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ORIGINAL PAPER

# Exploiting the Capabilities of Blockchain and Machine Learning in Education

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## Abstract

Today, technology has advanced tremendously that it is now being incorporated into the education sector for academic enhancement. Certain technologies like Artificial Intelligence, Machine Learning, Blockchain, Big data, Internet of Things, Augmented Reality, Cloud computing, etcetera changed the conventional education system making it a better platform for the growth of students. In this paper, we dissect the importance of two blooming technologies, Blockchain and Machine Learning, in the education field. Blockchain technology, having data immutability as one of its advantages, has been used in miscellaneous fields for security aspects. It can be used to securely store the degree or other achievement certificates. Such information would be added by the college or university to the blockchain, which can be accessed or shared by the student through the online CV with employers. This approach is secure as there is no need to worry about changes to the institution or the loss of data. Also, Machine learning with its fully capable learning algorithms is the breakthrough technology for future perspectives because it can accurately predict the future based on experience; hence, the incorporation of this technology in the educational field helps the student to make a strategy with the help of various algorithms. By doing such things, better outcomes should be made from present conditions. When the benefits of blockchain are combined with Machine Learning algorithms, we can get certain predictions beforehand and we can securely store the actual results, which is the proposed idea of this study. In this study, the emphasis is made on the impacts created by recent technologies in the educational field and review of various systems proposed by blockchain and machine learning technology and assumption is made for combining two technologies for the betterment of the educational field.

**Keywords** Machine learning · Education · Blockchain

## Abbreviations

| | |
|---|---|
| AI | Artificial intelligence |
| AIEd | Artificial intelligence in education |
| AODE | Averaged one-dependence estimators |
| API | Application programming interface |
| AR | Augmented reality |
| ARS | Audience response system |
| DT | Decision tree |
| EDM | Educational data mining |
| FFNN | Feed-forward neural network |
| GPA | Grade point average |
| IBM | International business machines corporation |
| IoT | Internet of things |
| LGR | Local and global regression |
| LRS | Learning record store |
| ML | Machine learning |
| MLCM | Multi label consensus classification |
| MLP | Multilayer perceptron |
| MOOC | Massive open online course |
| NBT | Naive Bayes tree |
| PDF | Portable document format |
| SNS | Social network service |
| SVM | Support vector machine |
| VR | Virtual reality |

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## Introduction

The word education by etymologically is derived from the Latin word 'Educare' meaning 'to bring us.' Education brings us up in civilization and embellishes the dignity of a being and increases the self-respect of a person. Life without education is like a boat without a helm. In today's life, it has been observed that education plays a vital role in human races' development and advancement, also the civilization with powerful and better infrastructure in education has dominated society. Education suffices us with the knowledge of the surroundings, and it changes the perspective of one to look at things, and it builds opinions and points of view on things in one's life. This denotes education has significant importance in one's life. As education is a human-centric phenomenon, it can be turned into a technology-centric phenomenon as technology is penetrating in the routine of one's life and education is nowhere away from it. Today, the combination of education and technology has become an essential need of a person. In today's education system, skill of a person is defined by the educational qualification he/she holds, so the authenticity of such holdings is very crucial as it evaluates the dexterity of a person. Such authenticity can be verified and guaranteed with the help of advancement in various technologies.

In recent years, technology has gained such a momentum that it is shifting and penetrating in each field of human society [1–6]. The fourth industrial revolution started the thinking of implementing use cases of disruptive technologies such as IoT, Robotics, Virtual Reality (VR), Artificial Intelligence (AI), Machine learning, and Blockchain in changing the ways we live [7–9]. Technologies can be implemented in education with the help of different methodologies, contexts, and perspectives [10, 11]. Technology has strongly influenced the education system in the past few years. Today, the amount of data, knowledge, and technology are motivating educational institutes to adopt new pedagogy strategies like teaching and learning processes. [12]. Certain technologies have changed the convention of the education system and made it suitable for students like Machine Learning, Blockchain, IoT, AI, Data mining, Big data, AR, Cloud computing, etcetera [13–16].

After the popularity of digital currency bitcoin, the backend technology behind it has become a matter of discussion among the various fields. The Blockchain's unique capabilities including immutability, transparency, and trustworthiness are useful not only in cryptocurrencies but in many other fields as well. Therefore, an increasing number of blockchain-based applications have been observed in many fields. [17] So the development of blockchain can be stated as Figure 1 Jiin-Chiou [18]. The explanation of this technology can be done as a permanent book of records that keeps track of all the data transactions that have occurred in chronological order [19]. For understanding how blockchain can relate to the education field, it is mandatory to understand its components. A blockchain is a digital event distributed record. It is a long chain of linked data items that are stored on each participating computer and where the next data item can be added only by the majority of most participants. PoW is used for the incorporation of new blocks inside the chain. In which nodes must prove that they have made adequate proof to obtain the right to perform the appended work [20]. The fundamental to the design of the blockchain is "Hashing," which is an application of cryptography, and it is a way for generating random but calculated strings of numbers and letters from any sort of input. Each block has its unique hash and a link to the previous block's hash in the blockchain. If an attacker tries to tamper with a block by modifying some data, the unique hash of the block gets changed. However, the following block does not update with this change of hash, it is still pointing to the previous block's hash. Hence, there is a mismatch among the blocks and the link between them is broken. This causes an invalid copy of the blockchain. In this way, the data inside the blocks in blockchain cannot be altered or tampered with. In other words, blockchain is an immutable set of records. Blockchains allow parties to transact securely without a centrally trusted intermediary, avoiding high legal and transaction costs [21]. Machine learning with its state-of-the-art learning algorithm has proved to be capable in predicting future based on experience taken in the form of a featured dataset (This property of ML can be considered as a breakthrough property for many fields [2, 4, 6, 22, 23]. Also, these disruptive properties of the ML algorithms can revolutionize the working of many systems in the world Jani et al. [24–27]. So basically Machine learning can be explained as "A field of study which gives computers the ability to learn without being explicitly programmed," a definition by Arthur Samuel. So machine learning on a good and trusted dataset can explore many unknown things that can work for the betterment of that particular field [1, 5, 25, 27, 28] Patel et al. [2]. By this, the use of machine learning in the educational field can help the students to address their weak areas and this helps in gaining the stability of any educational institute.

In this paper, we are going to discuss the importance of recent technologies in the education field and how they will change the field soon. In Sect. 2, we discuss the impacts of such technologies in the education sector. In "Related works in applications of Blockchain and Machine Learning in the educational field" section, the emphasis is made on two most disruptive technologies, blockchain and machine learning, and study their applications and case studies

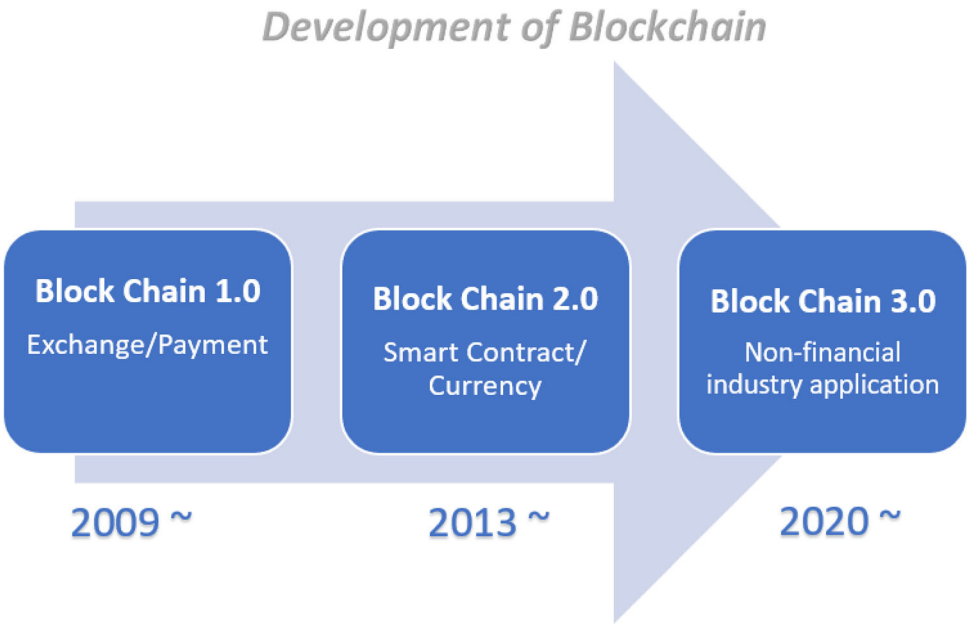


**Fig. 1** Development flowchart of Blockchain

based on various research areas which helps us to frame our proposed idea by considering the merits and demerits of these research areas based on case studies. In "Table of contents"section, we have portrayed various works done in this field by researchers along with their limitations and future scopes in a tabular form. In "Proposed idea"section, we have proposed an idea of how the synergy of blockchain and machine learning can help in the education field, and in "Challenges and future scope of the proposed system"section, the challenges and future scopes of the main objective of this paper, which is to combine two technologies, are discussed.

## Prevailing Impacts of Recent Technologies in the Educational Field

In this era, institutes are now adopting some of the advanced technologies due to their significant influence on improving pedagogy strategies and in properly directing the career of students. The impacts of these advanced technologies can be seen in many aspects of education, such as personalized content, learning activities, course presentations, sharing information and ideas [29, 30]. The reason we are studying the impacts of these emerging technologies is to change the perception toward traditional approaches in education nowadays [31]. So, before we go ahead with the in-depth discussion of Blockchain and Machine Learning in education, let us review some of the emerging technologies.

### ARS (Audience Response System)

ARS systems make it possible to use interactive text and images in the teaching and learning process. This is the change in teacher-student conventional text-based interactions, and this system promotes interactive learning and student engagement Richardson MD et al. [32].

### Biosocial and Neurocomputational Technologies

Many recent developments are done in the field of brain-based technologies of educational discipline, out of which one is under R&D that is being performed by Pearson to apply AI to education (AIEd) and the other is Cognitive computing by IBM which is being continued toward education.

The goals of the Pearson center were to gather too much data on educational activities and develop new learning process hypotheses and generate a global ranking of graded and assessed 'cognitive skills' performance of a specific country in education [33].

### AI

Pearson has been working on big data for the educational implementation of AI. AIEd offers more personalized, flexible, inclusive, and engaging learning of this kind.

Pearson offers smart tutoring programs that use AI technologies for private tutoring, and it also offers training exercises according to the intellectual needs of the learner and provides directing guidance appropriately, all without an individual teacher's presence.

### Cognitive Learning Systems

IBM's cognitive learning system is designed to be like the brain rather than being hard programmed, so that it can learn from experience and conform to the various environmental stimulation, in ways which reverberate with the latest biosocial perception of neuroplasticity and epigenetics.

IBM sees this program to refine and improve the teacher's function as a cognitive prosthetic or human value computer appendage.

### Augmented Reality

Augmented reality consists of creating the virtual scene that simulates the original scene which when applied in education makes the concept of student more clear. AR could help the learner to learn the phenomenon which was considered as nightmarish to understand by the conventional method of teaching. With AR, one can add the attractiveness in education because it lures the learner's mind by superimposing a computer-generated picture on the real-world view of the consumer [34].

### Cloud Computing

It is one of the innovative technologies that promise to bring many services in the educational field and has attracted various universities, schools, and researchers. With the capability of delivering virtual computing environments at any scale, cloud computing offers tools that provide sharing and mobility of computing practices which eventually improves productivity and expands collaboration in education [35]. Some educational benefits of cloud computing are diversity in available software applications, cost savings of licensing, security, machine life extension, and availability of connectivity outside of school [35, 36]. Many educators use Google Education Apps like Gmail, Google Drive, Google Docs, etcetera, and Microsoft's cloud service—Office 365 for Education like Office, OneDrive, OneNote, etcetera [35]. Cloud-based consortiums particularly allow the various institutions and experts to work in collaboration to enhance the research activities. For learning and teaching through cloud computing, Siemens [37] introduced a new theory of connectivism [35].

## Related Works in Applications of Blockchain and Machine Learning in the Educational Field

### Blockchain

The use of blockchain technology in the educational discipline can be done in many ways so various research areas which have proven to be effective in the education discipline are described below:

#### Certificate Digitization Using the Blockchain as Distributed Ledger

For admission to a new university or job, all kinds of student certificates are required. Data protection is one of the main features of blockchain. These certificates can be secured by storing them on the blockchain. Many researchers now find that the best way to secure those records is to digitize the certificates using blockchain [38]. Various researches on this discipline are as follows:

The unmodifiable assets of blockchain technology motivate its use in eliminating the use of counterfeiting certificates in education. So, Jiin-Chiou cheng [18] suggests that this can be done by the concept of a digital certificate. To generate a digital certificate, first we must make an electronic file of a paper-based certificate with related data into a database. Then, we must calculate the hash value of that electronic file and store that value into a blockchain system. At the time of the creation of the block of a student certificate, the timestamp is added to it, so the perfect time of the block creation can be verified in the future and no alteration with it is possible. The system was made on the Ethereum platform and is run by the Ethereum Virtual Machine. Schools or certificates providing units have access to the system and can browse the system database. After that, the student can inquire about the certificate they have gained. The Basic processes of the system done in this study are: (1) Entering data into the system and after it, the system records the students' serial number in a blockchain autonomously. (2) Validating the data. (3) Generating E-certificates containing quick response (QR) code for the verified students. An Enquiry number is also provided to the graduate students with the e-file of their certificate. This benefits at the time of applying for a job, which includes sending only a serial number or e-certificate with a QR code to the designated companies. After that, the companies send inquiries to the system to validate and verify the serial number. The QR code helps them to identify whether the certificate has been tampered with or counterfeit.

Grather et al. [39] suggested the idea of digital certificates that are cryptographically signed, an alternative to paper certificates. Blockchain seems ideal to solve the problems of fake certificates. The certification process is divided into three main tasks from a blockchain perspective. The first task is to create and maintain identities of the certification authorities, the second task is to carry out by the certification authorities by granting certificates to the students, and the last task is to check certificates by employees Based on Ethereum blockchain, they introduced a blockchain model for the educational platform. The model ensures greater efficiency and safety for certification authorities by digitizing current processes, issuing and storing certificates in a blockchain, and automated certificate tracking.

### Blockchain for Lifelong Learning Record

Blockchain can store a comprehensive, verified collection of educational activity records. Storing student achievements and learning outcomes gives students lifelong learning experience. It can also keep track of the teaching strategies and results of them; therefore, it provides a guideline for evaluating various pedagogy strategies. This specialty attracts attention from many types of research. Below is a list of different types of research suggesting the blockchain as a lifelong learning examination:

Applications of blockchain in education according to Alammary et al. [40] are management of certificate, supporting lifelong learning examination review, copyright and competition management, fees credit transfer, enhancing e-learning, evaluating student professional ability. Various advantages that blockchain technology should bring to education security are better control of how student data can be accessed, transparency, increased confidence, unnecessary cost reduction, authentication, data exchange efficiency, and student record management. Challenges faced while adopting blockchain technology in education are scalability, increase in more transactions leads to increased block size which leads to more transaction latency, high computation power issue; the immutability of blockchain could make it difficult to change data according to the new rule.

### Addressing the Problem of Counterfeiting Certificates and its Various Solutions

Falsified academic certificates are a longstanding issue among the academic community. Blockchain's unmodifiable and distributed property can prevent security issues in certificates. Out of which several works concerning the prevention of counterfeiting certificates are described as follows:

*Rujia Li and Yifan Wu* [41] *state that the security issues arise from counterfeit certificates*. The Massachusetts Institute of Technology Media Lab has published block-cert projects. These models propose four components 1. Verification application: they are responsible for checking the authenticity and veracity of the certificate before they are issued; it has two parts. (i) Web-based application. (ii) Client-based application. The verification applications get the transaction and get the information of verification through the API of blockchain, after that the system does the job of authentication through the validation of the verified information by comparing with the checking information of the receipt. The main function of the system can be portrayed as follows: (1) Firstly upload the PDF files/ Scan the QR code (2) Compute the hash value for the file (3) The client sends a request with the help of blockchain (4) The main logic of the verification: (i) Authentication management: the issuing address relationship with the school identity. (ii) The authentication of hash value on the certificate is done in case to avoid tampering. (iii) The authentication to confirm whether the hash value is in the Merkle tree or not. (iv) Authentication to check whether or not the Merkle tree root's hash value is on the blockchain. (v) The authentication of the validity of the certificate in a case to avoid the revoked certificate (vi) The authentication of the valid date of the certificate in a case to avoid the expired certificate.

Gopal and Prakash [42] suggested that blockchain technology's unmodifiable property can solve the problem of certificate forgery to improve the validity, security, and confidentiality of graduation certificates. A secure e-qualification certificate system can be used by the institution to issue time-stamped, signed, and access controlled e-certificates through a secured emailing system to an intended student. This certificate then can be seen by students, and they can send them to the reviewers. Blockchain having a smart contract for the digital certificates is a system of issuing digital certificates. In this system, first, an electronic file of certificate and related data is created into the database; on the other side, a hash value for the electronic file is calculated. In the end, the hash value of the file is stored into the block in the chain system. A QR-code and inquiry string code will be created and affixed to the certificate to verify the authenticity of certificates through mobile phone scanning or website inquiries. Thus, this system increases the credibility and reduces the loss risk of certificates due to the use of blockchain.

### Blockchain as a Decentralized Ledger for Sharing Documents Between Institutes

Blockchain is a decentralized ledger where the details and associated transactions are not under the control of third parties. This blockchain property could be used to solve the

problem related to student academic record sharing. Various case studies are discussed below:

Yumna et al. [43] state that in educational institutes the major problems are manipulation of the data, verification difficulties, and exchanging records between institutes. Blockchain provides enormous opportunities for the management of records in a decentralized manner. The wide scope of blockchain helps in educational field entities like, in certification, authenticate record, it helps employers in the recruitment process, management of the records, and it makes it easy to access these records. Some universities are using blockchain technology for storing student and faculty data. This technology was used by The University of Nicosia to handle student data, i.e., certificates they obtained from MOOC platforms. Holberton School is also saving the educational records of students that are their learning activities in the classroom, their identity, their learning process, by using this technology. MIT has advanced a learning machine technology that is based on blockchain technology and has built a wallet for their students which contains the student's academic records. Echolink is a blockchain platform at the international level that stores verified identity details, work experience, and skills in a hashed way that is immutable. All information is provided by the legitimate institutions and thus gives that data trustworthiness. Echolink has sanctioned a partnership with Microsoft to provide cloud service on Azure for blockchain applications. 'Teach Me Please' is a blockchain function that is multifunctioning which helps in creating and storing personal and verified professional and academic profiles. This helps the employing firms by providing the student's virtual curriculum created through his academic career, backed by proof of reputation. Sony Global Education uses blockchain to develop the technology to store academic skills and records of progress. An application called Open certificates uses Ethereum smart contracts to assign block-proof to educational certificates.

When students change institutes, their educational records and learning data remain immovable, and as institutes have their separate Learning Record Stores (LRSs) which are unconnected and therefore the problem of data continuity occurs. Thus, the current institute or future institute cannot get the analysis of the student's learning data that is stored in the previous institute. To solve the problem of lack of data-continuity, Ocheja et al. [44] implemented a platform that keeps track of achievements beyond certificates or transcripts, maintaining the digital hashes of learning activities and governing permissions with the use of blockchain smart contracts. The Blockchain of Learning Logs (BOLL) is a system where students or learners can move their educational or learning records from one institute to another in a verifiable and secure way. BOLL solves the existing problem of data-continuity and allows current learning data analytics systems to access training logs from other institutes with the consent of the students and/or institutes that originally owned the logs.

### Other Important Work in Relevant Field

Sharples and Domingue [45] talk about 'Educational reputation currency' called Kudos. They propose a system where the association of companies and institutes can establish a shared ledger for educational records and incentives. Companies like Uber and Airbnb are gaining credence by reviews and ratings, as reputation is the foundation of the new digital economy. This system suggests that each educational institute, organization, or an intellectual worker is given some initial reward based on some existing metrics. Then, any institute or a person can make a reputational transaction. This could be the awarding of a degree or diploma for a university, which includes publishing it on the blockchain and moving some Kudos from the awarding institute to the recipient. To an individual, this might work as an economy for online tutoring. This idea of educational blockchain provides a single secure record of educational attainment which is accessible and distributed amidst many institutions. To open up the scholarly reputation system currently associated with academics, a reputation management system associated with blockchain technology can be used. There are some profound ideological and practical issues raised by trading educational reputation as a means of exchange, the system might reduce education to a knowledge marketplace with no empathy for a scholarship or academic value, or widen the researchers and inventors community to someone with great ideas to share.

## Machine Learning

The use of machine learning technology in the educational discipline can be done in many ways, so various research areas which have proven to be effective in the education discipline are described below:

### Academic Performance Predictions

In recent years, the emergence of greater computing power has made the field of machine learning more successful. So, many types of research are going on, to efficiently predict the students' academic performance. The various types of research to predict student academic performance are discussed below:

Qazdar [46] proposed that the reinforcement courses needed for various students can be decided based on the prediction of various machine learning algorithms like

supervised, unsupervised, and semi-supervised on valid trusted data sets. They focus on the data of the 1st year's result and by having that data set they predict the student academic performance in 2nd year. The basic methodology proposed by them was (1)Understanding of Business: The first phase of the model proposed by them contains the understanding of Business in various aspects like application fields, objectives of the project, the requirements, and the management rules. (2) Understanding Data: The main focus in this process is on data collection, after which data are identified, analyzed, and managed using techniques designed to teach users about the data collected. (3) Preparation of Data: The final dataset is formed by the activity performed in this phase, which should be manipulated in the modeling phase to go further to predict the result. (4) Modeling: This phase performs the task of implementing various well-known algorithms of machine learning such as regression, classification, clustering, recommendation. The need for the project and input dataset, Output result determines which ML algorithm to use. (5) Model evaluation: Methods to evaluate the proposed model are Mean Absolute Error, Relative Absolute Error, Root Mean Squared Error and Relative Squared Error. (6) The last step is the deployment step; here, the proposed model is caused to run.

To predict the academic performance of students, Mrinal Pandey and S.taruna [47] proposed the best classification model. In this study, four classification models are tested, namely Neural Network (MLP), Lazy Learner (IBK), Naive Bayes Tree (NBT), and Decision Tree (J48) using a multi-level classification system using pre-processing techniques. The data set is the academic performance and demographic information of students which were collected from the engineering college for classification problems. The dataset consists of 1000 instances and 18 attributes. The results of this research indicate that the DT(MLCM) classifier achieved the highest accuracy of 99.79%. It notes that DT J48 (MLCM) is best suited to predict the academic performance of students.

### Data Mining to Find Out Hidden Patterns

Educational Data Mining helps to get the right outcome from the large chunks of unlabeled data accessible to the university. This is why so many researchers are making efforts to find a successful result from the data available [48]. So various types of research concerning the mining of educational data and deriving fruitful results from it are listed below:

Delawari (2011) suggested that data mining must be the most impactful technology in increasing the universities' and students' performance because it finds the hidden useful pattern from the data stored in a database of any particular university. So basically, the idea is to find out the hidden patterns, anomalies, and association with the help of data mining techniques hence by doing this we can bridge the knowledge gap in higher institutions so they can make better managerial decisions which have more advanced planning and which leads brain train movement in the right direction. The above-described facts are based on the experience of data mining in the educational field from this paper. There are 2 types of data mining models which help in making managerial decisions. (1) Descriptive model: This model describes the data set succinctly by only highlighting the general properties of data. It also shows the patterns in existing data, which may be used to guide decisions. (2) Predictive model: This model predicts performance based on significant data and builds a model with the known results of data so that it can be later used to especially predict values for different types of data (Two Crows Corporation 1999).

S. Lakshmi Prabha and Dr. A.R.Mohamed Shanavas [49] introduced the concept of Educational Data Mining (EDM), a research field using data mining methods and analytical strategies to understand student learning behavior. They considered MathTutor as an e-learning environment for students of the Tamilnadu State Board (India). EDM helps educational institutes in developing their learning management skills. Assessing a student's level of knowledge and arranging them accordingly to their learning performance, makes it easier for the educator to prioritize the weak area of students.

Today, proper guidance to first-year students in universities is considered very important. Dekker et al. [50] show the results of educational data mining case study aimed at Electrical Engineering students drop out after their first semester or even before they start their course. This case study was aimed at the Electrical engineering department of the Eindhoven University of Technology. These experimental results indicate that simple and intuitive classifiers yield a useful result with precision ranging from 75 to 80%. They performed supervised learning on the dataset of students who were in their first-year phase at the department and for labels, and they decided a method. A student having a diploma degree is classified as successful. They used several tools and techniques such as WEKA classifiers in their experimental study and compared two decision tree algorithms C4.5(J48) and CART(SimpleCart), a Bayesian classifier, a logistic model, the Random Forest, and a rule-based learner. They even considered the OneR classifier as an indicator of the predictive power of attributes and a baseline.

Anuradha et al. [51] show how clustering helps in classifying a student in a well-defined cluster and predicting students' outcomes based on their learning process at the early stages. Clustering among many data mining

techniques helps in classifying a student in a well-defined cluster to learn about the learning process and behavior of an individual. Data mining is a process of digging through the enormous sets of data, analyzing them, extracting the meaning of the data, and last predicting the behaviors and future trends, allowing the decision-makers to make useful beneficial decisions. Clustering analysis is one of the methods used in data mining which includes partitioning a series of data objects into subsets or clusters where each object is identical to each other but different from other clusters. Clustering methods: (1) Partitioning methods: each data object belongs to a single cluster and each cluster is represented by a representative of the cluster or a centroid. (2) Hierarchical methods: Group data items into a tree or hierarchy of clusters. (3) Density-based methods: Clusters are referred to as dense regions within the data space separated by sparser regions by density-dependent strategies. Clustering algorithms: (1) K-means clustering algorithm: Big datasets can be easily clustered by selecting K data elements as initial centers and Euclidean distance formula is used to calculate the distance between data items and the selected centroid and the process is repeated iteratively. (2) Hierarchical clustering algorithm: Start from '*n*' number of clusters and end up in one cluster. In general, hierarchical clustering is a collection of nested clusters arranged in a hierarchical tree. (3) BIRCH: Controlled Iterative Reduction and Clustering using Hierarchies is a hierarchical clustering algorithm based on a bottom-up approach that performs well on high-dimensional large datasets. (4) DBSCAN: Density-based Spatial Clustering of Noise Applications is a technique that divides data points into three parts: core points, border points, and noise points.

### Improving Student Results on Basis of Past Experience

Different predictions were made with the help of machine learning technology in the educational sector considering the students' data available with the university. But the result of such forecasts has been difficult to integrate into the discipline of education. Consequently, several researchers carried out the task of predicting the outcome and how to integrate it to enhance the students' performance are described below:

According to Danijel Kučak [52], some of the interesting areas which machine learning can change are: Predict Student Performance: One of the best applications of machine learning in predicting student performance. With the help of the data about each student, the model based on machine learning points out the weaknesses and can also suggest ways to improve, such as do they need extra lectures or study some additional literature. Test Students and Grade Students Fairly: Machine learning can help to generate flexible computerized evaluations. Machine learning based on this assessment provides teachers and students with continuous input on how students learn, what type of support they need, and how they are making progress toward their defined goals [53]. Increase retention: Machine learning can help improve retention rates, such as learning analytics. By analyzing "at-risk" students, various efforts can be made to improve such performance and find out which type of help they need Chui et al. [54].

Ioanna Lykourentzou [55] suggested a method of dropout forecasting to classify students who are likely to drop out during the initial stages of education. For prediction, three machine learning methods, probabilistic ensemble simplified fuzzy ARTMAP, feed-forward neural networks (FFNNs), and support vector machines (SVMs), were used. To enhance the performance of the machine learning algorithms, she divided student attributes into time-invariant attributes and time-varying attributes which were taken from two e-learning courses. Three machine learning techniques and three decision schemes were tested on these data, to figure out overall accuracy, sensitivity, and precision. Throughout the first section, this approach achieved a total student classification rate of 75–85 percent to hit a rate of 97–100 percent in the final sections.

Hu et al. [56] proposed to develop a system that identifies students who are at risk of failing or predict the student's performance. For the research purpose, course offered at a national university in Taiwan namely online undergraduate information literacy's dataset of 330 students was considered. C4.5, CART, and LGR are some single classification techniques that were applied to develop the system. The system consists of a data mining engine, a knowledge base, and an inference engine. Every time the student's learning portfolio is updated, and the inference engine is provided with a summary of the student's current learning records and new information to analyze the data and identify the poor learners. The system then automatically informs both the poor learner as well as the instructor through the user interface as well as email. Due to the early forecasting, the instructor can change their teaching approach and can provide students with additional guidance.

### Semi-supervised Learning in Education

Many times there may be the case where data available with the university must be in the form of half labeled and half unlabeled, so to apply machine learning concepts on such data requires the use of semi-supervised learning. Hence, the research on the use of semi-supervised learning in the educational field is described as follows:

Satı [57] has claimed semi-supervised learning to be one of the significant fields in data mining and machine

learning. This field deals with the dataset containing many unlabeled and only a few labeled samples; here, the approach of collective classification which uses the relational structure of combined unlabeled and labeled datasets is used to get higher classification accuracy. LLGC (Learning with local and global consistency), Collective IBk, Yatsi (Yet another two-stage idea), Collective Tree are the algorithms used in semi-supervised data classification. The algorithms were applied on a dataset of 397 students having 30 attributes using the WEKA machine learning tool. The result shows that the process attribute selection is very much effective for getting accurate results, and also collective tree and YATSI are the most effective algorithms in semi-supervised learning and collective classification in WEKA machine-learning tools.

After seeing the application of these two technologies in heterogeneous fields, we propose the idea of combining the benefits of them to mitigate some of the limitations of the above-mentioned systems and for providing a better future for advancement in the educational discipline.

## Table of Contents

### Further Abbreviated Applications and Description of the Impact of Blockchain and Ml in this Field is Described in the Tabular form Below

In the below-discussed Table 1, the Sr No. column describes the number of research sighted. The paper title column describes the main research criteria and aim of the respective paper. Next, the description column shows the elucidation of each research which guides the reader to get better intuition about the research. Also, the limitations and future scope column explain the challenges faced by the respective research and its future capabilities. Lastly, the references column shows the referencing of the work which is described.

## Summary of the Table of Contents

In the education sector, various research works from the field of blockchain and machine learning are portrayed in table above. By analyzing the related works and the above-mentioned research works, it has been observed that the incorporation between these two technologies can be advantageous in the field. Thus, in the next section, the system comprising both technologies is proposed which takes us further into the advancement in education settings.

## Proposed Idea

The current e-portfolio system used in schools or universities has a central managerial authority that governs the database. In the current scenario, the schools or universities have one database to store all of the academic data and these data are mutable thus endangering the security aspect. Further, having a central database makes schools or universities vulnerable to the risks of data loss (Fig. 2).

To overcome the above problems, the use of a system that does not have a central database and that can ensure the security of the data stored in it is proposed. Here, blockchain as a decentralized database could be used. To implement the decentralism feature of blockchain, multiple copies of a blockchain can be run on multiple servers and all the copies will be connected. This way, if a block is added to any of the blockchains, all copies will be updated. In the below figure, seven servers, i.e., seven copies of the blockchain are shown that are connected. By having decentralism and immutability as our features, we overcome the problems of data loss and insecurity, respectively (Fig. 3).

## Challenges and Future Scope of the Proposed System

Blockchain technology is currently in the early stage in the sector of education. There are some obstacles to applying blockchain technology in the education sector that needs to be tackled to prevent failure. Various challenges faced by blockchain technology in the educational field are high requirements of the computational power which cannot be served by our common computers, and the time-consuming process of adding a new block in the blockchain which is becoming a great question in tech field which needs to be addressed and also this causes the change the current centralized infrastructure of education which requires great efforts. The unmodifiable property of blockchain causes one problem in which once data updated on the block cannot be changed so even if there is a change in some of the rules, the data in the block cannot be updated regarding the change because blocks are unmodifiable in the blockchain. Many sources state that some educational institutions are still reluctant to share their data with the blockchain network, or they find it hard to decide which data to deliver via the blockchain network. Collecting records from different institutes on the blockchain is a herculean task. Machine learning is being used in the educational field for several years now, but if we want to enhance the performance of machine learning algorithms, the data quality should be the primary concern to make predictions accurately. The dataset on which the machine

**Table 1** Limitations and future scopes of the research done in blockchain and machine learning

| Sr no | Paper title | Description | Limitations/ Future scopes | References |
|---|---|---|---|---|
| Blockchain | | | | |
| 1 | Approach to create a model of trust in open and ubiquitous higher education using blockchain | Here, blockchain is used to manage competencies, teaching, and transactions of content, assessed by consensus among employers, students, and trainers, to eliminate the gap between the academic and the working world | To certify the students trained in different educational institutions for their competencies | Lizcano et al. [58] |
| 2 | Competency-based education with blockchain-a new mission for universities | This paper suggests universities to outsource course delivery and assessment to remain competitive. It proposes to move toward an authentic learning curriculum focusing on students' development as a whole person. These things are to be implemented using blockchain, AI, and data analytics | To change higher education by lowering the universities' monopoly over degree awards and to emphasize the development of students as whole persons | Williams [59] |
| 3 | Learning System based on Decentralized Learning Model using Blockchain and SNS | This paper suggested a decentralized architecture for e-learning platforms to develop a lifelong learning model | Traditional school and teacher-centered education can respond flexibly to diverse learning needs | Hori et al. [60] |
| 4 | Connecting Decentralized Learning Records: A Blockchain-Based Learning Analytics Platform | In this paper, they proposed a blockchain-based approach for connecting learning data across institutions and organizations | This approach can be used to set up connections between decentralized learning systems | Ocheja et al. [61] |
| 5 | EduCTX: A Blockchain-Based Higher Education Credit Platform | This paper proposed a global higher education credit platform EduCTX, based on blockchain technology | Students can use this platform to store their completed course history as well as universities that have access to data regardless of student's educational origins | TURKANOVIĆ et al. [62] |
| 6 | Blockchain in education | This paper explores the use of disruptive blockchain technology in education and focuses on how it changes the conventional education norms | Challenges faced by this technology is as blockchain is in early-stage there are many fields which are needed to be addressed due to its early stage there are also vast scope available in it | Grech and Camilleri [63] |
| 7 | Blockchain and smart contracts with digital certificate | This paper proposed a system which includes all the parameter needed for a certification system in blockchain | Due to immutability of blockchain data once updated in the block cannot be changed, so it is not that flexible to change | Jiin-chiou cheng et al. [18] |
| 8 | ECBC: A High Performance Educational@Certificate Blockchain with Efficient Query | The paper imposes the educational certificate blockchain (ECBC) which supports the idea of low latency, high throughput and also provides a method to speed up the queries | the paper focuses on certificate query management which carries the vast future scope, but also it holds the main drawbacks of blockchain | Y. Xu et al. [64] |
| Machine learning | | | | |
| 1 | A Predictive Model to Evaluate Student Performance | This paper proposes a new approach that uses text mining techniques for predicting student performance from their comments in classrooms using K-means clustering methods and Latent Semantic Analysis (LSA) | Neural networks and Support Vector Machines will be the candidates for improvement as compared to the present method. This approach can help a teacher give proper guidance and feedback to the student for improving their performance | Sorour et al. [65] |

**Table 1** (continued)

| Sr no | Paper title | Description | Limitations/ Future scopes | References |
|---|---|---|---|---|
| 2 | A Model-Based Approach to Predicting Graduate-Level Performance Using Indicators of Undergraduate-Level Performance | This paper explores the predictive power of undergraduate performance indicators and their aggregates with the help of regression models, which can help the admission committee in the selection process for a master's program | This study will support for deriving the admission rules, depending on the committee's main objective. However, the committee cannot rely on grades from a single course, instead, it should look at partially aggregated undergraduate grades | Zimmerman et al. [66] |
| 3 | Toward the integration of multiple classifier pertaining to the Student's performance prediction | This research presents a multiple classifier-based framework, which integrates three classifiers namely Decision Trees, K Nearest Neighbors, and AODE (An advanced version of Naive Bayes) for accurately predicting students' performance at the early stages of the degree program | This model has been proposed for predicting the academic performance of the students, particularly in the engineering curriculum, but this model can be of use in other disciplines of data mining applications as future work. This model can also be adopted for developing decision support systems | Pandey and Taruna [67] |
| 4 | A multi-level classification model pertaining to the students' academic performance prediction | This research proposes a Multilevel Classification Model with the combination of the pre-processing techniques like resampling filter and abolishing the misclassified instances from the initial classifiers, based on the Decision Tree algorithm, for predicting the academic performance of undergraduate students. Four classification algorithms (Decision Tree, Lazy Learner, Neural Network, Naive Bayes Tree) were studied and compared in this experiment | This research can be further embellished by administering the projected approach to the different levels of scholarly performance records of students and a potent student performance decision support system can be cultivated | Pandey and Taruna [47] |
| 5 | Academic decision making at higher educational institutions using machine learning based algorithms | In this paper, the support vector machine and artificial neural network algorithms are used because of their popularity in the related work and accurate predictions for assisting in decision making | In the future, factors other than academic grades like socioeconomic factors can be considered for better predictions | Nieto et al. [68] |
| 6 | Machine Learning Approach to Predict Student academic performance | Researchers have used various classification algorithms and ranker algorithms to find out valuable attributes. The researchers used three different approaches to this research paper. Cross-tabulation analysis, Feature selection, and balancing imbalance data. These approaches help to identify the most appropriate model for the prediction of student academic performance | Various educational organizations can use the results of this research to work on the student's weak zones at the right time by using the right pedagogies and achieving their respective goals | Kaur et al. [69] |
| 7 | Education 4.0 – Fostering Student's Performance with Machine Learning Methods | This paper has conducted an analysis based on support vector machines, neural networks, decision trees, and cluster analysis to examine a student's performance | The goal of this research was to identify students who are likely to dropout and teacher could personally motivate them | Ciolacu et al. [70] |
| 8 | Prediction and assessment of student behavior in open and distance education in computers using Bayesian networks | This paper introduces a theoretical approach based on Bayesian Networks for modeling the behavior of students in an Open University technology bachelor course | Build a framework for modeling their designer's educational experience and manipulating past data or data from their use | Xenos et al. [71] |

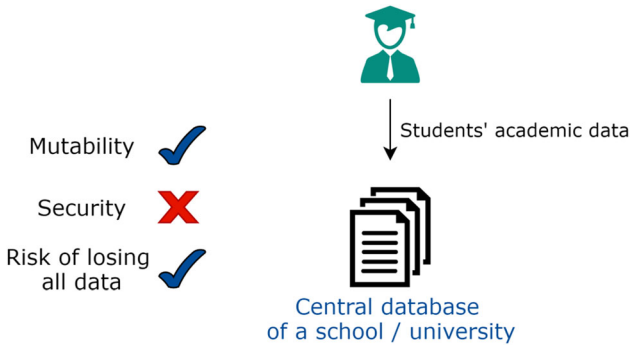


**Fig. 2** Current scenario in schools/universities

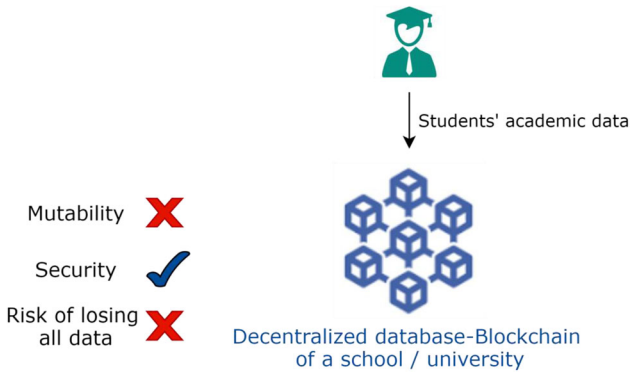


**Fig. 3** Proposed scenario to overcome the problems

learning algorithm is operated must be validated and true in every aspect. Different features may influence student performance in a given year, so all of these features need to be integrated into the dataset to make accurate predictions [72, 73].

Some educational institutions are researching how to overcome weaknesses of blockchain and utilize it to its full strength. So, the database of student's courses and achievements can be established in the blockchain which could replace the paper-based certificates by making them available to the digital medium. That will also make the validation process of certificates effortless. Machine learning technology has a considerable amount of influence over the field of education as it has been in use for several years now to predict learning performance. The accuracy of learning performance forecasts can be influenced by student characteristics and previous learning performance data. Future studies can incorporate these features to provide better predictions of learning success.

## Conclusion

In this paper, we reviewed the blockchain technology, machine learning technology, and the use of various technologies in the field of education. We proposed the combined use of two technologies blockchain and machine learning for the benefit of stakeholders in the field of education which are students, universities, and employers. This is because the security aspect of the educational field needs to be addressed as many misleading events have been occurring and may continue to occur if it is not taken into consideration. As blockchain is decentralized, secure, immutable technology, with the help of it the validation and security aspects are fulfilled because the blockchain consensus makes sure of it. So it can be used to store the predictions of students' future performance through their data present in the blocks with the help of machine learning algorithms. Although blockchain technology is in its infancy period in the educational field, it can be proved disruptive with the combination of machine learning by effectively handling the student data. Many challenges regarding validation and security are eliminated by the proposed idea in the paper.

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## Compliance with Ethical Standards

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**Ethical Approval** Not applicable.

**Consent for Publication** Not applicable.

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