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A Proposal to Implement a Blockchain-Based Model to Measure Student's Performance in Higher Education Institutions in Oman

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Abstract*— *the academic performance of students in higher education is considered as an essential benchmark to evaluate and measure the quality of students using the grades of academic activities. This study highlights the use of blockchain technology to measure the students' academic performance and achievements. In addition, it will help to improve the quality of evaluation of students in Higher Education institutions across the world. Obviously, when it comes to educational data maintenance and management, the blockchain and ledgers are likelihood technologies to be used to improve the ways for recording students' academic performance. One of the challenges in educational domain is that there is no distinguished mechanism to follow and manage academic and co- curricular activities, without having unified control to guarantee non-refusal of information. Based on literature review, there is no proper implementation done for measuring students' performance using blockchain technology. This paper aims to explore one of the potential benefits of applying blockchain-based system in measuring the academic performance of students in Higher Education institutions in Oman. We propose a blockchain-based model to explore how this technology can be used to track and measure students' performance, achievements besides academic results. The effect of student's involvement in academic and co-curricular activities and their effect on the academic performance have been analyzed. The outcomes of this research reveals to obtain some important indications on the influence of co-curricular activities on students' academic performance and the use of blockchain that will help to measure the students' competencies in an effective way.

Keywords— Blockchain, Ledgers, Higher Education, Students' Performance.

1. INTRODUCTION

Nowadays, the world has endless need to improve efficiency in any field of its applications. This include various fields such as banks, Healthcare and government agencies. Recently, with the development of network, digitalization and globalization of the learning environment, traditional educational institutions lack in the necessary means of resources and ability to verify learners' knowledge, skills, achievements, learning activities, processes, results, etc [1]. In the current situation, based on the introduction of new technology of blockchain, it enables the foundation of decentralized environment where all data and information are not under the control of third-party organization. Ref. [8] mentioned that any transaction ever done is recorded in a public ledger in a secure and verifiable way with a timestamp for each recorded block. This kind of technology is expected to revolutionize the functioning of industry, commerce and education [6]. Blockchain technology uses the consensus algorithms and cryptography to determine the features of immutability, traceability, decentralization and archive service properties [2]. With blockchain, all educational activities can be recorded including procedures and results from different learning environments, which were gathered and saved in a proper manner. Moreover, using blockchain to record student's performance gives a reference for faculty to measure and evaluate students' involvement in different kind of activities. So that it can help to demonstrate student ability and experience in various fields. In this way, blockchain has great potential application for both teachers and students.

This research proposes a blockchain technology-based measurements/evaluation system on students learning outcomes such as academic achievements and co-curricular activity participation. When student applying for a job, the proposed system can act as the most convincing reference for employers. The system can be used to trace data, if there is any doubt about result of student's performance evaluation, the evaluation process of students can be easily tracked back. For most of the employers, the experience is more valuable before hiring an applicant. The true test of a job applicant's character has always been discovered through candidate's life experiences. Therefore, the effect of co-curricular activities on students' academic performance students has been studied and analysed. The metrics of students' performance in this paper are Grade Average Point (GPA) and Activity Point Average (APA). The result suggests that considering the prediction GPA, which is a combination of 15% of student participation and 85% of GPA is

new contribution and will facilitate the process of evaluating student's success at university and when they apply for job. Additionally, the result obtains from this system considered as an evidence of the student's performance during the studying period. After the introduction, the paper has been divided into five sections. The second section introduces the concept of blockchain and the benefits that blockchain technology could bring to education field. Section three discusses methodology including developing the proposed system and data collection with performance evaluation. The analysis and discussion were explained in section four. Finally, the conclusion and future enhancement has been discussed at the last section of the paper.

2. RELATED WORKS

2.1 Bockchain Technology Overview

According to [6], Blockchain is a distributed database of records of all exchanged or digital events performed and shared between participants [1]. The system participants validate all the activity within the public ledger. It's validated by consensus and agreement of most members of the system. Once the data entered, it can never be changed. The blockchain maintains a record of every single exchange/transaction ever made [1]. Educational applications based on the blockchain property of working as decentralized unchangeable record of all sorts of data or assets. A group of leading universities has started to test and clarify cryptographically signed and variable certificates on blockchain. The students can get to or share data with any employers [6]. As stated by Ref. [3], Sony Global Education has implemented a project using Hyperledger platform to preserve and control transcripts using high security information like learning history in 2017. Some Universities such as Simon Fraser University in British Columbia, Nicosia University and The King's College in New York and Varna in Bulgaria accepted the digital currency for educational course payments [11]. The administration of reputation on Blockchain based ecosystem provides help for participants to get to remuneration appropriate to their expertise and service level.

2.2 Blockchain in Education

Applying blockchain technology can upgrade students' assessment records. In Ref. [3] they conducted a research that focuses on blockchain based on learning outcome. The blockchain was used to measure the learning performance based on achieved learning outcome results. Each block contains qualitative and quantitative information such as grades, course weight, course name, and graduation requirement indicators. After evaluating learning result accomplishments, other institution can freely and inclusively get to this data.

Reference [7] conducted a similar research that presented a learner-centred ecosystem for lifelong learning. These system lead learners to plan their learning journey more efficiently based on their desired career and offers them full control and ownership over their learning artefacts and processes. Currently they implement the core components of this ecosystem, using the Ethereum blockchain platform. And they're also working on learning scenarios and applications on real-life educational platforms platform [7].

Another research conducted by [13], they propose a global higher education credit platform, named EduCTX. The platform is based on the concept of the European Credit Transfer and Accumulation System (ECTS) [7]. It builds on distributed peer-to-peer (P2P) network system. The system envisioned for processing, managing and controlling ECTX tokens as academic credits and builds on a globally distributed P2P network, and users of the platform are students and organizations such as potential employers and potential employers. As a proof of concept, they presented a prototype implementation of the EduCTX platform which is based on the open source blockchain platform.

Other reviews on the use of blockchain technology in academic institutions by [12] and [2], they conducted a research on the proposed use of blockchain technology to give rewards in form of tokens and educational reputation coins for different set of academic achievements called kudos. This type of systems concerns only on managing learning achievements on the blockchain, while our research proposed a blockchain based model system to track and measure students' performance, achievement along with academic results.

Currently, the need to measure the quality of education using data records is being increased. Blockchain technology is one such instrument that can help to observe the academic development of an individual. Reference [12] mentioned that a few universities and colleges have applied blockchain for this purpose. Blockchain technology can formulate the whole transcript within the formal learning context, this incorporate learning process and outcomes, student's certification and achievement. This information can be securely stored and accessed on a blockchain network in appropriate ways.

In this research, we proposed a solution to the current challenge of measuring student performance, achievement and academic results. Thus, our key contribution is to provide a proposal to implement blockchain technology system to measure students' performance, achievement along with academic results. We represent that is possible to measure academic development of an individual using blockchain technology.

3. RESEARCH METHODOLOGY

This study presents an exploratory quantitative research. Many researchers have proposed different ways for measuring students' performance. However, students' performance cannot be measured by academic achievements only. This study provides different ways for measuring student capability in both academic and co–curricular activities and analysis of the relationship between student's academic performance and participation in co-curricular activities. The research methodology is explained in two parts. The first part was to develop the blockchain-based model. The second part was to analyse the student's performance in both academic and co-curricular activities participation. The proposed model is designed for measuring the performance of student achievements recorded in the ledger using blockchain technology. The system is able to calculate an academic achievement in terms of grades GPA beside co-curricular activities participation. The proposed system involves the following three substantial stages as illustrated in Fig.1:

1. *Capturing*: The system captures different kind of students learning activity that the student performs through studying period by interacting with other people, resources and services. Different kinds of co-curricular activities participation and academic results GPA are recorded in blocks. A learning block is self-describing, as it contains metadata about each submitted activity. Students can have complete digitized and updated records and the same will be used to evaluate their performance.
2. *Recording:* Once the transaction block has been generated for the student, it is approved first by the admin, who verify the transaction, by viewing the content and details of submission request to accept or reject. The hash of transaction block is then recorded on the blockchain. So that can later serve to verify the status of data inside the block which has not been tampered with.
3. *Validating:* The request transaction contains the issuers' information and the recorded details. The system provides mechanism to check the requested information. If the request is verified, a new block will be added to the blockchain while if the request is rejected, it will not be added. Usually rejected transactions are not included in the blockchain.

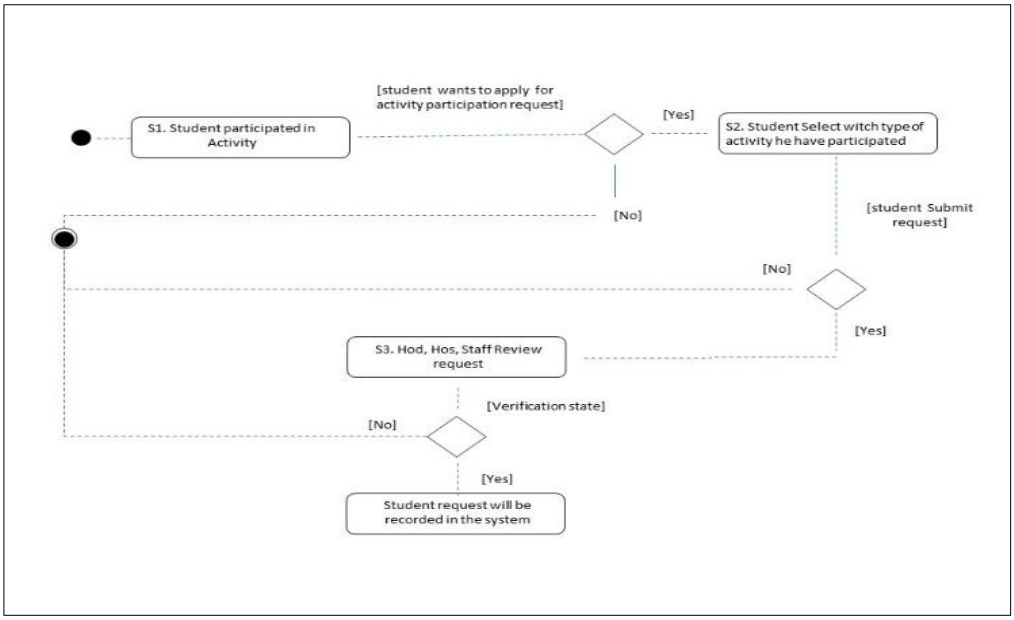

Fig.1. *Flow chart showing the process of capturing, recording and validating the data*

A. PROCEDURE OF PROPOSED MODEL

The proposed system is a dynamic evaluation platform for measuring university students' performance. The initial implementation focuses on developing a demo system. As first step, the system was developed using Hypertext Pre-processor PHP. It's designed for students to have access to their Profile and send transaction activity request to admin. The system recorded and calculated student GPA and APA using specific function. The system consists of the following:

- *Profile page:* which contains student details such as identity, name, major, year of joining and email which recorded when student register and login system. The blockchain generate random hash for each student. The hash has a relationship with each student account.

- Add activity page contains activity request details. Such as activity type, name, date, time, venue, presenter name, and type of involvement. In our case, five types of activities organized in blocks where students have to select such as: conference, research publication, seminar, workshop and academic group and club. As it seen in Table 1, every activity has different weighted point.
- The student must choose one activity in each block. Maximum numbers of activities are ten in one semester. APA is calculated for student's proficiency assessment rate in activities participation using the formula as the following:

$$x = \frac{Total\ Points\ Erned}{Total\ Points\ of\ participated\ activities} * 4$$

- Report page: where the student can see his reward points including APA along with GPA and the status of transaction. After submitting the request, it is sent to admin for the verification.
- Activity logs page: when admin login to the system, he can view request details and verify in order to accept or reject.
- Report: This page provides record of student's performance in academic and activity participation.

Table 1. Weighted points for recorded activities.

Types of Record		**Weighted Points**
Research Publication	Author	**10**
	Co-Author	**5**
Conference	Presenter	**9**
	Participant	**4.5**
Seminar	Organized	**8**
	Participated	**4**
Workshop	Organized	**7**
	Participated	**3.5**
Academic Group & Club	Organizer	**6**
	Member	**3**

The proposed model includes the following: assets, transactions and participation. Assets can be anything that has value which will be recorded and kept securely. Educational records such as student's academic results, record of achievements and participation in co-curricular activities are considered as system assets. Participants can be students and Staff /Supervisor or any member of blockchain network. Transaction is a part of business network model. From the blockchain system perspective, the business network model defines all operation that involved within the assets [10]. The block that added to the blockchain ledger contains information after validation such as assets, participants and transactions. The proposed model diagram which is illustrated in Fig. 2, has the following steps:

- Student attends workshop, seminar, conference or any other activities. Different number of Credits is assigned for each activity.
- Student / Admin simply access the system using a credentials such as ID and password though a web browser.
- The student applies for the credit by sending the request to staff / Supervisor.
- The system generates a student record and request details which are entered into blockchain network.
- Admin / HOD validate the request. If the request is accepted, it will be saved and time-stamped in a bock using specific function.
- The block is created and added to the blockchain; therefore, credits will be added to student dashboard.
- The system not only stores activities and participation but also grades. Credits assigned for each completed course or activity; the student can see how many credits they have scored. The system ensures the reliability of student's grades corresponding to the activities, they have participated.

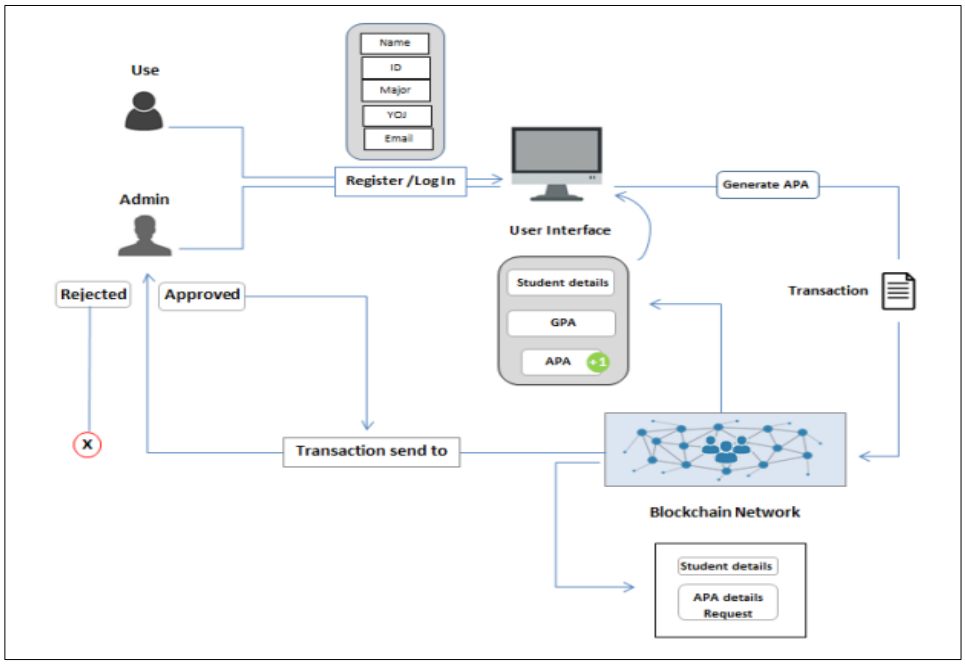

Fig 2. *Functional diagram of proposed model*

The proposed model facilitates the representation of learner performance in the form of transaction. By applying blockchain into the proposed system, the following features are incorporated.

- *Ownership:* following peer-to-peer principles of the blockchain, there is no single ownership on data. Instead, ownership resides in the participating community. As a consequence, the student, who also controls access to their portfolios, owns all data in the system.
- *Transparency:* all data on the blockchain are shared across the peer network and transactions are visible to all. Educational record in blockchain acts as a source of trust providing a high level of privacy by ensuring that transaction details are shared only amongst the participants involved in those transactions.
- *Immutability and reliability:* are ensured that the blockchain transactions are immutable records that are stored in blockchain ledger.
- *Privacy and security:* can be provided through two main routes. First, all sensitive data can be stored digitally and hashed in blockchain system. Second, data can be encrypted with the keys held by the relevant participant.

B. PERFORMANCE EVALUATION

The second part of this research was to collect the data from different departments in the College of Economics and Management and Information Systems at University of Nizwa. About 564 samples of data were collected. The contents of dataset include students' major and cumulative GPA. The data was collected from eight majors. Higher percentage of data involved students from Information Systems major, 24%. About 23% from Business Administration and 20% from accounting department. Further, the lowest percentage of students was from Web design and Information Security major and other majors.

After collecting the data, it was classified into four groups based on GPA The range of the first group, Excellent, is 4 to 3.30 and Good, is 3.29 to 2.40. While, the range of Satisfactory group is, 2.39-2.0 and the range of Probation group is, 1.99-1.40.
The data was filtered, and the duplication of data was removed. To summarize, the total number of datasets used was 454.There were 89 students have an Excellent GPA, 230 students have Good GPA, 58 students are in the Satisfactory level and 77 students are in the Probation level. The APA data for each student has been assigned with certain assumptions.
To see the effect of APA on GPA, two models with two different ratios of APA and GPA were used as the following:

- 85% of GPA and 15% of APA
- 50% of GPA and 50% of APA
- 25% of GPA and 75% of APA

Predicted GPA was calculated as the following:

- Predicted GPA= (GPA*0.85) + (APA*0.15)
- Predicted GPA= (GPA*0.5) + (APA*0.5)
- Predicted GPA= (GPA*0.25) + (APA*0.75)

The data was analysed using multi class confusion matrix to measure the influence of predicted GPA on students' group. Basically, confusion matrix is a summary of prediction result on classification problem and it has the form of table [12]. Additionally, it used to describe the performance of given classification model on set of data where the true values are known [11]. Table 2 shows the Confusion matrix for each classification model. Model (**A**) represents the effect of 15% of APA and 85% of GPA in four student GPA groups includeing Excellent, Good, Satisfactory and Probation. While model (**B**), represents using 50% of APA and 85% of GPA for all groups. And Model (**C**), represents using 75% of APA and 25% of GAP for all groups.
The three models have been evaluated based on the accuracy, which is the rate of the classifier being correct observed it has been calculate as the following:

$$Accuracy = (\mathrm{TP} + \mathrm{TN})/(\mathrm{TP} + \mathrm{FP} + \mathrm{TN} + \mathrm{FN})$$

After classifying and calculating the data, confusion matrix was generated with the accuracy result for each class as it shown in table 2.

Table 2. Confusion matrix for each classification

Model A: 75% of APA and 25% of GPA

		Actual				
		E	**G**	**S**	**P**	**Total**
Prediction	**E**	61	28	0	0	89
	G	4	208	18	0	230
	S	0	4	49	5	58
	P	0	0	33	44	77

Model B: 50% of APA and 50% of GPA

		Actual				
		E	**G**	**S**	**P**	**Total**
Prediction	**E**	31	40	8	10	89
	G	55	104	33	38	230
	S	14	24	12	8	58
	P	10	33	17	17	77

Model C: 15% of APA and 85% of GPA

		Actual				
		E	**G**	**S**	**P**	**Total**
Prediction	**E**	38	44	4	3	89
	G	25	161	29	15	230
	S	0	35	15	8	58
	P	0	39	19	19	77

4. RRESULTS AND DISCUTION

The major purpose of using the data was to measure to what extent GPA can be affected when using different ratio of APA. The multiple confusion matrix depicted in Table 2 was used to check the performance and evaluate the accuracy of classification. The finding of this study is summarized in Fig.3.

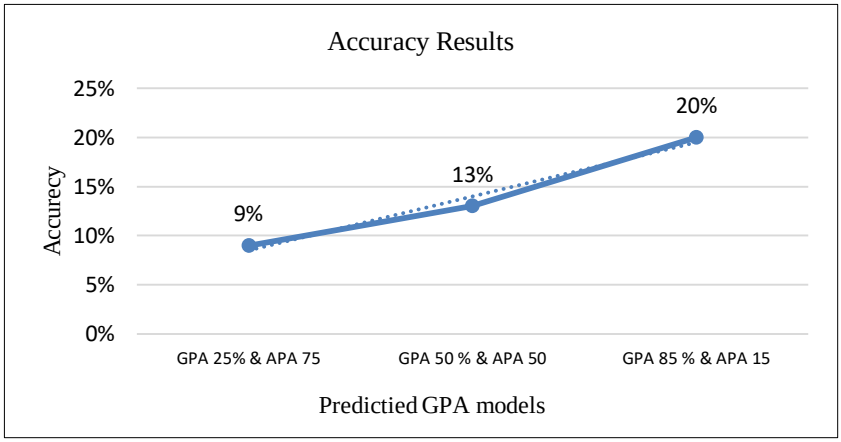

Fig. 3. *Accuracy of three models*

When using confusion matrix analysis, it can be seen that there was a significant difference in performance among three models. Model (**A)**, was able to predict the class of 165 objects out of 454, which gives an accuracy value of 0.9. While Model (**B**) was able to predict 233 objects out of 454, which gives an accuracy value of 0.13 and Model (**C**) was able to predict 362 objects out of 454, which gives an accuracy value of 0.9 as it seen in figure 3. Therefore, model **A** archived the best accuracy.

For the three models, a value of accuracy is obtained. Figure 3 represent the accuracy values corresponding to Excellent (E), Good (G), Satisfactory (S) and Probation (P) GPA groups. As we might expect from the performance in figure 4, the accuracy value of Excellent group is 0.7 when using the APA 15% and GPA 85% and then it increases up to 0.23 for Good group. However, when GPA decreases, the accuracy is being increased to 0.8 and 0.35 respectively. In other hand, when using APA 50% and GPA 50%, the overall accuracy is low. It can be seen that Good group achieves an accuracy of 0.35 which might be better compare to other GPA groups. However, the lowest accuracy of 0.03 in obtained for Satisfactory group. While using 85% of GPA, the overall accuracy is being increased up to 0.20. It is notable that Good group achieves the best accuracy of 0.46 compared to other groups. However, the lowest accuracy, 0.03 in obtained for Satisfactory group.

From the above results, we concluded that, the impact of APA on academic performance has been explored as the following:

- Model (**A)** performs with better accuracy rate which indicates that combining 15% of co–curricular activity participation to GPA would be better than 50% and 75% of APA.
- Based on the dataset has been used, the total numbers of students in Satisfactory and Probation group are almost close, the reason for both groups achieved close results in terms accuracy.

- Usually in educational institutions, the percentages of students who have Good GPA are more compared to other groups of GPA levels. In this study, the numbers of Good level students are 230 which are more than the number of Excellent, Satisfactory and

Probation students. This makes the significant effect of APA on Good (Group) compared to other three models of GPA groups as it can be seen in Fig.4.

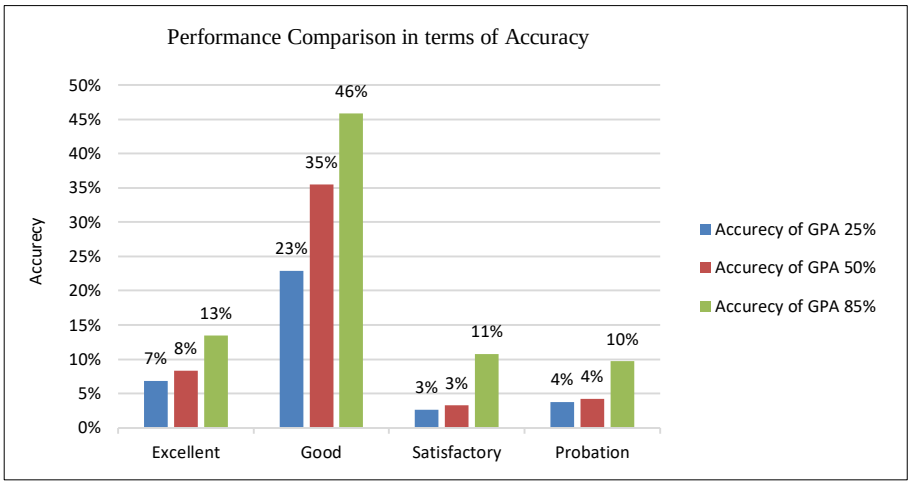

Fig. 4. *Accuracy for each GPA group*

The results indicate that students who are more experienced in different kind of activities were more likely to perform academically better. This result is almost similar to one of previous research study which was conducted by [12]. Their study compared two groups of students. The first group was students who participated in extracurricular activity and the second group of non-participants. The result showed that the first group had better GPA than the second group. Thus, it supports the argument that student participation dose not decrease the academic achievement.

The outcomes of this study is also correspond to a research study conducted by [16] at Purdue University in United States using set of records contained 7,392 information about engaged students and 182,666 records of Purdue student generally. The findings indicated that co-curricular activity participation resulted in higher engagement and the students' earned higher GPAs. Thus, those students were able to manage their time and exhibited higher level of satisfaction. According to their study, the students who engaged in co-curricular activities are the most satisfied students and they achieve higher GPAs than non-participants.

Usually employers and companies are looking for values, skills and ability when hiring applicant. Although GPAs can serve as predictors' success, there is no other important measure to employers than actual experience and skills that students get through studying period. There are many reasons why it is difficult to judge student based on their grades. Student with 3.5 GPA could be completely different from another student's 3.5 GPA. Students with wide range of experience are able to learn new skills and can cope better under pressure compared with non-experienced. So, the results of this study provide one solution to measure student performance. Predicted GPA which is a combination of student's participation and GPA could facilitate the process of evaluating student's success at university and when applying for job. Hence, considering the prediction of above GPA, which is a combination of 15% of student participation and 85% of GPA, is new contribution and it would be easy for the instructor or administrator to evaluate student's successes. The results obtained from this study facilitate the decision making process for institution administrators for allocating funds and personal to different kind of activities and either to keep or expand programs. Information about the impact of different kind of co-curricular activities involvement could inform these decisions.

5. CONCLUTION AND FUTER ENHANCEMENT

This paper discussed the different ways that educational filed impacted by the emergence of blockchain technology. An initial demo system has been developed and discussed for measuring student academic and co-curricular activities. The students can use this system to measure the performance in both academic and co-curricular activities. On the other hand, supervisor who wants to find an excellent student can request from the blockchain ledger. Blockchain offers technological features that generally guarantees the actors that makes the learning process. Significantly, the reliability, traceability and immutability of blockchain that indicate that

student data recorded on blockchain are more authentic, specific and anti-theft. Although there are no previous researchers have analysed the amount of effect of activity engagement in student's GPA in the way this research has been conducted by using four predicted GPA groups. However, the specifics of that effects need to be explored in detail to assess if there are any correlation among participation levels related to some factors such as students' major, gender, attendance, type of activity etc., which may explain the differences. Understanding this point may contribute to those factors affecting students' GPA, design and explore co-curricular activities that may contribute to their success. Moreover, increasing sample data will be helpful to generalize the result.

As next step, the system will be implemented in blockchain platform. The system will be used for collecting and managing immutable student records so that it can be used for accurate decision making.

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