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KNOWLEDGE ENGINEERING FOR USAGE EVALUATION: AN EDUCATION VALUE CHAIN

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ABSTRACT

The global learning and information sharing can inculcate a healthy competitive environment in universities across the world. Extending the traditional and electronic libraries into an ERP (Enterprise Resource Planning) cloud based e-library is expected to enlighten the academic fraternity. The paper emphasizes the need of an externally hosted private cloud computing platform to manage uniform quality of learning and measures the users' study behaviour. The availability of ERP-cloud based integrated e-library for downloading all types of study material across geographical locations is possible. The high usage of electronic devices and Internet by academicians on one hand and unavailability of measurement procedure of their productivity on the other hand, exhibits the need of an effort to compute the learning process quantitatively. The work proposes an application for learning and retaining appraisal 'LnRA' to evaluate the end users in terms of per hour learning and retaining productivity from their work on mobile devices, laptops, PCs and other wearable devices. The proposed application may be integrated with ERP-cloud to perform memory test periodically based on learning of the accessed material. The proposed system may lead to an improvement in the learning process and may induce the development of a formal system for the purpose.

Keywords: Enterprise Resource Planning, Cloud Computing, Integrated e-library, Digital Library, Knowledge Value Chain

In this digital era knowledge engineering is getting more complex with the evolution of new pedagogy in learning. The academic fraternity across the globe is getting habitual of electronic devices and the internet. The practice of information sharing through e-books, blogs, online articles and journals, data graphics, web contents and the like is changing the paradigms of learning. Acquiring knowledge from the extensive information sources is based today upon the existence of human feedback and collaborative learning [1]. Knowledge is supported by available information through a process of observing, reading, learning-by-doing, pondering over and by many kinds of exposures to live situations. However the actual thrust is on applying knowledge to practical issues which implies that the information has to transform the individuals [1], [2], [3], [4]. In the absence of appropriate knowledge application, educational institutions can neither achieve their academic goals nor transform the society or the environment which is the ultimate mission of education.

The value chain of learning and retention is directed to translate the input composition into controllable output (or desired result). To design the curriculum on the requirement of job market is one factor. The leaning and retention level achieved by students matching with market requirements needs to be measurable. In addition a continuous realistic improvement among them should be evidenced by recorded data with the administrator. The

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present input structure of e-learning knowledge objects like text messages, documents, images, graphics, maps, videos, audios etc. are at the cognitive level of users, which is within their flexible and adaptable capacity [5]. The challenge is to work on output driven mechanism and find out the solution on integration of value chain for delivering the available online material after amalgamation on a particular destination and benefit the interested and ignorant users through it [6].

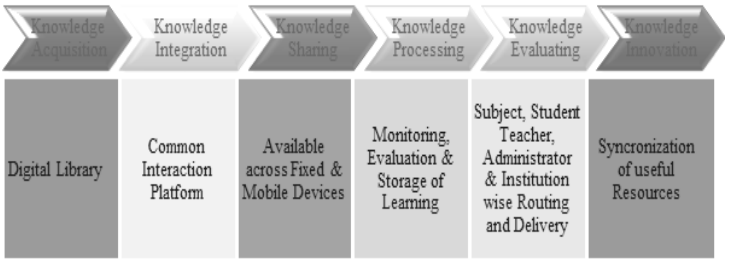

Figure 1: Knowledge Value Chain modified from [4, 12]

The revised structure of Knowledge Value Chain (KVC) model (see Figure 1) consists of six core stages of activities viz. knowledge acquisition, knowledge Integration, knowledge sharing, knowledge processing, knowledge evaluating and knowledge innovation [2], [7]. There is a transformation of input into output at each stage, and output of one is becoming the input for the next stage. This structured transfer and transformation of process based problem-solving expertise from scattered knowledge sources to a program-driven chain is the heart of the digital expert-system development process [8]. To retain and attract global talent from among the students, researchers and staff, there is a need to improve delivery modes and working arrangement within the untapped and potentially digitalized environment.

I. KNOWLEDGE ACQUISITION

Knowledge acquisition is the first stage activity in the knowledge value chain. The idea is to interlink course management systems, individual search systems, and library management systems on single digital platform. The focus will be on users' feedback based knowledge acquisition and giving an assuasive experience to all stakeholders (administration, faculty, students, and library staff etc.). A well-organized information system can nurture an active learner to create, integrate, and ameliorate knowledge rather than simply receiving knowledge passively [9]. Beiers (2000) [10] reveals that the learner/ user demands minimizing subject specific obstacles by providing responsive information architecture system to have a user-friendly learning environment. In a comparative study on problem-based learning performance supported by search engine and digital library (DL), it is found that those DL based learners are more satisfied and superior in performances [11]. The model of digital library (See Fig. 2 below) will involve end-users' participation through knowledge integration. The components of this model are elaborated below:

Digital Library (DL) is the architectural configuration of resources, infrastructure, experiences, expertise and services in the digital form encoded as sequences of bits [12]. The information can be stored in digital repository consisting data, metadata and a digital object identifier to give multiple services.

An Integrated DL System will evolve by acquisition, organization, storage, retrieval and dissemination of information resources in a systematic loop. Acquisition involves locating and capturing existing knowledge from

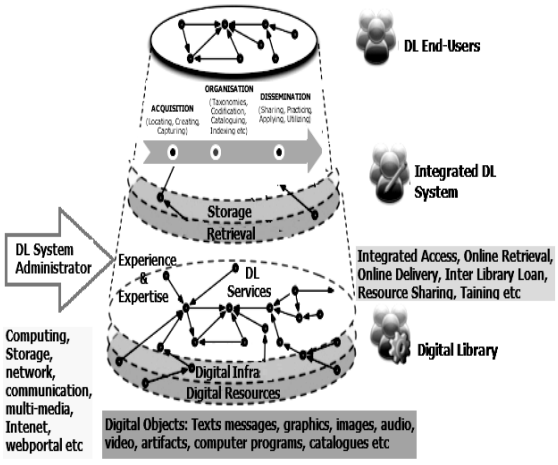

Figure 2: Digital Library For Knowledge Acquisition

DL and creating new knowledge from the user feedback. The next step is to organize knowledge using taxonomies, codification, indexing, filtering etc. Thus an integrated DL system is for processing knowledge and preserving it for permanent storage, while retrieval system is helpful for easy accessibility of information. Then the knowledge is disseminated to the users for practicing, sharing, applying and utilizing it. The motive is to enable the end-users to exploit integrated DL system on the semantics of the application domain in order to interact with available knowledge inputs and update them with their feedback, so that it is aligned with the needs of its potential users. DL end-users include information creators, information users, and the librarians.

DL automated process is a required software system and component of Digital Library Management System to ensure that the appropriate levels and types of functionality are available. The analysis of process automation depends on the depth of the involvement and output which will evolve in the value chain. The described modules encompass the whole spectrum of resource mobilization in the interaction of digital libraries. The hierarchical model of the DL universe is linked together (as depicted in Fig. 2) to operationalize the perpetual assembling and creation of a competitive knowledge base.

II. KNOWLEDGE INTEGRATION

The knowledge creation with an integrated library encourages the development of Grid Computing technology and the thrust is to accumulate large-scale data in database and the Web. The emerging trend in academic learning is bringing forth two broad problematic areas i.e. mobility and complexity or capacity of data to be dealt with. The DL is acting as a resource provider for the users' knowledge creation by making available the information from heterogeneous repositories through processing, searching, sorting, extracting and delivering. The complexities of user queries are caused by the diversity of their information needs. Because of the different objectives, the users may generate related or unrelated queries for the same subject. Keeping pace with knowledge growth and multiplicity of resources there is a need to provide exhaustive information flow through a stable and powerful computational potential of DL which is not possible through grid computing database system. Large-scale data traffic between the digital library and the mobile lot of users demands a larger capacity and powerful DL platform. Thus cloud computing emerges with massive data storage and integrated high performance computing when the goal is to corroborate libraries' free mobility. The large-scale data storage and high performance computing resources are urgently needed by the digital libraries so that the digital library services get closely linked to cloud computing [13], [14].

Cloud computing is recently evolved as a potential technology where researchers are continuously working to enhance the computational power and storage capacity which is independent of the user's limited resources and its capabilities. Using the services of cloud computing by its types based on infrastructure (LaaS), platform (PaaS) and software (SaaS) a model of DL is to be evolved to offer these upcoming benefits by Open Access Integrated Library (OAIL) for the users at server side. It would be a global learning and information sharing mode and a facility at the user end which will be measureable in quantitative terms by recording the learning process by users.

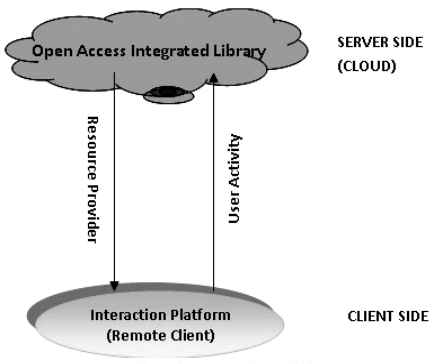

Figure 3: Cloud Server for Knowledge Integration

The given Fig. 3 of Server-Client based diagram is the architectural overview of the model. On server side, cloud based DL would provide the open access library resource at one place for the users' benefit. Providing the resources by making one single collaborative library would reduce the searching effort in learning and bring discrete resources at one place. This collaboration will also strengthen the library and would make this platform to serve the users with its diversity.

This part of the model would also require the hardware implementation. That cost of executing the hardware aspect would be high. Testing it at Hypervisor and Open Stack, the free and open source cloud computing software platform, the model may be visualised but in the long-run the hardware arrangement will involve the cost.

The challenges and opportunities (See Fig. 4) as proposed by Armbrust et al. (2009) [15] explain the desirability to switch over to cloud computing. The seamless knowledge creation is possible with multiple clouding in digital library along with an application of Distributed Denial of Services (DDoS) attack. The content becomes sharable with standardized APIs and data can be restricted with the compatible software by using hybrid computing. The DL cloud can give data confidentiality through deploying encryption and firewall. In cloud computing IP address, MAC address, VLAN and spatial data using GIS can make the data trafficking and auditability easier. The data are transferred and stored on a cloud with Virtual Machine (VM), FedEx Disk, Flash Memory and Higher BW Switches which enable speed and accuracy. It is further helpful in managing backup or archive of resources during processing and gives scalability to large distribution system. The Gang Schedule VM and Distributed VM can handle the capacity utilisation, concurrent processing and debugging in cloud DL. The server side clouds are efficient to use Meta Language (ML) for quick auto scaling and can offer reputation-guarding services (e.g. in email) for fate sharing. The application of users' authentication and bulk usages are the desired arrangements possible with cloud based DL.

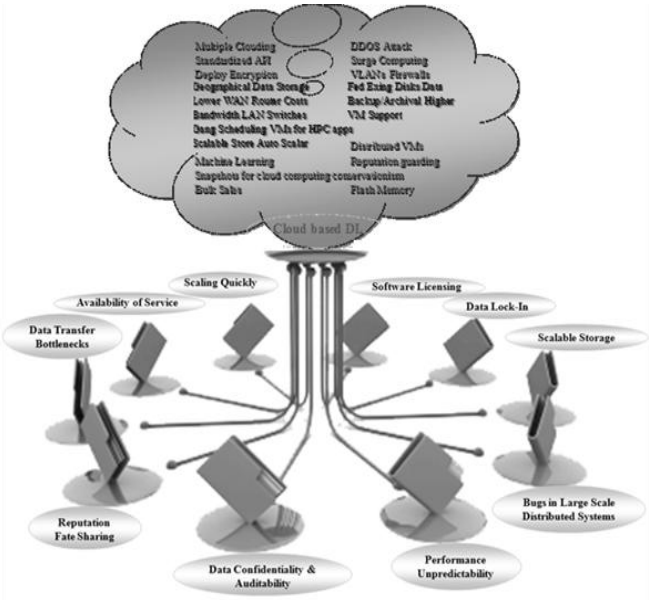

Figure 4: Opportunities of Cloud based Integrated Digital Library

III. KNOWLEDGE SHARING

The global trends are indicating the era of mass mobility in technology usage across the segments. Even in education the computer devices have taken the lead in the form of mobility devices like wearables, smartphones, tablets, laptops and desktops. A study conducted by a London based social media agency (We-are-social) [16] reveals the existence of 3.010 billion active internet users in the total population of 7.210 billion people worldwide. Globally, unique mobile users are 3.649 billion with a daily average internet usage per user as 4 hours and 25 minutes. Thailand, Vietnam, Indonesia and Malaysia are using the internet with an average about five hours

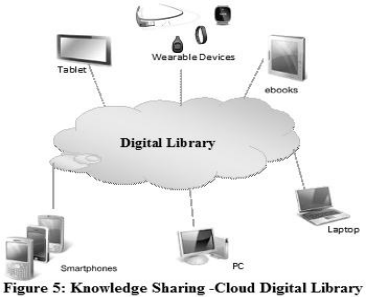

Figure 5: Knowledge Sharing -Cloud Digital Library

daily, but Philippine users are leading the chart with six-hour average daily usage. Significant variation in internet connection speed has been registered worldwide with the highest speed of 25 Mbps in South Korea and around 10 Mbps speed is available in Japan, USA, Singapore and Hong Kong. The average global internet connection speed is 4.5 Mbps although India stands at a lower side with 2 Mbps speed. On the other hand, a US based agency (IDC) [17] estimates the shipment of 11.4 million wearable devices worldwide in first quarter of 2015, which is an increase of 200% from previous year's first quarter. All these figures indicate a spectacular rise in mobile and wearable devices around the world.

Table 1: World Internet Usage and Population Statistics

DEC 31, 2014 - Mid-Year Update

World Regions	Population (2015 Est.)	Internet Users Dec. 31, 2000	Internet Users Latest Data	Penetration (% Population)	% Growth 2000-2015	Users % of Total
Africa	1,158,353,014	4,514,400	318,633,889	27.50	6958.20	10.30
Asia	4,032,654,624	114,304,000	1,405,121,036	34.80	1129.30	45.60
Europe	827,566,464	105,096,093	582,441,059	70.40	454.20	18.90
Middle East	236,137,235	3,284,800	113,609,510	48.10	3358.60	3.70
North America	357,172,209	108,096,800	310,322,257	86.90	187.10	10.10
Latin America / Caribbean	615,583,127	18,068,919	322,422,164	52.40	1684.40	10.50
Oceania / Australia	37,157,120	7,620,480	26,789,942	72.10	251.60	0.90
WORLD TOTAL	7,264,623,793	360,985,492	3,079,339,857	42.40	753.00	100.00

Source: www.internetworldstats.com. 2001 – 2015[18]

The study concludes that this generation has adopted mobility devices and supporting a phenomenal portion of their work by it. While the developed countries have adopted customized solutions for dealing with this magnitude of traffic and facilitated the knowledge sharing in the form of digital contents, journals, books, videos, audios, graphics etc. The multi-modal transfers and connections involving congestion in transmission causing latency and delays or failures in information delivery can be dealt with by integrating Content Delivery Networks (CDN) with the cloud computing centres which will involve distributing the loads on a number of CDN servers. The clients will by default get connected with their respective servers. This will in effect be a balancing of the global loads [19].

Learning in a hypermedia environment is facilitated by user's Personal Information Management (PIM) through their acquisition, organization, retrieval and processing of information [20]. A very interesting discussion is found in literature emphasising the key role of 'learning style' in total learning process [21], which is also a determinant of learning behaviour [22]. The 'cognitive style' is also focused in many writings giving it as a parallel term as a sub-set of learning style [23] which reflects the way in which one perceives, thinks, remembers and applies the information in problem solving. Learning behaviour is actually the outcome of learning style [22] and strategies in learning are adopted accordingly [24]. A different learning style will lead to adoption of a corresponding learning strategy in a given environment [24]. In fact the net accomplishment in learning is the result of 'learning style' used [21] causing a unique method of organizing and processing [25]. Frias-Martinez et al. (2007) [25] call it a 'cognitive style' of learning.

Learning and Retaining Appraisal (LnRA) is a software application which will work on mobile, wearable, tablet, laptop and personal computers to study cognitive learning of the users. The Apps have inbuilt memory to

capture users reading and surfing contents. The LnRA Apps will take periodic or content wise performance tests on user's request. The following Computation Process Algorithm is required for LnRA and ERP Cloud DL to nurture and develop users in respect with their academic goals.

Apps
1 Run on device
2 Retain DL usage / download
3 Analyse the learning
4 Test Performances
5 Retain Test Record

Cloud ERP
6 Acquire performance records of Apps
7 Retain User Performance Record using PIM
8 Check the required material available
9 Arrange the material on learning behaviour
10 Give procurement recommendations
11 Deliver User Result to Subject Faculty

Apps
12 Construct User learning Dashboard
13 Give Recommendations to User
14 Guidance for academic career

The algorithm 1 to 5 is input information available on mobile devices while 6 to 12 will be processed from Cloud ERP DL system. The result of captured Apps input (1 to 5) will be provided back to the Apps as output (given in 12 to 14) after knowledge processing and knowledge evaluation.

IV. KNOWLEDGE PROCESSING

The knowledge processing requires both at DL (Server) and client sides. The Knowledge acquisition and knowledge retrieval is to be integrated with a new interface with utmost automation in system. The automation of system needs ERP Cloud at DL side and LnRA Apps at client device side. The integrated functioning of both the systems requires knowledge processing ontology which will determine the future of academia. The proposed processing services capability is desired to turn the value chain in a unique frame of learning. The study recommends a framework by combining Cloud based DL, ERP and LnRA Apps to deliver a knowledge engineering mechanism for accessing the user's learning behaviour and at the same time improve course management and delivery of the reading material. The following pseudo code is depicting the communication between LnRA App (Client) and ERP Cloud DL (Server) and represents the overview of the activities at both sides:

```
procedure LnRA_progress      //LnRA(learning and retaining appraisal)
instantiate recordProgressClass.
On pdf/text file access event
        record the name and attributes of accessed file in recordProgressClass.
        record time of foreground access of text/pdf.
        cumulatively add foreground access of a particular pdf/text file access time and update.
Indicate to the LnRA_user the hourly progress for every document.

end

procedure browse_CloudERP
connect to the cloud repository over a HTTP connection.
provide LnRA credentials.
On successful login.
        send recordProgressClass as XML.
        browse the cloud customized library.
        On selection of a particular document
                send this document info to cloud as user interest.
end

server end process

procedure connect_user.
On request from user
        connect over a HTTP connection.
        authenticate on credentials.
        On successful login
                process recordProgressClass data in XML.
                        categorize the documents.
                        measure relative interest by time spent on each document.
                        update interest level of each category for the user.
                On browse library request from the user
                        customize view of library according to interest vector.
                On document selection
                        update user interest level for the document category.
end
```

The DL services can be enabled with ERP-cloud to the users with the help of SaaS or PaaS or IaaS and it will handle key computing paradigm to evaluate user learning and retaining performances. Every characteristic lying with it is providing an edge to make things available on Internet (online) in terms of storage, computing (processing), and software. If we see these characteristics only in terms of the benefits to the end user we can find endless other features:

IaaS: Remove the need of infrastructural dependence for end user.

SaaS: Accessibility of the software anytime anywhere without any prerequisite for the end user.

PaaS: Provides the computing platform with all corresponding necessities like operating system, programming language, databases etc.

The interface of the ERP will be available as mobile application (e.g. google android app) and it would be customised according to the credential of the user. This app interface will communicate with the Cloud to serve the purpose of information retrieval for the user. This app will also watch and store the academic activities of the user for administrative use.

V. KNOWLEDGE EVALUATION

Knowledge mining from ERP has two considerations; the first one is the purpose of mining like finding-driven knowledge mining or validation-driven knowledge mining, and the other one is the description for knowledge and identification. [26]

The underlying knowledge in ERP is of multi-factoring, non-uniform and non-linear characteristics. The overall purpose of the system is to evaluate the users' performance and acknowledge their academic need through the ERP. The content customisation will take place automatically according to the type of the users, their behaviour and interest. In the process of sorting, Apps oriented performance will be treated as L and the knowledge set created due to regular retention evaluation is considered as R(L). The D(L) represents the ERP-cloud DL database. The results in R(L) are based on the integrated knowledge availability or derived from D(L).

Stage 1: The ERP will perform the information retrieval task for the user; in effect, it is the way of providing the information against the users' query and serves the users' requirement appropriately. This will boost the learning process. The association and correlation analysis based on using rough set theory will enable the ERP to provide the useful material or contents based on their activities, interests and areas, and ultimately it will save effort and time of the users in learning [27], [28], [29]. The new correlated databases DR(L) will be obtained by using k-nearest Neighbour Method and Principal Component Analysis (PCA) [26]. The distance between any two samples x and y is defined as:

$$d(x,y) = \sqrt{\sum_{i-1}^{n}(x_i - y_i)^2}$$

This formula will give k-nearest neighbour near of x. Further the neighbours can be arranged into clusters with similarity measures among the samples of the same group. The two samples are kept into same cluster if and only if the distance between them is less than the maximum possible distance (dmax) in that cluster.

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Stage 2: By using PCA (Principal Component Analysis) the calculation of correlation factors is done between parameter. Assume matrix X of m×n-dimension vector,

$$X_{m\times n} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{1n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix}$$

Let m vectors form linear combination of n-dimension vector {x1, x2, ..., Xn},

$$y_i = \sum_{i=1}^{n} a_i x_i \quad i = 1,2,3,\ldots.m, m \leq (min(m,n))$$

yi (i = 1, 2, ..., m) can replace with matrix X to discover the knowledge from original data.

Stage 3: Approximation of Knowledge by k-fold cross validation method is desired. The knowledge validation is calculated for individual user by k-fold cross validation method. Each time, a single k subsample is kept as validation data for testing the model and the other k-1 subsamples are used as training data. The data set yi (i = 1, 2, ..., m) is divided into k subsamples, and the method is iterated k times for each of subsamples which is used exactly once as a validation data. The k result from the fold is averaged to produce the require data.

VI. KNOWLEDGE INNOVATION

The proposed model, in this paper, is providing the knowledge innovation by the use of ERP-cloud computing paradigm (see figure 6). The integration of the ERP, cloud, DL and mobility devices is capable to serve the heterogeneous audiences in different parameters. The audience or the user of this knowledge value chain may fall in any of the following categories; Student, Teacher, Administrator, Employer, Librarian, Funding Agency, Accreditation Board etc. This is the capacity of the ERP to serve totally different audiences with different perspectives with fulfilment of the requirement. The information retrieval by different mobility device users is challenging and time consuming and sometimes even irrelevant and directionless. Determining what information is relevant to the end user from the available information on the cloud would also require keeping track on their activities to understand the user and their interests. Further the activities log will serve other purposes like quantitative analysis of the users' learning rate etc.

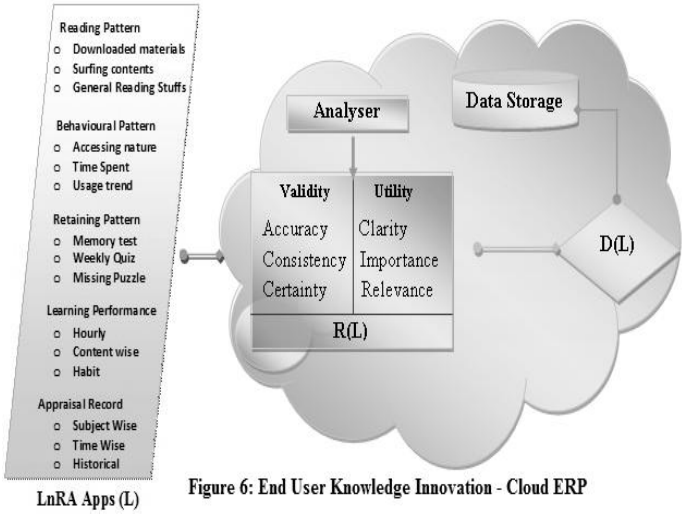

Figure 6: End User Knowledge Innovation - Cloud ERP

VII. CONCLUSION

The knowledge value chain in this paper describes the complete process which is an outline for future research on each of its components. It may only serve as a guideline for a broad arrangement of capacity building in education sector. The idea is to develop DL linked with mobility devices to enrich end users by innovative use of ERP system. The study provides a meaningful solution by conceptualizing the potential of growing and dominating mobility devices in the academic fraternity. The formal education should stretch further to evaluate

the learning and retaining pattern of individuals. The allotment of laptops or tablets is a global practice in educational institutions. The knowledge evaluation and innovation through these devices will nurture the potential talent of the beneficiaries.

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