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A Comparative Study of Deep Learning and Transfer Learning in Detection of Diabetic Retinopathy

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Abstract: Computer vision has gained momentum in medical imaging tasks. Deep learning and Transfer learning are some of the approaches used in computer vision. The aim of this research was to do a comparative study of deep learning and transfer learning in the detection of diabetic retinopathy. To achieve this objective, experiments were conducted that involved training four state-of-the-art neural network architectures namely; EfficientNetB0, DenseNet169, VGG16, and ResNet50. Deep learning involved training the architectures from scratch. Transfer learning involved using the architectures which are pre-trained using the ImageNet dataset and then fine-tuning them to solve the task at hand. The results show that transfer learning outperforms learning from scratch in all three models. VGG16 achieved the highest accuracy of 84.12% in transfer learning. Another notable finding is that transfer learning is able to not only achieve high accuracy with very few epochs but also starts higher than deep learning in the first epoch. This study has also demonstrated that in image processing tasks there are a lot of transferrable features since the ImageNet weights worked well in the Diabetic retinopathy detection task.

Keywords: Meta-Learning, Transfer learning, Deep learning, Medical Image processing, Diabetic Retinopathy.

1.0 INTRODUCTION

The evolution of machine learning has greatly contributed to solving some of the major problems in the world. Of particular interest is deep learning which has become a game-changer in computer vision due to its representation learning capabilities[1]. Under representational learning, a machine is fed with raw data and it develops its own representation needed to extract the data[1]. This is made possible by convolutional neural networks since they can extract features from an image using the convolutional layer and thus a separate feature extractor is not needed.

Deep learning has been applied in a variety of image processing tasks in various fields to solve image processing problems[2]. Deep learning has promising results in complex medical diagnostics. It helps physicians by providing a second opinion and flagging concerning areas in images[1].

Meta-Learning is also known as learning-to-learn makes it possible for deep learning models to do multitask learning and use transfer learning to enable them to solve a new but related task with just a few data samples also known as few-shot learning[3]. This helps in addressing the challenges of data shortage and increases the robustness of models developed using this approach.

Transfer learning involves training a deep learning architecture with huge amounts of data. This training involves feature extraction from the training dataset. Once the training is done the weights are then transferred and fine-tuned to a smaller dataset[4]. Thus, this makes it possible for the transfer learning model to leverage on previously acquired knowledge.

The main aim of this study was to do a comparative study of deep learning and transfer learning in the detection of diabetic retinopathy. Deep learning, involved training a model from scratch using the dataset. In transfer learning, a model is first pre-trained using the ImageNet dataset then the weights are transferred to the Diabetic retinopathy dataset. Further to this, the model is finetuned and the results of the two approaches are compared.

The other sections are organized as follows. 2.0 related works, 3.0 Methodology, 4.0 results, and discussion, 5.0 conclusion and future work.

2.0 RELATED WORKS

Diagnosis based on medical images has been very successful in using convolutional neural network-based methods. This is largely motivated by the fact that CNN has achieved human-level capabilities in tasks involving object classification[1]. CNN networks have also demonstrated strong performance in transfer learning in medical image-based diagnostics[1].

Diabetic retinopathy (DR) is an eye disease that is a result of diabetes. It is characterized by damaged blood vessels in the retina, swollen or leaking vessels, some close thus stopping

blood from passing through them, and abnormal vessels can grow in the retina. These changes can eventually result in loss of vision[5].

Diabetic retinopathy is usually classified into five main categories which are: No DR, Mild DR, Moderate DR, Severe DR, and Proliferative DR [6]. Several researchers have developed models aimed at classifying Diabetic retinopathy. The models are trained using public datasets such: as the EyePACs dataset, Indian Diabetic Retinopathy Dataset, APTOS 2019 blindness dataset, and Messidor Dataset[7][8] [9]. Researchers have used a combination of two or more of these datasets or just one dataset in developing their models.

Thiagarajan et al., (2020) used a Convolutional Neural Network and Grey-level co-occurrence matrix with the Indian Diabetic retinopathy dataset. The data preprocessing that was done involved horizontal flipping, scaling, zooming in, cropping, and translation. The model used the binary cross-entropy loss function to do binary classification.

Welling (2018) developed a model that pre-trained reptile with ImageNet dataset and then transferred the weights to the Diabetic retinopathy dataset. The researcher used the default reptile network architecture in pre-training and meta-learning. The batch normalization layer was removed during pre-training since it was found to be less transferrable. During transfer learning the weights apart from the last SoftMax layer were finetuned to the target dataset using the Adam optimizer and its default parameters (learning rate 0.001, $\beta1 = 0.9$, $\beta2 = 0.999$, and a batch size of 32) [10].

Ensembles of CNN models for transfer learning to create a meta-algorithm has also proved to be a good approach in the detection of Diabetic retinopathy. [11] proposed a model that ensembles state-of-the-art CNN networks which include: ResNet50, InceptionV3, Xception, Dense121, and Dense169. The networks were pre-trained using ImageNet and then fine-tuned to the Diabetic Retinopathy dataset. The ensembled model achieved 80.8%, 51.5%, 86.72%, 63.85%. and 53.74% in accuracy recall, specificity, precision, and F1-score respectively[11].

Previous works that tried to do a comparative study of transfer learning and other image processing approaches include; [4] which did a comparative study of deep transfer learning and shallow learning in accurate fingerprint detection. The deep transfer learning architectures considered were InceptionV3, NasNet, and ResNet50. While in shallow learning linear and non-linear Gaussian support vector machines were used together with the following image descriptors: Binarized statistical image features, weber local descriptor, and local phase Quantization. [4] did not compare Transfer learning against deep learning in the same environment set-up.

3.0 METHODOLOGY

In this section four neural network architectures which are EfficientNetB0, DenseNet169, VGG16, and ResNet50 have been used for both deep learning and transfer learning tasks.

DenseNet169

This architecture was proposed by Huang et al., [12]. It connects each layer to every other layer in the network in a feed-forward manner. Thus, for each layer, the feature maps for each preceding layer are used as inputs in the subsequent layers. DenseNets are advantageous in the following ways: they reduce the number of parameters, strengthen feature propagation, enhance feature reuse, and alleviate the vanishing gradient problem. DenseNets are easy to train since each layer has direct access to the gradient of the input layer from its loss function. This results to an implicit deep supervision[12], [13].

There exists the following variants of DenseNet: DenseNet121, DenseNet169, DenseNet201, DenseNet264 [12]. The numbers represent the depth of the networks[14]. DenseNet169 has the following features: 7*7 convolutional layers with 2 strides, 3*3 max pooling layer with 2 strides, a series of dense blocks, 7*7 classification layer, and 1000 D fully connected SoftMax [12],[15]. This architecture was chosen since literature has demonstrated it to be a high-performance architecture[15].

EfficientNetB0

EfficientNets were proposed by Tan & Le, (2019) as a new scaling method that uniformly scales in all dimensions of width, resolution, and height using a compound coefficient. By balancing the height, resolution, and width this architecture can achieve higher accuracy than the competitors. EfficientNets are a family that ranges from EfficientB0 to EfficientNetB7 which represents a combination of efficiency and accuracy on different scales. Compound scaling allows the EfficientNetB0 to avoid extensive grind search of hyperparameters thus surpassing models at every scale(Tan & Le, 2019).

EfficientNetB0 was chosen since it is the base model of the EfficientNet family and all the other architectures in the family are scaled from it by adding more layers [16],[17]. Thus, it provides a suitable baseline to compare deep learning and transfer learning. Also, the base model requires less computational power to achieve desirable performance[17].

ResNet50

Residual networks were developed by He et al., [18] with aim of making it possible for neural networks which are deep to be trained with less complexity and achieve high performance. In ResNet, the layers are reformulated as learning residual functions with reference to the layer's input. ResNet50 refers to the 50-layer residual learning network, which also has 3.8 billion flops.

ResNet50 solves the saturation and degradation of accuracy problem[19]. Mukti & Biswas [19], further records that ResNet50 surpasses AlexNet, VCG16, and VCG19 in plant leaf disease classification using transfer learning. This justified the choice of ResNet50 for this task.

VGG16

VGG extended Alex Net by increasing the depth of the network using small 3*3 convolution filters. VGG networks demonstrated the capability to achieve high performance even when used in relatively simple pipelines[20]. The architecture of VGG involves the following: First, the input layer which takes 224*224 pixels colored images. Second, the convolution layers which use a very small receptive field. The convolution layers are accompanied by a 1*1 convolution filter and a Relu unit. Third, three fully connected layers in which the first two have 4096 channels while the last has 1000 channels. Fourth a series of hidden layers with all of them using the RELU activation function[20].

Simonyan and Zisserman [21] record that there are three variants of VGG Networks which are: First, VGG11 which supports 11 weight layers in the model (convolution layers). Second VGG13 which supports 13 weight layers. Third, VGG16 which supports 16 weight layers. Fourth VGG19 which supports 19 weight layers. VGG19 and VGG16 are the most commonly used architectures of the VGG model. Researchers such as Khan et al. [21] used VGG16 to classify diabetic retinopathy and achieved an average accuracy of 83.8%.

3.2 Experiment Setup

3.2.1 Dataset Used

This study used a combination of two datasets namely the Indian Diabetic Retinopathy dataset and the Aptos 2019 blindness detection dataset. The combined dataset resulted in 4125 labeled and colored fundus images. The images were labeled using numbers as follows: 0-No DR, 1-Mild DR, 2-Moderate DR, 3-Severe DR, and 4 Proliferative DR. The researchers then combined Moderate-DR and severe DR into a single class. This was informed by [22] who used the Messidor dataset which has the same distribution. Also,(*Messidor - ADCIS*, 2021.) records that Moderate DR and Severe DR overlap.

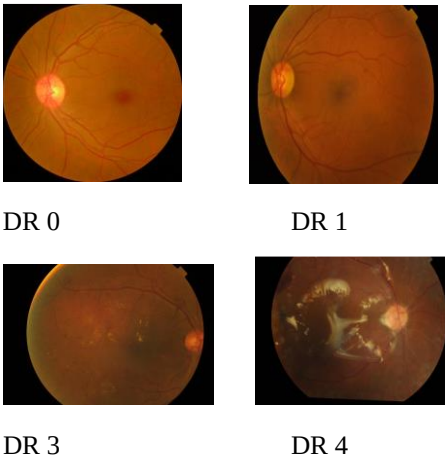

Figure 1: Sample Eye Fundus Images

Figure 1 shows sample Eye Fundus images and their respective labels.

3.2.2 Experiment

All the models were trained in Google Colaboratory with NVIDIA GPU, CUDA version 11.2, TensorFlow version 2.7.0, and Keras.

For the deep learning model algorithm, 3.1 was used in the experiment

3.1: Deep Learning Algorithm

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Input →Fundus Images belonging to 4 classes (DR0, DR1, DR3, DR4)

Output →A model that classifies fundus images into the four classes

1) Load the dataset
2) Data pre-processing
   - Split 80% training and 20% Validation (X_{train} $Y_{validation}$)
   - Resizing images
   - Data Augmentation
     - Horizontal random flip
     - Random rotation
     - Random Contrast
     - Random translation (h-factor=0.1, W_factor=0.1)
3) Import the architectures without the weights= (EfficientNet B0, DenseNet169, ResNet50, VGG 16)
4) Set the model parameters (Optimizer, Loss function, Metrics)

While α=0.01
    For epochs= 1 to 50 do
        Update the model parameters for each batch of (X_{train} $Y_{validation}$)
        Assess the Accuracy and Loss
    End
End

The data was loaded into the model then data pre-processing which involved resizing all images to shape (224, 224, 3) was done. This was followed by data augmentation. Data augmentation aimed to have several variants of the same image so that the network can learn how to extract features from images from different viewpoints. It also prevents the overfitting of the model[24].

The architectures were imported from Keras. The model weights were excluded so that the model can be trained from scratch. The following model parameters were set, Adam optimizer with the default learning rate of 0.001, categorical cross-entropy loss function, and Accuracy metrics. The EfficientNetB0 model had a total of 4, 054, 695 parameters out of which 42, 023 were non-trainable parameters.

The DenseNet169 model had 12, 649, 540 total parameters out of which 158, 400 were non-trainable parameters. The ResNet50 model had a total of 23, 595, 908 out of which 53, 120 parameters were non-trainable. The VGG16 architecture had 14, 719, 301 total parameters out of which 3, 589 parameters were trainable. Each model was trained in its own notebook for 50 epochs. The performance in terms of accuracy was then observed and recorded for comparison.

For the Transfer learning, architecture data pre-processing was similar to that of deep learning since the study aimed at comparing the two within the same setup. Algorithm 3.2 is the Transfer learning algorithm that was used.

3.2: Transfer Learning Algorithm

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Input →Fundus Images belonging to 4 classes (DR0, DR1, DR3, DR4)

Output →A model that classifies fundus images into the four classes

1) Load the dataset
2) Data pre-processing
   - Split 80% training and 20% Validation (X_{train} $Y_{validation}$)
   - Resizing images
   - Data Augmentation
     - Horizontal random flip
     - Random rotation
     - Random Contrast
     - Random translation (h-factor=0.1, W_factor=0.1)
3) Import pre-trained architectures with the weights= (EfficientNet B0, DenseNet169, ResNet50, VGG16)
   - Rebuild the top layer
   - Unfreeze the base model
4) Set the model parameters (Optimizer, Loss function, Metrics)

While model.trainable=true

While $\alpha=1^{e}$-5(low learning rate)

For epochs= 1 to 50 do

Update the model parameters for each batch of (X_{train} $Y_{validation}$)
Assess the Accuracy and Loss

End

End

End

The imported architectures were pre-trained using the ImageNet dataset. The architectures were then restructured to fit the task. The top layer was rebuilt as follows: A Global Average pooling 2D layer, a Batch Normalization layer, a dropout layer with a dropout rate of 0.2, and a dense layer as the output with SoftMax activation function, were added. The trainable function of the model was then set to true.

The following model parameters were used for all the models: Adam optimizer with a learning rate of ($\alpha=1^{e}$-5), categorical cross-entropy loss function, and accuracy metrics. The models were trained for 50 epochs and the performance was recorded. The EfficientNetB0 model had a total of 4, 059, 815 parameters out of which 44, 583 were non-trainable parameters. The DenseNet169 had a total of 12, 656, 196 parameters out of which only 161, 728 were non-trainable parameters. ResNet50 had a total of 23, 604, 100 out of which 57, 216 parameters were non-trainable. VGG16 had a total of 14, 719, 301 out of which 14, 718, 277 were trainable and 1, 024 were non-trainable.

4.0 RESULTS AND DISCUSSION

Table 1 shows a summary of the performance of the four models in both deep learning and transfer learning.

Table 1: Comparison of Accuracy achieved by the models

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Model	Deep Learning	Transfer Learning
EfficientNetB0	79.03%	**80.12%**
DenseNet169	75.39%	**83.15%**
ResNet50	77.70%	**81.33%**
VGG16	73.78%	**84.12%**

The results demonstrate that all the models achieved higher accuracy in transfer learning compared to learning from scratch. Also, VGG16 achieved the highest accuracy of 84.12%. This surpasses what is recorded in literature by [11] who achieved an average accuracy of 80.8%, and [21] who achieved 83.8%.

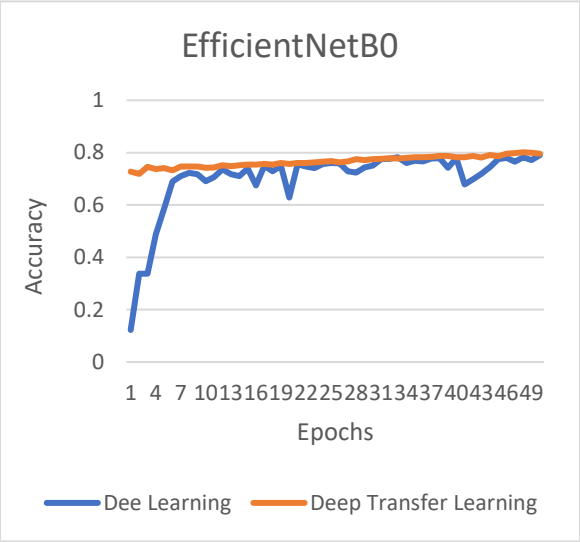

Figure 2: EfficientNetB0

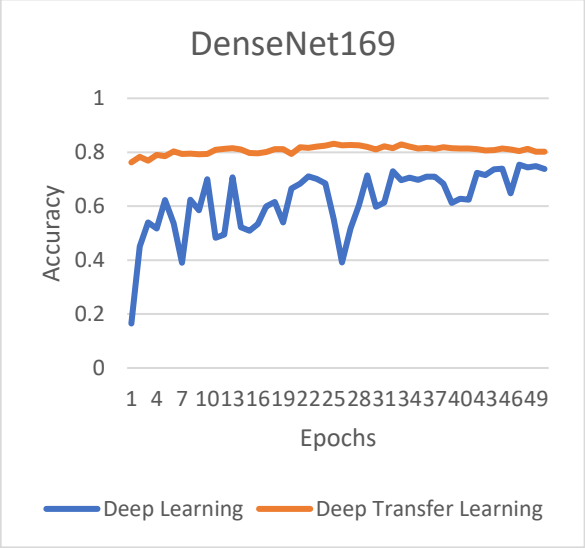

Figure 3: DenseNet169

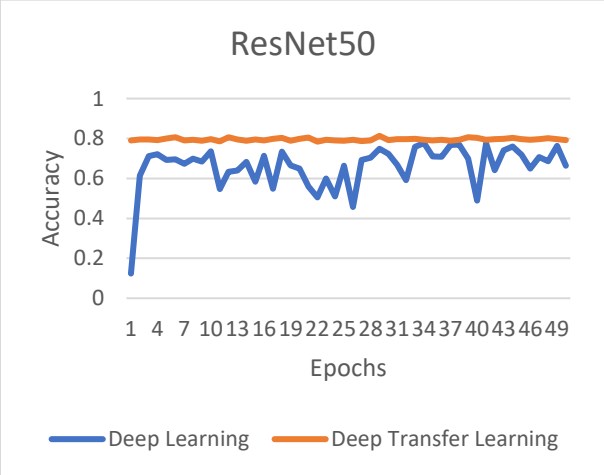

Figure 4: ResNet50

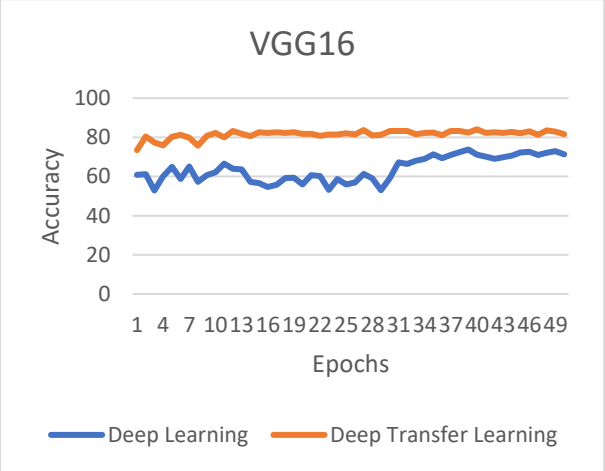

Figure 5: VGG16

Figures 2,3, 4, and 5 show a comparison of accuracy curves for both deep learning (learning from scratch) and transfer learning for 50 epochs. The results demonstrate that with transfer learning the models are easily able to extract features from the images by leveraging on their previous knowledge. While as in deep learning the models start by

learning from scratch that's why they achieve very low accuracies in the first epoch.

EfficientNetB0 represented in Figure 2 achieved 12.24% accuracy for deep learning and 72.73% for transfer learning in the first epoch. Within the first 15 epochs, deep learning had achieved an accuracy of 73.58% while transfer learning had achieved an accuracy of 75.15%.

DenseNet169 represented in Figure 3achieved 16.48% for deep learning and 76.24% for transfer learning in the first epoch. Also, within the first 15 epochs, DenseNet169 had already achieved an accuracy of 81.45% for transfer learning while deep learning had only attained an accuracy 0f 70.6%.

ResNet50 represented in Figure 4 attained an accuracy of 79.03% in the first epoch for transfer learning while deep learning attained an accuracy of 12.36%. Within the first 15 epochs, deep learning got an accuracy of 73.58% while transfer learning got an accuracy of 80.61%.

VGG16 represented in Figure 5 attained an accuracy of 60.85% and 73.5% in the first epoch of deep learning and transfer learning respectively. Within the first 15 epochs, deep learning had achieved an accuracy of 66.55% while transfer learning achieved an accuracy of 83.15% in the first 15 epochs.

4.1 Discussion

The results show that VGG16 surpassed all the others in transfer learning. This demonstrates that the CNN and the filters in the VGG16 architecture play a very critical role in feature extraction. While the replaceable fully connected layer enables the model to have some level of domain shift generalizability.

The accuracy curves show that transfer learning enables a model to easily avoid learning a new task from scratch and thus the model is able to achieve a high performance faster and with fewer computing resource needs. This is a great phenomenon since it makes it possible for developers to develop models with just a few shots of data.

The results from the study also demonstrate that weights obtained by pre-training a model on the ImageNet dataset can easily be transferred to solving diabetic retinopathy classification tasks. In this study, we have been able to compare deep learning (learning from scratch) with transfer learning across three state-of-the-art neural network architectures. We have also been able to attain a high accuracy with transfer learning compared to Qummar et al [11] and Pratt et al[25].

CONCLUSION

Meta-learning and transfer learning are some of the best developments in Neural Networks due to their capabilities. They have made it possible for researchers to explore medical imaging research even when big volumes of labeled data are a limitation. Thus, researchers can now be able to create models that automate the classification of diabetic retinopathy.

This study mainly focused on comparing the performance of deep learning and transfer learning in performing the task of classifying diabetic retinopathy. The findings of this study can act as a reference point for researchers who wish to explore computer vision research using neural networks.

DECLARATIONS

Authors declare that they have no conflict of interest in this research paper.

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A Blockchain-Based Conceptual Model for Curbing Institutional Academic Certificate Fraud

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Abstract: There is need of certificate authentication mechanism in Africa, specifically in Kenya that will solve internal fraud activities. This is because there are many fake certificates in circulation that appear to be genuine but were obtained illegal from accredited universities. This is caused by the assumption that certificates being issued at the university are authentic. While authentication of the final academic certificate has been studied in previous research, many researchers focused on securing the final academic certificate and assumed that all certificates issued by universities are genuine thus creating a loophole for institutional certificate fraud. It's possible for clients looking to get an academic certificate illegally to collude with university staff, who are responsible for generating the certificates, to acquire a legitimate academic certificate without going through the academic process.

The purpose of this research is to develop a blockchain based model that solves the current problem of institutional certificate fraud. The research targets only Kenya public universities. Sampling will be done using simple random sampling to identify a few universities that will participate in the study. A combination of secondary data and primary data will be used in the research. Secondary data will be used to test the model while primary data will be used to construct the data mapping structure/model. Primary Data will be collected from the registry department using questionnaires and interviews while the sample will be obtained using stratified sampling. The model will be deployed using permissioned blockchain. The proposed model will have controls to ensure a student goes through the entire learning process before he is awarded an academic certificate.

Keywords: Certificate authentication, blockchain, accreditation, certificate fraud, internal fraud

1. INTRODUCTION

In the world over, academic certificates are used in many places including universities and job places as a way of confirming one having acquired some specific skill set. It is therefore a norm to be asked to produce the credentials as a proof of one's claim of having completed a course. The relevancy of certificates comes into play while seeking to further studies, job employment, job promotions etc. In Kenya, for example, legislation required all members of parliament and governors have a degree. This led to many politicians who were not graduates and needed to vie for elective seats seek for the certificates. Academic certificate authentication has become equally important now days as a way of validating the different credentials acquired from different learning institutions.

Due to the significance attached to the academic certificates, an increase in different kinds of academic certificate fraud has been witnessed. Academic certificate fraud is the deliberate effort to use fake credentials knowingly and deceive people for personal gain. Academic certificate fraud is a threat to the intellectual integrity in which knowledge advancement depends on. Consequences of academic certificate fraud range from personal reputation, organizational reputation, the integrity of the institutions and effects on the economy and also could be fatal, for instance, a fake surgeon who operates people using a fake certificate. Academic certificate fraud taints the reputation of the institutions and its honest scholars and researchers. It may also cause investors to the institutions withdraw their support due to lack of integrity. Another negative impact is that people with fake certificate may be given jobs at the expense of those individuals with legitimate documents. Wrong job placements result into poor performance causing employers to suffer great losses. This may cause great harm even to students who legally acquired certificates from same institutions since no one will trust them. Individuals may also face the law against certificate fraud once the certificate have been proved beyond doubt to be fake. These malpractices cause even great harm in some critical domains like medicine, aviation, military etc. Some of the implicated cases include doctors, nurses and pilots etc. In 2013, the global corruption report on education recorded corruption instances exceeding a global average of seventy percent. One of the reasons that has contributed to the increase of certificate fraud is employers over relying on the academic certificates for employment and promotions at work places. This has made many workers to look for more academic certificates using all means at their disposal. In Uganda, the government in 2016 investigated Busoga University for giving over 1000 fake degrees to south Sudanese students who needed to secure government jobs back in their homeland [1]. In 2017, Uganda arrested 88 members of staff at Makerere University who colluded with students by altering students' grades and issuing of fake degrees [2].

Academic certificate fraud exists in many forms depending on the techniques used. Most common techniques used include manipulation of academic documents, bribery of university staff to forge academic certificates, bribery to ensure the licensing of academic institutions, ghost schools only existing on paper, the passing of examinations, fake admission into education programs and the award of degrees [3]. As a result, academic certificate fraud can be classified into document fraud, institutional fraud, diploma mills and accreditation fraud [1]. Some of these activities are easy to

detect but some very difficult to detect if advanced mechanism is not used. From research that has been done to curb the occurrence of certificate fraud in institutions, much focus has been the final academic certificate verification and authentication. The emerging problem is internal fraud where an employee may be bribed to manipulate records in the official university document so as to help someone get a certificate while he never attended any class or attended class but has never met all minimum requirements. The certificate may pass all verification and validation process since it is supported by the university official documents. To address the gap of institutional fraud, a solution is needed that will prevent internal staff of a university in charge of certificates from controlling when certificates are generated and for who. Controls need to be implemented right from the admission of students and keep track on the entire learning process. Blockchain technology is ideal for the proposed model to solve the current problems and loopholes in the certification process because of its desirable features such as transparency, elimination of trust on people and the immutability of records. This paper introduces a novel blockchain-based model for curbing institutional academic certificate fraud. By using blockchain in this model, we utilize its intrinsic features like immutability, decentralization, enhanced security and distributed ledger. The proposed model will make it impossible for learning institutions to admit students who do not qualify in their courses of choice, get an academic certificate before the lapse of the course duration and alter exam results stored in the blockchain. By preventing the three above, the model will thus prevent any form of certificate fraud thus ensuring that verified academic certificates are authentic. In addition, smart contracts will eliminate the trust placed on the people working in the certificate sections as they will not have control on who to generate certificate for. Certificates will be generated based on the certificate information from smart contracts, which is automatically fired once a student meets the requirements for certification. This therefore means that certificates generated out of the certificate information from smart contracts will fail the validation test during certificate verification using the blockchain.

The following is the main contributions of this work in summary:

i) This research proposes a unified data mapping structure that can be adopted by any university to allow it store data in the blockchain.

ii) By using blockchain, this model allows for distributed storage of academic certificates which is therefore tamper-proof, void of cheating and fraud.

iii) Strong cryptography of blockchain ensures that data stored in the blockchain has high degree of security and privacy even as it can be accessed by any third parties e.g. employers

2. PRELIMINARIES AND RELATED WORKS

2.1 Blockchain Technology

Blockchain technology is a distributed database that records transactions in a distributed ledger. Blockchain is a combination of many techniques such as cryptography, mathematics, algorithms and distributed consensus algorithms. It's characterized by features that makes it to be used in different domains for trust free systems.

Blockchain was first used to a peer-to-peer ledger for record keeping of the transactions of Bitcoin cryptocurrency. A blockchain transaction in the public ledger contains a verifiable record and once the information entered, it cannot be altered or erased in the future. The Blockchain technology eliminates third-party intermediary and allows for verification of transactions directly [4] Transactions completed are made available to all participating nodes thus becoming more transparent than the centralized database. Once consensus is met by all nodes, the record is added to the block. Each block contains a hash value of its last counterpart for connection to other blocks to form a blockchain [5]. Blockchain technology is being used in certificate authentication because it eliminates the need of trusted third parties. It has many desirable characteristics that gives it an advantage to other technologies. These desirable features include decentralized, immutability, timestamp, trust and transparent as described below [6]

1) **Transparent**: Blocks of transactions are made available to all participating nodes thus promoting transparency of transactions. It's also very difficult to rollback or delete a transaction once it is added to the blockchain. Blocks with incorrect transactions are quickly identified and cannot be added to the blockchain.

2) **Decentralization**: Blockchain is a distributed ledger where all transactions are shared to all participating nodes in the blockchain. This ensures that data is available even with a failure of participating node. It eliminates the problem of centralized database where when the relied source fails then all transactions and services fail. It also eliminates the problem of relying on third party agencies for some services such as verification and authentication of transactions.

3) **Immutability**: Blockchain is a technology that makes it difficult to change a record once it is added to the blockchain. This makes records to be tamper proof thus retaining originality of the transactions.

4) **Authenticity**: Blockchain ensures authenticity because of the decentralized system, the blockchain data is complete, consistent, timely, accurate, and widely available.

5) **Trust**: Another feature of blockchain is trust. This is because the technology eliminates the need of third party agencies to ensure integrity of transactions. Each block is verified independently by consensus models which provide rules for validation of the blocks. Once consensus is made by the different nodes, the block is added to the blockchain.

Figure 1 shows the different features of blockchain.

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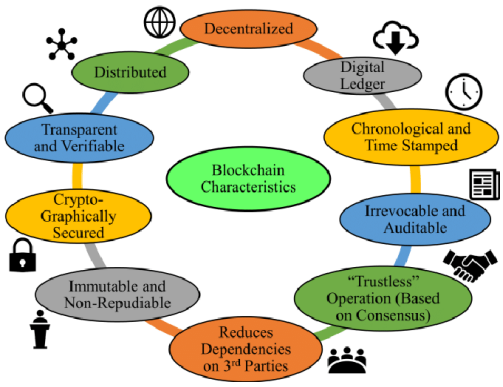

Fig. 1. Features of blockchain

There are three types of blockchain namely private blockchain, public blockchain and consortium blockchain. In public blockchain, information is open to the public and anyone can join the network and access information. It is a permission less type of blockchain. Private blockchain are permissioned. Only authorized individual who are approved can join the network and access information. Permissioned blockchain architecture ensures strict separation of roles and privileges. This makes it easy for system audit. Even if one participating node is honest, it will detect any malicious practices [1]. Consortium blockchain is a type of blockchain that is management by more than one organization. It's permissioned but some data could be accessible to the general public. It's more secure because participating nodes are geographical spaced [6]

Blockchain working begins when a node initiates a process and signs it with its private key, a block presenting the transaction is created on the platform. The transaction is broadcast to the peers within the network. The peer nodes then validate the transaction, after validation, it included in the block. At this point the transaction is confirmed. The block gets added to the ledger and links itself to the previous block. When a new block arrives after it, it cryptographically links itself to the back of the block. Figure 2 below shows the architecture of blockchain.

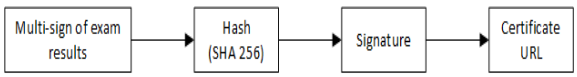

Fig. 2. Blockchain architecture

At the heart of blockchain is smart contracts. Smart contracts are programs stored on a blockchain that automatically execute when predetermined conditions are met. They are used to automate the execution of an agreement so that all participants can be immediately certain of the outcome, without any intermediary's involvement or time loss. Smart contracts are one of most attractive features associated with blockchain technology [7]. Smart contracts have various applications such as services in the financial domain, market prediction, utilization of the Internet of Things (IoT) [9], [10]. In the government sector, there are several smart contract frameworks and applications such as e-government, digital rights management, social media platforms, cloud storage, supply chain, smart transportation. This technology is used together with blockchain technology as the underlying technology to achieve trust less decentralized systems. Blockchain has a multi-signature wallet that can be used to collaboratively sign a transaction. Multi signature wallet is a well-known concept in the public cryptographic. It allows multiple parties to jointly sign on a document using their private keys. This practice is common where parties need to be in agreement for a transaction to take place [11].

2.2 Theoretical Framework

Theoretical review explains existing theories that are relevant to the study. This study is founded on fraud triangle theory and technology acceptance model theory.

1) **Fraud triangle theory**: Fraud triangle theory developed by Cressy in 1953 discovered three reasons why an employee may decide to commit fraud. The three elements are Pressure, opportunity and rationalization. Opportunity on the other hand is a weakness in an organization system that presents a chance for an employee with powers to commit and hide fraud. On the, other hand, rationalization is a personal justification of doing fraud in the organization. Instances of rationalization is "am doing it because others are doing it" or revenge to his bosses. Last but not least is pressure. It is either an external force or internal force or a threat making you to commit fraud [12]. The relevance of fraud triangle to the study is that institutional certificate fraud is done by employees of the organization and not people outside the organization. The three reasons stated by Cressy why employees may commit internal fraud positively relate to what may ignite an employer assist someone get a legitimate certificate without going through the learning process and meet minimum requirements to be awarded a certificate. A weak control system poses a greater opportunity to employees to commit and hide crime. On the other hand, it could be an Order from senior person to do a fraudulent act or an employee may do it because of personal interest. [13] Argued out that Opportunity carries a big risk to internal fraud cases compared to rationalization and pressure. He states that strong control systems and policies will eliminate any opportunity posed to employees to conduct crime even if under pressure or for his personal interests The theory supports the research on why there is need to develop a model to curb institutional academic certificate fraud by ensuring strong control system to eliminate any chance or opportunity posed to employees to commit fraud. In the existing certificate authentication systems, there exist opportunities (system loopholes) that internal employees may exploit and conduct certificate fraud. This is because existing solutions do not cover the process before the certificate 4 is generated creating an opportunity for internal fraud. These opportunities include but not limited to changing the enrolment date

and date of completion to suit client demand, falsify a record of non-existing student, illegal register a student in a program he doesn't qualify to, change grade to improve performance of a student, change classification of student, create fake transcripts for non-student etc.

2) **Technology acceptance model theory**: The theory was developed by Davis in 1985.Technology acceptance model theory is a theory majorly used in information systems. It specifies two components that determine the acceptance of technology by users. These elements are perceived ease of use and perceived usefulness of technology [14]. Prior to Davis work, Slevin and Schultz in 1975 carried out research and found that perceived usefulness of technology gave a reliable prediction of use of technology. [15] Replicated the work of slevin and Schultz and confirmed that there is a high correlation between perceived usefulness of technology and technology usage or acceptance [15]. Technology usefulness to the subject under research is a determinant of the usage and adoption of the technology and solution developed. This theory is relevant to the research on how to curb institutional certificate fraud since the solution proposed acceptance will depend on the relevance and usefulness of the technology used to build the solution. In this research blockchain technology will be used to develop the proposed model due to its usefulness and relevance of the technology to the problem under research. Blockchain technology abilities such as decentralized, transparent, tamper proof, immutable, timestamp preserves the state of document which creates integrity of the digital asset and makes blockchain more useful and ideal to certificate authentication than other technologies.

2.3 Types of Certificate Fraud

The malpractices in education sector can be classified into several ways such as document fraud, accreditation bodies' fraud, fabricated documents, diploma mills and institutional fraud [1].

1) **Document fraud**: Document fraud are falsified documents that are as a result of altering legitimate certificates or fabricating the entire documents by using fake logos, seals and serial numbers. [16] gave an example of document fraud where the Syrian migrants and refugees were sold forged documents on their way to Europe at the Syrian-Turkish border. Another fraud related to this is Accreditation bodies' fraud where accreditation bodies get compromised and legitimize false documents. The federal investigation agency in Pakistan probed many instances where regulatory bodies approve false degrees of powerful people [8].

2) **Diploma mills**: This is where fictitious universities sell fake credentials. Diploma mills operate in a highly structured and sophisticated manner that they make their customers have trust in them as legitimate universities. A recent example is the Axat international scandal where a Pakistan based company has a web of more than 370 diploma mills which collectively earned millions of dollars as revenue by selling fake degrees for various fictitious universities to clients worldwide [17]

3) **Institutional fraud**: Institutional fraud is where someone colludes with the relevant university employees to conduct fraud. A student or non-student of a particular university may bribe the employee so as to append his record in the university official document and get a certificate. A good example of this type of fraud is in the case Makerere University in Uganda where 88 members of staff were sacked for colluding with students to change their grades and issuance of fraudulently degrees. A similar case is the Busoga University in Uganda that awarded over 1000 tuition premium degrees in one month to south Sudanese in 2016 most of them being military so as to secure jobs in their homeland. This type of fraud is difficult to detect since it's backed up by the university records and it can withstand many tests imposed by accreditation bodies [18]. In Kenya for instance, it was found out that a few of current civil servants have fake degree papers and some still searching for papers in preparation for next year's election.

2.4 Academic Certificate Authentication Techniques

There are several ways that different institutions use to authenticate certificates both manual and automated solutions. The certificates are verified to check their validity through various means which include calling the said university to ascertain the certificate, by use of the accreditation bodies to verify certificate, use of Security holograms and institution seals, Verified university lists, Certified true copies, Verification forms/confidential letters, while technology based solutions include use of digital signature, use of Quick Response codes, use of blockchain technology and use of web application systems.

1) **Manual authentication**: This is done by an organization contacting the institutions in which the certificate originates so that they can validate a credential of interest. The institutions do manually verification at a given fee and it takes a lot of time since they have to go to archives and retrieve files in order to verify the certificate. This type of verification is also based on trust of the involved employees. In case these employees are compromised, they may end up validating an illegal certificate [19]. Other forms of manual authentication include security holograms and institution seals, verified university lists, certified true copies and verification forms or confidential letters written to employees.

2) **Technology-based techniques**: This is where the verification process in online and automatic i.e. it does not require human intervention.

Quick response code: A Quick response (QR) code is a machine-readable code consisting of an array of black and white squares, typically used for storing information for reading by the camera on a smartphone. QR codes

have been widely used to store information and can easily be scanned by mobile devices. A study done by [20] used QR code and digital signature to authenticate secondary school certificates so as to easy certificate verification process. It is a known fact that QR-codes can be exploited and easily be created over the internet. However, few studies have shown that QR codes can be secured with traditional security methods such as encryption thus QR codes cannot be used independently. This study didn't address the institutional fraud problem at hand since it cannot be used to record the learning process of the students so as to eliminate internal fraud.

Digital signature: Digital signature is a mathematical technique used to authenticate a digital document [21]. It involves the use of a pair of keys i.e. private and public keys and the hashing function. Private Key is used to encrypt the document while the public key is used to decrypt it. Digital signature checks for the integrity of information in transit between the sender and the receiver. Key may be hacked or lost which poses a security threat. Considering the problem at hand, digital signature cannot be used independently to control the learning process of students hence cannot be used independently to solve the problem of internal fraud.

Blockchain technology: Blockchain has been previously used in the academic sector to provide solutions to the forged certificate problem due to its characteristics. Characteristics such as time stamp, permanent, immutable, transparent, authenticity, decentralized makes blockchain an ideal technology to be used for certificate authentication and validation.

2.5 Related Works and Research Gap

2.5.1 Related Works: There are a number of existing solutions developed using blockchain technology such as blockCert, smartCert and EduCTX and frameworks that could be adopted in the certification verification

The initial research done by knowledge media institute (KMI) of the Open University (OU) initiated the use of badges and using ethereum to turn badges into smart contracts. KMI developed a prototype for issuing micro-credentials in the blockchain. In this research, certificate verification by other parties other than the insurer was not put into consideration. Similar research with same objective was done by [5] who developed a decentralized digital certificate application based on blockchain. This technology was selected because of its desirable features such as incorruptible, secure and permanent. The researcher needed to solve the problem of security where only physical documents were presented for verification in different events such as registration for courses, during interviews etc. Physical certificate led to mass duplication and alteration of certificates since it was difficult to verify with decentralized digital certificate application. With the use of digital blockchain based application, different institutions could verify the authenticity of certificate hence minimizing the problem of forged certificate. A similar initiative done by [22] is the open standard named blockCert that is used to develop apps for authenticating academic credentials. Certificate stored in the blockchain cannot be altered but BlockCerts is based on the self-sovereign identity of all the participants by providing components to create, issue, view and verify certificates in the blockchain. One of the drawbacks is, it does not have a separate validation service for verifying its validity. It also does not address some fraud cases such as the internal fraud.

[23]

Did a research on Security analysis of a blockchain-based protocol for the certification of academic credentials and found out that the blockCert standard lacks a way of verifying the ownership of keys used in signing of issued certificates as mentioned above. This may lead to impersonation of the insurer profile. The research proposed the use of public key infrastructure (PKI) to solve the problem. Another research done by [24] employed digital signatures and timestamps using blockchain technology. With the use of timestamp it made it difficult for one to claim having graduated earlier because records in blockchain cannot be changed thus reducing document fraud to a bigger extent. The researcher spells out that if the fraud takes place the same day of graduation, then it would be difficult to detect since the record will appear to be legitimate in blockchain thus still providing space for internal fraud.

A certificate verification framework using hyper- ledger to address security concerns such as confidentiality of information, authorization, ownership and authentication was developed by [25] Hyper-ledger was selected because of its desirable features such as permissioned access, transparent network and Uniquely Identifiable Digital Certificate SmartCert is another blockchain platform for credential verification and authentication. SmartCert was developed to establish the authenticity of academic credentials on a blockchain and to overcome the problem of fake certificates. SmartCert makes use of cryptography signing of educational certificates to provide transparency in the case of recruitment. The certificate holder shares the hash with the prospective employer to verify the certificate [25]. Again this solution does not address the problem of internal fraud and an illegal certificate that originated from the university will be approved as authentic. Another problem is the complexity of keys. The complexity of keeping and maintaining a series of keys triggered research on usability by [1]. The research focused on certificate verification and how they can tailor their solution to the existing verification ecosystem. Their main focus was on usability since many proposed solutions were not usable because parties have to maintain series of keys for authentication and authorization. They designed and implemented an online solution "Cerberus" one just need to scan the QR code to authenticate the certificate while maintaining all security features.

EduCTX is another research done by [26] was based on the concept of the European Credit Transfer and Accumulation System (ECTS). They proposed a blockchain-based higher education credit platform which exploit the benefits of the blockchain, as a decentralized architecture, offering security, anonymity, longevity, integrity, transparency and immutability. The goal of the research was to unify higher learning institutions systems so as one can access his or her credits scores from any university in case of transfer of students from one country to another. The EduCTX platform is implemented on the blockchain platform ethereum on a consortium-based network of Ethereum run nodes. The platform enables a globally efficient, simplified and ubiquitous environment to avoid language and administrative barriers [27].

2.5.2 Research gap: There is significant research on academic certificate authentication however researchers assumed that certificates issued by universities are genuine. Solutions

discussed above focused on the final certificate verification and not the entirely certification process. There is still lack of controls in the process leading to acquisition and issuing of the academic certificates. They make an assumption that certificate originating from a legitimate university are genuine thus covering internal fraud. It is possible for clients looking to get an academic certificate to collude with university staff, who are responsible for generating the certificates, to acquire a legitimate academic certificate without going through the entire academic process. Some of the activities that university staff may do which leads to internal fraud include

- Append a record of a fake certificate into the blockchain system so that it can be verified as genuine.
- Change students details like date of enrolment, date of completion, grade obtained in the local database so as to validate a counterfeit certificate.
- Accessing the local database and change grades.
- Classifying students in higher ranks which they do not deserve.

Due to the above reasons, a solution is needed that will eliminate all the loopholes that may lead to certificate fraud especially by internal staff of a university. Controls need to be implemented right from the registration of students and keep track on the learning process. Blockchain technology is ideal for the proposed model to solve the current problems and loopholes in the certification process because of its desirable features such as transparency and elimination of trust on people and the immutability of records.

The learning process of students' controls can be categorized into admission of student controls, examination in the entire program controls and finally issuance of an authentic certificate. It's evident from previous research that admission and examination has not been considered in the existing models but tackled final certificate authentication. This creates the loophole of internal fraud. Variables in student admission and examination needs to be captured into the blockchain and stored in the blockchain. This is because once information is stored in the blockchain, it is difficult to change since blockchain is distributed and makes it difficult for an individual to change. This brings in transparency and immutability of blockchain technology.

To avoid internal staff conducting fraud, conditions in the blockchain has to be set to ensure students meet and go through the entire learning process. In the proposed model, this is achieved through smart contracts. Smart contracts are self-executing programs that execute once conditions are met. In the proposed model, the variable defines smart contracts (program structure, progression smart contract and certificate smart contract), student details, Student Exam score and graduation date need to be captured into the model at different levels or times during the learning process and certification.

3. PROPOSED SOLUTION

3.1 Blockchain

Decentralization is one of the salient features of blockchain, which means that no single party or authority is governing or looking after the blockchain network. Parties make transaction through consensus thus establishing trust in a trustless network where there is no middleman involved. Another salient feature is a public ledger which ensures that every transaction is recorded in blocks. For a transaction to be accepted, every party needs to verify its validity. If majority of the parties agree that it's valid it is added to the public ledger. Once a record is added to the public ledger, no one can edit or delete the record. This promotes transparency and makes the entire process to be corruption-proof. Cryptography, another key intrinsic feature of blockchain is responsible for the security of records in the blockchain network [28]. By using blockchain in our solution, the entire certificate acquisition process is stored as transactions in the blockchain public distributed ledger thus making the academic certificate information to be secure, authentic and verifiable.

3.2 Academic Certificate Block

The academic certificate information will be stored in the blockchain to make it accessible on request and also authenticate the certificate. The process consists of four main components as follows:

i. Designated signatories use multi-sign to record exam results in the blockchain. Recorded exam results must conform to the established data mapping structure.

ii. Just like bitcoin, our solution uses SHA 256 in implementing the hash function during storage of the results. Any record added to a block in this models blockchain will consist of a hash of the actual exam result, a signature by the owner (student) and a URL to the stored results in IPFS.

iii. All academic certificates generated will be signed by the owner (student) any access to the record will require authorization from the owner.

iv. A URL to the academic certificate information for every academic certificate will be stored in the blockchain to make it possible to access the credential upon approval by the owner. Figure 3 shows the process of recording exam results and how the certificates will be stored in a controlled manner.

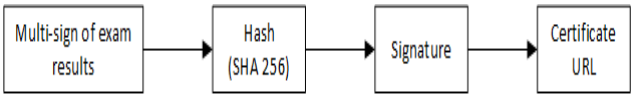

Fig. 3. High Level blockchain transaction for academic certificates

The details of each block in the academic certificates blockchain is as shown in figure 4 below.

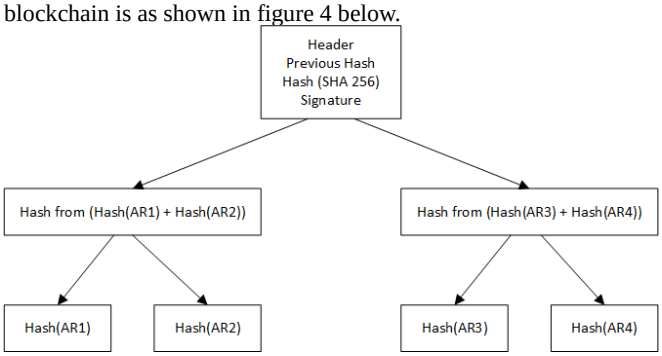

Fig. 4. Storage of academic records in the blockchain

The header contains the hash of the previous block, the hash of data to be stored plus the signature. AR1, AR2, AR3 and AR4 denotes Academic Record 1, Academic Record 2, Academic Record 3 and Academic Record 4 respectively.

3.3 Conceptual Model

Model Architecture: The detailed conceptual model synchronizes interrelated components and variables which help in solving a real-world problem. It clearly shows how components, variables interact with the process so as to eliminate internal academic fraud. Below is a model clearly showing the variables and the steps involved so as to eliminate internal academic certificate fraud? Figure 5 shows the conceptual model.

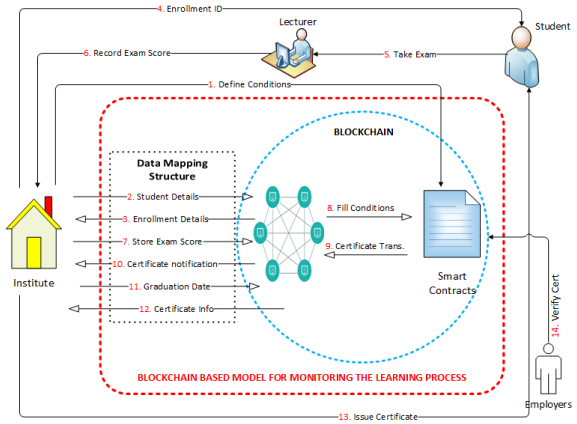

Fig. 5. Detailed conceptual model

Description of the conceptual model: It outlines the description of the process flow which takes into consideration all the requirements before admission of students, admission and examination activities and finally issuance of certificates.

a) **Define conditions:** These are smart contracts which are self-executing once the conditions are met. Three smart contracts will be defined by the learning institution which serves as a guide for the admission process, examination process and generation of academic certificates. The three smart contracts defined by the learning institution are as follows

1) **Course requirement smart contract**: The course requirements for admission will be defined for each academic programme. Here the overall minimum required and subject-wise minimum requirements to be admitted to a particular programme will be specified.

2) **Progression smart contract:** The programme structure for a given programme alongside criteria for progression to the next level of study is specified. Once a student successfully meets the requirements for the current level study i.e. after passing all required exams, the progression smart contract will elevate the student to the next semester and/or year of study. This will continue up to the final year of study, after which the student will be eligible to get a certificate.

3) **Certificate smart contract**: On completion of a programme duration and exams marks for the entire period having been filled, a certificate transaction or notification is generated. The institution provides additionally information such as the date of graduation to the blockchain. Classification is done inside the blockchain and information for preparation of a certificate is sent to the institution so as to prepare a physical certificate for the student.

b) **Admit student**: On admission, the student details and performance of the student is entered into the system. An API fills the course requirement smart contract to check with the pre-defined conditions for the particular course.

c) **Enrollment details**: The blockchain generates student enrolment Id if the student meets the course requirements.

d) **Issue student enrolment**: ID The student will be issued an ID using the information from the course requirements smart contract.

e) **Take Exam**: At the end of the semester, students will take exams for the units that they had registered for in that semester.

f) **Record Exam Score**: After students take their exams, lecturers mark the exams and records the scores for each student in the university system.

g) **Store Exam Score**: Exams undergo normal processing as per the requirements of the institution. Once results are declared, they are then added to the blockchain using multi-sign.

h) **Fill Conditions**: Each score of a student will be filled in the progression smart contract which executes once all the marks for a given semester are received. This continues until such a time when all the marks for a particular course are captured then the certificate smart contract gets executed. This initiates the process of generation of the academic certificate.

i) **Certificate transaction**: Once a student completes all the course requirements, passes all the required exams, the certificate smart contract is triggered. Upon execution, the certificate smart contract generates a certificate transaction.

j) **Certificate notification**: Once the certificate transaction is processed, a notification is sent to the institute to provide additional information such as date of graduation.

k) **Graduation date**. The graduation date is sent to the blockchain by the institute.

l) **Certificate information**: Certificate details are sent to the institution for purposes of generation of the certificates.

m) **Issue certificate**: Based on the certificate information, a certificate is printed and issued to the student. Also, multi-sign of the exams officer and registrar academics is required to be able to generate the certificate. The certificate contains the student details, classification, graduation date, issuance date and Code. The code can be used later to verify the authenticity of the academic certificate.

n) **Verify certificate**: Anybody can verify the authenticity of an academic certificate by use of code embedded on the academic certificate. On successful authentication of the certificate, you should see the student details, classification, university, date of graduation and issuance.

3) How the Proposed Model will Curb Internal Certificate Fraud:

- Admission of students is controlled since the student ID comes from the blockchain once the admission

conditions are met. This therefore makes it impossible to assist in admitting students who do not qualify.

- Performance of students for each unit in a semester is written in the university system. Once the results are declared, they are then saved into blockchain using multi-sign. The results thus become immutable, transparent and verifiable. This ensures that internal staff cannot change grades to assist students or disadvantage some students.
- Multi-sign of the departmental exams officer, chair of department and the chief exams officer is used to write students exam score. This spreads the risk of corruption since to insert a new falsified record requires collaboration of the three signing officers.
- Once all conditions have been met, the student will now be eligible to be awarded a certificate and the certificate smart contract gets triggered. After the certificate has been processed, the certificate information is stored in the blockchain using multi-sign of the relevant authorities. Once information is stored in the blockchain, it becomes permanent and very difficult to change.

Certificate information that did not originate from the blockchain cannot be appended into the blockchain thus unverifiable. This process limits internal staff who can be bribed to generate fake certificates and append them to the blockchain so that they can be verified as genuine but are not, therefore the model takes care of all loopholes used in internal certificate fraud..

4. VALUE OF THE PROPOSED SOLUTION

4.1 Benefits to Universities

The proposed solution will help universities to strengthen and seal all loopholes that internal staff can use to conduct internal certificate fraud. This will enable authenticity of academic certificates originating from universities. The article will help higher learning institutions to maintain their integrity and reputation. By eliminating institutional academic certificate fraud which taints the reputation of institutions, institutions will be able to attract more investors and researches to the institutions.

4.2 Benefit to Employers

On the other hand employers will benefit from the research in that they will be able to employ the right people for the right job which will automatically reflect in higher performance and productivity. It will also be easy for employers to verify certificates

4.3 Benefit to Students

Adoption of this model will mean that students are guaranteed of acquiring genuine certificates which can be authenticated by third parties.

5. CONCLUSIONS

By incorporating the salient features of blockchain, our solution will enable educational institutions to issue authentic and verifiable academic certificates thus curbing the gap of institutional fraud which is the hardest to prevent and detect. This will in a great way increase the reputation of educational institutions consequently increasing the quality of education as a whole. These academic certificates will be stored in the blockchain thus it is accessible on request by other educational institutions and employers. The students will approve any request for academic certificate verification in order to maintain data security and privacy.

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Using Videoconferencing to Augment Blended Learning for Synchronous and Asynchronous Teaching in Educational Emergencies

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Abstract: The unprecedented onset of COVID-19 and the emergency closure of institutions of Higher learning heralded a new way of completing the curriculum and taking the students through the academic calendar. Previous definitions of emergency education had tried to allude to war, civil strife, floods, drought and even some instances of HIV AIDS or children living on the streets. The COVID - 19 gave a new definition to emergencies, as it led to forced containment and requirement for social distancing on a global level. Prior to the pandemic, Learning Management Systems (LMS) had been around in what would be termed as E-Learning, computer-based education and other computer related terms, Most of the LMS would support both synchronous and asynchronous education. However, face to face learning was still the preferred mode of teaching, and the online component was considered complementary and supplementary. COVID-19 led to Emergency Remote Teaching, and this brought about a change in approach and rethinking of the technologies available for remote teaching. Many Universities had to find a way of providing a supplementary way of providing live and synchronous classes. Previous applications such a ZOOM, Google Meet and Microsoft Teams found their use in the educational setup, with many Universities subscribing to these tools as well as those that are embedded in LMS, such as the BigBlueButton as used to together with MOODLE as a plugin. The aim of this study was to establish how Videoconferencing tools are used to provide synchronous and asynchronous education. The objectives were to establish how Videoconferencing tools are used to aid in teaching and learning, how these tools are used to mirror a face to face class, as well as the challenges faced in integrating these tools in the classroom. This study used a quantitative and qualitative approach where a web-based questionnaire with both open and closed questions were posted to an E-learning special interest groups consisting of faculty in both private and public institutions in Kenya and some students taught by these faculty, and followed by in-depth interviews via Videoconferencing The study established that many institutions turned to stand alone and open source videoconferencing tools to teach both synchronously and asynchronously in a blended mode. The biggest challenge was in the IT element due to non- availability of stable internet connectivity and the fact that neither the students nor the faculty had clear training on the tools available within the videoconferencing applications, and there was no formal method of integrating the same to teaching. The study recommends a policy framework on the integration of such tools in the teaching.
Keywords: Videoconferencing. Blended Learning. Synchronous and Asynchronous teaching. ICT. COVID-19.

1. INTRODUCTION

The traditional classroom has always been visualized as having the teacher address the students in a room where there is face to face interaction. The introduction of ICT in education has seen Information Technology tools introduced to supplement the teaching. Information Communication Technologies (ICT) are increasingly changing both formal and informal education settings, giving students and teachers an enhanced level of synchronous interaction. There are many terms used to describe the use of computers in education, including Computer -Mediated Learning, Computer-Based Education, Computer Enhanced teaching, E-Learning, Online Learning, Virtual Learning, Digital and currently, Blended Learning as the buzzword. All these refer to a situation whereby ICT is used to provide some sort of support in content delivery and assessment, all with the aim of meeting the Learning Outcomes. Today, students and teachers are constantly looking for portable devices such as iPhones, iPads and smartphones. These devices came in handy during COVID- 19 [9] due to their multimedia applications such as audio, video and text capabilities. Many Universities migrated their learners to online teaching via Videoconferencing. Due to the emergency nature of the migration, staff and students were left to use whichever tools worked for them, so long as a there was actual teaching, delivery of content, discussions, assessment and even proctoring of examinations [1]. In Kenya, over 562,000 Kenyans enrolled in tertiary education were migrated to emergency online teaching [3] with varying levels of success. Most of this teaching was via Videoconferencing as some of the Universities did not have mature Learning Management Systems before COVID-19. Even where such existed, there were issues of accessibility.

In cases where videoconferencing has been successful, a learner centred rather than a technology-centred approach wins the day [2]. In addition, institutions should have a clear understanding of videoconferencing tools and their capabilities and usability in teaching before committing to the use of Videoconferencing technology, and therefore the technology readiness of the university in addition to mature pedagogy is important.

Previous studies may not have fully and sufficiently established the challenges posed by the use of different types of Videoconferencing Applications to the Higher Education policy makers. This study thus seeks to establish the videoconferencing tools in use, the challenges posed by these and how these can be addressed to enhance learning outcomes. This study sort to establish the experiences of Kenyan University Faculty students with the use of Videoconferencing during the Emergency Remote Teaching period in 2020 and 2021.

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2. LITERATURE REVIEW

2.1 Blended Learning and Constructivism

According to [21] and [23], blended learning is the offshoot of several generations of computer-based learning with the first generation having focused on presenting physical classroom-based instructional content over the Internet. This first-generation e-learning (digitally delivered learning) programs presented a repetition or compilation of online versions of classroom-based courses. The experience gained from the first-generation of e-learning gave rise to the conclusion that no single mode of instructional delivery is able to deliver the interactivity, variety, learning communities, relevance and content delivery demanded in achievement of learning outcomes. In the current wave of ICT in education, an increasing number of instructional designers are experimenting with blended learning models that combine various delivery modes. One of these delivery modes is the blended learning where a number of modes are used to enrich the process [23]. Blended learning is also defined as a combination of internet -based technology and other digital media in the classroom, and it is carried out both synchronously and asynchronously. Videoconferencing can be used to support the synchronous and the asynchronous modes [8].

Blended Learning is a form of partial virtual learning that comes into play in situations where participants are separated by distance [20]. During the Pandemic, Universities turned to the use computer-generated classrooms assisted by online tools to teach learners and facilitate continuation of classes due to the Government's rules and regulations on social distancing when COVID 19 was declared an emergency in March 2020 by the Kenya Government and this led to the emergency closure of Universities. However, faculty and learners would have needed proper training on computer-based instruction before it could be effectively implemented. There was no time for this training.

According to [19], there are four main categories of Blended Learning; These fall under the Spatial perspective and the Cyber perspective. The Spatial perspective considers a situation where all students must attend a physical classroom in either a face to face or a self-paced mode. In the face to face mode, teachers and students interact in a classroom in the traditional mode in a teacher-led synchronous approach. allowing several interactions such as teaching, peer discussions and group work. This is good for the constructivist view of teaching as it encourages interactions, collaboration [10], and communication in the classroom. In the self-paced mode, there is an individual learning process for each student learning by themselves using instruction materials or facilitators in the classroom. This requires adaptive instructions usually supplemented by computer-based solutions which allow students to learn at their own pace. In this mode, terms such as Computer Assisted Instruction, Computer Based Instruction, Web based Learning, Context Aware solutions and other interactive media are usually involved [11].
In the Cyber Perspective characteristics, a classroom in the real-world definition is not available, and the students learn in the cyber-world through the Internet, data communication networks and digital devices in a ubiquitous approach. In the Cyber approach, there is the virtual face to face instruction which fosters interactive teaching without real world distance obstacles [13]. Multimedia tools are used to bridge the distance. There is also the full ubiquitous approach where students access online resources in a self-paced manner using services such as mobile learning, web-based learning, context aware systems online and E-learning systems and terms such as the flipped classroom and MOOCS are common, and time and space are not an issue. This type of learning is largely asynchronous [22].

The Constructivist Learning Theory was proposed by Lev Vygotsky (1896–1934) and it defined the learning process in social interaction, language, and cultural aspects, concluding that human beings learn best through interaction as a learning technique [24]. According to this theory, learners working collaboratively in interactive group activities can actively construct their own knowledge, which increases engagement and improves the learning outcomes. Most blended modes of teaching endeavor to incorporate collaboration and interactivity in their approach. This constructivist approach to knowledge construction can auger well with the use of videoconferencing using a variety of collaborative learning tasks [18], problem solving, interaction and reflection where distance is an issue.

2.2. Synchronous and Asynchronous Teaching

The last two decades have seen an increase in online teaching [1], but there is a marked shift to blended learning due to the need for interaction and to mirror the traditional classroom. Instructional Designers have turned to blended modes where the use of synchronous and asynchronous methods is used concurrently

Synchronous teaching is a mirror of the traditional class and is normally offered via live links such as live chats and videoconferencing tools that require real-time communication and collaboration as if the participants were in the same place at the same time, providing real time engagement. This is easy to achieve with technology but large class sizes can still pose a problem, and different time zones can compound this further. On the other hand, Asynchronous tools are meant for communication and collaboration over a longer period of time where participants may be in in different places and different time zones, through a "different time-different places, allowing them to connect together at their own convenience and schedule [15]. These tools are meant to sustain interaction and collaboration over time using resources and information that are instantly accessible throughout the session.

Distance and Online learning, especially as driven by the COVID19 Pandemic has seen learners having to study without being in a specific place at a specific time, and hence both synchronous and asynchronous tools have become important. These are normally supplemented by quality materials, interactions and activities and instructions that create effective learning. Both the learners and teachers need to know how to use the tools for enhanced achievement of Learning Outcomes. Asynchronous tools can save time the lecture can be recorded and reused as they are built to provide better tools for recording and measuring participation by individuals. Note taking is kept to a minimum as the supplementary material is available digitally [12].

In a good blend, synchronous and asynchronous tools may provide for the posting of interactions in situations where text

and notes would be slower or cumbersome. Asynchronous methods allow shy learners who don't like sharing in public to share their submissions and ease the pressure of interacting in a live session, especially when resources such as internet connectivity and clarity of communication is compromised. Some of these tools allow students to edit their presentations and projects before submitting them, similar to text-based discussions. The main challenge is for faculty to strike the right balance between asynchronous and synchronous modes for different contexts [12]

Using the concept of blended learning, there can be a Blended synchronous educational context which allows remote learners to attend face-to-face classes using of rich-media synchronous technologies such as video or web conferencing. [7]
This approach allows remote learners to sit through a live lecture session, participate in the class discussion and ask question as if they were attending a face to face class, allowing social interaction and support from both peers and teachers. The same class can be recorded and revisited later in a blended asynchronous mode [16]. There now exists a variety of digital tools to provide synchronous and asynchronous learning and these are used to enrich the learning environment by making it more engaging and interactive. These tools provide. exactly real-time communication and immediate feedback eliminating anxiety and feeling of segregation that occurred a lot especially during the days of the Pandemic. Such tools include video conferencing applications such a Skype and Zoom. They go ahead and improve social, teacher and cognitive presence as established in the theoretical framework used to understand online interactions supporting teaching and learning is the Community of Inquiry (CoI) model, which consists of three key elements: Social Presence, Cognitive Presence and Teaching Presence [5]. It is the interactions of all three elements of the model that produce the educational experience for participants This is done by establishing new information, rules, research, ideas, and articles that contribute to cognitive presence; instructions, assessment, and class management that contribute to teacher presence; and also emotions, learning communities, self-disclosure, and group cohesion that contribute to social presence as also required in constructivism [17].

2.3. Videoconferencing in Education

Videoconferencing refers to technology that allows real-time transmission and reception of audio and video data over a network between users who can be at any distance from each other [14]. It is also described as technology that allows people living in different locations to hold face-to-face meetings without having to do so in physical space. This can take place between two or more people or groups from different remote locations so long as they have access to cameras, microphone, and speakers, either located on or connected to their computers or other digital devices. Multipoint video conferencing allows three or more participants to sit in a virtual conference room and communicate as if they were sitting directly next to each other [6]. Video conferencing has been used in many corporate meetings especially by multinationals. Some Learning Management Systems have also embedded the use of Videoconferencing (e.g. Google Classroom) while others such as MOODLE allow the use of plugins such as the BigBlueButton, increasing the use of Videoconferencing in Education. The onset of the Pandemic saw the increased use of Videoconferencing in Higher Education. The supportive nature of Videoconferencing tools offers pedagogical support through file sharing, presentation, and file transfer allowing the creation of external representations of theoretical concepts, evidence, and personal elaborations [4] in collaborative learning.

Common Videoconferencing applications include Skype, which was introduced in 2003, Zoom (introduced in 2011), Google Hangouts. Microsoft Teams and WebEx. These provide video, chat and voice calls through the use of computers, tablets and mobile devices over the Internet to other computers, phones and smartphones. Users can send instant messages, exchange files and images, send video messages, and make conference calls. Features include face-to-face chat, group video conferencing, screen sharing, use of plug-ins, browser ex-tensions, and the ability to record appointments. The features of videoconferencing tools found themselves useful in dealing with the emergency closure of Universities and the resultant demand for social distancing that interfered with the University Calendars.

It is apparent that the constructivist theory of education and the theory of Social Presence require some form of interaction with learners. Blended learning has been able to provide this through synchronous and asynchronous approaches, and Video conferencing provides the much-needed interaction especially in educational emergencies. This study looks at the functionalities that are provided by the Videoconferencing tools and the challenges impeding their full use in Kenyan Institutions of higher Learning.

3. METHODOLOGY

The study was carried out using an online survey with quantitative and qualitative items to 43 Universities in Kenya. These were sent to faculty members belonging to an eLearning Special Interest group. These faculty members were requested to share the survey to one student WhatsApp Group each. The survey was purposefully developed for the study and underwent two rounds of piloting. In the first piloting, four faculty familiar with the context were asked to review the survey and provide comments on its clarity, comprehensiveness and completeness, In the second round, 4 faculty members and four were asked to complete the survey. The researchers analyzed their responses and compared them to the intended purpose of each item. Based on the piloting, some items were revised for clarity and purpose.

The finalized survey included three sections relevant to this study: biographical information; Use of Videoconferencing; and Challenges and Opportunities. There was a total of 23 items. The quantitative items were primarily designed to collect biographical and general information, while the qualitative items were open ended and specifically designed to collect participants' specific use of Video Conferencing tools and the challenges in an explorative manner. The survey was administered to 43 faculty at the end of November 2021. Participants were recruited through convenience sampling from a special interest group and the related students. The link to the survey, which was created via Google Forms, was sent through e-mail, and WhatsApp, an instant messaging service to relevant contacts known to them with an invitation to complete the anonymous survey. The link was active for only 3 weeks. After participants completed the survey, they were requested to self-nominate for follow-up interviews.

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The survey dataset consisted of 43 faculty members, 23 who were from private Universities and 20 from Public Universities. There were 256 student participants, of which 67 were from private Universities and 189 from Public Universities. Of the total 299 participants, 53% were male and 47% were female. The second stage of data collection involved follow-up, semi-structured interviews with 12 faculty and 25 students who had completed the survey and expressed interest in participating. The 12 faculty and the 25 students were selected based on their responses in the survey to represent Universities that had turned to Videoconferencing as a mode of teaching after the Emergency Closure of Universities in March 2020. The interviews were conducted through Zoom and lasted between 40 minutes and 1 hour.. They were audio-recorded and transcribed. Ethical approval for the study was provided at the University level with all participants informed of the purpose and procedures of the study.

4.FINDINGS AND DISCUSSIONS

4.1Main Videoconferencing Applications

Of the 299 faculty and students who received the survey, 256 responded. Out of the 256 respondents, 223 had used videoconferencing during the COVID 19 pandemic, representing 87% of the respondents. The faculty and students had used a variety of videoconferencing platforms depending on the University that they came from. However, Zoom and the Big Blue Button seemed to have had University sponsorship, although the respondents indicated that at times they would use different platforms depending on availability and the application that was more accessible. Table 1 below shows the percentage of students and faculty using the different applications. The students were more exploratory with some using other videoconferencing apps such as WhatsApp video calls to communicate and collaborate. All of them had experience of at least three of the platforms. The most common tools and functionalities were the scheduling and timetabling function, the chat box, the share screen, the whiteboard and the breakaway rooms. 92% of the respondents indicated that they would switch off the video function in order to conserve bandwidth, 68% indicated that they would record their sessions for future use. However, synchronous teaching was the main reason for the use of videoconferencing, with 96% of the faculty and 82% of the students indicated that they preferred the live sessions rather than the recorded ones. The asynchronous approaches were used to provide learning activities for after school hours and for discussion forums.

Table 1: Main Video Conferencing Applications

Application	% of Faculty Using	% of Students Using
Zoom	89	83
Google Meet	50	75
MS Teams	72.	69
BigBlueButton	82	76
Skype	6	3
WeBEx	1	1
Others	4	52

From the qualitative interviews, 90% the faculty indicated that their Universities dictated the main Videoconferencing application, with Zoom being the most recommended one. The ZOOM application was either the corporate license with 46% of the faculty while 54% indicated that they used the free to use version that allowed 40 minutes of use. The users of the BiGBlueButton were largely going through the local NREN, KENET, whose services included an embedded video conferencing facility. The students indicated that they used open source software such a Google Meet unless the lecturer indicated a particular preference. Student no 7 said “our lecturers normally allow us to log into the lecture through YouTUBE” while student no. 25 said “I would normally attend the live lecture via Facebook as our class was too big for Zoom licenses subscribed to by the University.”.

4.2. Planning, Scheduling and Class Management

One of the main uses of the Videoconferencing Applications was planning, scheduling and class management as shown in Table 2. Below. Although many students indicated that their universities have Student Management systems and ERPs, these were found to be inaccessible during the lockdown die to network issues.

Table 2: Videoconferencing Uses in Panning, Scheduling and Class Management

Function	Description	Uses
Start a meeting	Create a videoconference.	Planning and Initiating classes
Schedule a meeting	Allows you to schedule a specific day and time for the meeting and manage the calendar	Scheduling classes
User management	You have the option to enable and disable the audio and video of the participants, as well as manage which user enters the meeting. The host can mute, set or delete a user.	Class management and attendance monitoring
Invite other users to join a meeting	Gives you a meeting link or code that you can send to other users.	Class management, collaboration and attendance monitoring

Multi-platform	Phone, pc, laptops, tablets so long as the device has audio and video functionality	Flexibility and accessibility
Time limit	Some platforms can run for 40 minutes to 24 hours depending on license terms	Scheduling
Settings	Shows other options available to the application, such as: audio distribution, screen appearance, etc that allows for online proctoring of examinations	Class management
Leave	By pressing that option, the member can exit the live class	Attendance monitoring and class management

The faculty indicated that they would schedule a class on the Videoconferencing application and then send a link via WhatsApp or Email. The students would then follow the link and join the class.

Many of the application allowed the lecturer to manage attendance, including having a waiting room that allowed them to vet participants and setting the duration of the lecture. The students were happy with the multi-platform ability of these applications and especially ZOOM that allowed then to use even the simplest Internet Enabled phone. Student no 7 said that "I could catch up with the lecturer using my earphones a s I travelled or did other things around the house, or record the class and listen in later". Lecturer no 16 said that the Videoconferencing applications allowed better class management as " I was able to monitor dormant learners and also mute the disruptive ones, and this brought discipline to my class"

4.3. Collaboration

The lockdown period and the resultant requirements for social distancing and restricted movement meant that the learners could not attend a physical class, reducing the much-needed collaboration and interaction even further. The faculty and the students turned to videoconferencing to improve this. The chat, screen sharing, virtual whiteboards and breakaway rooms provided synchronous and asynchronous ways of communicating and collaborating, allowing participants to stay in chat in multimedia modes including text, voice, video and graphics as shown in Table 3 below.

Table 3: Videoconferencing Uses for Collaboration

Function	Description	Uses
Screen sharing	Allows all participants to have the option to choose what to share with other meeting participants. Allows you to show your screen or the window of an application.	Collaboration and presentation
Virtual whiteboard	Allows you to draw, write or carry out explanations in an easier way.	Collaboration and presentation
Chat	Participants have the option to interact both directly and privately. Users can interact by sharing files and views.	Collaboration
Invite other users to join a meeting	Gives you a meeting link or code that you can send to other users.	Class management, collaboration and attendance monitoring
Breakaway sessions	Allows the lecturer to divide students into smaller discussion groups	collaboration
Reactions and Polling	Interaction of members, such as: raising your hand to give your opinion, then the host will respond to your request.	Collaboration, interactivity and assessment

Student no 1 stated that " I could talk to my classmates or the teacher in a private chat if I needed clarification confidentially" while teacher no 9 said "Teaching mathematics ws even easier as I could write formulae on the virtual whiteboard or enable my learners to draw a graph or demonstrate a concept on the same platform". The screen sharing tool allowed the collaborative editing or analysis of a problem and the learners felt that this removed the social isolation normally found in virtual learning.

4.4. Actual Teaching and Delivery

90 % of the lecturers indicated that they ensured that each session had a live lecture period to articulate the concepts and students were expected to attend, listen, take notes, ask and answer questions, do short quizzes, share their findings and experiences just as they would do in a normal face to face class. They allowed simultaneous and concurrent chats in the class and used functions such as the raised hand to elicit reactions to the learners. 100% of the students found this functionality very useful, and they would ask for a recording of the class to review the concepts later. Table 4. The polling function allowed the faculty to asses learning and concentration of the learners.

Table 4: Videoconferencing Tools in Actual Teaching and Delivery

Function	Description	Uses
Live Conference	Audio and Video Conference on the App and broadcast to Facebook and YouTube	Live Lecture
Screen sharing	Allows all participants to have the option to choose what to share with other meeting participants. Allows you to show your screen or the window of an application.	Collaboration and presentation
Virtual whiteboard	Allows you to draw, write or carry out explanations in an easier way.	Collaboration and presentation
Chat	Participants have the option to interact both directly and privately. Users can interact by sharing files and views.	Collaboration
Breakaway sessions	Allows the lecturer to divide students into smaller discussion groups	collaboration
Screen Recording	Allows you to record the sessions so that the student has all the information at hand. If in case the students want to listen to the class again	Asynchronous teaching and content management
Leave	By pressing that option, the member can exit the live class	Attendance monitoring and class management
Reactions and Polling	Interaction of members, such as: raising your hand to give your opinion, then the host will respond to your request.	Collaboration, interactivity and assessment

The virtual whiteboard and the screen share function allowed the usage of PowerPoint and other presentation Software, and lecturer 11 said" I found the Videoconferencing application to be very effective and I plan to continue using it in the future, especially when embedded to the Learning Management System". Student no. 5 said that "the breakaway rooms allowed me to discuss concepts with a smaller team which made it easier for us to break down content with likeminded individuals".

4.5. Proctoring and Other Uses

60% faculty indicated that they used live videoconferencing links to proctor exams. This required the student to log into the exam session and share their screen and also leave their video on to allow the lecturer to monitor activities. The learners indicated that the videoconferencing apps allowed them to build communities of learning, but to also do joint projects and papers, and also for social interaction beyond the normal classroom reaction. The faculty used video conferencing to give both synchronous and asynchronous feedback. Lecturer 10 said "I would record the answers to discussion questions and send then to the learners". One lecturer who teaches tourism said "I would provide a virtual tour of a pack via videoconferencing to keep my class captivated"

4.6. Challenges of Videoconferencing

While all the participants agreed that Videoconferencing had come to the rescue during the lockdown, a number of challenges cropped up which made it difficult to achieve the learning outcomes.

4.6.1 Students

The students were originally ill prepared for videoconferencing. They found it difficult to concentrate and would get Videoconferencing "fatigue" just sitting and watching a screen. Some of the students had had no prior experience with E-learning and had just joined the University in January 2020. They found themselves in foreign territory having to maneuver a class in virtual space without formal training. Although they had used some of these functionalities for entertainment and social purposes, adapting to educational use posed a challenge.

4.6.2 Content

Although there exist varying ways of delivering content such as a live oral lecture, PowerPoint slides, screensharing and virtual whiteboard, some content required a more physical feel and smell as well as 3-D presentations. Lecturer no 9 said "I teach hospitality and apart from color, food smell and aroma are important elements and these are still difficult to illustrate or demonstrate virtually, even with simulation software. Student no 24 said "there were practical classes that would normally take place in an actual lab and were unable to do these at home as we could not set up the experiments"

4.6.3 Pedagogy

The students were particularly perturbed by faculty who were not able to teach well online. "the lecture just came with the notes, shared the screen and continued to read through, so we could just log in and disappear to wait for the recording", said student no 16. This indicated a lack of training on online pedagogy on the part of the lecturer, which affected collaboration and interactivity. Just like the students, there were faculty who were encountering online learning for the very first time and they were not exposed to managing the class or delivering content via a technology intervention.

4.6.4 Information Technology

This dimension elicited the most challenges as elucidated from this study. Perhaps due to emergency nature of the migration, most respondents felt that there was lack of consensus on the application to use, and different lecturers and students would turn to whatever was available and familiar to them.

Technical challenges included poor connectivity especially when student and faculty were logging in from remote areas or buildings with poor low bandwidth. This resulted in poor sound and intermittent and rainy graphics, coupled with the high cost of the bandwidth, the respondents indicated that more often than not, they would turn off their video and also limit the live conference to a shorter period of less than 30 minutes, thus affecting the duration of the lecture, the quality of learning and syllabus coverage.

Some of the video conferencing applications had low compatibility with devices. Some users only had access to desktops with no video capabilities, and buying a camera was the only option, which also came with issues of compatibility. Others had phones with very small screens that were not conducive for interacting with huge amounts of text, thus affecting legibility even where there was screen sharing and virtual whiteboards.

Security of the applications was also an issue as some learners would share the links or hackers could access classes thus compromising the security of the learning experiences.

78% of the respondents indicated that they observed lack of a proper integration framework and some faculty would send links via the Learning Management Systems or other messaging services such as WhatsApp and SMS. This led to discrepancies in the use of the applications such as when using the applications for proctoring or for breakaway sessions or in attendance monitoring.

4. CONCLUSIONS

The study established that many Universities in Kenya turned to Videoconferencing to cope with the impact of the COVID 19 emergency. The main tools used were ZOOM and the big Blue Button, and both faculty and students found the tools available to be sufficient to mirror a face to face to face classroom. The major benefit was the flexibility, interactivity and the collaboration afforded by these applications. However, there were challenges emanating from the Students, the Content, the Pedagogy and the Information Technology, with the IT presenting the biggest challenge due to the technical nature of videoconferencing. The lack of a framework on how to integrate the Videoconferencing tools with the blended teaching compounded the problem. Such a framework would outline what is required of the students in terms of training and the devices to acquire. There would be a description of how to handle varying content over videoconferencing. A guideline on how to train the faculty and which approaches to use for both synchronous and asynchronous pedagogy as well as how to structure a class to be delivered via videoconferencing, handle questions, discussions and breakaway sessions on the part of the lecturer would be helpful. Finally, the ICT matters, and especially the actual videoconferencing application to use, how to integrate it with the Learning Management System and the ERP as well as the question of actual devices and compatibility should be addressed in the framework.

This study was carried out with the effects of COVID 19 still in mind, and it would be good to carry out a study to establish whether such frameworks have or are being developed post COVID as it is apparent that Videoconferencing is an application that many Universities would like to continue using.

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The Development of Supplement Book of Mycorrhizal Spore Based on Science Literacy at The Campus Forest in State University of Medan

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Abstract: This study aims to determine the feasibility and effectiveness of the supplement book of mycorrhizal spore based on science literacy at the campus forest in State University of Medan that has been developed. The subjects of this research are material experts, learning experts, design experts, and students who take the Lower Level Organism Taxonomy course in the Department of Biology, State University of Medan. Research and development (R and D) with the Thiagarajan (4D) model, namely: (1) Define data taken from the results of student needs analysis and get a score of 69% Students to need mycorrhizal spore supplement books based on scientific literacy, (2) Design the outline of the supplement book produces four chapters that will be discussed, namely, introduction, the development of mycorrhizae in the tropics, methods of observing mycorrhizal and mycorrhizal fungi on mahogany trees in the Unimed campus forest, (3) Development of field research that has been carried out to obtain results. the results of three genera of mycorrhizal spores found under the tree *Swietenia mahogany* L, namely *Glomus* sp. with 28 types of spores, *Gigaspora* sp. with 4 types of spores, and *Acaulospora* sp. with 3 types of spores. After the observation results are obtained, it is developed into a supplement book that will be tested for feasibility. The results of the material expert assessment obtained a score of 81% in the very worthy category and 95% for the assessment of scientific literacy aspects in the very worthy category, and the results of the learning expert assessment obtained a score of 85.5% in the very worthy category and the results of the design expert assessment obtained a score of 86.6% in the very worthy category. After the book is declared worthy, the fourth stage is carried out. Dissemination (dissemination) is carried out by individual product trials obtaining a score of 87% in the very worthy category, the small group test obtaining a very worthy score of 89%, and the limited group test obtaining a score of 87% in the very worthy category. To prove whether the developed supplement book is effective for use in the Lower Level Organism Taxonomy course, the N-Gain test obtained a score of 63% in the category of quite effective.

Keywords: Development, Supplement Book, Mycorrhizae, Science Literacy, Medan State University

1. INTRODUCTION

Scientific literacy according to PISA is defined as "the capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions to understand and help make decisions about the natural world and the changes made to it through human activity". Based on this explanation, scientific literacy

can be defined as the ability to use scientific knowledge, identify questions, and draw conclusions based on evidence, to understand and make decisions regarding nature and changes made to nature through human activities [18].

Learning is the most important part of determining the achievement of mastery of scientific literacy, Permendiknas RI No. 41 (2007: 6) [12] explains that the learning process in each primary and secondary education unit must be interactive, inspiring, fun, challenging, and motivating students to participate actively. Scientific literacy assessment is to assess students' understanding of science content, scientific processes, and the context of science applications. Content in scientific literacy includes material contained in the curriculum and material that is cross-curriculum with an emphasis on understanding concepts and the ability to use them in life. The scientific process refers to the mental processes involved when students solve problems. While the context is the area of application of scientific concepts. By this view, the assessment of scientific literacy is not merely a measurement of the level of understanding of scientific knowledge but also an understanding of various aspects of the scientific process as well as the ability to apply knowledge and scientific processes in real situations faced by students. especially in lesson mycorrhizae [18]. Mycorrhizae is a mutualistic symbiosis between fungi and plant roots. Various environmental conditions in Indonesia, such as soil type, can allow the diversity of mycorrhizal types on a land [10].

Based on the results of initial observations of student needs in the Lower Level Organism Taxonomy course to 32 Unimed Biology student respondents, 46.9% of students only used 1 learning resource for Low-Level Organism Taxonomy, 56.3% of students stated that the book Taxonomy of Low-Level Organisms The low level used is incomplete and requires improvement, 65.2% of students stated that the Low-Level Organism Taxonomy supplement book is very important, 62.5% of students need to supplement book of mycorrhizal spores and 69% of students need supplement book of mycorrhizal spore based on science literacy. From the results of this analysis of the needs of the general public, it is necessary to develop a mycorrhizal spore supplement book based on scientific literacy at the campus forests in the State University of Medan.

The lack of books on mycorrhizal spores and research on the development of supplement books is evidenced by observations in the Unimed, UMA, USU libraries, and several bookstores in Medan City, this is obtained from observations month June 2021. By because that, a need conducted to develop a book on mycorrhizal spores at the campus forest in the State University of Medan so that the community and students know the benefits of mycorrhizae and can recognize the types of mycorrhizal spores found in the campus forest of the Medan State University.

2. METHOD

2.1 Location and Time of Research

This research was conducted at State University of Medan which is located on Jalan Williem Iskandar, Medan Tembung, Medan City from August 2021 to May 2022.

2.2 Subject and Object of Research

The subject of this research consisting of: 1) Biology education student whose taking low-level plant taxonomy course in State University of Medan; 2) Material expert lecturers, learning expert lecturers, design expert lecturers and Instrument expert lecturers.

2.3 Type and Design of Research

This research uses the 4-D Model development model by Thiagarajan, et al (1974) which consists of 4 stages, namely: define, design, development, and dissemination. The development of this supplement book was made based on direct observations made. The research procedures carried out in product

development research can be seen in the picture following :

2.3.1 Define Stage

This stage aims to determine and define the needs in the learning process and collect various information related to the product to be developed. The product developed is aimed at Biology students at Medan State University in the Low-Level Organism Taxonomy course. This stage begins with an analysis of student needs, RPS analysis, and field observations.

2.3.2 Design Stage

After completing the definition stage, the next stage is the design stage. This design stage aims to select a medium that can be used as a source of additional knowledge about mycorrhizal spores for students and instrument compilers. The media chosen as a source of additional knowledge for students is a supplementary book. After selecting the media, an initial draft of the supplement book was developed. The initial design was in the form of an outline of the developed supplement book.

According to the Ministry of National Education [4], quality teaching materials are teaching materials that have a content component whose material can be used to answer student problems in achieving goals. Based on the authority of the body that performs standardization, there are two kinds of books, namely textbooks and non-text books. Supplementary books are included in the type of non-text books because they are reference books. Non-text books have the following characteristics: 1) Books that can be used in educational institutions but are not mandatory reference books for students; 2) books that provide material to enrich learning textbooks; 3) non-text books are not published in series based on level class or level education; 4) Books nontext lesson containing material that is not related by directly with the part of one of the competency standards contained in the content standards; 5) the material or content of non-textual textbooks can be used by readers from all levels of education and grade levels, so that they can be used in general [15].

Based on the characteristics of the non-textbook, which in this case is the supplementary book above, a scientific literacy-based mycorrhizal spore supplement book was developed in the forest of the Medan State University campus with the book cover, book identity, preface, table of contents, introduction, development of mycorrhizae in the region. tropical, method of observing mycorrhizal fungi, mycorrhizae on mahogany trees in the forest campus Unimed, glossary, bibliography and biography author. For instrument used in the research, is a book validation scale questionnaire for language, material, and *design*. Then used multiple-choice questions as many as 30 questions in the product trial, to determine the effectiveness of the book and test its feasibility of the book with a questionnaire.

2.3.3 Development Stage

After the design stage is completed, the next stage is the development stage. This development stage aims to produce a revised scientific literacy-based supplement book based on suggestions from expert language, material, and *design*. Stage composing book scientific literacy-based mycorrhizal spore supplements obtained from observations in the Medan State University campus forest with the following research *design :*

a. Plot Determination Sampling

The research plot was made purposively based on the condition of the campus forest which was dominated by mahogany trees and with observation carried out on the condition of season rain. The observation plot size is 10 m x 10 m and repeat 6 times so the total is 6 plots. The direction of the plot is made the same. Soil samples with mycorrhizal spores were taken from a depth of 10 cm under the host *Swietenia macrophylla* from each plot, put in a plastic bag, and given a label, location, and time. taking.

b. Observation Spores Mycorrhizae

Subsequent observations were made at the Plant Morphology Laboratory, State

University of Medan. The soil was dissolved with water, and the roots were separated, then using the pour-filter method (Pacioni 1992) and continued with the centrifugation technique (Brundett *et al*, 1996) using a microscope with a magnification of 40x the identification of mycorrhizal spores could be carried out and documented.

c. Expert Validation

This expert validation serves to validate the scientific literacy-based mycorrhizal spore supplement book in the forest of the Medan State University campus before the trial is carried out and the validation results will be used to revise the initial product. Supplementary books that have been compiled will then be assessed by material *expert lecturers*, namely lecturers who teach the taxonomy of low-level organisms, learning *expert lecturers, and design expert lecturers* so that it can be seen whether the book is feasible or not. Each validator is an expert in their field with a minimum educational qualification of S2 and a minimum of 5 years of experience.

2.3.4 Dissemination Stage

After the development stage is complete, then the distribution stage is carried out, the purpose of this stage is to disseminate books and test their effectiveness of books. After expert validation was carried out, a limited field trial was conducted to determine the results of applying mycorrhizal spore supplement books based on scientific literacy in learning. The trial of this supplement book was carried out in 1 class of Biology undergraduate students at Medan State University who took the 2nd-semester low-level organism Taxonomy course. then the data is analyzed with *N-Gain*. Trial this uses question choice multiple as many as 30 questions following mycorrhizal spores. This matter is used to get *Pretest* data results and *Posttest* students. Test conducted as much twice, namely before treatment and after treatment. *Pretest* was given to students (O1). After that, they were given treatment in the form of independent reading of mycorrhizal spore supplement books based on scientific literacy in the forest campus in the State University of Medan to students (X) for 7 days. In the final stage, a *posttest was carried out* on students (O2) with the same test questions as the *pretest*.

2.4 Collection Instrument Data

The instruments used in this development research consist of 3 instruments, namely validation sheet instruments for *expert validators* to validate scientific literacy-based books, questionnaires, or questionnaires for student needs and on the topic of *mycorrhizal spores*, multiple-choice test questions for Biology Undergraduate Students, the State University of Medan as product testing. The validation sheet instrument is used to determine the feasibility of the supplement book developed by the *expert validator* which contains research results, input or suggestions for the developed supplement book. Book validation sheets by *expert validators* consist of 3 types that are sheet validation *expert* materials, learning, and design.

2.5 Data Analysis

The data analysis tehcniques used in this research are descriptive qualitative data and quantitative data analysis techniques that describe the results of the validity test and student responses.

2.5.1 Validity Analysis

All of these data were analyzed for knowing the exact category of books by each validator along with his response. Each validator is an expert in their field with Minimum educational qualification of S2 and 5 years of experience. Data obtained in this research can be calculated by the formula [17]. The formula used to calculate validation data based on the questionnaire is as follows:

$$\text{Percentage of validity} = \frac{Obtained\ score}{Maximal\ score}\ x\ 100\%$$

The value the percentage of the scale of feasibility or product validity carried out by material experts, learning expert and design expert is as follows.

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Tabel 1. Criteria for the percentage of validity

Interval (%)	Feasible Criteria
<21%	Very unworthy
21-40%	Not worthy
41 – 60%	Decent enough
61 -80%	Eligible
81 -100%	Very worthy

2.5.2 Effectiveness Analysis

The N-gain test was carried out to determine the effectiveness of the use of the supplement book developed in improving students' cognition of mycorrhizal spores. The category of student cognitive improvement can also be determined by calculating the pretest and posttest scores using the Normalized gain formula by Metzer (2002) as follows:

$$\langle g \rangle = \frac{postest\ score - pretest\ score}{maximum\ score - pretest\ score}$$

The calculation results will be interpreted into the classification of gain index <g> which can be seen in the table according to Hake [6] as follows.

Tabel 2. Kategori N-Gain

Interval	Categories
g > 0,70	High
0,30 < g ≤ 0,70	Medium
g ≤ 0,30	Low

The results of the percentage effectiveness of the N-gain value can be percentage using the same formula, according to Hooke (1998) the results of the calculation of the gain are interpreted into the classification of the percentage of effectiveness of the N-gain can be seen as follows.

Tabel 3. Category for the percentage of Effectiveness N-gain

Interval (%)	Categories
<40%	Ineffective
40 – 55%	Less effective
56 – 75%	Effective enough
>75%	Effective

3. RESULT

Framework The OECD's PISA (Program for International Student Assessment) work (2019) defines literacy scientific as the ability for involved related problems with science and with the idea of science as a reflective citizen. Therefore, people who have literacy of scientific ready for involved in communication scientific about science and technology that requires competence to explain phenomena by scientific, evaluate and design investigation scientifically, as well as interpret data and evidence by scientific. Information theoretical this clarify fact that the direction of idea literacy scientific is the effort to use science outside practice scientific [16].

Products that have been developed in the form of book supplement spore mycorrhizae based on scientific literacy in the campus forest in State University of Medan can use as ingredient study addition to courses Taxonomy Low-Level Organisms. This book developed based on from observation spore mycorrhizae in the area campus forest in State University of Medan and developed with composing following aspect scientific literacy, namely, as stem body knowledge (*a body of knowledge*), science as a method for think (*a way of thinking*), science as a method for investigating *(a way of investigating*), and interactions between science, technology, and society (*interaction between science, technology, and society*) that can use as book study addition for eye studying that. Book supplement spore mycorrhizae based on scientific literacy in the forest Medan State

University campus is supporter learning for subject Taxonomy Low-Level Organisms. From analysis needs to get that students need source study addition about spore mycorrhizae based on scientific literacy for giving information by scientific and apply scientific concepts and perspectives. Book supplement spore mycorrhizae based on scientific literacy in the campus forest in State University of Medan designed as attractive possible as ingredient relevant references for find something new thing for applied for the student.

3.1 Result of Define Stage

The determination of the basic problem was carried out as the background for the creation of research on the development of Book supplement spore mycorrhizae based on scientific literacy in the campus forest in State University of Medan. The basic problems found were: (1) The results of the 2018 Pisa found that Indonesia was still weak in understanding information (literacy). Literacy is one of the abilities that must be possessed by every party to understand information and reflective ideas related to scientific issues. (2) The lack of reference books on mycorrhizal spores and research on the development of scientific literacy-based mycorrhizal spores, is evidenced by observations in the Unimed, UMA, USU libraries and several bookstores in the city of Medan obtained from observations in June 2021.

After determining the basic problem, the analysis of student needs is then carried out. This analysis was carried out on 32 respondents, students of the Biology Department, State University of Medan, who had taken the Low-Level Organism Taxonomy course. From the results of the needs analysis, 46.9% of students only used 1 learning resource on Taxonomy of Low-Level Organisms, 56.3% of students stated that the book on Taxonomy of Low-Level Organisms was not complete and needed improvement, 65.2% of students stated that the supplement book Taxonomy of Low-Level Organisms is very important, 62.5% of students need Mycorrhizal supplement books and 69% of students need scientific literacy-based Mycorrhizal Spores to supplement books.

3.2 The Result of Design Stage

The initial step taken at the design stage is to design the initial product. At this stage, the book is designed according to the characteristics of the book to be developed. The book that will be developed is a supplement book, where the supplement book is part of a non-textbook. As for the characteristics of supplement books, namely: (1) The use of supplement books, can be used in schools or general educational institutions, and is not a mandatory reference book for students participating in learning activities; (2) Supplementary books provide material to enrich textbooks, or as information about science and technology in-depth and broadly, or guidebooks for readers; (3) In its publication, supplementary books are not published in series based on grade level or education level; (4) The material or content of the supplementary book can be used by readers from all levels of education and grade levels or across readers; (5) For its presentation, supplementary books are loose, creative, and innovative so that they are not bound by the provisions of the learning process and systematics that are determined based on the science of education and teaching.

After obtaining the characteristics of the supplementary book, a book outline design was drawn up consisting of (1) Book Cover; (2) Book Identity; (3) Preface; (4) Table of Contents; (5) List of Images; (6) List of Tables; (7) Introduction; (8) Mycorrhizal development in the tropics; (9) Mycorrhizal Fungi Observation Method; (10) Mycorrhizae on Mahogany (10) Mycorrhizae on Mahogany Trees in Unimed Campus Forest; (11) Glossary; (12) Bibliography; (13) Author's Biography.

3.3 Result of Development Stage

3.3.1 Result of Observation Spores Mycorrhizae

After conducting field research, 6 sampling plots with a size of 10 x 10 m were obtained which were taken by random sampling of the soil taken from under the *Swietenia mahogany* L tree. Random sampling was carried out because the land area in the Unimed campus forest was rocky and there was a lot of plastic waste in the area. in the ground.

Soil samples that have been taken were brought to the Laboratory of Plant Morphology, the State University of Medan for extraction and identification of the types of mycorrhizae obtained. There were 3 types of mycorrhizal spores found, namely Glomus sp. with 28 types of spores, Gigaspora sp. with 4 types of spores, and Acaulospora sp. with 3 types of spores. The results of this observations are displayed in the suplement book that has been developed.

3.3.2 Material Expert Validation

The feasibility of the supplement book being developed was obtained based on the assessment of the material expert validator. The developed book is tested for feasibility by material expert validators to improve the quality of the material. In the process of due diligence, the book is assessed by the validator by providing scores and suggestions on each sub-assessment indicator from the material aspect. The following percentage of assessments carried out by material experts can be seen in the table below

Tabel 4. Percentage Material Expert

Assessment Component	Average Percentage (%)	Criteria
Material Suitability	89	Very worthy
Accuracy and Strength Theory	71	Eligible
Systematics of Learning	75	Eligible
Supplementary Book Efficiency in Learning	95	Very worthy
Language	76	Eligible
Average	81	Very worthy

Tabel 5. Percentage of Material Experts Assessment of Scientific Literacy

Assessment Component	Average Percentage (%)	Criteria
Science as a torso knowledge (A body of knowledge)	100	Very worthy
Science as a way to investigate (Way of investigation)	81	Very worthy
Science as a way of thinking (Ways of thinking)	100	Very worthy
Science, technology interaction with the community (Interaction of science, technology, and society)	100	Very worthy
Average	95	Very worthy

3.3.3 Learning Expert Validation

The validation of learning experts he percentage of assessments carried out by learning experts, which can be seen in the table below.

Tabel 6. Percentage Learning Expert Assessment

Assessment Component	Average Percentage (%)	Criteria
Appropriateness Contents	85,7	Very worthy
Kelayakan Penyajian	84,7	Very worthy
Appropriateness Serving	85,8	Very worthy

The validation assessed by learning experts is from the feasibility of the content and the feasibility of the presentation. Obtained an average rating of 85.5% with very good criteria. Thus the supplement book of mycorrhizal spore based on science literacy at the campus forest in state university of Medan has met the eligibility requirements so that it can be used as reading material for students.

3.3.4 Design Expert Validation

The expert validation of the mycorrhizal spore supplement book design. The validation assessed by the design consisted of the appropriateness of the graphic (book size, book cover design, and book content design). The following is the percentage of assessments carried out by design experts, which can be seen in the table as follows.

Based on the results of validation by design experts, namely from the feasibility of graphics (book size, book cover design, and book content design) an average rating of 86.8% was obtained with very good criteria. Thus the Supplement Book of Mycorrhizal Spore Based on Science Literacy at The Campus Forest in State University of Medan has met the eligibility requirements so that it can be used as reading material for students.

Tabel 7. Percentage Design Expert Assessment

Assessment Component	Average Percentage (%)	Criteria
Supplementary book size	91.7	Very worthy
Supplementary book cover design	87.5	Very worthy
Supplement book content design	81.3	Very worthy
Average	86.8	Very worthy

3.4. Result of Dissiminate Stage

Based on the results of the N-Gain test carried out from the results of the pretest and post-test students in the control class obtained 0.053 (5.3%) for the N-Gain test in the Low category (Ineffective). Meanwhile, in the experimental class, 0.63 (63%) was obtained for the N-Gain test with the Medium category (Effective enough). The data on the results of the pretest and post-test with N-Gain can be seen in table 8 as follows.

Table 8. Score Average of Pretest and Postest assessments with N-Gain

Subject (X)	Pretest (O1)	Posttest (O2)	N-Gain
Control class	12,2	10,2	0,053 (Low) 5,3% (Ineffective)
Experiment class	7,84	21,8	0,63 (Medium) 63% (Effective enough)

4. DISCUSSION

The research presented in this book motivates students to develop their ideas, thoughts, and insights as well as creativity. The result of research developed into a book product is a good implementation in the field of educational development [1].

Today, with the rapid and sophisticated development of the age, teachers, lecturers and students are not enough to use only one handbook as a learning reference but are required to read and study various relevant reading sources to be taught and learned. Most students only use the Textbook of Low-Level Organism Taxonomy as a learning material to learn about mycorrhiza where the discussion of mycorrhiza is only discussed in one piece. A quality book should be a book that has a content component whose material can be used to answer students' problems in achieving goals [5].

The developed supplement book is also equipped with mycorrhizal spore observation methods, starting from soil sampling, several stages of spore extraction, and identification of mycorrhizal spores. The book is also equipped with pictures and photographs of research results. Of course, this can clarify the results of the research contained in the study, the function of the pictures presented in the supplementary book is to attract and motivate students to develop an interest in learning something new. The presentation of material in the book must meet several requirements, namely (1) the material must be relevant to the competencies achieved; (2) material appropriate to the topic; (3) the presentation of material must be logical, systematic, communicative, and interactive; (4) pay attention to the characteristics and conditions of students, and (5) use techniques and use interesting presentation methods [9]. A good book when book is written using easy-to-understand and good language, its presentation is equipped with pictures and descriptions and illustrated following the author's ideas [4].

The chapters contained in the product developed as follows: (1) Introduction: This section contains the introduction of mycorrhizae, general characteristics of mycorrhizae, a grouping of mycorrhizae, and factors that affect the growth of mycorrhizae. (2) Development of mycorrhiza in the tropics. This section contains an explanation of the benefits of mycorrhiza and plant growth, the role of mycorrhiza in critical land improvement, and mycorrhiza as a business opportunity narrated in the form of narratives and various examples of previous research. (3) Method of observation of mycorrhizal fungi. This section describes the steps of soil sampling, five working steps that can be selected for several stages of spore extraction, and a mycorrhizal spore identification guide, such as characteristics of Glomus, Gigaspora, Scutellospora, Acaulospora, Enterophospora, and Sclerocycstis. (4) Mikoriza on a mahogany tree in the forest of Unimed campus. In this section, the observation data are presented, which are characterized according to their type. In this section, the results of field research are presented in 3 types, namely: (1) Glomus sp., (2) Gigaspora sp., And (3) Acaulospora sp. which contains photo documentation of the researcher's observations as well as an explanation of, characteristics, benefits, spore shape, color, size, number of spore walls and characteristics. Revealed that interesting, contextual learning materials, that can be presented through problem-solving found in the environment will provide a good learning experience [13].

Supplement Book of Mycorrhizal Spore Based on Science Literacy at The Campus Forest in State University of Medan was developed by following the steps of Thiagarajan model consisting of four stages (four-D Models) namely Define stage, Design stage, Development stage and Disseminate and Test effectiveness. Based on the results of validation by material experts, validation of learning experts, and validation by Design experts accompanied by a field test with an individual group test of 6 students, a small group test of 10 students and a limited group test of 21 students found that this book is very suitable to be used as a material for use as additional

material in the subject of Taxonomy of Lower Level Organisms. These eligibility results are assessed from assessment and revision by the validator. Books can be declared valid and fit for use after going through the validation and testing stages [14].

The products that have been declared good by the validator still need to be improved according to the recommendations of experts [8]. Reviews by experts and students' responses to the books developed are done following the point of view of their respective expertise, as well as referring to the regulations of the Minister. Pendidikan Nasional RI Number 2 of 2008 explains that books that are eligible to be used as teaching materials must include quality criteria (standards) including, (1) Eligibility of content/material, (2) Eligibility of presentation, (3) Eligibility of language, (4) Eligibility of graphics. These criteria have been listed in the components of the validation sheet that is assessed by the validators, a good teaching material if it meets the aspects of validity those are valid and practical. The validity of the developed book can be determined by the validity test, valid criteria can be determined if the value obtained from the experts is in the percentage interval of $81\% \leq X \leq 100\%$ and $61\% \leq X \leq 80\%$ with excellent and good criteria [18].

The results of validation by material expert of supplement book of mycorrhizal spore based on science literacy at the campus forest in state university of Medan to the assessment of the material area and material depth in general obtained a percentage of 81% with the very good or worthy category. The suitability of the content of a book indicates that the content of the book is developed following the learning objectives. The results of validation by material experts related to supplement book of mycorrhizal spore based on science literacy developed related to science assessment as 100%, Science as a way to investigate 81%, science as a way to think 100%and science interaction, technology with society get 100% assessment with excellent criteria.

The challenges of the Era of Industrial Revolution 4.0 require us to prepare qualified students with qualifications and competencies with science literacy skills. Science literacy-based supplement books are very helpful in accelerating this process. Science literacy skills are used to understand science and its applications. Students with science literacy skills will be able to apply their knowledge to solve problems in everyday life situations that are the ultimate goal of education [2].

Validation by science literacy-based mycorrhizal spore supplement learningb experts obtained an average percentage of 85.5% with the category of very good or very worthy. The feasibility of the book is also done to assess the accuracy of the material, the feasibility of presentation such as book cover title, table of contents and presentation of images validation of learning also assesses the language of course in the language supplement book used must be following good and correct Indonesian language methods. Textbooks should be useful for students and teachers. The grammar used is designed according to the level of development of students. If students find it difficult to understand a term, a glossary is provided as a guide to understanding difficult terms [16].

Validation by a book design expert of mycorrhizal spore supplement book obtained a percentage of 86.8% with the category of very good or very worthy. This book is validated by a designer to know the book format, book layout, and good and correct book typography including in the evaluation of book cover images, book size, book color, font type, font order, appropriate illustrations, and consistent layout. In addition, the pictures in the supplement book can affect a person's interest in reading because most see the pictures first before reading. Meanwhile, the type and font of writing affect the readability of the book. If a book has good readability, then it can affect the reader's interest, facilitate the reader and help the reader's memory and help the speed of reader efficiency [7].

Supplement book of mycorrhizal spore based on science literacy at the campus forest in state university of Medan that has been suitable for use was followed by a Gain test to determine the effectiveness of using supplement book developed in cognitive improvement in students taking Low-Level Organism Taxonomy course.

The effectiveness test was performed by giving pretest and posttest to 25 students in the control class who did not get the supplement book and 25 students in the experimental class who got the supplement book. Both pretest and posttest use multiple choice questions as many as 30 questions that have been validated by the validator. Based on the results of the N-Gain test, students in the control class obtained 0.053 (5.3%) with a category of Low N-gain (Ineffective). While the experimental class was obtained 0.63 (63%) with the category of N-gain Medium (Fairly Effective).

A normalized gain test (N-Gain) was performed to determine the improvement of students' cognitive learning outcomes after being given treatment derived from pretest and posttest assessment. N-Gain is a comparison of the actual gain score with the maximum gain score, the effectiveness of the use of supplement books developed in improving good cognitive if the N-Gain score is greater than 0.4 [6].

5. CONCLUSION

1. Assessment results expert Theory to book supplement spore mycorrhizae based on scientific literacy in the forest Medan State University campus, obtained score percent by 81% with very decent category and 95% for evaluation aspect scientific literacy with very category worth.
2. Assessment results expert learning to book supplement spore mycorrhizae based on scientific literacy in the forest Medan State University campus, obtained score percent of 85.5% with every category worth.
3. Assessment results expert design book supplement spore mycorrhizae based on scientific literacy in the forest Medan State University campus, obtained score percent by 86.6% with every category worth.
4. The results of the N-Gain effectiveness test of mycorrhizal spore supplement books based on scientific literacy in the Medan State University campus forest were carried out from the results of the pretest and posttest of students obtained 63% with a moderately effective category.

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Implementation and Evaluation of Advantage Actor-Critic Algorithm on a Desktop Computer with a Multi-Core CPU

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Abstract: In this paper, the implementation and evaluation of the Advantage Actor-Critic (A2C) algorithm, one of the most important Deep Reinforcement Learning schemes, is performed. The objective is to determine the behavior of the algorithm on a desktop computer with a multi-core CPU, establishing its behavior, performance, and resource consumption for embedded applications. This algorithm makes use of multiple agents on parallel instances of the environment so that each agent adds knowledge to the system, which is weighted by a value of Advantage that evaluates its interaction in the environment. This assessment is performed on OpenAI's CartPole-v0 playground, so the results are comparable and easily reproducible. The results show a high performance of the algorithm for different instances with fixed-length segments of experience, which allows us to think of successful use on more resource-constrained hardware platforms.

Keywords: A2C; agent; cartpole-v0; environment; optimal policy; reinforcement learning; value function

1. INTRODUCTION

Reinforcement learning (RL) is a Machine learning strategy inspired by the behaviorist psychology of John B. Watson, under which the actions of agents are determined by their interaction with the environment, leaving aside consciousness and introspection [1]. Under this idea, the agent makes decisions to maximize some reward or reward function throughout their interaction [2, 3]. Given its simplicity of the concept, and its high performance in a multitude of tasks, the strategy has been successfully used in many disciplines such as control, game theory, search problems, optimization, and even robotics [4–6]. Although in much of the research related to RL the problem tends to focus on the search for optimal solutions [7], its usefulness as a learning strategy and in tasks related to generalization and approximation has been widely documented and appreciated [8, 9]. In addition, great similarities have been observed with the Markov Decision Process (MDP) given how the agent is related to the environment, which is an important tool of Machine learning, but with the possibility of being used in highly complex problems since the RL does not require explicitly defining the MDP relationships [10]. Another important feature of RL is that, unlike supervised learning, RL does not require Input/Output training pairs, but takes the information for the model from exploration and interaction in the environment [11].

RL models consist of a set of states of the environment, a set of actions, a set of rules for switching between states, rules for evaluating the reward associated with state change, and rules for interpreting the agent's observations. In this sense, a system built to be trained as an RL model can also be described by the nomenclature of a hybrid system [12] or as a reactive system described by Linear Temporal Logic (LTL) [13, 14]. It is precisely this type of structure that allows the use of deep neural networks as the agent's learning architecture to structure what has been called Deep Reinforcement Learning (DRL) [15]. In this framework, the agent's decisions tune a neural model that defines the behavioral policy, which is reflected in the agent's action on the environment (Fig. 1).

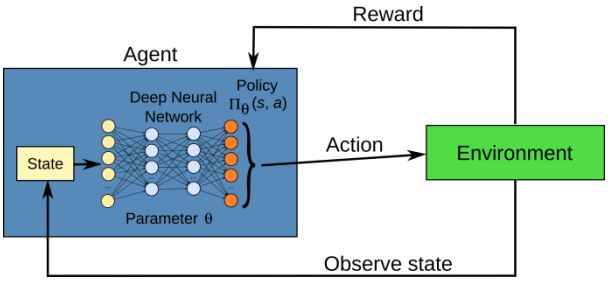

Figure 1. Deep Reinforcement Learning scheme.

One of the most recent DRL-type algorithms, and among the most influential, is the Asynchronous Advantage Actor-Critic (A3C) [16]. The algorithm is called asynchronous because unlike other DRL algorithms with a single agent in a single environment, A3C uses multiple agents each in its environment with its parameters [17, 18]. Each agent interacts in its environment asynchronously with the other agents, learning from its interaction. As each agent gains knowledge, this knowledge contributes to the knowledge of the overall algorithm. This scheme is similar to the experience gained individually by each person but contributes to the joint development of projects. An alternative implementation of the algorithm allows each actor to finish its learning segment before performing an update, which achieves synchronization of the agents, thus forming a better-performing algorithm called Advantage Actor-Critic (A2C) [19, 20]. The Actor-Critic role names are assigned since the algorithm uses a Value function $V(s)$ (Critic) to update the Optimal Policy function $\Pi(s)$ (Actor). The Advantage designation is given since the agent receives a value of Advantage instead of a reward, which improves the learning process.

In this paper, the implementation and evaluation of the A2C algorithm are performed. To generate knowledge, multiple agents are run synchronously in parallel, each in its

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environment (all identical instances), letting each one finish its interaction process before starting a new epoch of the system adjustment [21]. At any instant of the tuning process, each agent experiences a different state, which allows the algorithm to decorrelate the data of each agent. The algorithm is run on a desktop computer with a multi-core CPU to determine its actual performance without the use of GPUs. The algorithm is evaluated with OpenAI's CartPole-v0 playground, in which the agent is a cart controlled by two possible actions that cause left and right movements [22].

2. METHOD

In our implementation of the Advantage Actor-Critic algorithm, we consider the traditional RL approach in which an agent interacts with an environment $\boldsymbol{E}$ over time, observed in a finite number of discrete steps (Fig. 1). At each of these time steps, the agent observes a state s_t in the environment, to which it responds with action a_t selected from some set of possible actions $\boldsymbol{A}$, and in coherence with a behavioral policy π. The action value $Q^{\pi}(s,a)$ (Eq. 1) corresponds to the expected return for the selected action a in state s and according to policy π.

$$Q^{\Pi}(s,a) = \boldsymbol{E}[R_t|s_t = s, a] \qquad (1)$$

Under this context, Π (set containing all π) is a mapping from states to actions. Upon executing this action, the agent receives a reward r_t, and the state of the system evolves to a new observable state $s_{(t+1)}$. This process continues for each time step until a final state is reached, evolving in such a way that the agent at each step maximizes the reward received. In the end, the cumulative return is given by Eq. 2 for a discount factor $\gamma \in (0,1]$.

$$R_t = \sum_{k=0}^{\infty} \gamma^k r_{t+k} \qquad (2)$$

In value-based RL strategies, the function value is approximated utilizing some suitable model, e.g., a neural network. In this case, the approximator takes the following form (Eq. 3):

$$Q^{\Pi}(s,a) \approx Q(s,a;\theta) \qquad (3)$$

This corresponds to an action-value function approximator with θ parameters, where the value of such parameters is iteratively updated by various RL algorithms, as in the case of Q-learning, again maximizing the reward it receives at each transition. As an alternative to value-based methods there are policy-based methods, in which the policy is parameterized in the form (Eq. 4):

$$\pi(a|s;\theta) \qquad (4)$$

Here again, the θ parameters are adjusted, but in this case through an ascending gradient over the environment considering the cumulative return.

The variance of the estimate can be reduced by subtracting the learned function of the state $b_t(s_t)$ from the cumulative return value R_t. This parameter $R_t - b_t$ becomes an estimator of the advantage of the action a_t in state s_t. It should be remembered that R_t is an estimate of Q^{π}, and that b_t is an estimate of $V^{\pi}(s_t)$. This structure is known as actor-critic architecture (policy π is the actor and b_t is the critic).

Asynchronous Advantage Actor-Critic (A3C) is a robust, simple, and high-performance Deep RL algorithm compared to other Deep RL schemes, particularly in tasks with complex state and action spaces (Fig. 2). It is called asynchronous because the algorithm uses multiple agents, each in its environment, which are trained in parallel, contributing their experience (knowledge gained) individually regardless of the progress of the other agents (asynchronous update). The advantage is the metric used to evaluate the actions of each agent, and the Actor-Critic model is used for decision making (actor) and the evaluation of how good the action was (critic).

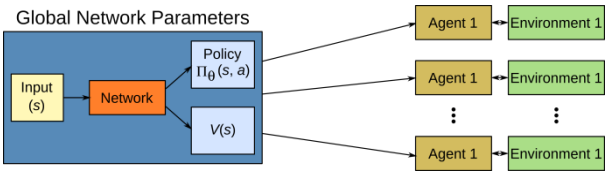

Figure 2. Asynchronous Advantage Actor-Critic (A3C).

Advantage Actor-Critic (A2C) is a variant of A3C, with similar performance, in which it waits for each agent to finish its experience segment in the environment before performing the update, which makes it simpler than A3C, and suitable for running on CPU-only machines (no GPU). A coordinator is included in the overall scheme, which activates each agent in sequence, reducing the computational cost of the algorithm (Fig. 3).

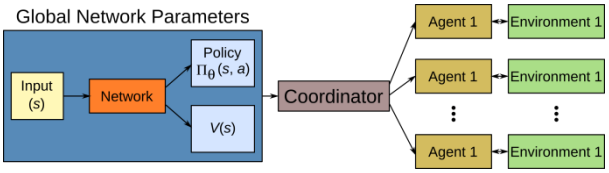

Figure 3. Synchronous Advantage Actor-Critic (A2C).

Our implementation of the A2C algorithm was developed in Google Colab because of its accessibility without prior configuration, interactivity, the possibility of using GPU, and ease of sharing content. A Google account is sufficient to access this tool. A recommended first step is to connect the Google Drive service to the Google Colab virtual computer, which can be done as illustrated in Fig. 4.

```
from google.colab import drive
drive.mount('/content/drive/')
```

Figure 4. Connecting Google Drive to Google Colab.

After account verification, the Drive storage service is connected to the virtual machine. The next step is to import the necessary libraries. In addition to numerical manipulation and visualization, the Torch tools, an open-source machine learning library used to implement the learning model, must be imported (Fig. 5). Also in this part, it is convenient to configure CUDA in case you have and want to use this capability in the hardware.

```
import sys
import math
import random
import gym
import numpy as np

import torch
import torch.nn as nn
import torch.optim as optim
import torch.nn.functional as F
from torch.distributions import Categorical
from IPython.display import clear_output
import matplotlib.pyplot as plt
%matplotlib inline

use_cuda = torch.cuda.is_available()
device   = torch.device("cuda" if use_cuda else "cpu")
```

Figure 5. Import of Torch and other libraries.

The environment used is CartPole-v0, OpenAI's gym was also imported with the other libraries. It is a simple playground

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widely used to train and test RL algorithms, which in turn makes it a platform that guarantees performance comparison between different strategies and implementations. In this environment, the agent is a cart balancing a vertical bar (inverted pendulum), which is controlled by two possible actions that force it to move to the right or the left. A reward of +1 is assigned to each step that manages to keep the bar in its vertical position since the control objective is to prevent it from falling to either end. The goal of our model is to maximize the total reward throughout the process, which would guarantee that the bar does not fall, and therefore that the problem has been solved. Before creating the environment, it is necessary to install some libraries to the virtual machine to perform the simulations (Fig. 6).

```
!apt-get install python-opengl -y
!apt install xvfb -y
!pip install pyvirtualdisplay
!pip install piglet
```

Figure 6. Installation requirements for the environment.

After fulfilling these requirements, the next step is to create the environments. In our case, we are creating 20 environments (Fig. 7).

```
from pyvirtualdisplay import Display
Display().start()

num_envs = 20
env_name = "CartPole-v0"

def make_env():
    def _thunk():
        env = gym.make(env_name)
        return env

    return _thunk

envs = [make_env() for i in range(num_envs)]
envs = SubprocVecEnv(envs)

env = gym.make(env_name)
```

Figure 7. Creation of environments.

The other important element of this Deep RL model is the deep neural network. For it, a method was created capable of constructing the network from the needs, stacking layers with the Sequential model of the required size. The activation function used in the hidden layers is ReLU and in the output layer Softmax (Fig. 8).

```
class ActorCritic(nn.Module):
    def __init__(self, num_inputs, num_outputs, hidden_size, std=0.0):
        super(ActorCritic, self).__init__()

        self.critic = nn.Sequential(
            nn.Linear(num_inputs, hidden_size),
            nn.ReLU(),
            nn.Linear(hidden_size, 1)
        )

        self.actor = nn.Sequential(
            nn.Linear(num_inputs, hidden_size),
            nn.ReLU(),
            nn.Linear(hidden_size, num_outputs),
            nn.Softmax(dim=1),
        )

    def forward(self, x):
        value = self.critic(x)
        probs = self.actor(x)
        dist  = Categorical(probs)
        return dist, value
```

Figure 8. Creation of the deep neural network.

The cumulative return can be calculated at each step with a simple function that receives the reward for a given value of γ, which in this case has been set to 0.99 (Fig. 9). The values are accumulated by keeping track of previous results.

```
def compute_returns(next_value, rewards, masks, gamma=0.99):
    R = next_value
    returns = []
    for step in reversed(range(len(rewards))):
        R = rewards[step] + gamma * R * masks[step]
        returns.insert(0, R)
    return returns
```

Figure 9. Function for cumulative return calculation.

The next step is to configure the model characteristics. The number of inputs and outputs, hidden layers of the deep network and their learning rate, the type of model, i.e. Actor-Critic, and the optimizer to be used are set. In our case, we have used the Adan variant of the gradient descendent (Fig. 10).

```
def compute_returns(next_value, rewards, masks, gamma=0.99):
    R = next_value
    returns = []
    for step in reversed(range(len(rewards))):
        R = rewards[step] + gamma * R * masks[step]
        returns.insert(0, R)
    return returns
```

Figure 10. Adjustment of model features.

Finally, the training of the model is performed. This is done within a cycle that calls the functions and evaluates each parameter at each step (Fig. 11).

```
state = envs.reset()

while frame_idx < max_frames:

    log_probs = []
    values    = []
    rewards   = []
    masks     = []
    entropy = 0

    for _ in range(num_steps):
        state = torch.FloatTensor(state).to(device)
        dist, value = model(state)

        action = dist.sample()
        next_state, reward, done, _ = envs.step(action.cpu().numpy
                                                ())

        log_prob = dist.log_prob(action)
        entropy += dist.entropy().mean()

        log_probs.append(log_prob)
        values.append(value)
        rewards.append(torch.FloatTensor(reward).unsqueeze(1).to(
                                                device))
        masks.append(torch.FloatTensor(1 - done).unsqueeze(1).to(
                                                device))

        state = next_state
        frame_idx += 1

        if frame_idx
            test_rewards.append(np.mean([test_env() for _ in range(
                                                10)]))
            plot(frame_idx, test_rewards)

    next_state = torch.FloatTensor(next_state).to(device)
    _, next_value = model(next_state)
    returns = compute_returns(next_value, rewards, masks)

    log_probs = torch.cat(log_probs)
    returns   = torch.cat(returns).detach()
    values    = torch.cat(values)

    advantage = returns - values

    actor_loss  = -(log_probs * advantage.detach()).mean()
    critic_loss = advantage.pow(2).mean()

    loss = actor_loss + 0.5 * critic_loss - 0.001 * entropy

    optimizer.zero_grad()
    loss.backward()
    optimizer.step()
```

Figure 11. Model training cycle.

3. RESULT AND DISCUSSION

As indicated above, we used the CartPole-v0 by OpenAI playground as an evaluation platform for the algorithm. Many experiments were performed on this platform for different configurations of the algorithm, which guarantees the stability and scalability of the results. In all cases, the reward and its accumulated value throughout the training were recorded and plotted.

The code was developed on a machine with a single Intel Core i7-7700HQ eight-core 3.8 GHz CPU with 64-bit architecture and 24 GB of RAM. This machine runs a Debian Bullseye Linux OS with kernel 5.18.0. Within Google Colab we used Torch 1.11.0+cu113, gym 0.17.3, piglet 1.0.0, pyvirtualdisplay 3.0, python-opengl 3.1.0+dsfg-1, matplotlib 3.2.2, and numpy 1.21.6, configuring a GPU in the Runtime.

Fig. 12 shows four of our experiments with 16 environments, 256 hidden layers in the deep neural network, and a learning rate of 3e-4. The average run time of each experiment was 2 minutes and 16 seconds. The cumulative reward in the experiment in Fig. 12(a) was 186, in the experiment in Fig. 12(b) it was 200, in the experiment in Fig. 12(c) it was 112, and in the experiment in Fig. 12(d) it was 134.

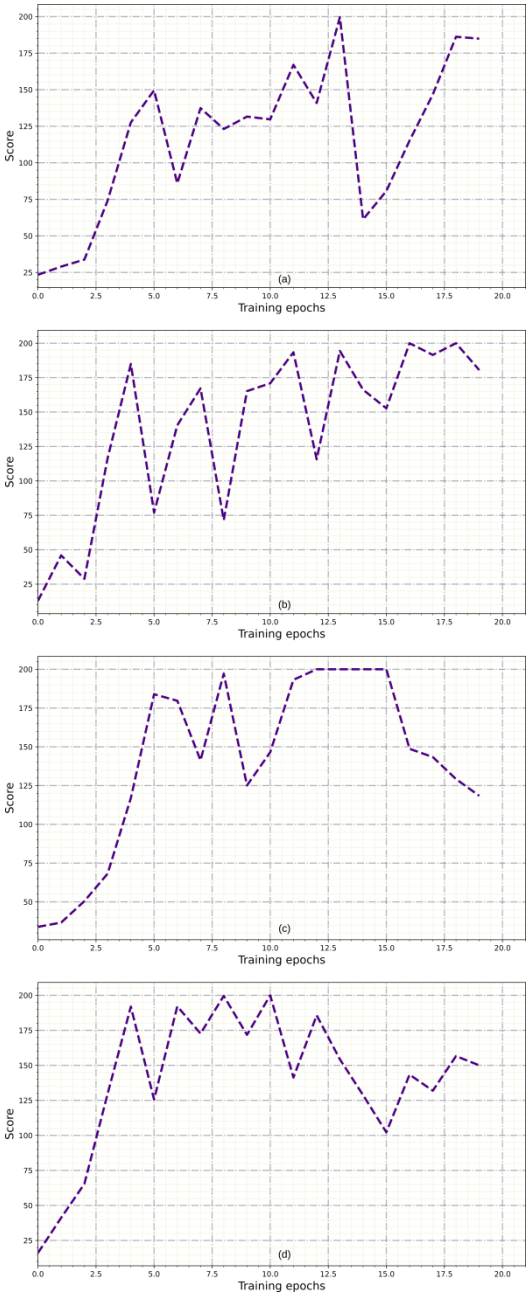

Figure 12. Comparison of learning in four experiments with 16 environments, 256 hidden layers in the deep neural network, and 20 epochs: (a) case with 186 cumulative rewards, (b) case with 200 cumulative rewards, (c) case with 112 cumulative rewards, and (d) case with 134 cumulative rewards.

The first two experiments in Fig. 12 perform better in reaching a higher cumulative reward and maintaining a high reward value throughout the training than the last two cases. In addition, the latter two cases tend to deteriorate their behavior after epoch 15. To evaluate the effect of the parameters on the algorithm, similar training was performed by varying only one of these parameters, first the number of training epochs, then the number of environments, and finally the depth of the neural network. In the first set of experiments, the number of training epochs was doubled, and the result is shown in Fig. 13. The cumulative reward in the experiment in Fig. 13(a) was 200, in the experiment in Fig. 13(b) it was 171, in the experiment in Fig. 13(c) it was 200, and in the experiment in Fig. 13(d) it was 200. The average time per experiment was four minutes and 34 seconds.

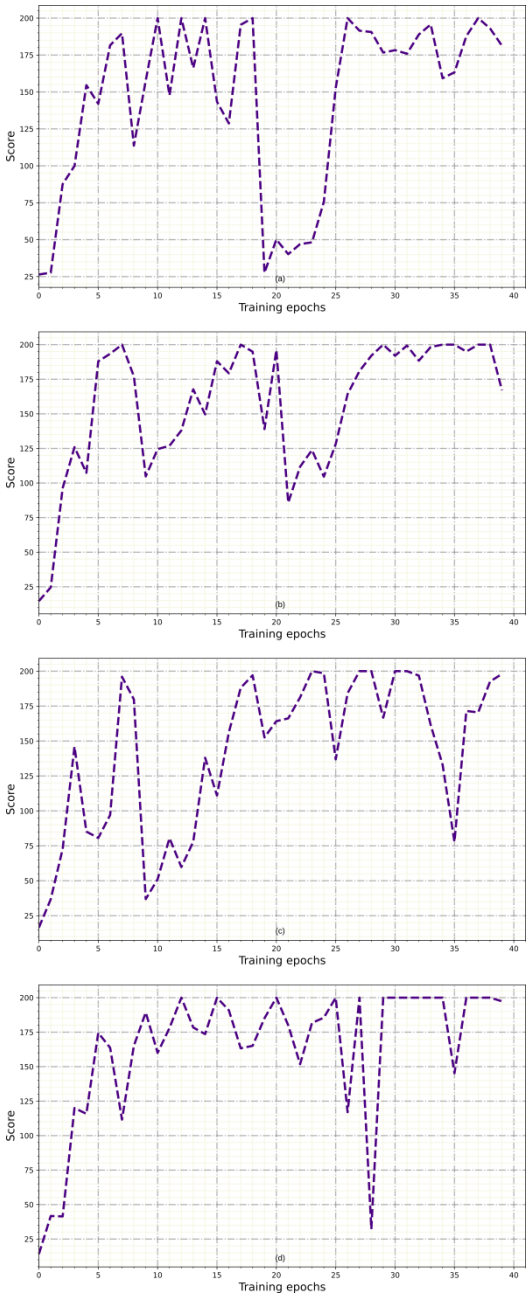

Figure 13. Comparison of learning in four experiments with 16 environments, 256 hidden layers in the deep neural network, and 40 epochs: (a) case with 200 cumulative rewards, (b) case with 171 cumulative rewards, (c) case with 200 cumulative rewards, and (d) case with 200 cumulative rewards.

By doubling the training time, a better behavior of the models is observed. In many of the experiments it is observed that at some point the reward decreases, but somehow this contributes to increasing the stability of the process, since the reward value increases again, and remains high for the rest of the training.

The third set of experiments again reduced the training time to 20 epochs, and doubled the number of environments to a total of 32, keeping all other parameters constant. The results are shown in Fig. 14, in the experiment in Fig. 14(a) the cumulative reward was 110, in the experiment in Fig. 14(b) the cumulative reward was 200, in the experiment in Fig. 14(c) the cumulative reward was 200, and in the experiment in Fig. 14(d) the cumulative reward was 200. The average time in these experiments was two minutes and 40 seconds.

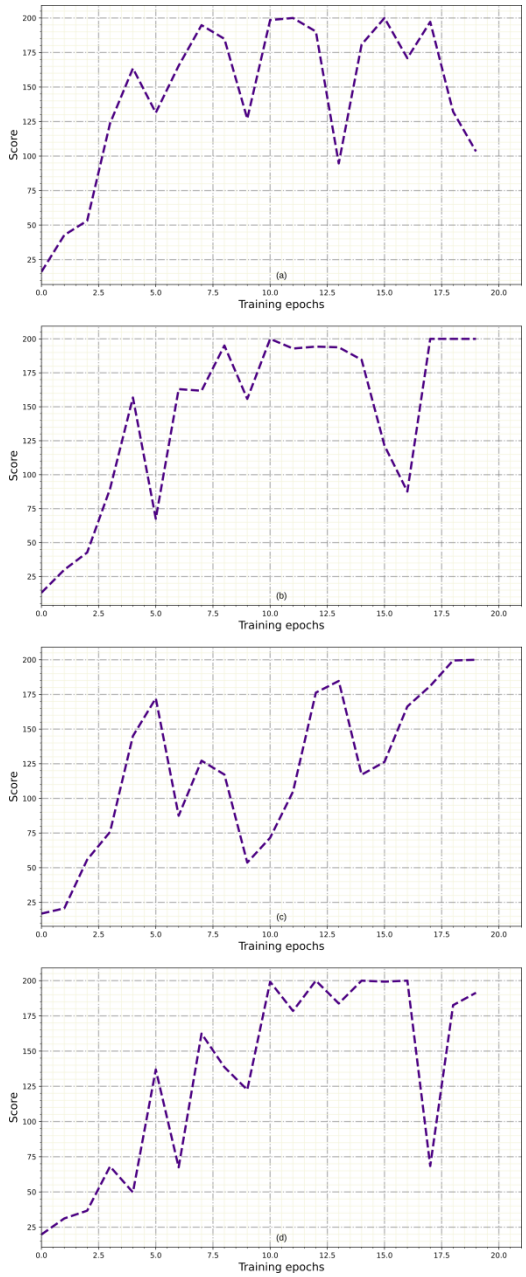

Figure 14. Comparison of learning in four experiments with 32 environments, 256 hidden layers in the deep neural network, and 20 epochs: (a) case with 110 cumulative rewards, (b) case with 200 cumulative rewards, (c) case with 200 cumulative rewards, and (d) case with 200 cumulative rewards.

In these experiments, it is observed that the increase in the number of environments has an impact on the stabilization of the reward, since unlike the experiments in Fig. 12, the reward value remains more stable, and the final cumulative reward values also increase. The time cost for half of the environments is only 17.6% additional.

The last set of experiments evaluates the impact of neural network depth, returning to the 16 environment configuration, and increasing the number of hidden layers to 512. All other model parameters are kept the same. Examples of these experiments are shown in Fig. 15, in the experiment in Fig. 15(a) the cumulative reward was 98, in the experiment in Fig. 15(b) the cumulative reward was 200, in the experiment in Fig. 15(c) the cumulative reward was 200, and in the experiment in Fig. 14(d) the cumulative reward was 86 The average time in these experiments was two minutes and six seconds.

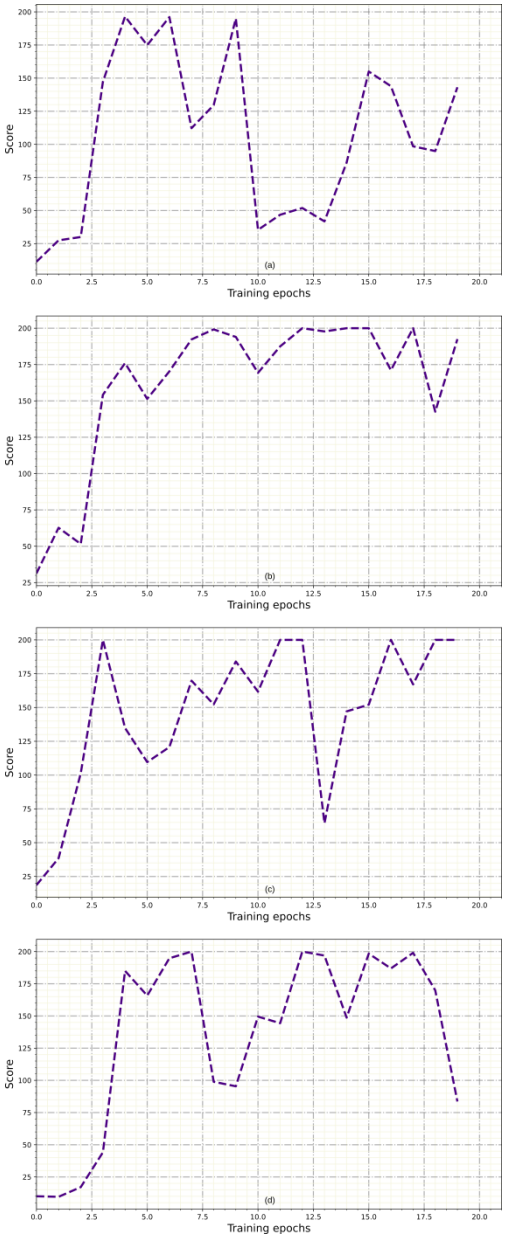

Figure 15. Comparison of learning in four experiments with 16 environments, 512 hidden layers in the deep neural network, and 20 epochs: (a) case with 98 cumulative rewards, (b) case with 200

cumulative rewards, (c) case with 200 cumulative rewards, and (d) case with 86 cumulative rewards.

The increase in the complexity of the deep neural network has an interesting effect on the performance of the agent, as it increases its performance. This is observed in a small reduction in the total training time (7.3% reduction), which indicates that it is easier for the agent to learn in its interaction with the environment. Even so, the overall performance in terms of cumulative reward is similar to that observed in the earlier experiments with a shallower neural network.

4. CONCLUSION

This paper implements and evaluates the Advantage Actor-Critic (A2C) algorithm to determine its actual performance for different combinations of parameters running on a single multi-core CPU system without GPU. The algorithm was implemented in Python on the Google Colab platform, making use of its GPU service, and with PyTorch support. The sensitive parameters of the algorithm were number of agents/environments, neural network depth, and training duration. From the results of multiple experiments it was concluded that the variables with the greatest impact on performance are those that improve the level of interaction of the agent with its environment. In particular, longer training times have a significant impact on the stability and final value of the accumulated reward. The depth in the neural network also facilitates the learning of the environment, and the number of environments helps to stabilize the reward behavior along the process. Therefore, it can be stated that a higher level of interaction of the agent in the environment significantly increases its level of learning. In addition, since the algorithm is faster and more robust than classical RL algorithms, it is more suitable than other similar techniques for use in embedded systems, even more so if one considers that it can be used in both discrete and continuous space problems.

5. DECLARATIONS

Authors declare that they have no conflict of interest in this research paper.

6. ACKNOWLEDGMETS

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An Overview of Domain Details Tool

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Abstract: The Get Domain Details uses the DIG command to provide hostname or Domain Name Server details for particular location or edge server IP. An information collection and preparing device is accounted for DIG. The tool permits the management of a product cycle to have the option to extract information from a repository to groom the information and to create reports. The reports are pointed toward helping the management in the control of the product advancement process. DIG allows the executives to construct a total portrayal of the efficiency information to more readily coax out the boundaries and figure out the reasons for variety in the information. Also, the information acquired and prepped by DIG might be utilized to align and apply process control models.

Keywords: software testing, report, GANTT plan, deployment, dnslookup, plugins

1. INTRODUCTION

This paper presents the utilization of the tool DIG. The tool was developed to satisfy the requirement for information collection in a software process environment; especially for the approval of a model of the interleaved occasions of coding and testing incremental programming improvement. DIG is a robust command-line tool developed by BIND for querying DNS nameservers. It can identify IP address records, record the query route as it obtains answers from an authoritative nameserver and diagnose other DNS problems. Dig is more advanced than dnslookup and host commands. It is noticed that such a tool could uphold numerous information-driven drives including management works, process improvement, and control, preparing prescient reproduction models or measurements development for different purposes. Generally speaking, the alignment of a product cycle simulation model demands tedious manual extraction, preparation, and translation of verifiable interaction execution information from different sources. In these assignments, the issues may not loan themselves to natural arrangements; for this situation, it could be useful for the model creators to give devices to plan specific process elements to demonstrate ideas, and for extricating model boundaries from defective arrangements of information. While DIG worked to align a particular model, its more extensive utility lies in the way that it gives a system for the development and translation of time-series information from process curios. This tool you can verify if the routing between a user and edge server is optimal and if the domain has any Canonical Name records, namely whether your domain has other domains acting as its aliases and if there are any issues with the resolution of domain names.

2. GOALS

When interpreting the data removed from the artifacts of a specific cycle, looking at the information inside the setting of the interaction that produced it is vital. For instance, think about Figure 1. In the figure, by overlooking the GANTT plan one could reason that the efficiency of code creation, drops off moderately immediately followed by a significant stretch of low efficiency. Given the appropriate setting, notwithstanding, one can without much of a stretch see that the store information for Release 0.2 addresses the execution of two undertakings: Coding and then the slow Rework task. This is the essential objective of the DIG instrument: to give the semi-computerized component for incorporating crude process information with the setting given in the task plan. Upon this objective we place three positive properties: i) The center application ought to uncover, in an object structure, the gathered information by means of a public connection point expected for those applications which would consume the information; ii) The revealing capability of the device ought to help a secluded 'estimation' which is free of a specific perspective on the information/computations, and iii) The tool ought to have the option to work with the momentum variants of the cycle relics and give changed information and computations consistently upon artifact update.

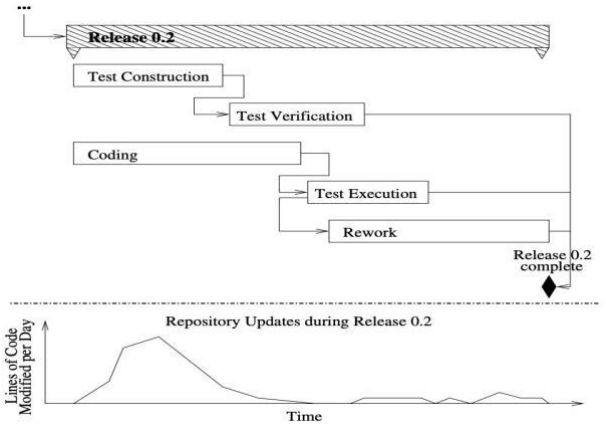

Figure. 1 Interpretive context provided by project schedule

3. RELATED WORK

The literature on automated data collection and analysis lays out the primary motivating factors driving the construction of automated tools. They may be briefly summarized as i) Data collection is expensive, and there is no instant gratification for doing it; ii) Data collection is unreliable, owing in no small part to the fact that developers find it irritating and secondary in priority; and iii) Errors in the recording of the data seem to occur more frequently in the critical parts of the development process;

precisely when the data are most needed. The literature espouses a particular modular architectural structure consisting of the following components : i) Data collection/Data grooming - those parts of the system which act as an interface between the data storage/processing central component and the raw data sources (e.g. SCM tools, Project Mgmt. tools, IDEs, etc.); ii) Data storage and representation - the central component which gathers the groomed data from the collection components, and makes it available in some object form to client applications/applets; and iii) Data clients - the client applications/applets which use the data provided by the data storage module to calculate metrics, charts, or model parameters. Here, the term 'component' is used to refer to the idea of 'add-on software components, both to a central application – as per our approach illustrated in Figure 2, as well as 'deployment modules' as per where the notion is that of a stand-alone client application which runs elsewhere on the network. The authors propose the idea that future tools should support "a more explicit view of the process," as the current tools tend to focus on the raw data from the sources in isolation from the perspective provided by the context of the process as a whole. Here we note the distinction between product and process metrics. The product variety may likely be calculated without regard to an explicit representation of the process; these are metrics such as complexity, size, etc. The process metrics, such as defect insertion rates, productivity, etc., require context for interpretation. For example, while one may simply use completion data to derive coarse productivity metrics, we note that extrapolation from such metrics must assume that future work is performed in a similar environment; it is only by considering the confounding environmental factors (e.g., vacation days, concurrency in the schedule, etc.) that one may derive an understanding of process metrics that is capable of being applied to widely varying future environments. We propose that there is value inherent in tying the raw data to the project schedule as the minimum satisfaction of the premise that the process should find representation in any such data collection tool. To support this conjecture, we draw an analogy with best practices using high-level programming languages: it is suggested that the 'goto' command be avoided because it destroys the logical Constructs which simplifies program

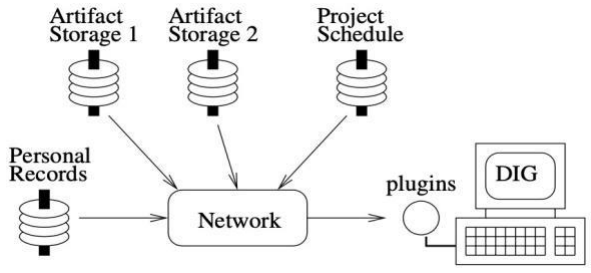

Figure. 2 Deployment of DIG in a networked environment

We make a similar case for why it's important to include raw time-series data in the project plan; this way, external effects and confounding factors can be easily identified and the link between the factors and the metrics under study may be better understood. To increase understanding, we (in DIG) compel the linkage of time-series data to schedule components.

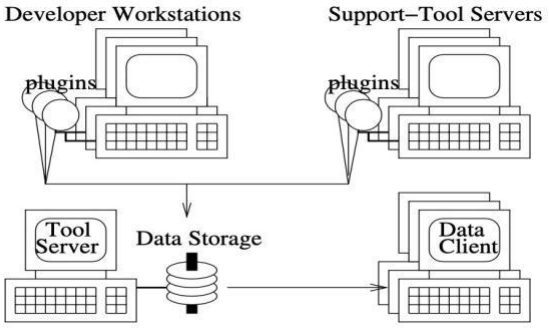

Figure. 3 Tool Deployment Scheme

4. ARCHITECTURE OF DIG

To promote wide applicability, DIG is constructed as a framework; a core application that manages the association of data and schedule elements, and a set of organization-specific plug-ins to parse out the data from the proprietary artifacts and provide. The ConcreteCompletionDataPlugin class in Figure 4 represents the custom-written parser; the classes represent the standardized interfaces to the raw data that the parsers must provide; the interface exposes a set of mappings (i.e. 'cross references'): i) from the Tasks to the Workforce members who were responsible for their completion; ii) from each Workforce member to those units of change of the Task which for which they were responsible, and iii) from each unit of change to a time-series of completion data. In Figure 5 we give an example of the mappings that were required to extract the data from the SCM system in our case study work. As can be seen, the SCM Completion Profile acts as a Facade for the calculations on the SCM Repository elements that are parsed out of the data within the SCM plug-in. For this example, The plugin's user interface requires the specification of the ChangeIDs associated with each Schedule Task of interest; where ChangeIDs are a part of our partner's change management system. This is an instance of semi-automated data collection, as the mappings must be supplied manually, but the subsequent analysis and computation are automated. In designing a general data representation for the schedule and raw completion data, we have chosen to provide an object structure that clients may traverse in order to gather the collected data. This structure is an object representation of a GANTT-like work-breakdown structure representing the schedule, with the plug-in-supplied data attached to the leaf tasks as seen in Figure 5, in the tree structure to the bottom-left of the diagram. The link to the plug-in-supplied data is represented by the association to the ConcreteCompletionProfile through the CompletionProfile interface. The calculation model of DIG is a point of novelty. In contrast to the common architecture seen in the literature, we provide an interface for the specification of a calculation independent of a view. Thus, one may implement a calculation once, and use it to drive several graphical views, textual report generators, more complex calculations, etc. In order to support the read-only, external usage of the current process artifacts, DIG and its plugins must identify data elements by immutable identifiers. Thus, upon the reloading of a project configuration after an artifact update, all of the artifacts are reparsed, and the mappings are reapplied – were still applicable – to the new set of artifact entities. DIG also supports a 'type' tag for the tasks in the schedule. Currently, DIG supports five task types: i) Feature Coding; ii) Test Case Authoring; iii) Test Case Verification; iv) Regression; and v) Defect Elimination (debugging); where 'Test Case Verification' refers to the preliminary execution of a test case against an internal product

release for the purpose of evaluating the correctness of the test case.

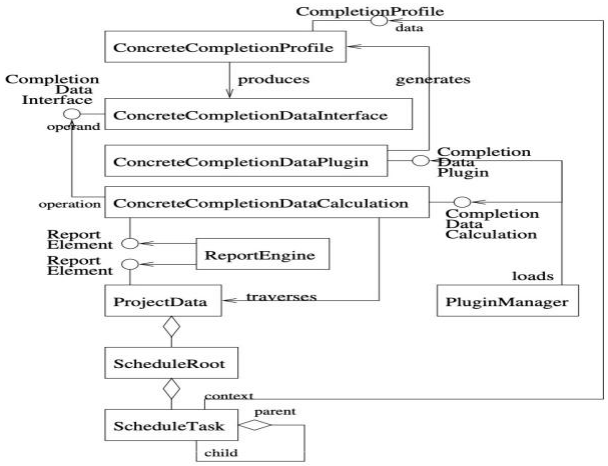

Figure. 4 Inter Object relations in DIG Framework

These categories are not intended to cover the entire spectrum of task types but are intended to demarcate certain tasks as being 'of interest' so that the majority of the schedule may be ignored were extraneous. Further, by having the task types, heuristic methods may be applied (e.g., for determining the flows of work between tasks)

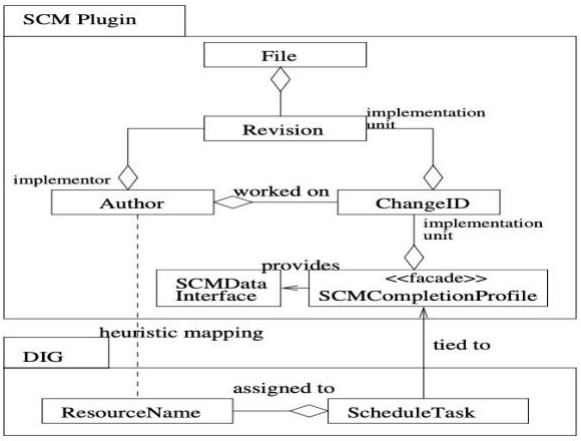

Figure. 5 Proprietary data manipulation via plugins

5. RESEARCH METHODOLOGY

The following discussion touches upon the interesting problems encountered during the construction of DIG, and their methods of resolution. In some cases, we note how automated methods might be facilitated given a small process augmentation.

Task completion. DIG was built originally to determine production rates and to characterize how the productivity rates change as a function of the proportion completed of tasks. Thus, one needs the notion of task completion, and more specifically for the characterization of productivity-rate change, one needs to be able to define the partial completion of a task. While being a seemingly benign requirement, the scheduled tasks Often represent the completion of activities (i.e., coding, testing, etc.) with respect to a particular feature (or set of features); which begs the question, "What does 'half of a feature' mean?" In our plugins, we assume that most of the partial completion is understood in terms of the proportion of the artifact that is complete (e.g., the proportion of the total lines of code being currently complete). The consequence is that we must wait for a feature to be completed before DIG can analyze its data. Also, consider the question of how defects and changes in requirements fit into the definition of task completion. We mark the completion of a task as the first point at which all of the known work for a task is complete. Future defects and changes to requirements are treated as reparative work.

Workforce allocation. Our conversations indicate a preference in the industry for allocating the workforce to tasks in a task-centric, rather than worker-centric, manner; ensuring that a task has the 'right' people outweighs consideration of the workload of the individual workers. This necessitates the notion of task concurrency for a worker. Our plugins treat the allocation of workers to tasks in terms of worker equivalents - which we define as the fractional portion of an average worker's effort which is applied to a task as the result of giving an equal portion of each work-day to each of the active concurrent tasks to which the worker is assigned. It should be noted that it is possible that all tasks to which a worker has been assigned are blocked due to unsatisfied dependencies in the schedule. In such a case, we assume that these workers are pulled into external projects and thus contribute nothing to the current project.

Process representation. The process representation used by DIG is the stripped-down entirely pragmatic version found in the inter-task dependencies in the schedule. Thus, DIG handles changes in procedure seamlessly: for those projects which must now conform to the new process, the schedule will be updated, and DIG will automatically use the new dependencies. For those projects which are allowed to use the older process (i.e., grandfather clause), there is no schedule change, and so the official procedure change is transparent to DIG.

Flow of work. The schedule alone may not be sufficient to understand the dynamics of the development and test process; as one team lead from our collaborative partner put it: "There're lots of little cycles that you just can't represent very well in a work-breakdown structure". This is per- haps the best illustration of what we term 'flow of work' – the quote above was made in reference to the cycles of rework and re-evaluation that are part of the debugging process. More technically, workflow refers to the producer/consumer relations between the tasks. One cannot interpret the productivity of a faster downstream task without considering that slower upstream tasks may be limiting its productivity by 'starving' the downstream process for work. Models which require this data may attempt to acquire it heuristically using the 'task type' tags and the inter-task dependencies in the schedule.

Definition of task types. The task type tags may not ap- ply directly to the tasks in the schedule. Consider a common process definition where the development team is responsible for both the writing of code and its informal unit testing where

the schedule includes separate tasks for coding and the informal unit test. Any completion data which is as- signed to the coding task will likely include the execution of the unit testing activity as well. We note that by requiring the scheduling granularity to match the type tag granularity, this becomes a non-issue.

Scheduled Vacations. DIG extracts scheduled vacation days for employees from MS Project schedules and provides APIs for date calculations. Ambitious plugins may adjust for vacations in their interpretation of historical raw data, or in future projections.

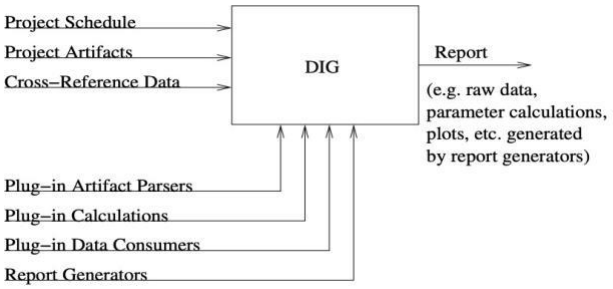

Figure. 6 Usage of the Dig tool

Relative task difficulty. DIG supports using the a priori initial work estimates from the schedule (in MS Project, these are the 'baselines') for calculating relative difficulty metrics. The motivation for this choice is a desire to include the expertise of the project planning team in the set of data that DIG can access.

Name mapping. The problem of disparity between the names of workers as they appear in one artifact vs. another. DIG provides a simple fuzzy name mapping API that compares the names by evaluating histograms of the letters A-Z present in the names in each artifact.

Ad-hoc artifact organization. For plug-ins that read collections of artifacts (e.g., test logs), obtaining the correct subset of the collection for a particular task may be nontrivial depending on the organization of the records. To handle ad hoc organization, the test log plug-in we implemented supports date filtering, file-name filtering, and compressed archive support so that one need not touch the archives to be able to read the appropriate subset of files.

Parameter correction. DIG provides the data and the context from which a simulator can be calibrated and executed. The modular calculation objects revises parameters estimates based on simulation accuracy, etc.

6. RESULTS AND DISCUSSION

The issues encountered in the construction of DIG lead to the following observations. The key to automating the entire system is traceability from the schedule to the elements in the artifacts. The majority of the functionality in DIG is to allow the specification of these cross-references. Implementation of a change management system, in contrast to separate change tracking and software configuration management, is a likely first step in building the process infrastructure to support automated model calibration. Integrating knowledge of the schedule into a change management system would be a final goal. Upon this information source, tools like DIG would become extremely simple to use. During initial testing of the DIG tool, we found multiple examples of improper semantics in the usage of the schedule dependencies – almost a colloquial dialect based on the originally intended semantics of the dependencies. Also, we found occurrences where dependencies were simply not used, and the desired temporal structure was imposed on the schedule by constraining the start dates of tasks to particular dates. While this still allows the normal mapping of data to tasks, it breaks any of the heuristic methods which rely on traversing the schedule dependencies. As a project lead in our collaborating company said, "No one wants to enter that data twice, you spend hours doing it just once". The colloquial usage of dependencies in the project schedule is a practice that should be avoided. While it may be an effective medium to convey the appropriate message to subordinate workforce members, it pre-includes the ability to use any standard tools to extract meaningful data from the schedule. Interest in the tool, the architecture, and potential applications may be directed to the authors via email.

7. FUTURE WORK

As the truism goes, "Programming is rarely finished"; while DIG is certainly not a business device, DIG is an exploration model valuable to handle control scientists who need to remove information from project storehouses with the end goal of boundary assessment and use in process reproduction models. Reports produced by DIG have likewise been thought of as valuable by test supervisors. A couple of inquiries stay as for the specific situation portrayal. It is widely known that an enormous number of gatherings during a day or week unfavorably influences productivity, so it appears to be that DIG ought to attempt to pull in a representation of "meeting thickness" to finish the image that we are attempting to draw around the relic information. As far as extension, DIG is right now custom-made to accumulate and work out time-series (for example efficiency) information. Future work ought to expect to extend the extent of DIG to envelop the full scope of information assortment tracked down in modern practice. The subject of "what is the fundamental arrangement of programmer information?" emerges in planning the information portrayal that DIG would have to help if seeking after this line; this might be a fascinating inquiry with regards to itself. Ultimately, for simplicity of organization, it appears to be that the construction of a "stock module library" of parsers for normal relics and computations for normal models/measurements/and so on would be of extraordinary guide.

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An RFID-Based Students Security Model Using IoT

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Abstract: The abduction of school children has increased over the last few years particularly in northern Nigeria, for various reasons such as child labor, ransom, forceful marriages, and suicide bombers. Due to this reason, parents are cautious about sending their children to school. Security issue is a major challenge in secondary school education in north west and north east Nigeria. and it is worrisome that most of the schools do not have adequate security for effective teaching and learning. This study is aimed at improving the security challenges in secondary schools with the use of Radio-Frequency Identification (RFID) reader at all entrances. Security based system using RFID technology for use in Federal Government Girls College, Yola has been proposed for efficient and effective school security to curb the security challenges faced by schools in northern Nigeria.

Keywords: RFID, Security, secondary school, Surveillance, Authentication. Internet of thing

1. INTRODUCTION

Security in secondary schools in north east and north west Nigeria is a growing concern, most especially with the current threat the country is facing owing to insurgency, kidnaping of school children and suicide bombing. School environment is given little or no attention when it comes to security and safety as compare to places like airport, hospitals and national buildings where different level of security are put in place to ensure safety of lives and property. The heartless, incessant attacks on Schools should serve as a tipping point for school security policy restructuring. Squelch (2001) defines a safe school as one that is free from danger and possible harm, where non-educators, educators and learners can work, teach and learn without fear or ridicule, intimidation, harassment, humiliation or violence. A safe school is therefore a healthy school, in that it is physically and psycho-socially safe. The instance of Chibok school girls on the 14th of April, 2014 where book haram took away 250 (Hassan,2014). The Adoption of Dapchi school girls in Yobe state and the kidnapping of FGC school children Yauri in Kebbi state in 2021 make parents uncomfortable sending their children to school.

Over the past few years, an innovative idea “Internet of Things (IoT)” which was first introduced by Kelvin Ashton in the year 1998, has gained huge attention in the academic and industrial sector. In recent years, scientists severely used the term “Internet of Things” to introduce to the general idea of things, especially the objects that are readable, recognizable, locatable, addressable, and controllable via the Internet-whether via RFID, wireless LAN, wide-area network, or other means (Salma et al.,2019).

There are many technologies that support to solve this issue of security. But best among them is RFID (Radio Frequency Identification) as the names suggest it uses the radio waves to identify and track the object or individual. The communication with respect to RFID is wireless using an electromagnetic and electrostatic coupling, where a radio frequency of spectrum is used to communicate. The system is built using RFID card reader and RFID cards/tags. The RFID system consists of RFID tag (or card) and RFID reader. The tag (or card) has a unique ID which is initially stored in the database before assigning it to the user. The user has to place the tag at a specific distance from the RFID reader so as to be identified. The tag consists of a microchip that helps to store unique sequence number that is useful in identifying objects. The microchip includes micro circuitry and an embedded silicon chip. The tag has a rewritable and permanent memory which can be repeatedly programmed by multiple times. RFID tag (or card) is used to exchange data with the RFID reader using the radio waves where the tag is made up of the antenna which receives the radio waves and the other component is an integrated circuit which is mainly to process and store the data. It reads the raw data from the tag and transmits it to the middle-ware for processing. Tags at varying frequencies are interrogated by the reader. The reader is further connected to the computer for processing the data this can be done via a USB connector or any wireless connection.

RFID access control and security based system is one of the solution to address the problem of insecurity in secondary schools in northern Nigeria. This system can also be used to control the movement of authorized users and grant access to valid users only. The ability to uniquely identify each person based on tagged on their ID card make the process easier, faster and secure as compare to conventional method. Students and workers only need to place their ID card on the RFID reader and the system grants them access to the school premises. Whenever an invalid card is use, the alarm turns on and such person is arrested.

2. RELATED WORK

Baha et al. (2016) developed a RFID gate control system to streamline the process of identifying students and other persons wanting to enter into the university campus. The system employed the used of RFID in verifying the identity of staff, students and others seeking access into the university. Kalyani et al. (2016) designed an RFID hostel based security system to provide security in the students hostel, each student have tag cards whose information is stored in a microcontroller, the tag card whose information is not in microcontroller is not allowed to enter in the hostel. If the code get matched with the information that already present in the microcontroller ,the gate open automatically and after few seconds it automatically get closed. RFID is also use in tracking vehicles for security reasons, Archie and Dhaves (2017) proposed a way to locate the current location of the vehicle, Capture the thief's image and shutdown the engine. This system is built upon a mobile application that is used to control the entire system. Additionally Sruthi et al. (2016) has proposed a microcontroller system that informs the owner about the theft. This system is reliable and is cost efficient but does not deal with biometric access. Ravi et al. (2013) developed an RFID based security system that will identify only authorized persons. This security system gives information about the authorized and unauthorized persons. Primarily, the two main components involved are a Radio Frequency Identification system is the Transponder (tags that are attached to the object) and the Interrogator (RFID reader). In this project, when the card is brought near to the RFID module it reads the data in the card and displays on the LCD. The data in the card is compared with the data in the program memory and displays authorized or unauthorized message. The door opens for an authorized person, closes for an unauthorized person; it alerts the persons through a buzzer. The RFID module indicates a buzzer whenever it reads the data from the RFID card.

Automatic Access Control Using Student ID Card Based on RFID Technology was designed by Geoffren (2012), In his study, the automatic access control system evolves to prevent illegal entry of people into a building and preventing unauthorized people from gaining access to certain organization resources. The door locking system functions in real time, the door open as soon as the user scans the tag. The system also stores the login and logout information of the user. Mojares (2013) developed Inotified an SMS and RFID Based Notification System enables parents to monitor the presence of their children at a specific time. The time in and out of every student is generated through scanning of their ID card at the gate followed by sending the SMS notification of the attendance to their parents. Limitation of the system is that there is no acknowledgement between the sender and the receiver.

Alphale. Chaudhari and Bansod (2014) did a study on Automated Toll plaza using RFID and GSM to eliminate wastage of time, fuel, and enhance vehicle security. In their study, the system provided a set of features such as sending a text message to the registered mobile number of the owner, displaying the information about the vehicle on screen, and automatic opening and closing of the barricade. The system reduces time and fuel wastage.

Geofrey (2012) developed an Automatic Access Control Based on RFID technology, the door locking system functions in real time and the door opens automatically any time a valid card is placed on the RFID reader.

DRAWBACKS OF EXISTING SYSTEM:

I. Authentication of students, staff, visitors and parent is done using human efforts.

II. Human guards provide physical security to protect valuables from threats.

III. The present system is vulnerable to attack

IV. There is a possibility that sensitive data could be leaked to untrusted environment.

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3. WORKING OF THE SYSTEM

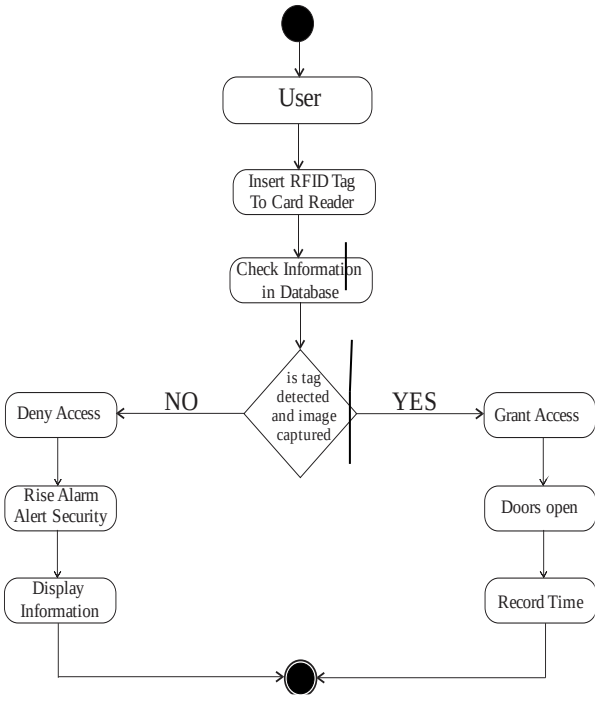

Figure1. Authentication and Surveillance

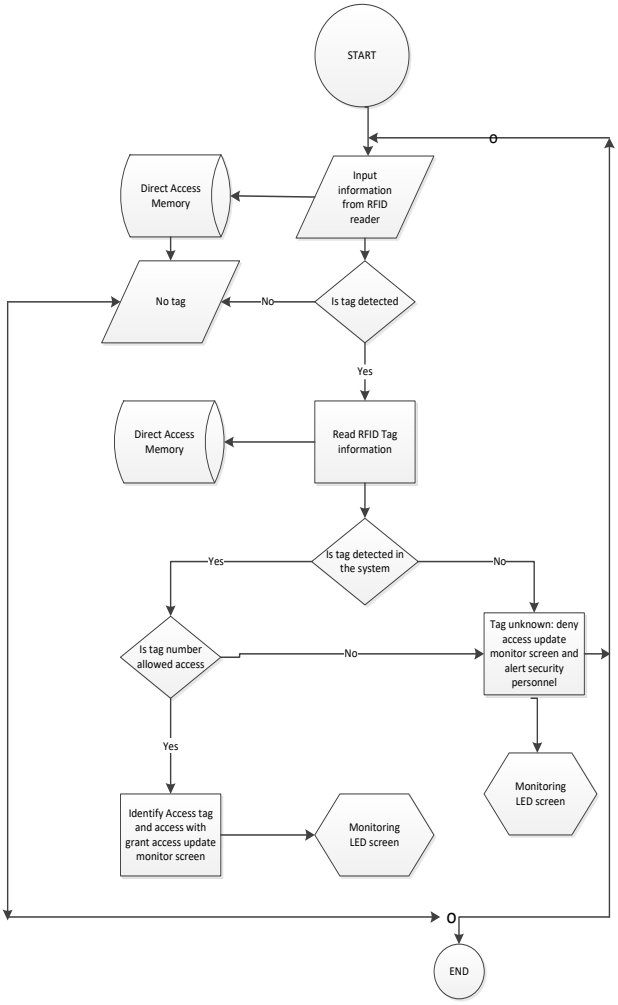

Figure 2. System Security Authentication

4. IMPLANTATION

Figure 3.Admiration log in

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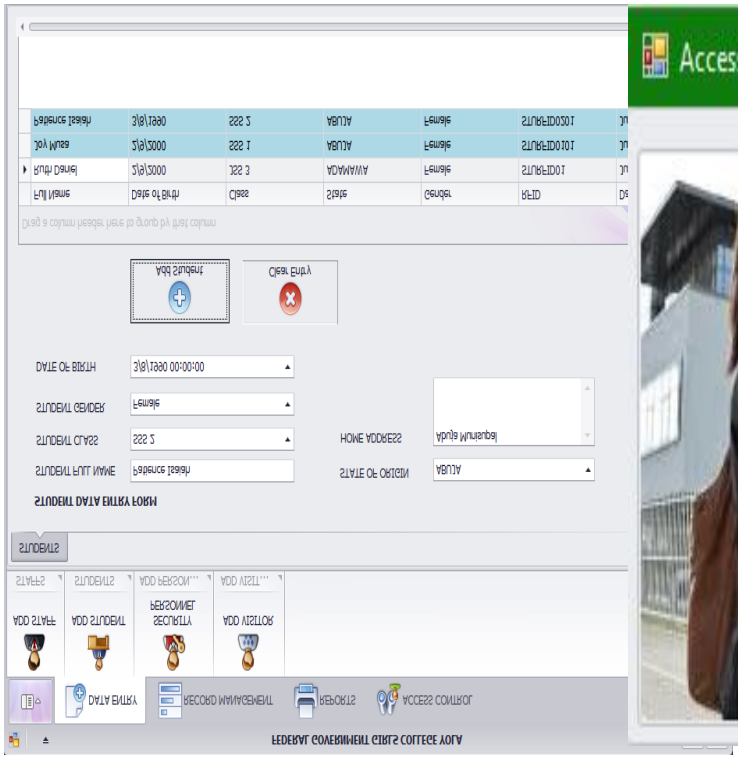

Figure 4. Student, staff, security personnel and visitors registration Form

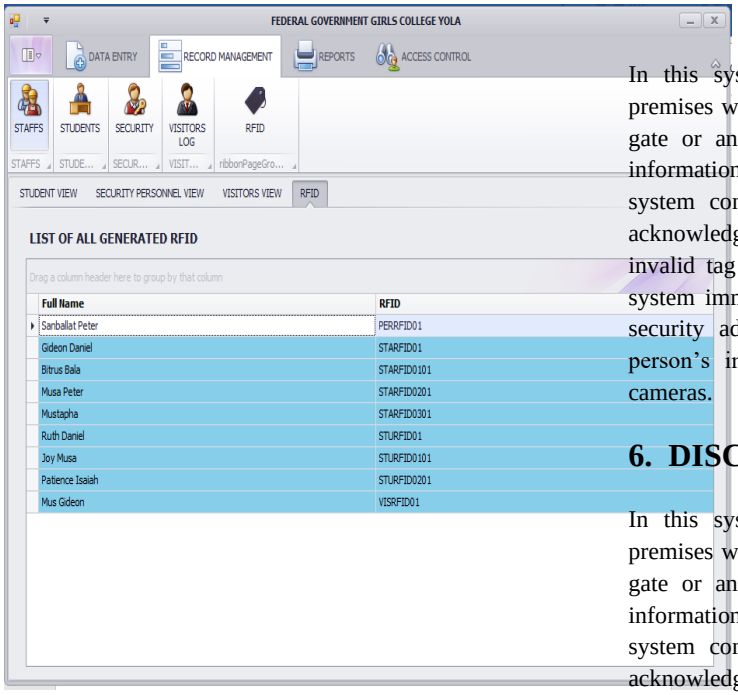

Figure 5. RFID View Registration Form

Figure 6. RFID entrance control and surveillance

5. WORKING

In this system, the user seeking access to the school premises will move the tag close to the RFID reader at the gate or any point of entry then the system checks the information to determine the validity of the tag. Once the system confirms that the tag holder is a valid user it acknowledge the user and grant access to the user. All invalid tag is rejected and the user is denied access, the system immediately sends a security alert message to the security administrator alerting him of an intruder. The person's image is already captured through the CCTV cameras.

6. DISCUSSION AND RESULT

In this system, the user seeking access to the school premises will move the tag close to the RFID reader at the gate or any point of entry, and the system checks the information to determine the validity of the tag. Once the system confirms that the tag holder is a valid user it acknowledge the user and grant access to the user, then the LED screen will be updated. All invalid tag is rejected and the user is denied access, the system immediately sends a security alert message to the security administrator alerting him of an intruder. The person's image is already captured through the CCTV cameras and will be displayed on the LED screen. Security based system for secondary is proposed to identify authorized students, staff, security personals, and visitors to grant them access into and within the school premises. The system was successfully

developed for Federal Government Girls College, Yola Adamawa State Nigeria. The major contribution of the study is the writing of a functional code for a microcontroller to communicate with the RFID device and store authorized person's data. The implementation of the system minimizes the technical human guard limitation and such enhances an improved and secured school environment.

7. CONCLUSION

The paper includes the interfacing of RFID module with PC for authentication, surveillance and intrusion detection using MYSQL database in conjunction with visual studio C# programming language, UML was used to model the design. In this when the user taps the RFID card on the readers, the reader matches information on the tag to that on the database to authenticate user. The system can be installed at the entrances of the school premises to prevent unauthorized persons.

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