

Research Paper

Do Chinese Students taking Algebra Courses Perform Better in a Cloud-based or Online Course? A Cross-sectional Comparative Study

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Introduction

Purpose and Significance

The purpose this research is to test whether a cloud education model can be equivalent to the teaching and learning model in efficacy of teaching and learning in a college algebra class in Chinese universities. China is a developing country with the largest population in the world, and access to college education is a critical factor for Chinese youth. Although Chinese universities tend to cost relatively little compared to American ones (e.g., approximately \$1,000-\$2,000 per term), even this cost can prove to be a barrier to Chinese secondary education. Cloud education platforms can be much less expensive to use to provide education, but it is important to make sure the effectiveness that has been shown using the teaching and learning model is preserved when using a cloud education platform.

The advent of cloud computing brought about challenges and opportunities for education. Immediate attempts were made to transform or convert the traditional teaching and learning model to a totally new approach. On one hand, cloud education technology creates the possibilities of sharing resources in the large scale globally and without time restriction. Experts in various fields from all over the world could be integrated into a faculty network to provide excellent teaching resources. In addition, students bored in a traditional classroom may be inspired by the ability for cloud education classes to be experienced at the student's own pace, where the student can

choose when and what online resources available to use. More importantly, the world has changed, and the internet puts much factual information at the fingertips of many people around the world. Cloud education could promote lifelong learning, both within and outside established online educational programs. Because online learning happens “anywhere, anytime”, students develop new patterns of consuming education. As they progress through life, the hope is that as new educational needs are identified (such as the need for an individual to update his/her knowledge of his/her field of expertise), students of cloud education would move forward using online learning to continue to develop. However, how to actually realize these potentials is not clear. First, developing an cloud education curriculum that achieves learning equally or better than the teaching and learning model in the traditional classroom poses a challenge. Some educational approaches, such as a lecture, are easily replicated online, while in-class discussions or activities would need to be modified for cloud education while preserving quality of learning.

Although cloud education is quite common in the United States, it has not been implemented or studied widely in China. Hence, my research will study how an implementation of a cloud education curriculum compares to a traditional implementation in a standardized course in Chinese universities.

Literature Review

Although the Internet has made the digital world seem ubiquitous, not all individuals have access to the same digital world. Cloud education has been a reality in the U.S. and Europe for some time, but challenges exist in countries such as China at

developing this type of infrastructure (Rings et al., 2009). Although China is certainly using cloud computing, the type of educational implementations are limited compared to those in the U.S. Through the U.S. and others' experience with cloud education, much has been learned about its comparison with traditional classroom education, and how to optimize learning online. Further, it has been shown that quality education can take place in a cloud environment at a cheaper rate (Pepper, 1978). For this reason, pursuing the implementation of cloud education in Chinese universities is a worthy cause.

Whether considering China, the U.S., or elsewhere, humankind has entered the “information age”, and communication by way of technology has significantly changed. Based on a report from the Horizon Project (2013), higher education is being deeply affected by new technology. The Horizon Project identified six key technology trends in higher education such as tablet computing, massively open online courses, games and gamification, learning analytics, 3D printing, and wearable technology (Horizon Project, 2013). As the era of Web 2.0 came about, the philosophies and technologies of Web 2.0 were disseminated and applied widely. In the higher education field, this shifted the concepts of how the teaching and learning model should be applied. The cloud education model of teaching and learning emphasizes not only the acquisition of knowledge, but also improvement of skills necessary to make use of resources available online. The online student is forced to learn how to look for, select, and use the online resources necessary forward his or her own personal learning. As long as the internet is available, these skills are transferable to lifelong learning. Students with these skills will be likely

to continue learning throughout life without the restrictions of location and time (Owen, Grant, Sayers & Facer, 2006).

In China, the trends of new technology and Web 2.0 employed in higher education have effected a critical transformation in China's post-secondary education in the past several years. China has developed the basic technology infrastructure to form a new digital teaching and learning model. For example, China has established the China Education and Research Network (CERNET), the China Education Satellite Broad Band Transmission Net (CEBSat), and several education networks in different cities and provinces to share the information and resources among educational institutions ("China Education and Research Network," n.d.). These networks connect all the universities in China and form a basic educational networking system. Among these networks, the CERNET is the largest national academic network in the world, connecting more than 2,000 educational and research institutions with more than 20 million users (*The national medium - and long-term plan for education reform and development 2010-2020*, 2010).

China's digital educational resources, although they do not currently include cloud education, are well-developed. In the early 2000s, China initiated developing its digital educational resource system to cover every level of education, including both grade school and post-secondary education. This progress pushed the transformation of the digital teaching and learning model in China. In higher education area, most of the universities in China opened their teaching resources, such as libraries of writings and presentations, for sharing among instructors. In terms of educational resources available to general public, currently, China's universities include 1,800 libraries that are

accessible online, and more than 3,800 national high quality courses offered online (Turner & Acker, 2002). These are not grade-, certificate-, or degree-granting courses when offered publically. Without cloud computing, these courses amount to providing digital access to all the teaching materials used in the course, such as presentations, lectures, and readings. However, no testing or evaluation is available. Although the availability of these new educational resources in China encouraged the Chinese public to seek knowledge in various topics that was now made available, these new resources did not achieve a new method of cloud education.

To assign grades, certificates, and degrees, China has many established “TV and radio universities” which have not been as popular in the U.S. These consist of courses administered through the television or radio that are connected with local universities. These course programs are seen as equivalent to classroom instructions, and degrees are granted. Beijing Open University and Shanghai Open University are famous examples of TV and radio universities (“China Education and Research Network,” n.d.). However, because of the well-established infrastructure behind the television and radio course delivery, cloud education has not been developed here.

Converse, the cloud technology used in real teaching has been demonstrated as effective in many research studies, but these have taken place outside China. The Electrical Engineering and Computer Science (EECS) open courseware project claims that despite the challenging economic climate, cloud computing has actually enabled the project to expand the services it offers to faculty and students rather than cut them back due to the monetary efficiency involved in the educational delivery (DeCoufle, 2009).

Delic & Riley (2009) assessed the current state of Enterprise Knowledge Management and methods of sharing ideas and opinions based on cloud technology through different technology architectures and related applications. Mitchell (2008) used rational and logical analysis to show the challenges and opportunities of cloud technology in education. Mitchell concluded that current university professors and students are effectively sharing information through cloud technology, and that teaching can be effective. These are examples from research that demonstrate the possibilities of how cloud computing could be used distribute to improve access to secondary education by way of a cloud education teaching and learning model in China.

There are six main factors that illustrate how cloud technology could positively impact the teaching and learning model in Chinese universities. Firstly, all of the information is stored in the cloud drive, which is unlike the situation now, where individual library databases and other educational repositories can be accessed online. These are all located and maintained on separate drives, and therefore, cannot be integrated (Ren & Zhang, 2010). With cloud educational services, all the data from the cloud service are collected from worldwide onto one cloud drive. The large scale of information service makes it easier for each individual to access much more information, thus improving educational equity (Rong & Shi, 2001). Cloud-enabled open courses could provide high quality knowledge that enhances the knowledge that can be gained from accessing China's existing databases and educational infrastructure. Simply training the Chinese public in how to use cloud computing as well as access existing online resources could improve educational equity throughout China.

Secondly, cloud technology allows the professor and student to customize the teaching and learning experience without confusing the student, because cloud computing is so common, Chinese citizens use it every day in other areas (Maloney, 2007). Smartphones, tablets, laptop computers, and other digital technologies are widely adopted in China, and the Internet is widely used. Because of the high adoption already of TV and radio universities, the next step to cloud computing seems logical.

Next, cloud educational modules that are easily adoptable to the Chinese public can be designed using original “Grid Computing” technology (Ren & Zhang, 2010), and this can save money without requiring extra effort at the universities offering cloud education services. Using grid computing, educational providers do not need to own the basic equipment required for information technology support (such as data servers), but only rent the cloud service, which is offered by grid computing provider. In this system of cloud computing, every level of the cloud computing service components can be selected a la carte by each university to meet different level of needs (Inoue, 2007). Not only could grid computing allow universities to tailor their offerings, grid computing could also be enabled to collect information from students, and provide on-demand knowledgebase (Rings et al., 2009).

Fourthly, cloud education changes the balance of roles and their responsibilities the teacher and the students when compared to the traditional teaching and learning model. In China, because of long-standing traditional precedents, even classroom teaching in colleges is mainly lecture, with little interaction (Johnson & Johnson, 1986). This model is reflected in the education modules of the TV and radio universities.

Therefore, the implementation of cloud computing will require teachers to learn new class interaction skills, as well as students to develop knowledge-seeking behavior (Stansbury, 2012). Those these challenges to current paradigms exist, cloud computing has the potential to break current barriers in China associated with this more “passive” teaching approach, and can extend the learning in new, interactive ways. Cloud computing will require teachers and students to become equally proficient with information acquisition and online interaction between in their respective roles (Sultan, 2010). The role of teacher will change from initiator to mentor, where the teacher is no long the center of the education process, and students become the momentum behind the progress of the class. When students need guidance, teacher will be recruited to support their educational needs and assist them with access to the vast platform of resources and information available, and self-learning by students will be expected. Educators will find it easier to utilize new media technology such as wikis, video tutorials and blogs from the Internet to share as educational materials with students. Students can decide when, how and where they want to access course materials, and will have the choice of contents, progress and timing (Stansbury, 2012).

Next, the cloud education platform offers more new teaching and learning activities and options that are not available in the traditional classroom. The cloud technology based on Web 2.0 technologies allows social networking popularized by Facebook as a feature (Maloney, 2007). Because online social networking is currently well-adopted throughout the world, social interaction within cloud courses has been shown to be outstanding. Instead of the traditional process where the teacher lectures and the student listens, in cloud education, students can discuss and share with each other and

with the teacher. Many researchers believe that learning is a social activity, and people retain knowledge better by sharing information and communication (Bruner, 1996; Lave & Wenger, 1991; Vygotsky, 1978). Research has also found that the interactive and collaborative learning method might help students absorb the knowledge in a more effective way and make knowledge more accessible (Johnson & Johnson, 1986).

Finally, cloud computing system service does not require the installation of a special operation platform or software applications. The basis stage for cloud computing is the Internet. Users who access cloud services and applications only need to use a common computer with an Internet browser ("The real cost of cloud computing services," n.d.). For these reasons, costs of a cloud computing system for a college is minimal, as special software and applications do not need to be maintained or provided. This feature of cloud computing is called "serve more for less cost", and can reduce tuition expenses from cost containment at the college level (Ercan, 2010).

Research Question

In summary, cloud education has been shown to be effective with the teaching and learning model, and this has been successfully deployed in many countries in post-secondary learning, but not China. China appears ready for this change, as its citizens have a high level of digital literacy and have experience with distant learning. However, cloud computing has never been attempted in Chinese universities.

To that end, the following research question is proposed: Can Chinese students in a cloud-based course in college algebra perform comparatively to an identical course delivered in the traditional classroom?

The null and alternative hypotheses are:

H_0 : Final algebra score in traditional classes is not different from the final algebra score in online classes.

H_1 : Final algebra score in traditional classes is statistically significantly different from the final algebra score in online classes.

Methodology

Study Design

This study will involve evaluating an online cloud-computing course in college algebra to be tested at Beijing University. Originally, Beijing University held a traditional college algebra course in the fall, and then a geometry course in the spring. Most students in most majors took this sequence. Later, they retooled the course to make it an online (cloud-based) course. It is identical to the traditional course in that it meets once per week 14 times over the term. Attendance in the online course is evaluated by whether or not the student posted necessary homework over the previous week. This online course was implemented a few years ago, and no students take both the online and the traditional version – they take one or the other.

The administration wanted to know if the online course was as effective as the traditional course, specifically in algebra, because this precedes the geometry course, and students must have the concepts well-understood to do well in the geometry course. Therefore, the administration provided a sample of data to analysts on this project so the grades could be compared between algebra courses that took place in Fall of 2013, online vs. traditional.

The administration has explained that the following characteristics are associated with higher grades in algebra in general: Being an honors student, and attending class more frequently. They also believe that most of the poorer students (or students requiring a student loan) will not have the money to buy a computer for the online course, so will be forced to take the traditional course. Also, this may cause complications with their attendance, because it is harder to get to the university than to take an online course, which can be done anywhere. Additionally, the university wants to ensure that both men and women are learning at the same rate.

The dataset provided by the administration will be described here. It had the following variables:

Table 1. Variable Description

Field Name	Description	Values
ID	ID Number	integers
ClassType	Type of class	1=Traditional, 2=Cloud-based
Subject	Subject of class	1=Algebra, 2=Geometry
Sex	male and female	0=Female, 1=Male
Score	Score on math class final grade	Continuous, 40 to 100 (percentages)
Honors	Whether or not student is honors student	0=Not Honors, 1=Honors
Loan	Whether or not student gets a loan	0=No loan, 1=Loan
Attendance	How many class student attended out of 14	integers

The ID variable is the student ID and is unique to each student. The subject of the class was either Geometry or Algebra because the dataset covered the Spring of 2012 as well as Fall 2013. Sex was recorded for each student, and whether or not they were in an honors course or had a student loan that semester was included. Scores ranged from 40% of the points to 100% of the points as the final grade. Attendance at the 14 classes was recorded as well.

Population

The comparison is between the online and the traditional algebra courses. All students are Chinese and go to Beijing University, but the dataset included both the geometry and algebra grades. Therefore, all students in the geometry courses will be removed before the analysis.

Sampling

Because this program of online and algebra courses just began, there is only one complete term of data for algebra with both conditions, which is Fall 2013. Therefore, the entire dataset for that term will be used. This is convenience sampling, but it is necessary due to lack of data.

Sample Size Calculation

The administration does not want to see more than a 10% (or 10-point) difference between the online and the traditional mean scores in Algebra in either direction. Since math scores were put on a 100 point percentage scale, this means the effect size to power the study for is 0.40. Alpha (Type I error rate) was set at 0.05, and power set at 80%. G*Power (2014, version 3.1.8, Faul, Universitat Kiel) was used to calculate minimal sample size required; 100 students would be required in each group at least to demonstrate statistical significance at an effect size of 0.40.

Statistical Analysis

To answer the main question as to whether Chinese college students in a standardized cloud-based course in college algebra can perform comparatively to an identical course delivered in a traditional classroom, math scores between the online algebra course and the traditional algebra course will be compared. For each variable described above, descriptive summary statistics (means and frequencies) will be presented. Next, bivariate analysis will be presented, where means and frequencies for each of the variables will be presented by class type (online vs. traditional).

To address the statistical tests, first, statistical assumptions about the variables (normality, equality of variance, etc.) will be assessed. If assumptions are not violated, next, the mean score in the traditional course will be t-tested against the mean score on the online course using Student's t-test at the level of $\alpha = 0.05$. Next, an analysis of variance (ANOVA) will be presented. If the F-test on the ANOVA is statistically significant at $\alpha = 0.05$, a multivariate linear regression model will be developed using class type as the independent variable, math score as the dependent variable, and the other variables as controlling variables.

Human Subjects Considerations

Beijing University changed the IDs to unique study IDs before transferring the dataset. Therefore, it is de-identified. However, it will be kept on a secure server so it is not subject to breach of confidentiality. This study was approved by the Beijing University Institutional Board for the Protection of Human Subjects.

Results

Over Spring 2012 and Fall 2013, 362 students took either the Algebra or the Geometry course; 122 (33.7%) were only enrolled in Geometry so were excluded from the analysis, leaving a sample of 240 students who completed the Algebra class. Assumptions behind ANOVA were tested, and were found not to be violated (normality, independence, and constant variance). The gender, honors status, loan status, attendance and score for the sample and for each class type (traditional vs. online) are presented in Table 1.

Table 2. Univariate and Bivariate Analyses.

Category	Level	All (n, %)	Traditional (n, %)	Online (n, %)
	Total	240, 100%	120, 50%	120, 50%
Gender	Female	114, 48%	58, 48%	56, 47%
	Male	126, 53%	62, 52%	64, 53%
Honors Status	Not Honors	178, 74%	92, 77%	86, 72%
	Honors	62, 26%	28, 23%	34, 28%
Loan Status	No Loan	158, 66%	60, 50%	98, 82%
	Loan	82, 34%	60, 50%	22, 18%
	Variable	All (mean, sd)	Traditional (mean, sd)	Online (mean, sd)
	Attendance	10.9, 2.56	9.9, 2.99	11.9, 1.5
	Score	79.21, 15.78	72.75, 17.89	85.67, 9.81

Fifty-percent of the sample had completed the traditional course, and 50% completed the online course (n = 120 in both groups). The distribution of sex and honors status was no different across groups; a slightly higher percentage of males was in each group (traditional = 52% and online = 53%), and approximately one-fourth of students were in the honors program (traditional = 23% and online = 28%). Students in the traditional class were more likely to report having student loans (traditional = 50%, online = 18%). The mean classes attended overall were almost 11 (10.9 classes), but for traditional, the mean classes attended was lower (9.9 classes) compared to online (11.9 classes). Finally, scores overall approached 80% which would indicate a B- (mean = 79.21), and mean scores were higher in the online group compared to the traditional group (means = 85.67 vs. 72.75 respectively).

Next, a t-test was performed comparing traditional vs. online scores, and unequal variances were assumed. The results was $t = -6.937$ at 184.632 ($p = 0.000$). Therefore, online scores were statistically significantly higher than traditional scores.

After this, an ANOVA was run with all covariates listed in Table 2 as independent variables, and score as the dependent variable. The result was statistically significant, with $F = 11.75$ at 5 df ($p = 0.000$). Therefore, the linear regression model was interpreted (see Table 3).

Table 3. Linear Regression Results.

Category	Covariate	Standardized β Coefficient	p-value
	Constant	66.135	0.000*
Class Type	Traditional	Reference	
	Online	0.493	0.000*
Gender	Female	Reference	
	Male	-0.091	0.126
Honors Status	Not Honors	Reference	
	Honors	-0.150	0.805
Loan Status	No Loan	Reference	
	Has Loan	0.760	0.226
	Attendance	-0.140	0.028*

* indicates statistical significance at $\alpha = 0.05$.

After controlling for gender, honors status, loan status, and attendance, taking the online version of the algebra course was positively statistically significantly associated with score ($p = 0.000$). Moving from the traditional to the online class would be associated with increasing the score by 0.493 (holding other covariates constant). In the model, gender, honors status, and loan status were not statistically significantly

associated with score. However, after controlling for the other factors in the model, higher attendance was statistically significantly negatively associated with score ($p = 0.028$).

Discussion and Conclusions

In the analysis, final algebra score in online classes was statistically significantly higher compared to the algebra score in traditional classes, and this relationship persisted after controlling for other variables. In addition, in final models, it was found that attendance was statistically significantly negatively associated with score. It is possible that this is because the traditional course is not as high of quality as the online course, so attending does not improve one's score.

It was interesting to note that on average, attendance was higher in online vs. traditional courses (see Table 2). This is likely associated with the hassle involved with getting to class in a traditional course. As expected, those with loans were more likely to be in the traditional course, yet those in honors were equally disposed to take online vs. traditional classes.

This study is not without limitations. Only one term of algebra courses were included in the analysis; this does not take into account time or seasonal trends, or the effect of a particular professor. In addition, only a few predictors that were available in the dataset provided were available for modeling. Other predictors, such as past performance in math, might have explain the differences between online and traditional course performance. This study is also not generalizable outside of Beijing University, as other universities conduct their courses differently.

Future research on this topic should go further to include more predictors than just the few included in this study. In addition, consideration should be given to surveying the students, as using data from a database can limit the analysis. In addition, more universities than just Beijing University should be studied, and it is possible that trends like this could be found in more math subjects, such as Geometry, as well as in other science subjects, such as Physics. More research is required in the area of the efficacy of online vs. traditional classes.

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