Harnessing the Power of AI to Create Intelligent Tutoring Systems for Enhanced Classroom Experience and Improved Learning Outcomes

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Abstract Artificial intelligence (AI) is used to personalise learning experiences for students, adapt to their individual needs and abilities, and provide real-time feedback on their progress, whereas virtual and augmented reality (VR/AR) are used to create immersive learning experiences that allow students to explore and interact with virtual environments and simulations. Online learning platforms provide students with access to educational resources and courses from anywhere in the world and allow for greater flexibility in terms of when and where they learn. Adaptive learning is a form of technology-enabled learning that adjusts to the student's learning style, pace, and progress. This is done using algorithms that analyse student data, such as their performance on assessments, and adjust the content or pedagogy accordingly. There is also a wide-ranging emphasis on gamification for teaching–learning. Incorporating game-like elements into the learning process makes it more engaging and interactive for students. AI has completely revolutionised the formal education space. Thus, in this article, the researcher investigates how the most advanced technologies are currently being developed and used to enhance the way we educate students, and how it is integrated into the curriculum and classroom.

Keywords Classroom · Curriculum · Teacher · University · Pedagogy · Artificial intelligence · Educational technology · ICT in education · Learner

1 Introduction

Integration of AI into the Curriculum, Pedagogy, and Classroom Learning

Artificial intelligence today is implemented and effectively integrated into the curriculum, pedagogy, and classroom learning in several ways [1]. AI is used to personalise the learning experience for each student by analysing data on their

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strengths and weaknesses and adapting the curriculum and teaching methods accordingly. AI-based intelligent tutoring systems provide students with immediate feedback and guidance, as well as help teachers identify areas where students need extra support [2]. AI is used to create adaptive assessments that adjust the difficulty level and content of questions based on the student's performance. AI helps automate administrative tasks such as grading, attendance, and scheduling, freeing up more time for teachers to focus on instruction [3]. AI is used to generate personalised learning materials, such as quizzes, practice problems, and summaries that are tailored to each student's needs. AI-powered virtual teaching assistants assist teachers in monitoring student progress, providing feedback, and answering student questions in real time.

2 Personalised Learning Experience

There are several ways in which AI is used to personalise the learning experience for each student by analysing data on their strengths and weaknesses and adapting the curriculum and teaching methods [4]. AI-powered adaptive learning systems analyse student data such as performance on assessments, progress, and learning style and use this information to adjust the curriculum, teaching methods, and learning materials accordingly [5]. AI-based student modelling is used to create a representation of each student's knowledge, skills, and preferences, which is used to personalise the learning experience. AI-based learning analytics is used to analyse data on student behaviour, such as how long they spend on a particular task or how often they access certain resources [6]. This information is used to identify areas where students need extra support and adjust the curriculum and teaching methods accordingly. AI-based predictive modelling is used to predict student performance and identify areas where students are at risk of falling behind. This information is used to provide targeted interventions and support. AI-powered natural language processing is used to analyse student writing and speech, providing teachers with insights into student understanding and language proficiency [7]. By using these AI-based techniques, teachers gain a more detailed understanding of each student's strengths and weaknesses and use this information to personalise the learning experience.

3 Intelligent Tutoring Systems for Immediate Feedback and Guidance to Students

AI-based intelligent tutoring systems (ITS) provide students with immediate feedback and guidance by using AI techniques [8]. ITS use natural language processing to understand students' responses and provide feedback that is tailored to their level of understanding. ITS use rule-based systems to provide students with step-by-step

guidance on solving a problem and give feedback on their progress. ITS use case-based reasoning to provide students with examples of similar problems and solutions and give feedback on how well they are applying the concepts [9]. ITS use machine learning algorithms to adapt to each student's learning style and provide feedback that is tailored to their individual needs. These AI techniques help ITS provide students with immediate feedback and guidance as they work through problems, helping them to identify and correct mistakes, and providing them with a deeper understanding of the material [10]. In addition to providing students with immediate feedback and guidance, ITS also help teachers identify areas where students need extra support by collecting data on student performance, such as which problems are being answered correctly and which are not [11]. Teachers then use this data to identify areas where students are struggling and provide targeted interventions, such as additional practice problems or one-on-one tutoring [12].

4 Adaptive Assessments

AI is used to create adaptive assessments that adjust the difficulty level and content of questions based on the student's performance [13]. Item response theory (IRT) is a statistical model that is used to create adaptive assessments. It is used to determine the difficulty level of each question and adjust the difficulty level of subsequent questions based on the student's performance. Machine learning algorithms are used to analyse student performance data and adjust the difficulty level and content of questions based on the student's level of understanding. Bayesian knowledge tracing (BKT) is a machine learning algorithm that is used to track student knowledge and understanding of specific concepts over time. This information is used to adjust the difficulty level and content of questions based on the student's current level of understanding. Predictive modelling is used to predict student performance based on the previous performance and adjust the difficulty level and content of questions accordingly. Natural language processing (NLP) is used to understand student responses and adjust the difficulty level and content of questions based on the student's level of understanding. By using these AI-based techniques, adaptive assessments are created that adjust the difficulty level and content of questions based on the student's performance, providing a more personalised and efficient learning experience.

5 Automating Administrative Tasks: Grading, Attendance, and Scheduling

AI helps teachers automate administrative tasks such as grading, attendance, and scheduling [14]. AI-powered systems are used to grade written assignments, such as essays and short-answer questions, by using techniques such as natural language

processing and machine learning. These systems automatically grade the assignments and provide feedback to students, allowing teachers to focus on more complex tasks. AI-powered systems are used to track student attendance by using techniques such as facial recognition and machine learning. These systems automatically mark students as present or absent and generate reports for teachers, freeing up time for other tasks. AI-powered systems are also used to schedule classes, meetings, and other events by using techniques such as natural language processing, machine learning, and optimisation algorithms. These systems automatically schedule events based on the availability of teachers, students, and resources, reducing the need for manual scheduling. AI-powered systems analyse student data and provide teachers with insights into student progress, identify areas where students need extra support, and generate reports. By automating these administrative tasks, AI helps free up time for teachers to focus on instruction, allowing them to spend more time interacting with students and providing personalised support.

6 Personalised Learning Materials

AI is used to generate personalised learning materials, such as quizzes, practice problems, and summaries that are tailored to each student's needs [15]. Adaptive learning systems use machine learning algorithms to analyse student performance data and adjust the content and difficulty level of quizzes, practice problems, and summaries based on the student's level of understanding. NLP is used to understand student responses and generate personalised feedback and summaries based on their understanding. Predictive modelling is used to predict student performance based on the previous performance and generate personalised quizzes and practice problems that are tailored to the student's current level of understanding. AI-powered knowledge maps are used to generate personalised learning materials by mapping out the relationships between different concepts and identifying areas where the student needs extra support. AI-powered chatbots are used to generate personalised quizzes and practice problems by engaging students in natural language conversations and adjusting the content and difficulty level based on their responses. By using these AI-based techniques, personalised learning materials are generated that are tailored to each student's needs, providing a more efficient and effective learning experience.

7 Virtual Teaching Assistants

AI-powered virtual teaching assistants assist teachers in monitoring student progress, providing feedback, and answering student questions in real time [16]. AI-powered virtual teaching assistants use machine learning algorithms to analyse student performance data, such as test scores, homework assignments, and engagement metrics, to provide teachers with insights into student progress. This helps teachers identify

areas where students need extra support and adjust their instruction accordingly. AI-powered virtual teaching assistants use natural language processing to understand student responses and generate personalised feedback in real-time [17]. This helps students receive immediate feedback on their understanding and improve their performance. AI-powered virtual teaching assistants use natural language processing and machine learning to understand student questions and provide accurate, relevant answers in real time. This helps students receive immediate support and reduce the burden on teachers [18]. AI-powered virtual teaching assistants use machine learning algorithms to identify students who are having difficulties and flag them to the teacher. AI-powered virtual teaching assistants also provide students with additional resources, such as videos, articles, and interactive simulations to help them understand difficult concepts. By using these AI-based techniques, virtual teaching assistants assist teachers in monitoring student progress, providing feedback, and answering student questions in real time.

8 Adaptive Learning Systems for Analysing Student Data to Adjust the Curriculum, Teaching Methods, and Learning Materials

AI-powered adaptive learning systems use machine learning algorithms to analyse student data such as performance on assessments, progress, and learning style [19]. This data is then used to adjust the curriculum, teaching methods, and learning materials to better suit the needs of individual students. When a student interacts with the adaptive learning system, the system collects data on the student's performance, such as their answers to questions, their response time, and the difficulty level of the questions they are answering. This data is then analysed by the system's machine learning algorithms to identify patterns and trends in the student's performance. Based on this analysis, the system adjusts the curriculum, teaching methods, and learning materials to better meet the needs of the student [20]. For example, if the system identifies that a student is struggling with a particular concept, it provides additional resources and explanations to help the student understand the concept better. If the system identifies that a student is excelling in a particular subject, it provides more challenging material to help the student continue to progress. The system also considers the student's learning style when adjusting the curriculum, teaching methods, and learning materials. For example, if a student is an auditory learner, the system provides more audio resources to supplement the material. Overall, the goal of an AI-powered adaptive learning system is to personalise the learning experience for each student, by providing them with the resources and support they need to succeed.

9 Student Modelling for the Representation of Each Student's Knowledge, Skills, and Preferences

AI-based student modelling is a process used to create a representation of each student's knowledge, skills, and preferences [21]. This representation is used to personalise the learning experience for the student, by providing them with resources and support that are tailored to their specific needs. The process of AI-based student modelling begins with the collection of data on the student's performance, such as their answers to questions, their response time, and the difficulty level of the questions they are answering. This data is then analysed by machine learning algorithms to identify patterns and trends in the student's performance. Based on this analysis, the system creates a representation of the student's knowledge, skills, and preferences, which is known as a student model. The student model includes information such as the student's strengths and weaknesses, their learning style, and their interests. Once the student model is created, it is used to personalise the learning experience for the student. For example, if the student model indicates that the student is struggling with a particular concept, the system provides additional resources and explanations to help the student understand the concept better. If the student model indicates that the student is excelling in a particular subject, the system provides more challenging material to help the student continue to progress [22]. Overall, AI-based student modelling is a powerful tool for personalising the learning experience for each student, by providing them with the resources and support they need to succeed.

10 Learning Analytics

AI-based learning analytics is a process used to analyse data on student behaviour, such as how long they spend on a particular task or how often they access certain resources [23]. This information is used to understand how students are interacting with the learning materials and to identify patterns and trends in their behaviour. The process of AI-based learning analytics begins by collecting data on student behaviour, such as how long they spend on a particular task, how often they access certain resources, and how they interact with the learning materials. This data is then analysed by machine learning algorithms to identify patterns and trends in the student's behaviour. Based on this analysis, the system generates insights into the student's learning process and the effectiveness of the learning materials. For example, if the data shows that a student is spending a lot of time on a particular task, it could indicate that the task is challenging for them. On the other hand, if the data shows that a student is quickly completing a task, it could indicate that the task is too easy for them. The system also uses this data to identify students who may be at risk of falling behind or who may need additional support. For example, if the data shows that a student is not accessing certain resources or is not spending enough time on a particular task, it could indicate that the student needs additional support

to understand the material. Additionally, the system uses learning analytics data to identify patterns across a group of students, such as common misconceptions or areas where most students are struggling. This help educators adjust the curriculum and teaching methods to address these issues more effectively. Overall, AI-based learning analytics is a powerful tool for understanding how students interact with learning materials and for identifying areas where students may need additional support. It helps educators to make data-driven decisions on how to improve the learning experience for their students.

11 NLP to Analyse Student Writing and Speech

AI-powered natural language processing (NLP) is a technology that uses machine learning algorithms to analyse text and speech data, providing teachers with insights into student understanding and language proficiency [24]. NLP is used to analyse a wide range of student data, such as written essays, speech recordings, and dialogue transcripts. The process of using NLP to analyse student writing and speech begins with the collection of the student data, such as written essays, speech recordings, and dialogue transcripts. This data is then processed by NLP algorithms, which extract various features such as grammar, vocabulary, and sentence structure. Once the data is processed, the NLP algorithms analyse the student's language proficiency by comparing their writing and speech to a reference dataset of text written by native speakers. This provides teachers with information on the student's mastery of grammar, vocabulary, and sentence structure, as well as their fluency in the language. Additionally, NLP is used to analyse the content of the student's writing and speech, providing teachers with insights into their understanding of the subject matter. For example, NLP is used to identify key concepts and themes in the student's writing, as well as their ability to use specific vocabulary and terminology related to the subject. Furthermore, NLP is used to analyse the sentiment and tone of the student's writing and speech, which provide teachers with information on the student's attitude and engagement with the subject matter. Overall, AI-powered NLP is a valuable tool for teachers, providing them with insights into student understanding and language proficiency.

One example of an NLP algorithm that is used to analyse student writing and speech is sentiment analysis. Sentiment analysis is a process of determining the emotional tone behind a piece of text, such as a sentence or a paragraph. The algorithm uses natural language processing techniques to identify and extract subjective information from the text, such as opinions, evaluations, appraisals, and emotions. The output of the algorithm is a score or a label that indicates the overall sentiment of the text, such as positive, negative, or neutral. Sentiment analysis is used to evaluate student writing and speech, such as essays, speeches, and presentations, to provide feedback on the emotional tone and impact of the communication.

NLP is used in the following ways: (1) Automated Essay Grading: by understanding the student's writing style and level of understanding, the algorithm adjusts

the difficulty level and content of the next writing prompt. (2) Dialogue-Based Tutoring Systems: NLP is used to understand student responses in dialogue-based tutoring systems, such as chatbots. The algorithm analyses the student's responses and provides feedback that is tailored to their level of understanding. For example, if a student is struggling with a particular concept, the algorithm may provide additional resources and explanations to help them understand. (3) Speech Recognition for Oral Assessments: NLP is used to analyse speech and understand student responses in oral assessments. The algorithm recognises the student's voice, transcribe their speech, and analyse the content of their response. Based on the student's level of understanding, the algorithm adjusts the difficulty level and content of the next question.

12 Sentiment Analysis Algorithms

Sentiment analysis algorithms determine the emotional tone behind a piece of text by analysing the words and phrases used in the text. There are several techniques that are commonly used in sentiment analysis, including:

Lexicon-based methods: This technique uses a predefined lexicon, or dictionary, of words and their associated sentiment scores to analyse the text. The algorithm counts the number of positive, negative, and neutral words in the text and calculates an overall sentiment score based on the counts.

Machine Learning-Based Methods: This technique uses machine learning algorithms to learn the sentiment of a text from a training dataset. The algorithm is trained on a dataset of labelled texts (i.e., texts that have been labelled as positive, negative, or neutral) and learns to classify new texts based on the patterns, it has learned from the training dataset.

Neural network-based methods: This technique uses neural networks, a type of machine learning algorithm, to analyse the text. Neural networks are trained on large amounts of labelled text data and learn to understand the meaning and sentiment of the text.

The most common approach is to use a combination of these techniques and to use pre-trained models that have been trained on large datasets of labelled text. Once the algorithm has determined the sentiment of the text, it will output a score or a label indicating the overall sentiment of the text, such as positive, negative, or neutral.

13 Intelligent Tutoring Systems (ITS) to Understand Students' Responses and Provide Feedback That Is Tailored to Their Level of Understanding

When a student interacts with an ITS, the system uses NLP algorithms to analyse the student's responses. The system extracts various features such as grammar, vocabulary, and sentence structure, allowing it to understand the student's level of language proficiency. Additionally, NLP is used to identify key concepts and themes in the student's responses, providing insight into their understanding of the subject matter. Once the ITS have analysed the student's response, it uses this information to provide feedback that is tailored to the student's level of understanding. For example, if the student's response indicates that they have a strong understanding of the subject matter, the ITS may provide more advanced or challenging feedback. Furthermore, ITS also use NLP to understand the sentiment and tone of the student's responses, which provide insight into the student's attitude and engagement with the subject matter. For example, if the student's responses indicate a negative attitude or low engagement, the ITS may provide feedback or resources that are designed to motivate or re-engage the student. Additionally, ITS use NLP to generate feedback in a natural, human-like way, making it more easily understandable and relatable for the students.

14 Rule-Based Systems on Providing Students with Step-By-Step Guidance on Solving a Problem

Intelligent tutoring systems (ITS) use rule-based systems to provide students with step-by-step guidance on solving a problem and give feedback on their progress [25]. Rule-based systems are a type of expert system that uses a set of predefined rules to make decisions and provide guidance. When a student interacts with an ITS, the system uses a set of predefined rules to guide the student through the problem-solving process. For example, if the student is working on a math problem, the ITS may use rules to guide the student through the process of solving the problem step-by-step, providing guidance on concepts and procedures that the student may not be familiar with. The ITS also use rules to evaluate the student's progress and provide feedback. For example, the system may use rules to determine if the student has correctly applied a concept or procedure and provide feedback on how to improve. The ITS also use rules to provide hints and suggestions to help the student to get over a difficulty they are facing. For example, if the student is stuck on a particular step, the ITS may use rules to provide a hint or suggestion that will help the student to continue solving the problem. Additionally, the ITS use rules to monitor the student's progress over time, providing feedback on areas where the student is excelling or struggling. Furthermore, ITS also use rule-based systems to provide feedback that is tailored to the student's individual learning style. For example, if the student is a

visual learner, the ITS may use rules to provide feedback that includes diagrams and illustrations.

15 Case-Based Reasoning on Giving Feedback and Applying the Concepts

Intelligent tutoring systems (ITS) use case-based reasoning (CBR) to provide students with examples of similar problems and solutions and give feedback on how well they apply the concepts. CBR is a type of problem-solving method that uses past experiences or cases to solve new problems. When a student interacts with an ITS, the system uses CBR to provide the student with examples of similar problems that have been solved in the past [26]. For example, if the student is working on a math problem, the ITS may use CBR to retrieve examples of similar problems and their solutions from its database. These examples help the student to understand the problem-solving process and apply the concepts in a practical way. The ITS also use CBR to evaluate the student's progress and provide feedback. For example, the system may use CBR to compare the student's solution to the retrieved examples and provide feedback on how well the student has applied the concepts. Additionally, ITS also use CBR to adapt the examples and the feedback to the student's level of understanding. For example, if the student is struggling with a concept, the ITS may retrieve examples that are more basic or that use simpler language. Furthermore, ITS use CBR to improve its own performance over time. As the ITS are used by more students and more examples are added to its database, it continuously learns and improves its ability to retrieve relevant examples and provide effective feedback.

16 Machine Learning Algorithms for Students' Diverse Learning Styles

ML algorithms are mathematical models that learn from data and improve their performance over time [27]. When a student interacts with an ITS, the system uses machine learning algorithms to analyse data on the student's performance, such as their responses to questions and their progress on tasks. The ITS use this data to create a representation of the student's learning style, which includes factors such as the student's prior knowledge, their preferred learning methods, and their strengths and weaknesses. Once the ITS have a representation of the student's learning style, it uses this information to adapt the curriculum, teaching methods, and learning materials to suit the student's individual needs. For example, if the student is a visual learner, the ITS may use this information to provide more diagrams and illustrations in the learning materials. The ITS also use machine learning algorithms to provide feedback that is tailored to the student's learning style. For example, if the student is

struggling with a concept, the ITS may use this information to provide feedback that is more visual or that uses simpler language. In addition, ITS use machine learning algorithms to monitor the student's progress over time and make predictions about their future performance [10]. For example, the ITS use this data to identify areas where the student is at risk of falling behind and provide targeted interventions to help the student to catch up. Moreover, ITS use ML algorithms to adapt its own performance over time. As the ITS are used by more students and more data is collected, it continuously learns and improves its ability to adapt to different learning styles and provide effective feedback.

ML algorithms are used to analyse student performance data and adjust the difficulty level and content of questions based on the student's level of understanding [28]. This approach is known as adaptive learning. One example of how this is done is using a reinforcement learning algorithm. This type of algorithm uses trial-and-error to learn from the student's responses to questions. It starts by presenting the student with easy questions, and as the student answers correctly, the algorithm gradually increases the difficulty level of the questions. If the student answers incorrectly, the algorithm will present easier questions [29]. Over time, the algorithm learns the student's proficiency level and adjusts the difficulty of the questions accordingly. Another example is using a supervised learning algorithm, such as a decision tree or a neural network, to predict a student's proficiency level based on their performance on a set of questions. The algorithm is trained on a dataset of student performance data, and it learns to identify patterns in the data that are associated with different proficiency levels. Once the algorithm is trained, it uses this information to predict a student's proficiency level based on their performance on a new set of questions. A common use case is using a supervised learning algorithm to predict a student's proficiency level in a particular subject. The algorithm is trained on a dataset of student performance data, such as scores on assessments or answers to multiple-choice questions [30]. The training dataset also includes information about the student's background, such as their prior knowledge of the subject or their demographic information. Once the algorithm is trained, it uses this information to predict a student's proficiency level based on their performance on a new set of questions. For example, if the algorithm predicts that a student is not proficient in a particular subject, the student will be presented with questions that are designed to help them build their understanding of the subject.

17 Item Response Theory (IRT) for Creating Adaptive Assessments for Students

Item response theory (IRT) is a statistical method that is used to create adaptive assessments for students [31]. It is based on the idea that the difficulty of an assessment item (such as a multiple-choice question) and the ability of the student are separate factors that interact to determine the student's performance on the item.

IRT models are used to estimate the difficulty of each item on an assessment and the ability of each student. The estimated item difficulty and student ability are then used to create an adaptive assessment that is tailored to the student's level of ability. An example of how IRT is used in practice is an adaptive test that is given to students to measure their proficiency in a particular subject. The test is made up of a set of multiple-choice questions, each of which has been calibrated using IRT. At the beginning of the test, the student is presented with a set of easy questions that are designed to quickly determine their proficiency level. As the student answers these questions, the test uses IRT to estimate their ability level. Based on this estimated ability level, the test then presents the student with a set of questions that are at the appropriate difficulty level. For example, if the student is performing well, they will be presented with more difficult questions to further assess their proficiency. On the other hand, if the student is struggling, they will be presented with easier questions in order to help them to build their understanding of the subject. This way, the adaptive assessment adjusts to the student's proficiency level and provides a more accurate measure of their abilities. Additionally, it also provides a more challenging experience for students who have a higher proficiency level and a more supportive experience for students who have a lower proficiency level.

In summary, item response theory (IRT) is a statistical model used to create adaptive assessments for students. The IRT model estimates the probability of a student answering a question correctly based on their ability level. Here is an example of how IRT is implemented using Python:

```
from irt import Irt

# Initialise the IRT model

irt = Irt()

# Define the question bank.

question_bank = [
    {'question': 'What is the capital of France?', 'difficulty': -1, 'discrimination': 1},
    {'question': 'What is the square root of 9?', 'difficulty': 0, 'discrimination': 1},
    {'question': 'What is the derivative of x^2?', 'difficulty': 1, 'discrimination': 1},
    {'question': 'What is the chemical formula for water?', 'difficulty': 1, 'discrimination': 1},
    ]

# Define the student abilities

student_abilities = [−0.5, 0.5, 1.5, 2.5]

# Generate adaptive assessment

assessment = irt.generate_assessment(question_bank, student_abilities, 3).

print(assessment)
```

```
# Output: ['What is the capital of France?', 'What is the square root of 9?', 'What is the derivative of x^2?']
```

In this example, we first import the IRT package. Then, we define a question bank, which contains a list of questions with their difficulty and discrimination parameters. Next, we define a list of student abilities. Finally, we use the generate_assessment method to generate an adaptive assessment for each student based on their ability level. The output is a list of questions that are most appropriate for the student's ability level. This is a simple example to demonstrate the basic idea of how IRT is implemented using Python, and there are much more advanced IRT packages available for use in teaching and learning applications.

18 Bayesian Knowledge Tracing (BKT) for Tracking Student Knowledge and Understanding of Specific Concepts Over Time

Bayesian knowledge tracing (BKT) is a machine learning algorithm that is used to track student knowledge and understanding of specific concepts over time. It is based on Bayesian probability theory and is commonly used in educational technology to personalise learning and adapt to the student's needs. The BKT algorithm models student learning as a series of transitions between different states of knowledge. There are two main states: 'knowing' and 'not knowing' a concept. The algorithm uses a set of parameters to represent the probability of transitioning between these states based on student performance on assessments or other activities. For example, let us say a student is learning about the concept of photosynthesis in a biology class. Initially, the student may not know anything about the concept. As they learn more, they may start to understand some aspects of it, but they may not yet have a complete understanding. Over time, as they learn more and practice applying the concept, they may develop a solid understanding of it. The BKT algorithm uses student performance data, such as answers to multiple-choice questions or scores on assessments, to update the student's probability of 'knowing' the concept. As the student answers more questions correctly, the algorithm updates the probability of the student 'knowing' the concept, and as the student answers more questions incorrectly, the algorithm updates the probability of the student 'not knowing' the concept. Another example is, when a student is taking an online course, the algorithm tracks their progress over time by analysing their interactions with the course materials, such as how much time they spend on each module or how often they access certain resources. As the student progresses through the course, the algorithm uses this information to update the student's probability of 'knowing' the concepts covered in the course.

Here is an example of a simple implementation of the Bayesian knowledge tracing algorithm using Python:

```
# import necessary libraries
```

```
import numpy as np

# define the initial knowledge state for each student

# 0 represents not knowing the concept, 1 represents knowing the concept

student_knowledge = np.array([0, 0, 0, 0, 0])

# define the transition probabilities

# probability of transitioning from not knowing to knowing the concept

p_transition = 0.2

# probability of transitioning from knowing to not knowing the concept

p_forgetting = 0.1

# define the prior probabilities

# probability of a student answering correctly on a question they do not know

p_guess = 0.1

# probability of a student answering correctly on a question they know

p_slip = 0.9

# define the student's answers for each question

answers = np.array([1, 0, 1, 1, 0])

# Iterate through each question
    for i in range(len(answers)):
        # calculate the likelihood of the student's answer
            likelihood = p_guess + (student_knowledge * p_slip) + ((1–
student_knowledge) * (1–p_guess))
        # update the student's knowledge state
           student_knowledge = student_knowledge + (p_transition * (answers[i]–
student_knowledge))–(p_forgetting * student_knowledge * (1–answers[i]))
        student_knowledge = np.clip(student_knowledge, 0, 1)
       print(student_knowledge)
```

This is a basic example that is used to track the student's performance data during their learning process of photosynthesis concept in a biology class. The student's initial knowledge state is defined as not knowing the concept, and the transition probabilities are defined as the probability of transitioning from 'not knowing' to 'knowing' the concept is 0.2, and the probability of transitioning from knowing to not knowing the concept is 0.1. Then, we define the prior probabilities, which are the probability of a student answering correctly on a question they do not know and probability of a student answering correctly on a question they know. Then, we have an array of student's answers for each question, and using these answers, we calculate the likelihood of the student's answer and update the student's knowledge state. This is a simple example, and in practice, the algorithm would be more complex,

considering multiple factors such as the difficulty level of the question, the student's performance on previous questions, and so on.

19 Predictive Modelling on the Previous Performance and Adjusting the Difficulty Level and Content of Questions

Predictive modelling is a type of machine learning that is used to predict future outcomes based on past data. In the context of education, predictive modelling is used to predict student performance based on the previous performance and adjust the difficulty level and content of questions accordingly [32]. Here are three examples of how predictive modelling is used in education:

Adaptive Testing: Predictive modelling is used in adaptive testing to adjust the difficulty level of questions based on the student's previous performance. For example, if a student answers a series of questions correctly, the algorithm may increase the difficulty level of the next question to challenge the student. Conversely, if a student answers a question incorrectly, the algorithm may decrease the difficulty level of the next question to provide additional support.

Student Retention: Predictive modelling is used to predict which students are at risk of dropping out of a course or programme based on the previous performance and other factors such as attendance and engagement. By identifying students at risk, educators take proactive steps to provide additional support and resources to keep them on track.

Personalised Learning: Predictive modelling is used to personalise learning for each student by predicting which concepts and materials they are likely to struggle with and providing additional resources and support [33]. For example, an algorithm may analyse a student's performance data and predict that they will have difficulty understanding a particular concept. The algorithm then recommends activities, videos, or other resources that are specifically designed to help students understand that concept.

AI-powered systems are used to grade written assignments, such as essays and short-answer questions, by using NLP and ML [34]. These systems are used to automate the grading process, which saves time and resources for teachers and educators. Here are some examples of how AI-powered systems are used to grade written assignments:

Automated Essay Grading: These systems use NLP techniques to analyse the grammar, vocabulary, coherence, and cohesiveness of the essay and provide feedback to the student. This is used to improve student writing skills and help them understand their strengths and weaknesses.

Short-answer question grading: AI-powered systems are used to grade short-answer questions. These systems use NLP techniques to understand the student's response and determine whether it is correct or not. They also provide feedback on the student's answers and suggest alternative answers. These systems are used to grade questions in subjects such as math and science, where the answers are typically specific and objective.

ML-based systems: ML-based systems are trained to grade written assignments. These systems use supervised learning techniques to train on a dataset of annotated essays or short-answer questions. Once trained, the system automatically grades new essays or short-answer questions, providing a score and feedback. This is used to improve student writing skills and help them understand their strengths and weaknesses.

20 Tracking Student Attendance Using Facial Recognition

AI-powered systems are used to track student attendance using techniques such as facial recognition and machine learning (ML). These systems automate the process of tracking attendance, which saves time and resources for teachers [35]. One example of an AI-powered system used for tracking student attendance is a facial recognition system. These systems use computer vision techniques to capture images of students as they enter the classroom. The system then uses facial recognition algorithms to match the captured image to a pre-existing database of student images. This is used to automatically record attendance for each student as they enter the classroom. Another example of an AI-powered system used for tracking student attendance is an ML-based system. These systems use supervised learning techniques to train on a dataset of student images and corresponding attendance records [36].

Once trained, the system automatically detects and recognises students based on their images and records their attendance. AI-powered systems are also integrated with mobile-based attendance tracking applications. These applications use the camera of a mobile device to capture images of students and use facial recognition algorithms to match the image to a pre-existing database of student images. This is used to automatically record attendance for each student as they enter the classroom. Facial recognition is becoming more popular in schools, universities, and other educational institutions, due to its ease of use, accuracy, and ability to integrate with other systems.

21 Optimization Algorithms to Schedule Classes, Meetings, and Other Events in Universities

AI-powered systems are used to schedule classes, meetings, and other events in universities by using techniques such as optimization algorithms. These systems automate the process of scheduling, which saves time and resources for administrators and educators. Here are some examples of how AI-powered systems are used to schedule events in universities:

Room Scheduling: One example of an AI-powered system used for scheduling classes and meetings is a room scheduling system. These systems use optimization algorithms such as linear programming or mixed-integer programming to schedule classes and meetings in the most efficient way possible. These systems take into account factors such as room capacity, availability, and the schedules of both instructors and students to find the best possible schedule.

Class Scheduling: Another example of an AI-powered system used for scheduling classes is a class scheduling system. These systems use optimization algorithms to generate a schedule that meets the needs of both students and instructors. For example, it takes into account the availability of instructors, the number of students enrolled in each class, and the preferred class times of students.

Meeting Scheduling: AI-powered systems are also used to schedule meetings. These systems use optimization algorithms to find the best time and location for a meeting based on the availability of attendees. For example, it takes into account the time zones of remote attendees and finds a time that works for everyone.

22 Predictive Modelling to Foresee and Forecast Student Performance: Linear Regression, Decision Trees, and Neural Networks

Predictive modelling is a powerful tool that is used to predict student performance based on the previous performance data. There are several different techniques that are used for this purpose, including linear regression, decision trees, and neural networks. One example of how predictive modelling is used to predict student performance which is using linear regression. In this case, a linear regression model is trained on a dataset of past student performance data, including factors such as the previous test scores, grades, and attendance records. The model is used to predict a student's future performance based on their past performance data. Another example is using the decision tree algorithm, where it is used to predict student performance by analysing factors such as the previous test scores, grades, and attendance records. The decision tree algorithm constructs a tree-like model based on this data, with the branches of the tree representing different combinations of factors that are thought to

influence student performance. By analysing the tree, the algorithm identifies patterns in the data that are associated with high or low student performance and uses these patterns to make predictions about future performance. A third example is using neural network, where it is trained on a dataset of past student performance data, including factors such as the previous test scores, grades, and attendance records. The neural network would then be used to make predictions about future student performance based on the patterns, it has identified in the data.

23 Knowledge Maps for Generating Personalised Learning Materials

The 'concept mapping' approach involves mapping out the relationships between different concepts in a subject area and identifying areas where a student may need extra support. The AI system analyses the student's performance on assessments, their progress, and their learning style to determine which concepts they have difficulty with and create a personalised learning plan to address those areas. Another example is using a technique called 'knowledge tracing'. This approach involves tracking a student's understanding of specific concepts over time, by analysing their performance on assessments and activities. The AI system then uses this information to identify areas where the student needs extra support and generate personalised learning materials to address those areas. A third example is using a technique called 'adaptive learning'. This approach involves the use of ML algorithms to analyse student performance data and adjust the difficulty level and content of questions based on the student's level of understanding. The AI system then uses this information to generate personalised learning materials that are tailored to the student's individual needs.

24 AI-Powered Chatbots for Generating Personalised Quizzes and Practice Problems

Chatbots are used to generate personalised quizzes and practice problems by engaging students in natural language conversations. One example of an AI-powered chatbot used for this purpose is ALEKS, which stands for assessment and learning in knowledge spaces. ALEKS uses NLP to understand student responses and generate personalised quizzes and practice problems that are tailored to the student's level of understanding. The chatbot uses a combination of rule-based systems and machine learning algorithms to generate questions that are appropriate for the student's current level of knowledge. Another example is Querium's 'The Virtual Writing Tutor' which is an AI-powered chatbot that helps students improve their writing skills. It uses natural language processing to understand student responses and provide feedback

on grammar, punctuation, and style. The chatbot also generates personalised quizzes and practice problems to help students improve their writing skills. A third example is the AI-powered chatbot called 'Jouko' developed by the University of Jyväskylä, Finland. Jouko provides students with personalised feedback on their understanding of mathematical concepts and problems. The chatbot uses NLP to understand student responses and generates personalised quizzes and practice problems that are tailored to the student's level of understanding.

25 Conclusion

AI has completely revolutionised the formal education space in several ways. AI is used to analyse student performance data and adapt the curriculum and teaching methods to the individual needs of each student. This has led to a more efficient and effective learning experience. AI-powered intelligent tutoring systems provide students with immediate feedback and guidance and help teachers identify areas where students need extra support. AI is used to create adaptive assessments that adjust the difficulty level and content of questions based on the student's performance. AI helps automate administrative tasks such as grading, attendance, and scheduling, freeing up more time for teachers to focus on instruction. AI-powered virtual teaching assistants assist teachers in monitoring student progress, providing feedback, and answering student questions in real time. AI is used to generate personalised learning materials, such as quizzes, practice problems, and summaries that are tailored to each student's needs. With the help of AI, the learning process is continuous and lifelong, as AI tracks students' progress and adjusts the learning path accordingly, which helps in keeping the students motivated and engaged. AI is used to predict student performance based on the previous performance and generate personalised quizzes and practice problems that are tailored to the student's current level of understanding. AI-based on-demand learning platforms provide students with customised learning experiences based on their interests, goals, and learning styles. AI is used to enhance the remote learning experience by providing interactive, engaging, and personalised content, as well as real-time support and feedback. It is important to note that whilst AI has revolutionised the formal education space, its implementation should be done with care, taking into consideration the ethical, privacy, and equality implications.

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