A University of Greenwich Case Study of Cloud Computing – Education as a Service

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ABSTRACT
This paper proposes a new Supply Chain Business Model in the Education domain and demonstrates how Education as a Service (EaaS) can be delivered. The implementation at the University of Greenwich (UoG) is used as a case study. Cloud computing business models are classified into eight of Business Models, this classification is essential to the development of EaaS. A pair of the Hexagon Models is used to review Cloud projects against success criteria; one Hexagon Model focuses on Business Model and the other on IT Services. The UoG case study demonstrates the added value offered by Supply Chain software deployed by private cloud, where an Oracle suite and SAP supply chain can demonstrate supply chain distribution and is useful for teaching. The evaluation shows that students feel more motivated and can understand their coursework better.

1. INTRODUCTION
The Joint Information Systems Committee (JISC) has announced Cloud Computing is increasingly attractive for research and education, and they believe there are the following five reasons for University Cloud adoption (JISC, 2011):

- Reduce environmental and financial costs - where functions are only needed for short periods.
- Share the load - when a university is working with a partner organisation so that neither organisation need develop or maintain a physical infrastructure.
- Be flexible and pay as you go - researchers may need to use specialised web-based software that cannot be supported by in-house facilities or policies
- Access data centres, web applications and services from any location.
- Make experiments more repeatable - write-ups of science experiments performed in the cloud can contain reference to cloud applications like a virtual machine, making the experiment easier to replicate.

The UK Universities are adopting Cloud computing, either private cloud or hybrid cloud, to save operational costs, enhance quality of service and improve efficiency (Chang et al., 2011 e; JISC, 2011). Indeed, Cloud Computing offers a variety of benefits including cost-saving, agility, efficiency, resource consolidation, business opportunities and green IT (Chang et al., 2010 a; 2010b; 2011 b; 2011 d; 2011 e; 2012; Foster et al, 2008; Kagermann et al., 2011; Schubert, Jeffery and Neidecker-Lutz, 2010). As more organisations adopt Cloud, there are challenges such as security, interoperability, migration measurement of Cloud business performance (Chang et al., 2011 b; 2011 c; 2011 d). To address these increasing requirements, a structured framework is necessary to support business needs and recommend best practice which can be adapted to different domains and platforms. Cloud Computing Business Framework (CCBF) is the proposed solution (Chang et al., 2011 a; 2011 b; 2011 c; 2011 d; 2011 f). The goal is to

help organisations achieve good Cloud design, deployment and services, and deliver solutions, recommendations and case studies to businesses.
Clouds are commonly classified into Public Clouds, Private Clouds and Hybrid Clouds (Ahronovitz et al., 2010; Boss et al., 2007; Sun Microsystems, 2009). Their definitions are summarised as below:

- Public Cloud – Cloud services offered in public domains such as Amazon EC2 and S3. This approach is for organisations wishing to save costs and time without obligations on deployment and maintenance. For organisations without Cloud Computing deployment, this is the quickest way to make use of Cloud Computing. The down side is there are concerns for data security in public domains including data loss and conflicts, legal and ethical issues (Krutz and Dean Vines, 2010).
- Private Cloud – Bespoke cloud services are deployed within the organisation, thus data and accessibility are only for internal users. This approach is suitable for organisations focusing on privacy and data security, or to change or simplify the way people work. The downside is that some implementations are complicated, time consuming or costly to complete.
- Hybrid Cloud – An integrated approach is to use part public and part private cloud to deliver a solution. This approach is suitable for universities wishing reducing costs, whilst maintaining privacy and data security. Downside is that integrating the different architectures is not easy and it is likely this model ends up either public cloud or just private cloud due to complexity and time involved.
- Community Cloud – Ahronovitz et al. (2009) from National Institute of Standard and Technology (NIST) proposes four types of Clouds, the fourth is Community Cloud, which they define as "A community cloud is controlled and used by a group of organisations that have shared interests, such as specific security requirements or a common mission." The downside is that it takes years to establish a working community for sharing and mutual learning. However, the added values and benefits for Academic Community could be worth far more than the time and effort spent. Briscoe and Marinos (2009) propose that the concept of the Community Cloud draws from Cloud Computing, Digital Ecosystems and Green Computing, with these five major characteristics: Openness; Community; Graceful Failures; Convenience and Control; and Environmental Sustainability.

This paper is not about the literature of Cloud Computing but how it can be adopted in the education domain. It proposes Education as a Service (EaaS) and explains its business model, content, technology, impacts to education and benefits involved.

1.1 Education as a Service Definition

Educause and Nacubo (2010) jointly propose shaping the Higher Education by using Cloud Computing services to improve delivery and content of Education. They explain the term "Education as a Service" (EaaS), which includes Cloud architecture, applications and services delivered by Cloud to education in the form of lectures, quizzes, assignments, marking, tutorial, discussions, debates and student support. They focus more on the benefits of doing so, rather than the details of how to achieve EaaS. They explain this is a sustainable business model and may shake up the way education goes forward. Fogel (2010) explains the benefits of adopting EaaS and presents EaaS some information of how to do it by emphasising the architecture of services, connectivity and service integration. He argues that education can get more benefits by service integrations of EaaS. Both papers strongly support that EaaS is not only a new way of delivery of education but also an economical and sustainable business model.

1.2 University of Greenwich (UoG) Case Study Overview

In the University of Greenwich (UoG) case study, the aim is to present how Cloud Computing can offer a unique business model for higher education and transforms the way modern higher education is delivered. This includes demonstrations of the followings:

- The use of Cloud Computing Business Framework (CCBF) recommends suitable business models for Education such as Education as a Service (EaaS). The use of the pair of Hexagon Models assessing Cloud projects against elements of success criteria.
- Demonstration of Oracle supply chain private cloud that has been used in teaching to improve learning efficiency.
- Strategic plan of adopting enterprise software for quality teaching and learning.

The structure of this paper is as follows. Section 2 present a classification of Business Models and their application in an EaaS. Section 3 introduces the use of a pair of Hexagon Models. Section 4 presents the use Oracle to help Supply Chain Business Model, the results of the evaluation. Section 5 describes a strategic plan for adopting SAP using a supply chain business model in higher education. Section 6 presents topics for discussions and Section 7 sums up with the Conclusions and Future Work.

2. BUSINESS MODEL CLASSIFICATIONS AND THEIR USES

The Cloud Cube Model (CCM) proposed by the Jericho Forum (JF) is used to enable secure collaboration in the appropriate cloud formations best suited to the business needs (Jericho Forum, 2009). However, CCM does not classify Cloud operations into different business models and additional work is required, where Chang et al. (2010 a; 2010 b; 2011 a) demonstrate key area of Cloud Computing Business Framework (CCBF) by categorising eight business models and explain how CCM fits into each business model with strength and weakness presented. These eight models proposed by CCBF are categorised as follows:

- Service Provider and Service Orientation;
- Support and Services Contracts;
- In-House Private Clouds;
- All-In-One Enterprise Cloud;
- One-Stop Resources and Services;
- Government funding;
- Venture capitals
- Entertainment and Social Networking.

The education sector is increasingly regarded as a service industry for providing training, knowledge and skills for students and general public. Cloud Computing for higher education is identified a key strategic area in the UK (JISC 2011) and this provides a unique business model to meet demands from continuously-improved education and services. UoG adopts multiple business models including Support and Services Contracts; In-House Private Clouds and One-Stop Resources and Services to deliver educational services. There will be detailed descriptions about Business Models and their examples and business cases.

2.1 How these business models help organisations for Cloud adoption

Having the winning strategies also greatly influences decision-makers from traditionally non-cloud organisations. Wolfram is a computational firm providing software and services for education and publishing, and it has considered adopting “Support and Services Contracts”, the second business model (HPC in the Cloud, 2010). Upon seeing revenues in iPhone and iPad, they added a new model, the eighth model, by porting their applications onto iPhone and iPad. Similarly MATLAB, adopted the first and

second model, and began the eighth model by porting their application to iPhone and iPad in order to acquire more income and customers. There were start-ups such as Parascale using the seventh model to secure their funding, and they adopted the first model by being an IaaS provider. They moved onto the second model to generate more revenues. The National Grid Service (NGS) has used the sixth model to secure funding, and their strategy is to adopt the fifth model by becoming the central point to provide IaaS cloud services for the UK academic community. Facebook has used multiple business models, the first, seventh and eighth model to assist their rapid user growth and business expansion.

Guy's and St Thomas' NHS Trust (GSTT) and Kings College London (KCL) spent their funding on infrastructure and resources to deliver a PaaS project. Knowing that outsourcing would cost more than they could afford financially with possibility in project time delays, they decided to use the third business model, "In-House Private Clouds", which matched to cost-saving, a characteristic of Cloud. They divided this project into several stages and tried to meet each target on time. In contrast, there was another NHS project with more resources and funding, and they opted for vendors providing the second and forth business models, "Support and Service Contract" and "All-in-One Enterprise Cloud".

Multiple uses of business models are useful for Cloud-adopting organisations. An example is Facebook, which adopts the first, seventh and eighth model, and have seen growth rate of active users begun in 100 millions to more than 500 millions between Year 2008 and 2010 (Sullivan, 2010). Another example is Microsoft, which adopts the first and fourth business model, and they plan providing other service models such as the fifth and eighth to maximise their sources of revenue and maintain the competitive status.

2.2 Education as a Service – multiple uses of Business Model

The year 2012 is a challenging year for UK academic institutions due to the rise of annual tuition fees from £3,350 to approximately £9,000 for each UK and EU student. The level of funding and support have been shifted from the government support model to the university independence model where each university should find additional funding itself to support academic programmes and research projects (Guardians, 2011, 2012). This makes universities look for additional funding and to transform the way higher education content and activities are delivered, so that students can perceive as values for such a fee rise. Transformation includes the way the higher education content and activities are delivered as a value-added service which can highlight the strengths in each university, improve learning efficiency and integrate different learning activities and outcomes. The new term is called Education as a Service (EaaS), which can offer the followings:

- A blended learning (Ginns and Ellis, 2007; Samarawickrema and Stacey, 2007) environment to allow students learning from face-to-face lectures and tutorials, and online resources such as videos, games and simulations.
- A platform to integrate different learning resources and to encourage students with peer learning and interactions with tutors.

EaaS requires a unique strategy and the multiple uses of business models can help to achieve this goal. This includes the use of suitable business models such as:

- Support and Services Contracts (second model): A small number of projects can be outsourced to selected vendors.
- In-House Private Clouds (third model): A few projects can be done in-house.
- One-Stop Resources and Services (fifth model): Working with central IT services and joint project with another department, Cloud-based services and initiatives can start from a central place which offers resources, advice and training.
- Government funding (six model): European and UK government funding offers several Cloud projects.

- Venture capitals (seventh model): Additional funding from industry and external collaborators are in place.
- Entertainment and Social Networking (eighth model): Cloud services should have online forum and functionalities similar to social networking to encourage peer learning and ensures students are on learning activities when they are online.

EaaS includes these business models to ensure the maximum Return on Investment (ROI) can be achieved, which Chang et al (2011 e) demonstrate the benefits of Cloud adoption for the University of Southampton, and ROI include cost-saving and improvement in services and user satisfaction. This helps universities to sustain their business model and also enhance the quality of education in the use of Cloud Computing. In this paper, all Cloud projects are designed, deployed and serviced based on EaaS and demonstrations include technologies and activities for e-Procurement and supply chain.

3. THE PAIR OF THE HEXAGON MODELS

The origins of the Hexagon Model are from Sun Tzu's Arts of War which Chang et al. (2010 b; 2011b) demonstrate the use of the Hexagon Model (Business Model, strategic focus) to review Cloud business performance against six success criteria. Another Hexagon Model (IT Services, operational focus) can be used to review service performance (Hosono et al. 2009, Chang, 2010 b). This pair of the Hexagon Model can be used for any Cloud projects, providing managers and stake holders a quick review of the project performance. In addition, the pair of the Hexagon Model is related to the CCBF by providing the bridge between qualitative and quantitative Cloud research methods. For example, if a project is difficult to measure its ROI, the pair of the Hexagon Model can be used to measure the performance of each success criteria and the area occupied within the Hexagon Models can indicate a business or a project's strengths and weaknesses visually for decision-makers.
Success criteria include the followings:

- Popularity, investors, valuation, innovation, consumers and get-the-job-done (GTJD) for the Hexagon Model with Business Model focus. These six elements are supported by Anderton (2008); Waters (2008); Hull (2009).
- Usability, performance, portability, security reliability and scalability for the Hexagon Model with IT Services focus. These six elements are supported by Hosono et al. (2009, 2010).

3.1 The Overview for Cloud adoption at University of Greenwich (UoG)

University of Greenwich (UoG) started Cloud adoption since 2010 in the following IT initiatives:

- The e-Procurement project: It allows procurement activities from different departments to take place on a central platform where different products, services and suppliers can be selected. Users include Procurement Manager, Director of Resources and Finance officers from each School.
- Oracle development for Supply Chain and business process: Enterprise Oracle software was installed and used to demonstrate the concept of supply chain, operation management and business process. It was used in lectures and tutorials to demonstrate how they can work.
- Sharepoint 2007 and 2010 projects: Sharepoint 2007 has been developed to serves as a digital repository, and is offering automated administrative process to improve efficiency and reduce the level of printing. Migration to Sharepoint 2010 can improve the existing functionality, but can integrate different and more services than Sharepoint 2007. Additional features for Sharepoint 2010 can cope with increasing demands. Active users are all members of staff who have different levels of administrative duties.
- Media server project: It allows improves learning services for members of staff and students, and offers a platform to upload, share and review video clips related to teaching, learning and research. Active users are some academic staff and their students.

3.2 The Hexagon Model (Business Model) Review for Cloud adoption (University of Greenwich)

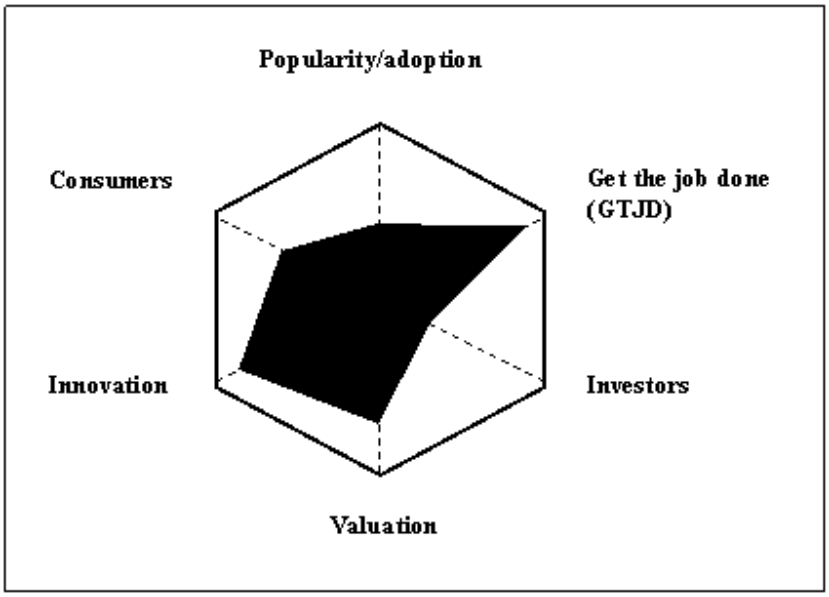


Figure 1. The Hexagon Model (Business Model) for University of Greenwich

Figure 1 shows the Hexagon Model (Business Model) for University of Greenwich. Each of six elements are assessed and marked (Chang et al., 2010 b; Chang 2011 a). The area occupied by the shaded region shows the overall performance of the project. Brief explanations are as follows. Innovation and GTJD score very highly because these initiatives have unique designs to ensure requirements are met. Projects are served for its purpose, which integrates different resources and provides a platform for students to learn and share. Simulations or workflows are provided to simplify complex processes which can be presented in a way that students can understand with ease. This also ensures valuation of these Cloud projects is high. In addition, the student feedback on simulation and workflow demonstrations is rated highly, and thus consumers are marked in a good score. There are two issues. Firstly, some features in the Cloud projects are not as easy to use, since it requires specific knowledge and training prior using these initiatives. Secondly, some of these projects are not getting stake holders and investors financial support. These two issues make the score for popularity and investors lower. Communication and funding availability are important factors to make overall scores better.

3.3 The Hexagon Model (IT Services) Review for University of Greenwich

Figure 2 shows the Hexagon Model (IT Services) for University of Greenwich. These six elements are assessed and the area occupied by the shaded region shows the overall performance. Performance, Portability, Reliability and Scalability are high to reflect the strengths of these services. Security is good as there are security technologies and measure in place. Usability is lower because some systems are not entirely open.

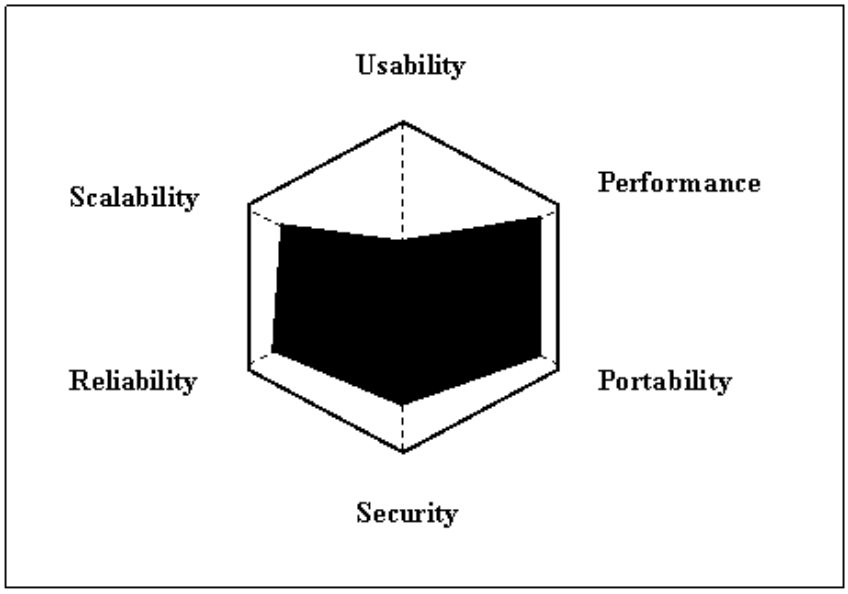


Figure 2. The Hexagon Model (IT Services) for University of Greenwich

3.4 Supply Chain Business Models in the Education domain

Section 2 and Section 3 explain the significance of Business Models and present how EaaS can be delivered as multiple uses of Business Models. There is an increasing demand in higher education to adopt the emerging technologies and concept for various benefits such as motivating more students, improving quality of higher education, making teaching more interesting and enhancing the opportunities for funding and collaboration (Chang 2003; 2006;Zhou et al., 2008; Chang et al., 2011 e). Therefore, it becomes apparently important to demonstrate new business model for higher education. Supply Chain Business Model is proposed to meet this demand, and it consists of using private cloud to demonstrate supply chain teaching and delivery, where Section 4 and 5 have more to discuss.

4. THE USE OF OPEN SOURCE ORACLE FOR TEACHING

Introduction to Business process at UoG is a subject with emphasis in operation management, supply chain management and marketing. Management of Information Systems (MIS) at UoG is a subject introducing different aspects of IS to explain how it can be useful and adopted by organisations, which include technological, economical, social, political and cultural factors. Teaching has become more challenging since different concepts and different subject areas have to be taught to different levels of students who are from different backgrounds and expectations. There is an IT initiative to adopt IT systems to enhance teaching, where the major benefits include “Simulations of business processes and supply chain management can be used for effective teaching” (Zhou et al., 2008). Details are discussed in Section 4.1 to demonstrate how Oracle can be used for supply chain in the private cloud.

4.1 Demonstration of Supply Chain

Candido et al. (2009) propose SOA approach for Supply Chain, and review a number of research papers and analysis. They explain two models, Orchestration and Choreography, and compare their strengths and weaknesses. Drawbacks for these two models are summed up in terms of orchestration and choreography:
Orchestration (use a centrally control set of workflow logic to facilitate integration or interoperability of two or more applications):

- No horizontal interaction by definition

- Use middleware and a device is always a “slave” in a master-slave model.
- No particular research challenge.

Choreography (a schema or process to set up an organized collaboration between different distributed services, without any other entity controlling the collaboration logic):

- Need to distribute the workflow logic to all involved devices, although less complex.
- No consensus about possible solution, such as within industrial automation scope.
- Possible network traffic boost when a large number of services are connected and active
- Difficult to scale to large and complex applications.

The use of Cloud can minimise these two drawbacks and offer more opportunities to offer better delivery of supply chain education and supply chain business model (Chang et al., 2011 e; 2011 f; 2012; Leukel, J., Kirn, S. and Schlegel, 2011). This explains the importance of adopting the right technologies. The use of Supply Chain in SOA-based Private Cloud enabled by Oracle technologies offer improvements, which are described as follows. It offers any processes the ability to link to the next related phase, and also report to the correct application or department. The use of middleware or Web Services is optional, and even where they are in use, it is an open and free linkage-oriented model which has horizontal and vertical connections. Supply Chain can be demonstrated by simulations done by Oracle software to show the relationship between goods, services, suppliers, distributors and consumers. See Figure 3 for the example to demonstrate coffee supply chain network between South America and different states in the America.

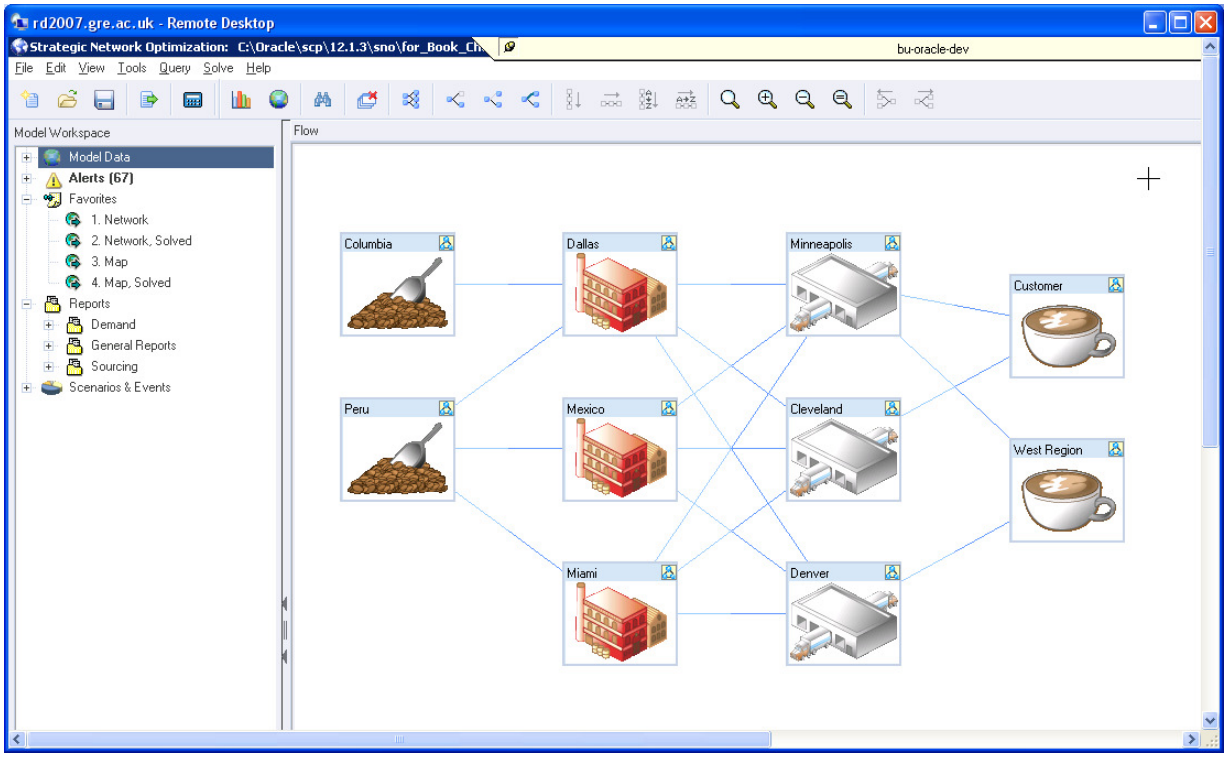
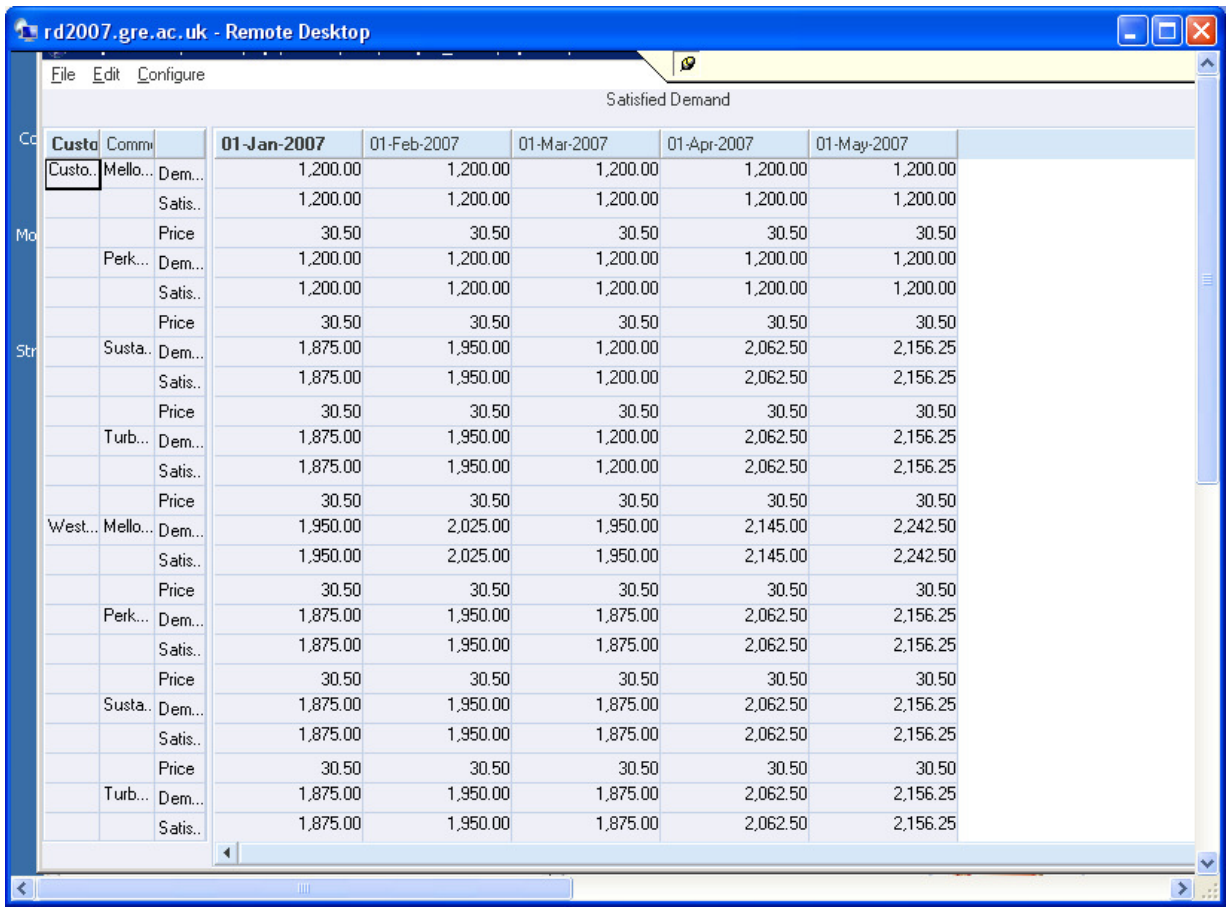


Figure 3. Coffee supply chain network between South America and different states in the US

Oracle provides a platform to demonstrate visually how supply chain distribution can work, and explains relationships between different sites, where cash flow, goods, demands and supplies can be checked and monitored in a private cloud environment. Supply chain distribution in Figure 4 can calculate accounting and cash flow between different suppliers, distributors and customers. It offers reporting functionality to

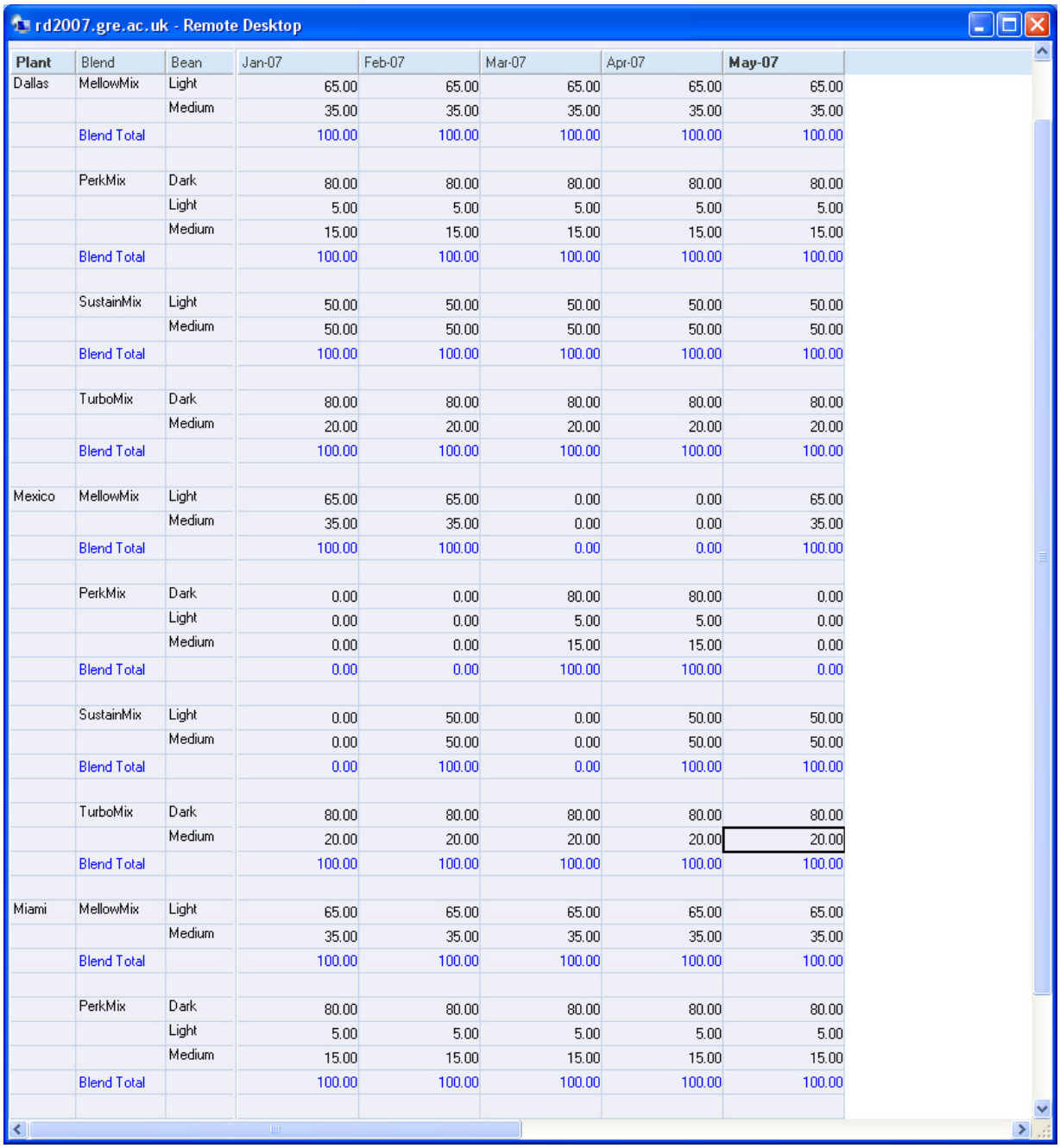
display all the cash flow in each entity and between two entities by clicking the object (entity) on the screen. Figure 5 shows an example of the cash flow in the distribution network between customers and suppliers between January and May 2007.



Custo	Comm		01-Jan-2007	01-Feb-2007	01-Mar-2007	01-Apr-2007	01-May-2007
Custo..	Mello...	Dem...	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
		Satis..	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
		Price	30.50	30.50	30.50	30.50	30.50
	Perk...	Dem...	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
		Satis..	1,200.00	1,200.00	1,200.00	1,200.00	1,200.00
		Price	30.50	30.50	30.50	30.50	30.50
	Susta..	Dem...	1,875.00	1,950.00	1,200.00	2,062.50	2,156.25
		Satis..	1,875.00	1,950.00	1,200.00	2,062.50	2,156.25
		Price	30.50	30.50	30.50	30.50	30.50
	Turb...	Dem...	1,875.00	1,950.00	1,200.00	2,062.50	2,156.25
		Satis..	1,875.00	1,950.00	1,200.00	2,062.50	2,156.25
		Price	30.50	30.50	30.50	30.50	30.50
West...	Mello...	Dem...	1,950.00	2,025.00	1,950.00	2,145.00	2,242.50
		Satis..	1,950.00	2,025.00	1,950.00	2,145.00	2,242.50
		Price	30.50	30.50	30.50	30.50	30.50
	Perk...	Dem...	1,875.00	1,950.00	1,875.00	2,062.50	2,156.25
		Satis..	1,875.00	1,950.00	1,875.00	2,062.50	2,156.25
		Price	30.50	30.50	30.50	30.50	30.50
	Susta..	Dem...	1,875.00	1,950.00	1,875.00	2,062.50	2,156.25
		Satis..	1,875.00	1,950.00	1,875.00	2,062.50	2,156.25
		Price	30.50	30.50	30.50	30.50	30.50
	Turb...	Dem...	1,875.00	1,950.00	1,875.00	2,062.50	2,156.25
		Satis..	1,875.00	1,950.00	1,875.00	2,062.50	2,156.25

Figure 4. Reporting functionality to show cash flow in the distribution network between customers and suppliers between January and May 2007

Supply Chain distribution can show the Demand functionality in each supplier. Upon clicking each object (entity), it shows the report for Demand. This is useful for customers and suppliers to keep track of supply-demand relationship and understand any changes in the order and consumer behaviour. Figure 5 is the screenshot with details about different product demands between January and May 2007.



Plant	Blend	Bean	Jan-07	Feb-07	Mar-07	Apr-07	May-07
Dallas	MellowMix	Light	65.00	65.00	65.00	65.00	65.00
		Medium	35.00	35.00	35.00	35.00	35.00
	Blend Total		100.00	100.00	100.00	100.00	100.00
	PerkMix	Dark	80.00	80.00	80.00	80.00	80.00
		Light	5.00	5.00	5.00	5.00	5.00
		Medium	15.00	15.00	15.00	15.00	15.00
	Blend Total		100.00	100.00	100.00	100.00	100.00
	SustainMix	Light	50.00	50.00	50.00	50.00	50.00
		Medium	50.00	50.00	50.00	50.00	50.00
	Blend Total		100.00	100.00	100.00	100.00	100.00
	TurboMix	Dark	80.00	80.00	80.00	80.00	80.00
		Medium	20.00	20.00	20.00	20.00	20.00
	Blend Total		100.00	100.00	100.00	100.00	100.00
Mexico	MellowMix	Light	65.00	65.00	0.00	0.00	65.00
		Medium	35.00	35.00	0.00	0.00	35.00
	Blend Total		100.00	100.00	0.00	0.00	100.00
	PerkMix	Dark	0.00	0.00	80.00	80.00	0.00
		Light	0.00	0.00	5.00	5.00	0.00
		Medium	0.00	0.00	15.00	15.00	0.00
	Blend Total		0.00	0.00	100.00	100.00	0.00
	SustainMix	Light	0.00	50.00	0.00	50.00	50.00
		Medium	0.00	50.00	0.00	50.00	50.00
	Blend Total		0.00	100.00	0.00	100.00	100.00
	TurboMix	Dark	80.00	80.00	80.00	80.00	80.00
		Medium	20.00	20.00	20.00	20.00	20.00
	Blend Total		100.00	100.00	100.00	100.00	100.00
Miami	MellowMix	Light	65.00	65.00	65.00	65.00	65.00
		Medium	35.00	35.00	35.00	35.00	35.00
	Blend Total		100.00	100.00	100.00	100.00	100.00
	PerkMix	Dark	80.00	80.00	80.00	80.00	80.00
		Light	5.00	5.00	5.00	5.00	5.00
		Medium	15.00	15.00	15.00	15.00	15.00
	Blend Total		100.00	100.00	100.00	100.00	100.00

Figure 5. Different product demands between January and May 2007

The use of Cloud technologies for Supply Chain helps to motivate students and improve their learning satisfaction, and details are in another Section.

4.2 Students' learning satisfaction

Students feel more motivated and interested in learning and undertaking coursework. This may help to improve efficiency and enhancing the student's learning experience (Klassen and Willoughby, 2003; Nix, 2004; Zhou et al., 2008). The use of open source Oracle e-Business applications is an IT initiative to meet both criteria. Virtual servers have been allocated where the virtual machines can be used to install

different versions and application suite. There is a virtual server specifically used for that purpose and is installed with Oracle e-Business suite that shows some examples of supply chain management. Workflows and business process technologies are used to demonstrate supply chain and operation management. Students feel they can understand much better. To demonstrated the effectiveness of using simulation in a lecture, two cohorts at the UoG where both given the same lecture on supply chain management. Each cohort received two lessons, where one was focused on supply chain and operation management theories and case studies without software demonstration. The other lesson contained class-based teaching and software simulations. Each time their feedback was collected and learning satisfaction was rated by students in terms of percentages. The learning satisfaction with and without Oracle simulations was recorded and compared. Results are presented in Figure 6 below.

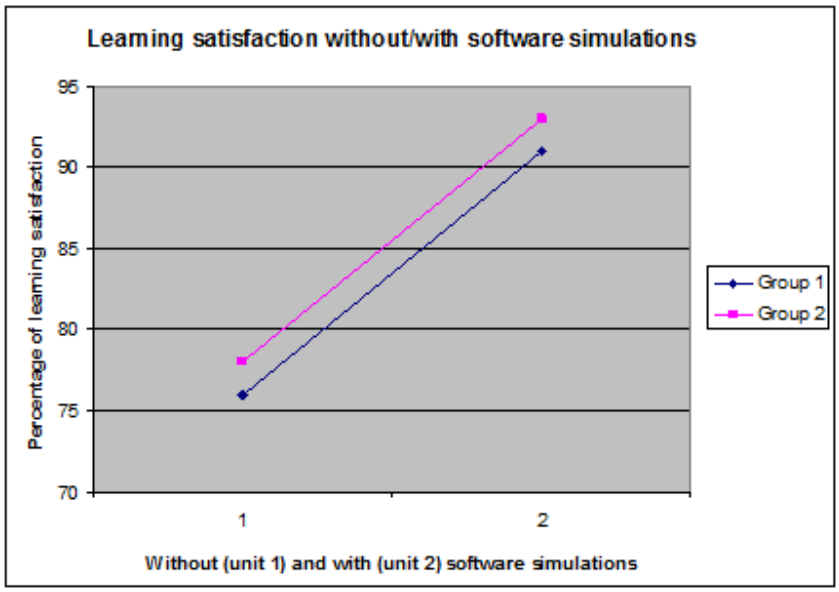


Figure 6. Learning satisfaction without/with software simulations

Learning satisfaction for Group one was 76% on average without software simulations and was raised to 91% with software simulations. Similarly, learning satisfaction for Group two improved from 78% to 93% when software simulations were included. Some feedback suggested that students can pay more attention and can understand some complex theories much better with the aid of software simulations. Two groups of cohort studies conform there is 15% improvement in learning satisfaction. Details are presented in Section 4.2.1. Students could understand better the management of a supply chain and they could articulate what they learned well. This is particularly helpful for lecturers' perspective to enhance students' learning experience and students felt they had a greater sense of learning satisfaction when they could understand the topics of discussions in lectures and tutorials. Another round of surveys will take place to see if the knowledge they have learnt and experience they had remains. The next few sub-sections describe the effective use of blended learning, which is the combination of class-based teaching and online/IT learning.

4.2.1 Statistical analysis for two cohorts

There are two cohorts taking part in this case study. The first group has sixteen students where an hour lesson was taught without simulations and another similar lesson was taught with the aid of simulations to help explaining complex theories. Rating for learning satisfaction for each student was recorded and results are computed by STATA 11 and are recorded in Figure 7. The first variable is "group1_without_simu" which refers to learning satisfaction without simulation and the second variable

is “group1_with_simu” which means learning satisfaction with simulation. Their detailed statistics are broken down, where “group1_without_simu” has a mean of 76, standard deviation of 3.596294, variance of 12.93333, Skewness 0.0977015 and Kurtosis of 2.566904. Second variable, “group1_with_simu”, has a mean of 91, standard deviation of 3.405877, Variance of 11.6, Skewnes -0.7528698 and Kurtosis of 2.8696.

Variable	Observations	Mean	Std. Dev.	Min	Max
group1_without_simu	16	76	3.596294	70	83
group1_with_simu	16	91	3.405877	83	95

Variable: group1_without_simu

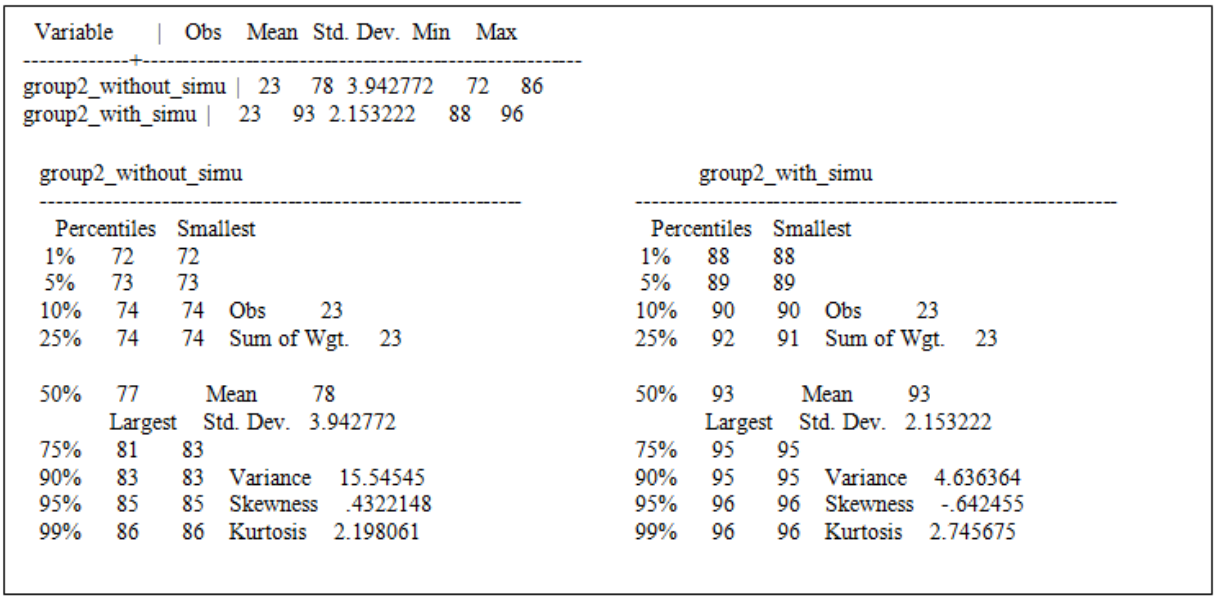
	Percentiles		Smallest	
1%	70	70		
5%	70	70		
10%	70	73	Obs	16
25%	74	74	Sum of Wgt.	16
50%	76		Mean	76
		Largest	Std. Dev.	3.596294
75%	78	78		
90%	81	80	Variance	12.93333
95%	83	81	Skewness	.0977015
99%	83	83	Kurtosis	2.566904

Variable: group1_with_simu

	Percentiles		Smallest	
1%	83	83		
5%	83	87		
10%	87	88	Obs	16
25%	88	88	Sum of Wgt.	16
50%	92		Mean	91
		Largest	Std. Dev.	3.405877
75%	93	93		
90%	95	95	Variance	11.6
95%	95	95	Skewness	-.7528698
99%	95	95	Kurtosis	2.8696

Figure 7. Statistical summary of first cohort computed by STATA 11

The second group has thirty three students where an hour lesson was taught without simulations and another similar lesson was taught with the aid of simulations to help explaining complex theories. Rating for learning satisfaction for each student was recorded and results are computed by STATA 11 and are recorded in Figure 8. The first variable is “group2_without_simu” which refers to learning satisfaction without simulation and the second variable is “group2_with_simu” which means learning satisfaction with simulation. Their detailed statistics are broken down, where “group2_without_simu” has a mean of 78, standard deviation of 3.942772, variance of 15.54545, Skewness 0.4322148 and Kurtosis of 2.745675. Second variable, “group2_with_simu”, has a mean of 93, standard deviation of 2.153222, variance of 4.636364, Skewnes –0.642455 Kurtosis of 2.745675.



Variable	Obs	Mean	Std. Dev.	Min	Max
group2_without_simu	23	78	3.942772	72	86
group2_with_simu	23	93	2.153222	88	96

group2_without_simu

Percentiles		Smallest		
1%	72	72		
5%	73	73		
10%	74	74	Obs	23
25%	74	74	Sum of Wgt.	23
50%	77		Mean	78
	Largest		Std. Dev.	3.942772
75%	81	83		
90%	83	83	Variance	15.54545
95%	85	85	Skewness	.4322148
99%	86	86	Kurtosis	2.198061

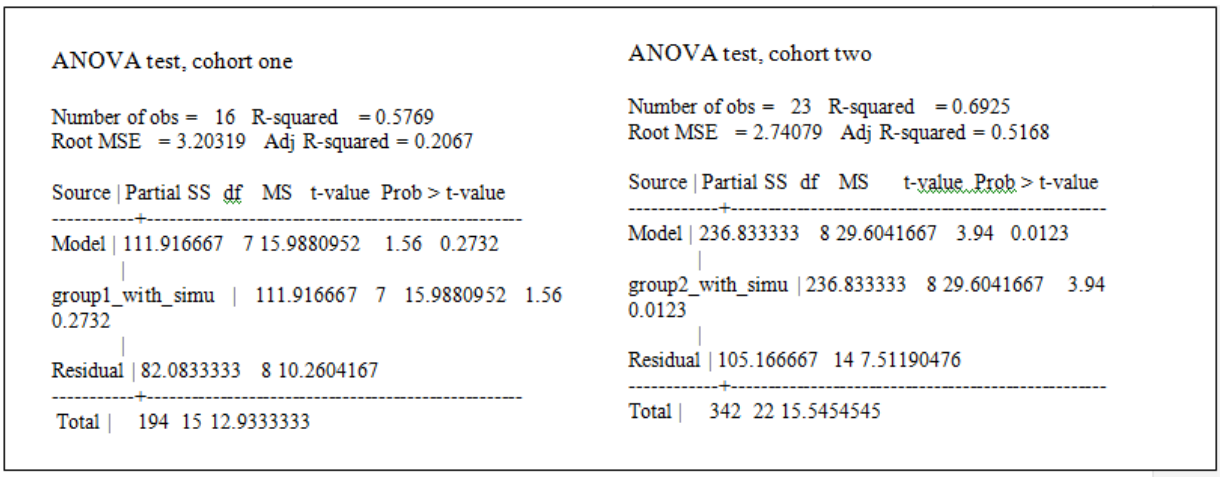
group2_with_simu

Percentiles		Smallest		
1%	88	88		
5%	89	89		
10%	90	90	Obs	23
25%	92	91	Sum of Wgt.	23
50%	93		Mean	93
	Largest		Std. Dev.	2.153222
75%	95	95		
90%	95	95	Variance	4.636364
95%	96	96	Skewness	-.642455
99%	96	96	Kurtosis	2.745675

Figure 8. Statistical summary of second cohort computed by STATA 11

4.2.2 Analysis of variance (ANOVA)

Analysis of variance (ANOVA) provides statistical test of whether means of several groups are equal and can generalise t-test to two or more groups (Stevens, 2002). ANOVA can be used when these two cohorts have close means and each group has two sets of data. Figure 9 shows the ANOVA with t-test for Cohort one and two. Cohort one has t-value = 1.56 and Prob > t-value is 0.2732. Cohort two has t-value = 3.94 and Prob > t-value is 0.0123.



ANOVA test, cohort one

Number of obs = 16 R-squared = 0.5769
Root MSE = 3.20319 Adj R-squared = 0.2067

Source	Partial SS	df	MS	t-value	Prob > t-value
Model	111.916667	7	15.9880952	1.56	0.2732
group1_with_simu	111.916667	7	15.9880952	1.56	0.2732
Residual	82.0833333	8	10.2604167		
Total	194	15	12.9333333		

ANOVA test, cohort two

Number of obs = 23 R-squared = 0.6925
Root MSE = 2.74079 Adj R-squared = 0.5168

Source	Partial SS	df	MS	t-value	Prob > t-value
Model	236.833333	8	29.6041667	3.94	0.0123
group2_with_simu	236.833333	8	29.6041667	3.94	0.0123
Residual	105.166667	14	7.51190476		
Total	342	22	15.5454545		

Figure 9. ANOVA test for cohort one and two

4.2.3 The use of blended learning

Blended learning uses video, web-based materials and class-based teaching makes learning more interesting and effective, where there are reports of added values offered by blended learning (Ginns and Ellis, 2007; Samarawickrema and Stacey, 2007). In my other course, blended learning has been used and students find it interactive to learn and share. They can keep their learning progress up-to-date and can develop learning culture and peer learning with the assistance of Web 2.0 technologies. In addition, the

benefits of e-Learning and blended learning are observed when the students' motivation and their learning interests have increased (Freeman and Capper, 1999). Strengths of blended learning are summed up in Table 1.

Table 1. Strengths of blended learning (Horton, 2000; Chang 2003)

Advantages	Descriptions
1. Blended learning saves costs	Saves 40-60% of the expense of training by traditional means. Savings include (1) travel expenses; (2) facilities and supplies costs; (3) administrative costs; (4) salaries and (5) lost opportunity costs.
2. Blended learning improves learning	• Blended learning uses learning technologies that assist students and trainees towards learning. • The interactions between peers and instructors can 'activate learners'. • Blended learning exposes learners to real-world data, which saves learners time in searching information and also assists learners analysing large collections of data. • Blended learning provides a more in-depth learning experience.
3. **Extra advantages for learners**	• Learners can get the best instruction available. • Training occurs "just in time". • Learners set the pace and schedule. • Learners can have better access to instructors. • Training adapts to the learning styles. • Blended learning produces positive effects.
4. **Extra advantages for instructors**	• Instructors can teach from different locations. • Instructors travel less. • Course content can be dynamic.
5. **Extra advantages for organisations**	• Blended learning delivers high-quality training, including training around the globe without travel or minimum travel. • Blended learning creates valuable learning resources.

4.2.4 Extent of interactions in learning and assessment

I have another class which adopts blended learning as part of curriculum where feedback has been collected. Figure 10 shows results, where 45% of them strongly agree blended learning is useful for their learning and assessment, 30% agree, 25% stay neutral and 0% disagree. Some of those 25% of students are the ones who seldom attend class and online participation.

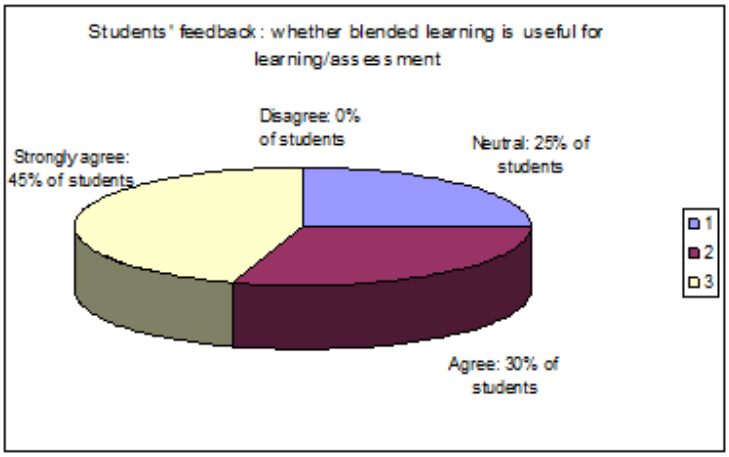


Figure 10. Students' feedback: whether blended learning is useful for their learning and assessment

Based on students' feedback, the degree of interactivity is another highlight of the present effective blended adoption. The purpose of getting a high degree of interactivity in blended learning is to strengthen the ease of communications and knowledge sharing among learners and instructors, eventually leading to improvement in learning efficiency. When students have questions, they get feedback from tutors. Peer blended learning allow them to improve on the quality of work based on genuine feedback they receive (Chang, 2003; Ginns and Ellis, 2007; Samarawickrema and Stacey, 2007). Peer blended learning ensures they feel motivated and rewarding to learn and share.

5. STRATEGIC PLAN OF ADOPTING ENTERPRISE SOFTWARE SUCH AS SAP

The motivation is similar to Section 4 except most of Business School members of staff at UOG do not come from technical IT backgrounds and the use of open source software is time consuming to fix issues and errors. The use of enterprise solution is acknowledged and supported by recent review programme since it helps improving quality of teaching and learning efficiency. Another reason is when students are equipped with skills in the enterprise software, it improves their employability since they are relevant skills for industry. This is another IT initiative (strategy focus for Business School) to acquire the right software for teaching, where a number of them such as SAP and commercial options will be proposed. The management decides the use of SAP can meet their strategic goals briefly as follows.

Curriculum:

- ERP software skills expected from graduates today
- Students demand teaching of ERP software
- Using SAP software leads to competitive advantages for study programs

Cost:

- Hosting of SAP software more cost-effective than self-hosting
- High-quality SAP system operations and support
- Maintenance

Quality:

- Competence Center approach
- Development of curriculum material
- Fast problem solving through problem solution database
- High service level quality.

5.1 The new Supply Chain Business Model in the higher education domain

The SAP enterprise architecture can enhance the quality of higher education and offer the proposed "Supply Chain Business Model" where Education as a Service (EaaS) can be delivered by UoG Business School. Joint collaboration between Business School and School of Engineering of UoG is in place to ensure courses offered by SAP can be fully utilised for undergraduate and postgraduate training, which also promote transferrable skills in the higher education. The logistics programme suite in Business School is focused on the specialisation of supply chain management. There are the SAP Distributed Requirement Planning (DRP) and SAP Fulfilment packages which focus on SCM and the decision is to take on two SAP modules, which are Fulfilment and DRP. More courses can be added on later on. Collaboration with SAP based in Munich can ensure instructor training is provided so that academic staff can be well-equipped with up-to-date skills and knowledge.

Although the first two courses offered are related to e-Logistics, new courses are likely to be developed jointly with SAP. There are different services under its enterprise architecture which include:

- Customer Relationship Management (CRM): a service and tool to manage relationship and interactions between clients, stakeholders and sales. It can be used for marketing, business development, customer service and support.

- Supplier Relationship Management (SRM): a service and tool to work collaboratively with suppliers and to get the knowledge about their stock, pricing and update.
- Supply Chain Management (SCM): a service and tool to manage a network of interconnected businesses involved in the provision of products and services required by customers.
- Product Lifecycle Management (PLM): a service and tool to manage the process of the entire lifecycle of a product from its conception, through design and manufacture, to service and disposal.
- Enterprise Resource Planning (ERP): a service and system to integrate internal and external information management systems across the entire organisation. This may include integration of some functionality described above.

All these services can be jointly integrated and used in a central platform, the SAP Business Suite and enterprise architecture (Krcmar, 2011). EaaS should contain all these services. Using SAP rather than Oracle can achieve the following two benefits:

- Learning satisfaction can offer an additional of 15% as described in a previous section.
- More time and effort can be focused on curriculum development rather than troubleshooting in the case of using Oracle.

5.2 Staff development and service development of SAPious section

A workshop was organised in April 2012 to help staff members to get familiar with SAP which had around 95% of participant satisfaction rate. Advanced user such as the lead author was involved in architecture development. SAP is useful for staff development since academic staff can learn new skills and update their existing skills. It ensures staff can understand how EaaS service such as SAP can allow them to use CRM, SRM, SCM, PLM and ERP efficiently. When the staff members become competent in the use of SAP, they can teach their students to understand how to use software to get their jobs in CRM, SRM, SCM, PLM and ERP done. Acquiring skills relevant to industry, it helps students having a better employability perspective (Krcmar, 2011). When some of staff members have the competent skills and plan to upgrade their skills as a developer/architect, they can learn the back-end technologies and relevant computer languages to modify functionality in SAP. This includes performance optimisation and tuning, which allows SAP to take on more jobs/services, or complete the jobs/services much faster, or both of these.

6. DISCUSSIONS

UoG case study has demonstrated how Cloud Computing can be used as a Business Model and an innovation for modern Higher Education. This includes the use of technologies to improve education and the way education content and activities are delivered, including Moodle, GradeMark, media streaming, video-conferencing and mobile learning. Success elements include technological, social, economic, political, cultural and environmental factors centred on Cloud Computing Education. This leads us into the proposal in EaaS, where education content and activities can be delivered and accessible to learners and students, who can demonstrate they meet their learning criteria and tutors can monitor their progress. There are four issues for discussions.

6.1 The role of CCBF for Supply Chain, e-Procurement and other IT projects

The role of CCBF is strategic in directing the right direction that EaaS is heading into and providing support and assistance to offer a good Cloud Education design, deployment and services including the followings:

- Consolidate existing resources and services. Ensure Business Model integrate with EaaS.

- Design of new curriculum and development of existing curriculum including the use of simulations for teaching.
- Continuously improvement in the way learning and teaching is delivered. Investigate new ways to get students motivated in learning and to improve their academic performance.

6.2 Oracle and SAP: SAP is more suitable for Business School of UoG

Section 4 presents a case study for Oracle development used for teaching and the effectiveness in demonstrating supply chain distribution, cash flow and demands between different entities. Section 5 presents strategic plans of adopting SAP for undergraduate and postgraduate training and benefits of such adoptions. Both are usable for Supply chain management and course delivery. However, their differences can determine suitability for Business School. The summary is presented in Table 2.

Table 2. Oracle and SAP supply chain software comparisons

Oracle	**SAP**
Software is provided without support. Support and training comes to an additional cost. Supply chain software – the orientation and content is more suitable for those with technical backgrounds. More time is spent on development and making software to work.	The entire package such as software, support and training is provided at an agreed price. Supply chain software – the orientation and content is more suitable for business analysts. More time can be focused on content development and delivery of course. Support team can take care of technical issues.

Comparisons in Table 2 demonstrate that SAP is more suitable for Business School to adopt since more focus can be spent on content development and delivery of the course rather than development of software-related work. The content can be customised for students who desire to work as business analysts upon graduations.

6.3 How to model supply chain in the Cloud

Figure 11 shows the architectural view of how to model supply chain in Cloud from service provider and infrastructure provider perspective. Service provider (Greenwich) accepts Service Level Agreement (SLA) and gets to infrastructure provider (SAP), where they have service management to monitor accounting and billing, SLA protection and service lifecycle management. Once they pass on this, control actions are required to access to monitoring channel, and users can access all Cloud resources. Applications are available in the Cloud resources but the lead architect is required to be involved in programming on Platform as a Service (PaaS) to ensure SAP on Software as a Service (SaaS) are running. Another alternative is to use outsourcing model and contract work to SAP in UK or Germany to achieve the same level, but it is not the model discussed in this paper.

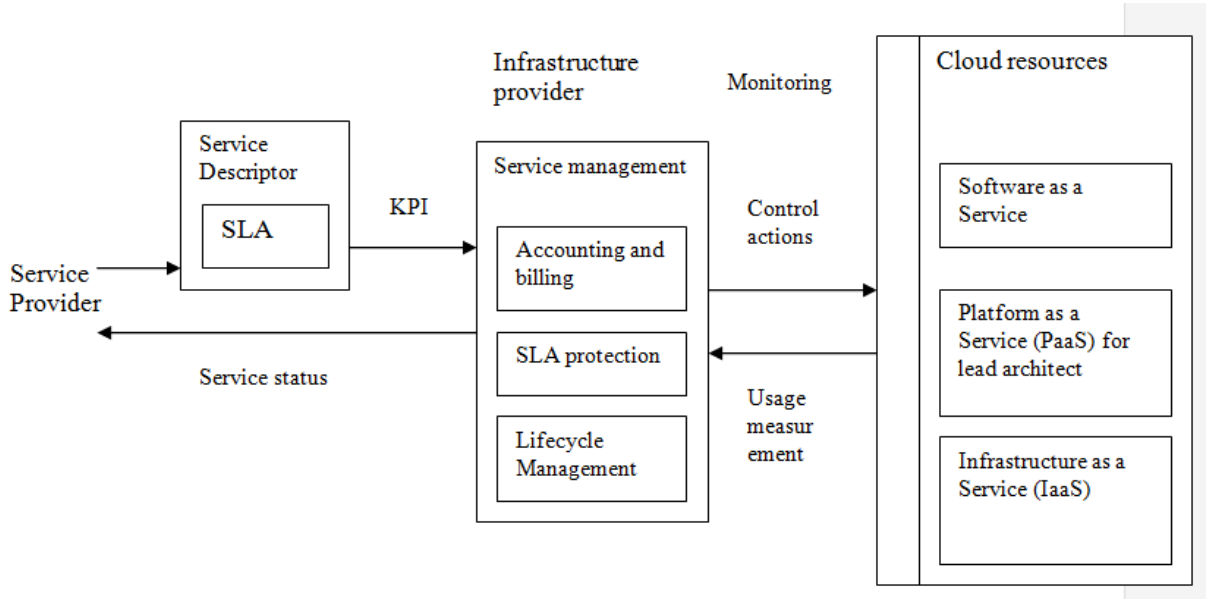


Figure 11. How to model supply chain in the Cloud

6.4 Education as a Service (EaaS) in summary

Section 2 proposes that EaaS has multiple Business Models and Section 3 proposes Supply Chain Business Model that uses private cloud tom demonstrate supply chain teaching and delivery. Section 4 demonstrates EaaS in the form of Oracle software to simulate supply chain distribution and the relationship between different entities, suppliers, distributors and customers. Statistical analysis confirm that the use of simulation for teaching can improve student learning satisfaction by an additional 15% and results show two cohorts agree with this outcome. Section 5 explains the strategic plan of using SAP to meet Business School of UoG education and delivery. SAP enterprise architecture also includes different services such as CRM, SRM, SCM, PLM and ERP. All these examples fully support EaaS can be implemented in the educational environment to provide good quality of services, improve curriculum, reduce costs and improve students' learning satisfaction.

6.5 The use of Hexagon Models for EaaS

Previous sections present the pair of the Hexagon Models with Business Model and IT services focuses to evaluate Cloud project performance. Key criteria are presented in the visual form in the Hexagon which can indicate strengths and weaknesses of overall services. However, they are not just for Oracle and SAP adoption, which are essential part of EaaS at UoG. The strategic plan of using SAP for undergraduate and postgraduate education can improve performance in various key criteria. Based on review meeting and stakeholders' feedback, both Hexagon Models can be used to forecast the likely performance for our EaaS, which curriculum delivery offered by SAP plays a central role.

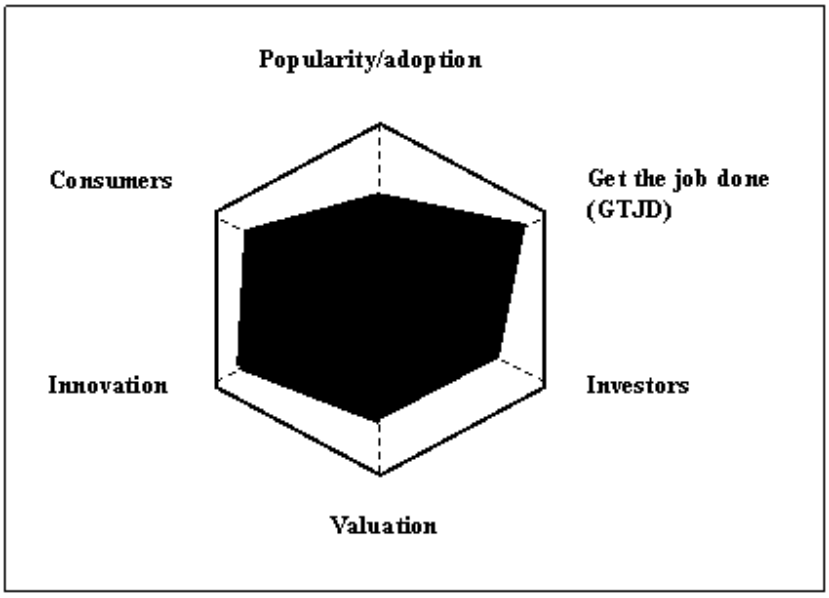


Figure 12. The Hexagon Model (Business Model) to forecast the likely performance for our EaaS

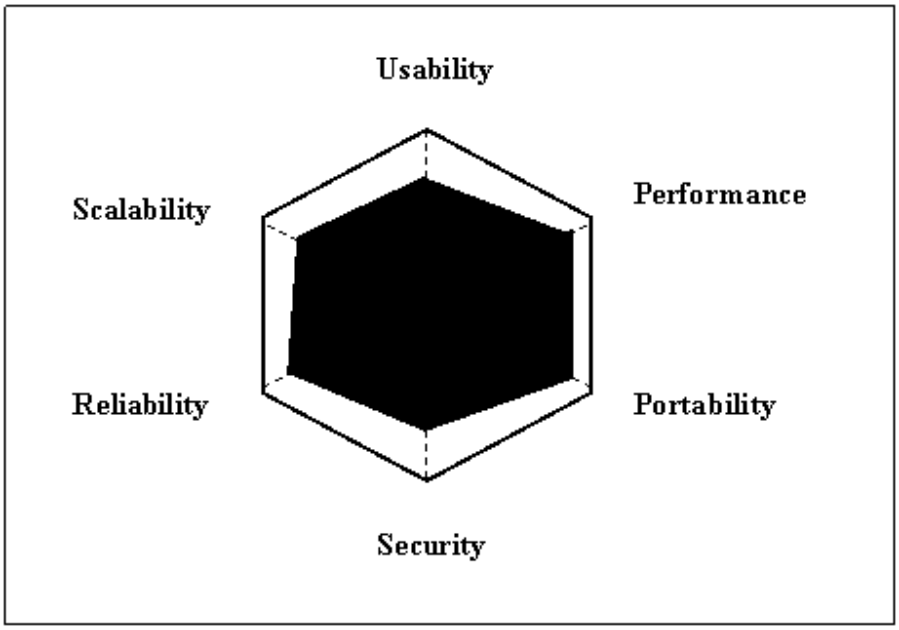


Figure 13. The Hexagon Model (Business Model) to forecast the likely performance for our EaaS

Figure 12 shows the Hexagon Model (Business Model) to forecast the likely performance for our EaaS, where there are significant improvements comparing to Figure 2. Main reasons include the full support from management and the University as the whole, which makes investors and popularity higher. SAP or business analyst software for supply chain is one of the most favourite lists amongst academic staff and students. There will be a slight increase in customers due to improvement in user confidence. Figure 13 shows the Hexagon Model (IT Services) to forecast the likely performance for our EaaS, where the significant improvement is seen on Usability because troubleshooting will be fully supported and staff can focus on teaching and delivery. Chang et al. (2011 b; 2011 c; 2011 d) use quantitative techniques to compute performance forecasting. One major benefit of using both Hexagon Models can make sensible

performance forecasts without the need of detailed quantitative analysis. This ensures any project managers to assess project performance against key criteria.

CONCLUSION AND FUTURE WORK

In UoG case study, we present that Cloud Computing offers a new business model and transforms the way Education is delivered. We use of four step sequence to demonstrate Education as a Service (EaaS), which offers the following benefits:

- Cloud Business Model can integrate with EaaS and consolidate existing resources and services.
- Improves an additional 15% of learning satisfaction in the use of Oracle simulations for teaching supported by statistical analysis. Simulations of business processes and supply chain management can be used as an effective tool for teaching.
- Students feel more motivated and interested in learning and undertaking coursework, enhancing the student's learning experience (Klasen and Willoughby, 2003; Nix 2004). Adoption of blended learning is particularly useful.
- SAP application (part of EaaS) meets strategic plans for Business School and can improve our quality of teaching and suitability of our curriculum to match requirements of job market.

EaaS is a new Supply Chain business model useful for academic institutions such as UoG. Oracle suite has been used to demonstrate supply chain distribution to explain relationship between suppliers, distributors and customers and to help to calculate cash flow and demand/supply. SAP is strategic in EaaS adoption since it can integrate CRM, SRM, SCM, PLM and ERP. SAP is more suitable for Business School since they offer the whole package of software, training and support and staff can focus more on content and delivery rather than troubleshooting. Courses are relevant to train those who pursuit careers as business analysts. The use of Hexagon Models can evaluate all these projects and also Oracle/SAP initiatives in particular, so that performance against key criteria can be assessed in regular periods. Both Hexagon Models are effective to make sensible performance forecast for EaaS, which SAP plays a central role.

The UoG case study can fully support that Education can be further improved for learning and this is particularly important for Universities to adopt Cloud strategies and migration. The CCBF is strategic in directing the right direction that EaaS is heading into and has helped the Universities to achieve good private cloud design, deployment and services while meeting their requirements and challenges. This paper also strongly supports JISC vision of University Cloud adoption which offers key benefits to education and research. Future work will include EaaS case studies and demonstrations, and development of new academic programs and its impacts at UoG.

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KEY TERMS AND DEFINITIONS

Keyword: Education as a Service (EaaS), Simulations for teaching, Supply Chain and Cloud, Hexagon Models, Cloud Computing Business Framework (CCBF).