EDUCATION CLOUD MATURITY CODE

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Abstract

The education field is slowly adopting the cloud though there are constraints like suitability (fit), cost, speed of deployment, flexibility, reliability, transferring existing systems onto cloud etc. There are many cloud maturity models designed for enterprise adoption. Education cloud adoptions are widely prevalent in universities due to OER and MOOC but still nascent at school levels. The objective of this paper is to design a unified Education Cloud Maturity Code (ECMC) to rate the cloud components based on each adoption stage such as ***apprised, assessed, acted and advanced*** *of any educational institution to arrive at an education cloud code (ECC) based on the six components of cloud implementation namely I-Infrastructural, G-Geared, R-Resourceful, A-Administrative/Authoritative, M-Managerial, S-Secured. This code helps the educational institution to self-assess their maturity stage of adopting education cloud.*

Keywords: Education Cloud, Education Cloud Maturity Code, Education Cloud Code, Education Cloud Adoptions

1. INTRODUCTION

Technological adoptions in educational institutions have gradually increased (R1, 2010) after such adoptions have been successful in many enterprises and organizations. Technologies defined in yester years as cloud and big data have evolved and are now available for adoptions. So any study on such technologies must start with their adoptions. The cloud adoption by enterprises and organizations have been studied to a certain extent but the study of such technologies in the educational sector is still nascent.

The Cloud used by set of users (including teachers, students, parents, administrators, and others) to access a variety of education services provided by the cloud, using whatever device or devices they have access to (laptops, desktops, PDAs, etc.) (Fogel, 2010) is considered to be Education Cloud. Google Cloud offers various applications which are free for schools with 24/7 support at no cost (Google Apps for education, 2014). Free services provided for teaching and learning like Open Educational Resources (OER) and MOOC like Coursera, Udacity and edX have made many educational field stakeholders use cloud features (network, applications, storage etc) without releasing that they are already using it. These drive the point that the education sector has already stepped into this road. Education cloud and its characteristics are still being researched. The objective of this paper is to create an education cloud code (ECC) through designing a technique to derive education cloud maturity code (ECMC) to find the maturity stage of cloud in an educational institution which will help the stakeholders to evaluate the cloud implementation status.

The first section is the literature review of Education cloud platforms and cloud maturity models. This is followed by the proposed education cloud code (ECC) model development and the education cloud maturity code (ECMC). The next section is about how to calculate the ECMC which is explained using an example. The next section states the current status of research and the conclusion mentions the future activities.

2. LITERATURE REVIEW

All the existing cloud models defined by researchers and practitioners were studied and it was found that they were mainly for enterprises. There are different types of enterprise cloud models like Cloud Cube Model (CCM) proposed by the Jericho Forum which is used to enable secure collaboration in the appropriate cloud formations best suited to one's business needs (JF 2009), and Cloud Computing Business Framework(CCBF), business based Hexagonal model and IT service based Hexagonal model (Chang 2013).

To design an education cloud model we have adopted the **Holland Code** (Holland 1973) framework which refers to a theory of careers and vocational choices based on personality types.

The six cloud components such as infrastructure, security & privacy, applications, management, devices and providers were derived at based on the study of issues and challenges faced in cloud implementation from various sources like journal articles, organization white papers and articles on various websites (for eg., Sun Microsystems 2009).

Based on Roger's **Diffusion of innovations** (DOI), the five attributes of an innovation influencing the adoption and acceptance behavior are *relative advantage, complexity, compatibility, trialability and observability* (Rogers and Kim 1985). The five stages of maturity measures defined by Rogers (1995) are *Awareness, Interest, Evaluation, Trial, and Adoption*. Numerous studies have been done on cloud adoptions and the maturity models based on this and several other models. Maturity models for

organizations and health care are widely prevalent and some of the maturity models were created by the practitioners.

The adoption stages of education cloud is different from that of the enterprises as there are many free tools available to create cloud awareness for educational institutions. So the five stages of maturity measures of Rogers have been modified to include the stages of *apprise* (along with trial), *assess* (interest and evaluation), *act* (adoption). Since we are developing the maturity model, the stage beyond adoption which is advance is also considered. .

The Technology Organization Environment (TOE) framework defines how the firm's context influences the adoption and implementation of innovations (Tornatzky & Fleischer 1990). Since the adoption in a business driven enterprise is surely different from that of an educational institution, whose objective is to create knowledge based society focusing on high value educational services (Intel 2010), the maturity model of education cloud has been considered for study in this paper.

2.1 Versatile Education Cloud

Class room learning has now expanded to the real field while E-learning has brought a new wave of group learning and self-learning activities. Education Cloud is slowly coming into limelight as educational institutions are implementing virtual learning environments (VLEs) to communicate and bring together the stakeholders like teachers, students, parents and educational authorities (Glossary of Education Reform) under one roof from early childhood education in schools to professional learning in organizations.

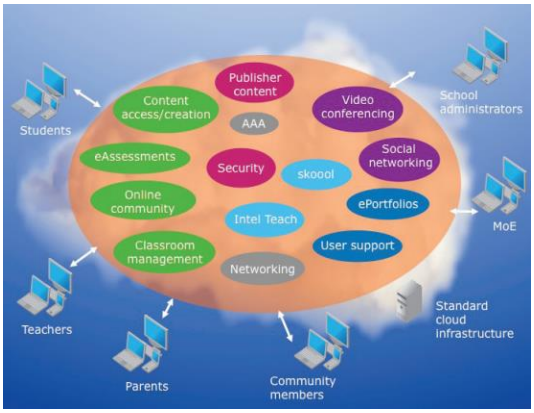


Figure 1. Intel's Education Cloud Services (Intel 2010)

Education cloud services presented by Intel as depicted in Figure 1 shows a set of users (including students, teachers, parents and others) gaining access to a variety of education cloud services, using whatever device or devices they have access to (laptops, desktops, PDAs, etc.) (Intel 2010). But education cloud adoptions in K-12 schools are still under study. This paper tries to propose a model to find the extent to which cloud technology is adopted in schools.

2.2 Versatile Maturity Cloud Models

Studies were done on various existing maturity models taking into consideration all the stakeholders and the required facilities for education cloud. In most of the maturity models common properties of the cloud give a solid base to manage the migration and management of IT services and IT-enabled services in the Cloud (Duarte 2013) for organizations and enterprises. To have a better understanding, Figure 2

shows one of the many organizational maturity models that were developed by practitioners and researchers in the recent past.

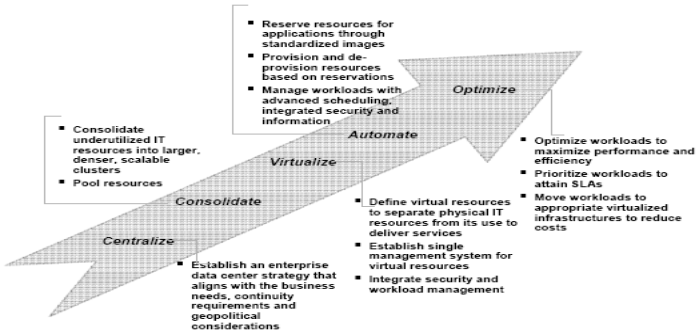


Figure 2. Cloud Maturity Model (Mahesh, 2009)

As the cloud implementation in an organization is mainly based CAPEX and OPEX (Meiko, et.el 2009) and is entirely different from the educational institutions, which have a lot of free tools available in the market and implementation is not revenue driven but knowledge based. A study on education cloud is inevitable and this paper targets this aspect.

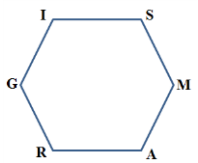
3. Proposed Education Cloud Maturity Code

Different schools adopt the cloud in different ways depending on their budget. To find the maturity level of the education cloud, we have proposed the education cloud maturity code after analyzing the different stages of cloud implementation under different cloud components. This helps to sort schools based on the education cloud code.

To do this, two frameworks the **Education Cloud Code (ECC)** and the **Education Cloud Maturity Code (ECMC)** were developed.

3.1 Education Cloud Coding Model

The theoretical framework of Cloud Code Model has been designed and presented in this paper. Each letter or code characterizes the education cloud as Infrastructural (infrastructure), Geared (device usage), Resourceful (applications), Administrative/Authoritative (Governance of providers), Managerial (management) and Secured (security and privacy) as depicted in Figure 3. Education cloud implementation components can be categorized as one of these six types. This six components scheme is built on the assumption that there are only six kinds of education cloud implementation process in the world is unacceptable on the strength of common sense alone. But possibility of 720 (6!) different education cloud patterns exists from the six component scheme that allows a simple ordering of a cloud's resemblance to each of the six components. As the model is applied in cloud implementation and type classification, it is usually only the most dominant code (first 3 characters) that is used for identifying education cloud implemented in a particular school.



I – Infrastructural
G – Geared
R – Resourceful
A – Administrative/Authoritative
M – Managerial
S – Secured

Figure 3. Education Cloud Code Model

Infrastructural – During the development of the education cloud adoption we have taken into consideration the following items of the infrastructure component that helps schools to store large volumes of information like photos, videos and other documents containing non-sensitive data based on references such as Ignacio, 2012:

- Data servers, storage options and Management
- Backups of data (local servers or cloud servers)
- Compliance issues
- Application resilience with automatic failover of application services with support for replication of services across sites
- Automatic horizontal and vertical elasticity of application services
- Scalable management of network, computing and storage capacity across multiple sites across diverse clouds providers
- Network Latency in Propagation, Transmission, Router and other processing, computer and storage delays
- Multi-zone management for high availability, performance or energy efficiency

Geared – We have taken into consideration the following aspects of the front end devices used by the school stakeholders like the laptops, handheld, mobile and virtual devices to create a smart school environment based on references for eg., Kristy 2012 while developing the education cloud adoption.

- Usage of virtual desktops and laptops
- Usage of Windows Phone applications
- Usage of iPad, iPhone, Android
- Use tablets in activity-based learning, project-based learning.
- Portability of virtual appliances

Resourceful - Education cloud adoption taken into consideration the following aspects of the **Applications** that takes care of all educational applications like content creation, content delivery, education platform, teaching evaluation and education management based on reference for eg., Behrend 2011.

- Usage of Email, document collaboration tools (google docs and Excel)
- Usage of Microsoft 365, AWS or other applications like Google Apps for Education suite
- Usage of Google's Chromebooks for secondary and primary schools
- Use of educational apps (more than 115,000 available for free or for small fee)
- Common and standard interfaces for cloud computing
- Application Management
- Virtual/Remote Lab facilities
- Autonomous adaptation of services and context-aware applications

Administrative/Authoritative - Education cloud adoption takes into consideration the following aspects of the providers to have mutual agreement in handling the cloud safely, securely and diligently while out-sourcing the services to the providers for cloud implementation based on the reference for eg., CSA 2012.

- Pricing and licensing
- Contract lock in and exit strategies
- Longevity/credibility of suppliers
- Mergers and acquisitions
- Data ownership and custodian responsibilities

- Sharing of resources between cloud providers
- Legal issues
- Government regulations keeping pace with the market

Managerial - Education cloud adoption takes into consideration the following aspects of the Management component while care of usage levels of teaching and learning tools, school management systems including financial, library and office applications for the smooth running of the school based on the reference for eg., CSA 2012.

- Extent of using school management systems including financial, library and office applications
- Efficient resource management to reserve, allocate, track and limit resource utilization
- Extent of use in teaching and learning
- Public cloud, Private cloud
- Integration of cloud with internal systems
- Testing and assurance
- Outages and other service interruptions

Secured - Education cloud adoption takes into consideration the following aspects of the Security and Privacy component to safe guard their data and maintain data privacy based on reference for eg., Ignacio, 2012.

- Isolation of applications
- Advanced secure multi-tenant environments
- Multiple-role support
- International data privacy
- Data integrity storage resources
- Security mechanism for storage resources
- Fault tolerance cloud infrastructures for high availability of cloud management services
- Fault tolerance with redundancy across sites

All the measures that have been discussed above have been tabulated in Table 1 in Appendix 1 based on which the study will be done to arrive at the Cloud Code of any institution.

To arrive at the education cloud code, we need the maturity stages of the education cloud component adoptions based on all the above.

3.2 Education Cloud Maturity Code

To code the stages of different components of education cloud, we have considered the four stage model that consists of **apprised, assessed, acted** and **advanced** as depicted in the figure 4 below from Versatile (existing legacy systems) stage to Matured stage.

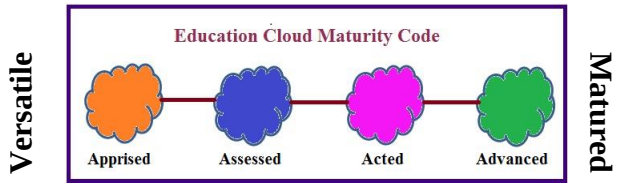


Figure 4. Education Cloud Maturity Code

Apprised – It is defined as the extent to which the education cloud adopter is aware of the education cloud components but lacks complete information about it (Rogers 1995). Sometimes, free cloud tools (Bartholomew 2012) that are available will help to get this apprised. Trial (Rogers 1995) stage goes into this in cloud adoption for educational institutions.

Assessed – It is defined as the extent to which an education cloud adopter mentally applies the education cloud components to their present and anticipated future situations in the institution, and then decides whether or not to try it (Rogers 1995). We consider the evaluation stage also in this as the education cloud is getting free offers to do this evaluation.

Acted – It can be defined as initial deployment of the education cloud component in the school that the users, e.g. teachers and students, have started to use the deployed education cloud component (Rogers 1995).

Advanced – It is defined as the final stage of the maturity model that all users have skillfully and productively used the deployed education cloud component (Intel CS 2014).

3.3 How to calculate ECMC?

Using the four stages of maturity code AP – Apprised, AS – Assessed, AC – Acted, AD – Advanced as a base, the measures have been decided upon. Table 1 lists out all the components with its items to find the maturity stage. In each section, only one maturity stage can be circled. Based on the stages of adoption, we have considered the value to be 1 for AP, 2 for AS, 3 for AC and 4 for AD and the total for each component is arrived at. By writing the letters from the three components containing the first three highest, we have arrived at the ECMC. We can classify the cloud type to be based on the first letter of the code.

This code helps the school authorities to know which aspect of the education cloud they have implemented well and what needs to be taken care of for better results.

Table 1 in Appendix 1 shows an example of an anonymous education cloud implemented in an educational institution. ECMC for the school is **M** (25) **A** (22) **G** (21).

In this case, the education maturity cloud code is Managerial implying that they have implemented managerial requirements of education cloud with more focus on and administrative/authoritative and device aspects which are at next levels. Other three **I**nfrastructural (15) **R**esourceful (18) and **S**ecured (13) needs more attention to get better results.

4. CURRENT STATUS

A survey form with all the measurement items for schools is being developed and will be used in surveying various schools in Hong Kong (or elsewhere in other regions). Contacts have been developed with the education cloud provider of Hong Kong to do that.

Self-assessment form will be designed to get the ECMC which will help the schools to self-assess themselves and find the maturity level of their education cloud. If the overall codes of a set of schools is collected, then we can analyze to find the area which has been utilized the most and those areas having issues and challenges. This can help the Application Developers and Providers to develop better education cloud based on the cloud maturity codes of the schools to target the education cloud business. If the study is successfully done in Hong Kong, possibly it can be extended to schools in other countries like China and India.

5. CONCLUSION

In this research-in-progress paper, literature review is done to find the existing gap of unavailable education cloud maturity code. To propose an education cloud maturity code, an education cloud code based on six components (I-Infrastructural, G – Geared, R- Resourceful, A – Administrative/ Authoritative M – Managerial, S- Secured, in short as IGRAMS) has been designed and the method to arrive at the code has been explained with an example. This will help the educational institution stakeholders to evaluate the cloud implementation maturity. This research project therefore is important for decision makers and providers to make a decision about the implementation of the education cloud in order to refine their school educational environment.

Appendix A

Table 1: Example to show the method of arriving at Education Cloud Code

Calculating Education Cloud Code - Example

Follow the directions below to discover the cloud type you belong to.

1. In each section, mark only one maturity stage.
2. Considering 1 for AP, 2 for AS, 3 for AC and 4 for AD, the total is arrived at.
3. Write the letters from the three components containing the highest below, from greatest to smallest. This is your cloud code.

Infrastructural					Value
Data servers, storage options and Management	AP	(AS)	AC	AD	2
Backups of data (local servers or cloud servers)	(AP)	AS	AC	AD	1
Compliance issues	AP	AS	(AC)	AD	3
Application resilience with automatic failover of application services with support for replication of services across sites	(AP)	AS	AC	AD	1
Automatic horizontal and vertical elasticity of application services	AP	AS	AC	(AD)	4
Scalable management of network, computing and storage capacity across multiple sites across diverse clouds providers	(AP)	AS	AC	AD	1
Network Latency in Propagation, Transmission, Router and other processing, computer and storage delays	AP	(AS)	AC	AD	2
Multi-zone management for high availability, performance or energy efficiency	(AP)	AS	AC	AD	1
Total					15

Secured					Value
Isolation of applications	(AP)	AS	AC	AD	1
Advanced secure multi-tenant environments	(AP)	AS	AC	AD	1
Multiple-role support	AP	(AS)	AC	AD	2
International data privacy	AP	AS	(AC)	AD	3
Data integrity storage resources	AP	(AS)	AC	AD	2
Security mechanism for storage resources	AP	(AS)	AC	AD	2
Fault tolerance cloud infrastructures for high availability of cloud management services	(AP)	AS	AC	AD	1
Fault tolerance with redundancy across sites	(AP)	AS	AC	AD	1
Total					13

Resourceful					Value
Usage of email,document collaboration tools (google docs and Excel)	AP	AS	AC	(AD)	4
Usage of Microsoft 365, AWS or other applications like Google Apps for Education suite	AP	AS	AC	(AD)	4
Usage of Google's Chromebooks for secondary and primary schools	AP	AS	AC	AD	0
Use of educational apps (more than 115,000 available for free or for small fee)	AP	AS	(AC)	AD	3
Common and standard interfaces for cloud computing	(AP)	AS	AC	AD	1
Application Management	(AP)	AS	AC	AD	1
Virtual/Remote Lab facilities	AP	AS	(AC)	AD	3
Autonomous adaptation of services and context-aware applications	AP	(AS)	AC	AD	2
Total					18

Managerial					Value
Extent of using school management systems including financial, library and office applications	AP	AS	AC	(AD)	4
Efficient resource management to reserve, allocate, track and limit resource utilization	AP	AS	(AC)	AD	3
Extent of use in teaching and learning	AP	AS	(AC)	AD	3
Public cloud	AP	AS	(AC)	AD	3
Private cloud	AP	AS	(AC)	AD	3
Integration of cloud with internal systems	AP	AS	(AC)	AD	3
Testing and assurance	AP	AS	(AC)	AD	3
Outages and other service interruptions	AP	AS	(AC)	AD	3
Total					25

Geared					Value
Usage of laptops	AP	AS	(AC)	AD	3
Usage of Windows Phone applications	(AP)	AS	AC	AD	1
Usage of iPad	AP	AS	(AC)	AD	3
Usage of iPhone	AP	AS	(AC)	AD	3
Usage of Android	AP	AS	(AC)	AD	3
Use tablets in activity-based learning	AP	AS	(AC)	AD	3
Use tablets in project-based learning.	AP	AS	(AC)	AD	3
Portability of virtual appliances	AP	(AS)	AC	AD	2
Total					21

Administrative					Value
Pricing and licensing	AP	AS	(AC)	AD	3
Contract lock in and exit strategies	AP	AS	(AC)	AD	3
Longevity/credibility of suppliers	AP	AS	(AC)	AD	3
Mergers and acquisitions	AP	AS	(AC)	AD	3
Data ownership and custodian responsibilities	AP	AS	(AC)	AD	3
Sharing of resources between cloud providers	AP	(AS)	AC	AD	2
Legal issues	AP	AS	(AC)	AD	3
Government regulations keeping pace with the market	AP	(AS)	AC	AD	2
Total					22

Education Cloud Code is : **MAG**

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