability and how it should be analyzed implies that the more nuanced and holistic the data, the better – at least in terms of identifying meaningful patterns and using advanced algorithms to measure and analyze them. Their opacity is a major problem when applied to educational contexts, despite the fact that machine learning models consistently perform well across many domains. Stakeholders have a harder time understanding model predictions due to interpretability difficulties, which limits the finding of important information needed to provide personalised interventions that increase student flexibility(Nnadi *et al.*, 2024).  *AI methods have been used in adaptive learning systems for individual students to automatically identify new material.*

## Related Work

Automatically categorising students based on their preferred learning style is advantageous as it is both more efficient than having students fill out surveys and may be adjusted based on the students' actions. These methods take a page out of the ML playbook when it comes to personalising online education by automatically and dynamically mapping student behaviour characteristics to a model that maximises individual learning and improves the online learning experience overall (Essa, Celik and Human-Hendricks, 2023). This section brings a systematic literature review and synthesis of prior studies on how to predict students’ adaptability with different approaches with a focus on ML and DL:

### Students’ Adaptability using Machine learning

In this study (Zhao and Wang, 2024b), applied an advanced Artificial Intelligence (AI) tool to analyze 1,205 students, aiming to enhance adaptability prediction and identify key influencing factors. Using K-means clustering, students were categorized into two groups, revealing distinct learning behaviors and characteristics. Automated Machine Learning (AutoML) technology, utilizing Baidu's Easy DL, predicted online learning adaptability for each group, which is assessed by various performance indicators. The results demonstrated that the accuracy of adaptability prediction for the two groups, Cluster\_0 and Cluster\_1, was 91.3% and 98.1%, respectively.

In this research (Zhao and Wang, 2024a) used AutoML technique for students’ preparedness to learning through implementing analytical models that predict their success in online learning. Utilizing Baidu's AI development platform EasyDL, this research conducted an in-depth analysis of 1, 205 data samples provided by the Kaggle platform. In an effort to measure the effectiveness of the model and to compare it with more traditional approaches in practice of ML, the performance metrics were based on F1-score, recall, accuracy and precision. Results from the experiments show that the model accurately predicts students' adaptation to online learning using AutoML technology, with a rate of 90.9%.

In this study (Nnadi *et al.*, 2024), provide a comparison of XAI methods for analysing ML models that try to categorise students' degrees of adaptability. Using a large dataset of 1,205 occurrences, they used several ML techniques, with RF showing the best performance with 91% accuracy. RF achieved a precision0.93, a recall0.94, and an F1-score0.94 in the models' evaluations of recollection, precision, and performance. They exposed the particular contributions of different variables affecting adaptation forecasts using SHAP, LIME, Anchors, ALE, and Counterfactual explanations. The relevance of 'Class Duration' was underlined by SHAP values (mean SHAP value: 0.175), and the complicated effect of socio-economic and institutional elements was described by LIME. The anchors emphasised demographic traits and offered rule-based explanations with high confidence (97.32% confidence). The positive slope of "Financial Condition" was emphasised in the ALE analysis, and the effect of a half-point change in "Class Duration" was underlined in the counterfactual scenarios. Class duration and financial condition are consistently important determinants, and the research also highlights the minor impacts of institution type and load-shedding.

In this research (Diaconu-Gherasim *et al.*, 2024), investigated how future time perspective is related to career adaptability and whether grit may play a mediating role in this relationship. A sample of 483 university students (*M*age = 20.03, 92.3% women) filled in scales measuring future time perspective dimensions (i.e., connectedness, value, extension, and speed), grit, and career adaptability comprised in an online survey. Findings showed that career adaptability was positively associated with connectedness and extension, and negatively associated with speed future time dimension.

In this study (Mingwei and Liu, 2024), analysed the factors impacting the adaptability of online learning among adolescents and identified the most suitable model for prediction using data from the "Chinese Adolescent Online Education Survey" that ran from 2014 to 2016. The five ML algorithms used were LR, KNN, RF, XGBoost, and Cat Boost. They show that the main variables influencing students' adaptation in online learning settings are age, family financial situation, and course length. Moreover, the question of adaptability is much dependent upon age among the pupils. When it comes to predicting, the random-forest model does an excellent job of capturing the traits of students' adaptability, but the XGBoost and Cat Boost algorithms also show greater performance.

In this research (Salloum *et al.*, 2024), use data collected from Kaggle, which contains descriptive parameters of 1,205 students and their education facilities and equipment availability, learning environment preferences. For the purpose of predicting students’ levels of fit with online learning, a RFC was employed within a One-vs-Rest approach. Several performance indicators were used to assess the accuracy of the model, such as: recall, accuracy, precision, F1-score. However, highly acceptable accuracy level of 88.3% was achieved by using the Random Forest class.

In this study (Chutikarn Sriviboon, Nutthapat Kaewrattanapat, Martusorn Khaengkhan, Jarumon Nookhong, 2024), examined, using ML methods, the degree to which undergraduates adapted to hybrid learning settings. The goal is to compare three different algorithms—DT, k-NN, k=3, and NB—and find the most important parameters that affect adaptation. To forecast adaptation levels, researchers examined extensive student data that included demographics, behaviours, and degrees of adaptability. Overfitting probably limited the Decision Tree algorithm's capacity to predict increased adaptability, but it did provide a basic knowledge. The k-NN algorithm outperformed the competition, showing exceptional proficiency in determining moderate levels of adaptation and attaining the best total accuracy of 74.80%.

In this research (Kazmi, Kazmi and Arava, 2024), aimed to gather information on various relevant parameters grouped into four sections: “General Information”, “Perceived Stress Scale”, “Cognitive Assessment”, and “Social Dependency”. The Watson ML platform was used to develop a model under the “supervised learning” option, incorporating various algorithms including the ETC and RFC. The machine proposed two best algorithms including Random Forest Classifier that gave an accuracy of 66.4% in which feature enhancements such as hyperparameter Optimization and feature engineering.

In this study (Li, 2024b), predicted the adaptability of online students using ML methods. After comparing many prediction models—including LR, k-neighborhood algorithm, RF, XGBoost, and Cat Boost—we find that the RF model (with an accuracy of 89.6%) is the most effective in predicting students' capacity to adapt to online classrooms. The prediction accuracy of the XGBoost model was 89.1% and that of the Cat Boost model was 88.6%, demonstrating their superiority in this area as well. On the other hand, the prediction accuracy of the logistic regression model is 68.8% and that of the KNN model is 77.1%.

In this research (Liu and Wan, 2024), started with a thorough data preparation step to guarantee high-quality data, then used effective data balancing methods to reduce bias. Feature extraction strategies are utilized to discover noteworthy patterns in the data by focussing on educational data mining or higher education. The straightforward Modified Jaya Optimisation technique was used to fine-tune the hyperparameters of the resilient WideResNeXT architecture, which served as the foundation of their classification technique. The suggested WResNeXt-MJ model has shown to be a strong competitor with outstanding performance metrics. The model's remarkable precision score of 98.4%, low log loss of 0.05%, and average accuracy of 98% across all datasets show how effective it is at improving accuracy and predictive ability in flexible learning situations.

In this study (Wang, 2024), extracted thirteen features from a Kaggle repository: subjects' age, region of residence, daily online class attendance, online class medium, self-study time, daily meal count, weight change, health issue, stress-relieving activities, time used, family connection, and preferred social media platform. The goal was to determine each student's level of satisfaction with online schooling. The research involved 1182 students of different age groups from schools across the Delhi National Capital Region, utilizing the IBM platform to deploy a variety of algorithms for the creation of predictive models. RFC, LR, and DTC with and without enhancements were employed. They achieved moderate accuracy levels, above 50 percent.

In this research (Li, 2024a), saw that most students' adaptation was medium, suggesting that online education had an average impact overall. Lower levels of adaptability are seen among students in the age ranges of 6–10, 16–20, and 26–30 years old. College and university students make up a disproportionately large portion of this poor adaptability group. The online education system is better suitable for students majoring in information technology, whereas students whose major is not in IT are less adaptable. In general, local students are better equipped to adjust to online learning than international students. The flexibility of pupils is often poorer in places where the energy is unreliable. Overall, the model accuracy of the decision tree algorithm's predictions was strong, with students' degrees of adaptability having a greater impact on the quality of their forecasts. The model's predictions were outstanding, with a test set accuracy of 93.27 percent and precision and recall of 93.33 percent.

In the study (Feroz Khan and Samad, 2024), Higher education has seen a significant decrease in the expenses related to producing online material as a result of greater technological integration. Due to the COVID-19 epidemic, there has been a movement towards remote learning, which has brought attention to how important LMSs are for delivering specialised information, using a variety of pedagogical tactics, and encouraging student participation. There has been a recognition that one of the key factors that determine success in the intensity of online learning is flexibility – the ability to alter actions, cognition, and emotional responses to unanticipated circumstances. Using advanced MLTs, this research introduces the new framework of OLAMLTs to investigate the factors that influence student adaptability. MLTs assist in identifying patterns and associations with respect to adaptation by working on massive datasets comprising of indicators of students ‘activities, behaviors, and performance on the forums. The OLAMLTs approach provides tailored suggestions for educators by using a retrospective analysis to characteristics including motivation, self-regulation skills, and technical competency.

In this research (Kar *et al.*, 2024), proposed an AI-based system that utilises ML to determine the most important learning metrics for measuring students' adaptation in online courses. An assortment of XAI algorithms, including LIME, SHAP, and FAMeX, were utilised by the authors of this study to determine the crucial learning parameters that determine a student's adaptability level. The solution's effectiveness was evaluated using a dataset consisting of respondents from online and offline surveys with students from various educational levels in Bangladesh. Full of surprises and even paradoxical, such data appear.

In this study (Sree *et al.*, 2023), have attempted to assess to what extent students have adapted to the online delivery of classes and what factors have supported or hindered the same. Students' adaption in online learning varies substantially, according to early statistics, based on personal circumstances. Kaggle ML provided the dataset students\_adaptability\_level\_online\_education.csv that was used in the research. Since the dataset's minority class contains an imbalanced collection of values, the SMOTE is used to equalise it. The values for the minority class are randomly raised to ensure that the data distribution is equitable. Students' level of adaptation to online education has been predicted using datasets and several ML algorithms, such as XGBClassifier, KNN, SVM, and RF. When using classifiers, the highest accuracy of 92% was achieved with the use of the Random Forest classifier.

In this research (Iparraguirre-Villanueva *et al.*, 2023), suggested using XGBClassifier, RF, KNN, SVM, and LR for prediction of students’ adaptation to online educational process. The students were obtained from Kaggle and a total of 1205 students varied in education level enrolled in the study. First, data was cleaned or rather defined. After this, they tuned, evaluated and cross checked the model. The efficiency of these models has been benchmarked using the following features; accuracy, specificity, sensitivity, F1 count and precision. The findings demonstrate that each of the five models is capable of producing top-notch prediction outcomes. For instance, when compared to the other models, the RF and XGB versions performed the best, with an accuracy rate of 92%. Because of their superior prediction performance, the RF and XGB models are recommended for use in online education adaptability level prediction. Additionally, the performance of the KNN, SVM, and LR models was 85%, 76%, and 67%, respectively. The findings demonstrate that the RF and XGB models clearly outperform the others in terms of prediction accuracy.

In this study (Tiwari, Misra, *et al.*, 2022), investigated the level of student acceptance of technological tools used in the classroom. The article categorises students' levels of adaptability using ML techniques. They employed a number of ML algorithms to forecast how many students will use Industry 4.0 features. The best methods, including neural networks and random forests, achieved a classification accuracy of 93%.

In this research (Zhao *et al.*, 2022), used a ML strategy to investigate how students' coping mechanisms and college transition affected their ability to adapt to the interruptions caused by COVID-19. Academic adjustment, emotionality adjustment, social support adjustment, overall COVID-19 regulations reaction, and discriminatory effect were the five psychological domains in which they created predictive models to differentiate between pupils who had adjusted successfully and those who had not. Individual student characteristics measured using well-established commercial and open-access surveys on three psychological domains—WAYS, SACQ, and PSS—serve as predictive features for these models. A confidential survey dataset consisting of responses from 517 American students during the height of the epidemic formed the basis of their investigation. Across all five domains, their models averaged an AUC score of 0.91. For each categorisation task, they used the SHAP approach to further identify the most significant risk variables.

In this study (Tiwari, Jain, *et al.*, 2022), examined the opinions of students on the usage of technology in the classroom. They make use of the concept of XML, which holds that individuals can understand the results of ML computations. However, the "black box" theory maintains that no one, not even the AI's designers, can explain how it came to a certain conclusion. To predict how often students would utilise Industry 4.0 characteristics, several ML algorithms were used. NN was determined to be the most effective strategy, with a remarkable 93% accuracy in classification.

In this research (Wang and Yang, 2022), sought to investigate, during COVID-19, how Chinese nursing students' professional identities affected their capacity to adapt to E-learning. Methods: The research was place from August 2020 to October 2020 at three different medical colleges in China's Yunnan Province. Three parts made up the data gathering process: participant characteristics, learning adaptability, and professional identity. Results: There was a modest degree of E-learning adaptation among 585 nursing students. A significant connection (r = 0.316~0.505, p < 0.001) was found between the capacity to adapt to E-learning and one's professional identity. Furthermore, among nursing students, there was a significant association between professional identity and factors that predicted adaptation to E-learning (p < 0.001).

In this study (Hosny and Elkorany, 2022), proposed the development of a hybrid model that integrates semantic and ML clustering algorithms to classify students, identify their preferred learning styles, and propose appropriate assessment strategies. Using the Open University Learning Analytics Dataset, a series of tests were carried out to determine the efficacy of the suggested model. Results from experiments demonstrate that the suggested model achieves an accuracy level of 93% on average when predicting students' relative assessment method(s) and 95% when clustering them according to their various learning activities.

In this research (Suzan *et al.*, 2021), collected information from primary, secondary, and university students using online and offline questionnaires. A person's socio-demographic characteristics make up the form. In order to forecast the level of student adaptation to online education, they used a number of ML algorithms on their dataset. These algorithms included DT, RF, NB, SVM, KNN, and ANN. The purpose of this was to evaluate how well online courses work. The RFC achieved the most accuracy of all of the techniques used, coming in at 89.63%.

In this study (Xiao, Liu and Jiang, 2021), intended to construct a predictive diagnostic model of autonomous adaptation of 947 medical college students using their personal traits, socio-demographic information, self-evaluation, and group dynamics upon their return to school. The efficacy of a model was assessed with two sets of data: one set included 757 medical students and was examined using 10-fold cross-validation using seven classifiers; the second set had 190 medical students. The Cat Boost technique outperformed the others with an AUC of 80.0% and a prediction accuracy of 96.32%.

In this research (Meilanda, Sugiyo and Sunawan, 2021), purposed to ascertain if students' career adaptability is successfully enhanced by CDSE group counselling. There were a total of 18 participants drawn among 360 students; they were split evenly between an experimental group and a control group. The study used a randomised pretest-posttest design. They utilised Mixed MANOVA for data analysis. The results showed that students' career adaptability was improved by career choice self-efficacy group counselling (F (1.16) = 1401.74, p < 0.01). It was also possible to see this efficacy in the time effect (F (2,32) = 462.18, p < 0.01) and the time-group interaction effect (F (2,32) = 443.38, p < 0.01).

### Students’ Adaptability using Deep learning

In this study (afarpour Motealegh Mahalegi Homayoun, 2024), implemented the deep learning strategy for predicting students' adaptability to online learning using Python inside the Jupyter Notebook environment. Using the Kaggle dataset, a neural network model was developed using the Keras and TensorFlow tools. The data is organised into testing and training sets, and the neural network model is visualised using the Keras plot model utility function. Two hidden layers should be built into the DL model, with activation functions selected at random from the following: RELU, sigmoid, tanh, elu, and selu. It is also recommended to have an output layer that uses the softmax activation function. Following a process of fine-tuning until the changes were stable, this model attained an accuracy level of 89.63%.

In this research (Veeraswamy, 2024), suggested a development of an Enhanced Hybrid XAI model to forecast. The model combines Using of ML and DL with the ensemble methods to enhance an accuracy of a predictions. A model combines Characteristics of bagging, boosting, and stacking, SHAP and LIME and Attention mechanisms for the model interpretability and transparency. Some of the steps that were utilized involve data wrangling on a large scale, training of a number of different both ML and DL models and lastly the effectiveness was ascertained by using standard metrics such as F1-score, recall and accuracy. Over a range of adaptation categories, the RF model performed optimally, with precision values between 0.88 and 0.93, recall between 0.85 and 0.92, and F1-score between 0.87 and 0.92.

In this study (Kong, Ling and Xiong, 2023), proposed an intelligent assessment of the student welding projects using semantic segmentation approach. The approach to evaluating student welding works makes use of a classification model and a semantic segmentation model. Classification uses the statistical information from the labelled picture to assign each segment to its matching class, once the segmentation model has partitioned each image into segments with semantic meaning. Using numerical and geometrical statistics, the approach assesses the component arrangement and welding process. Improved segmentation and classification capabilities, as well as increased model flexibility, are outcomes of the method's retraining process, which involves merging the original dataset with a batch of forecasted student welding work data. Their approach surpasses PSPNet and ICNet, according to the experimental data, which provide a MIoU of 0.776.

In this research (Wang, 2022), evaluated the student hierarchical management evaluation system's mechanisms, examined its implementation, and put it to use to guarantee high-quality instruction and motivate students to study. Being highly adaptable, having a basic structure, and requiring few training parameters has made BPNN a research hotspot in many scientific domains. The student hierarchical management evaluation system was designed and implemented using the target detection algorithm, which makes use of BPNN. This system has great scholarly and practical importance. Of the total number of participants, 74, 85, 63, 96, and 52 were from colleges and universities. With regard to the hierarchical management assessment system, the corresponding student recognition degrees are 91.2%, 93.8%, 90.4%, 89.5%, and 92.7% alike.

In this study (AlKayyali1 *et al.*, 2022), after decide a degree of adaptation in e-learning, a dataset was gathered from the Kaggle repository. A collection of ML and DL algorithms were used to predict the extent to which students will adapt to e-learning in order to ascertain the efficacy of e-learning. The DTC outperformed all other ML algorithms with a 92.00% accuracy, precision, recall, and F1-score. On the other hand, the proposed deep learning method achieved F1-score (94.61%), recall (94.70%), precision (94.80%), and accuracy (94.67%).

In this research (Sun, 2022), used a D:-based personalised federated learning algorithm with an adaptive federated learning strategy to provide a method for forecasting students' performance. In order to provide college students with criteria that are helpful for evaluating their athletic ability, these methods integrate the quantitative ways to evaluating motor skills. This creates the sports performance prediction model after adopting the performance prediction framework. Based on the examination of sports performance analysis instances, it has been shown that the model suggested here can predict students' athletic performance with high accuracy, with an average accuracy rate of 91.7% for each sports item.

In this study (Zhang *et al.*, 2022), sought to investigate ceramic art teaching methods for modern pupils. An autonomous question-answering (QA) system is developed based on DL, novel teaching techniques are examined, and the Internet is integrated with the QA system to assist students in resolving issues that arise throughout the learning process. They begin with an examination of the relevant DL and personalised learning concepts. With the goal of developing a single model or a hybrid model, this paper compares and contrasts many DL-related theories, including BPNN, CNN, LSTM, and GRU. The second step is to go through all of the student enquiries, process them, and then establish the experimental parameters in several models so that they may compare them. The results of the trials demonstrate that traditional retrieval methods have an upper limit of around 0.5 for both average accuracy and MRR. With an average accuracy of around 0.81, the basic neural network's LSTM and GRU structural models are competent enough to provide better results. The BiGRU-Attention model achieves the highest results with an accuracy of 0.87 and an MRR of 0.89, while the hybrid model may attain an accuracy of about 0.82.

In this research (BOYACI, 2022), was to look into how students' self-esteem and their capacity to adjust to new careers were affected by their educational training. This research included 235 volunteer pedagogical formation students (190 females and 45 men) who had obtained pedagogical formation education from various universities. This research gathered information from participants using the following instruments: the Personal Information Form (PIF), the Career Adapt-Abilities Scale (CAAS), and the Self-Liking/Self-Competence Scale (SLSC). Results from the studies demonstrate a favourable and statistically significant correlation between self-liking, self-competence, and career flexibility. Furthermore, when the research was done to see whether self-liking and self-competence might predict career adaptabilities, they were found to be strong indicators of how students' career adaptabilities were shaped in the classroom (R2=.37, p <.01). The study's results reaffirmed the need of career counselling.

In the study (Holliman *et al.*, 2021), The goal of this meta-analysis of research was to examine how social support and flexibility relate to the prediction of different mental health outcomes. The sample sizes for the three studies were as follows: 73 college seniors in Study 1, 102 university students in Study 2, and 141 people from the general public who were not enrolled in any academic programs. Results demonstrated that adaptability substantially contributed to psychological discomfort and well-being (life satisfaction, flourishing, psychological wellness, and general affect) apart from variance linked to social support. This pattern was consistent across all investigations. Social support significantly contributed independently to most well-being outcomes (except psychological distress in university students) when deep learning was used to generate predictions beyond the impacts of adaptation. Study 4 used the same outcome measures to compare 243 adults—some of whom were university students and others who were not—in order to identify the elements that forecast psychological well-being. College students ranked adaptation higher than non-studying adults, who ranked social support higher. As a last point, it was unexpected that adaptation and social support did not work together to predict psychological outcomes; rather, they were shown to be separate main effects.

In this research (Ezz and Elshenawy, 2020), developed an adaptive recommendation system to help college-bound students choose the best academic track(s) for them. Automated use of various data mining approaches for feature extraction and model construction allows for the adaptation to diverse educational pathways. A one-versus-all format was automatically applied to the dataset, and the task was presented as a multi-label multi-class binary classification issue. Students enrolled in the engineering program at AL-Azhar University are used as an example to demonstrate how the suggested model works in practise. Each student's academic record is used to determine which of seven engineering disciplines would be the best fit for them. To make its recommendations, the system takes into account information from each division (i.e., curriculum). The next step is to choose the best performing deep learning algorithm for each department's recommendation process after determining the appropriate set of features for each department. The findings shown that the suggested model accurately recommends the most appropriate engineering department(s) for students, finds the necessary data that is essential for the recommendation process, and suggests the best deep learning algorithm (model) for each academic department.

## Research Gap

Although there has been much research done on the problem of predicting student adaptability through the employment of ML and DL, there are still weaknesses. Recent works are accurate but fail to apply state-of-the-art explainable AI (XAI) to identify major adaptability determinants. The most common variables used in research are demographic and behavioral, while psychological variables, such as motivation and perseverance, are investigated far less frequently. There is also the absence of flexible, context-sensitive models that can learn from student data in relevant immediacies as multiple contexts of learning environments. Furthermore, repeater model retraining to fit changing educational paradigms is rarely discussed in the literature, which makes the development of accurate, explainable models, based on the predictive and psychological properties of the learning process a crucial task.

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