Effectiveness of Technologies Interventions on Learning Outcomes of Online-College Algebra Students

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ABSTRACT

Integrating technology into the pedagogy is becoming a major part of our educational institutions with the objective to stay competitive in today's Net Environment. During *Fall 2006 to Spring 2007*, the investigator taught technology-rich undergraduate mathematics courses that allowed him to immerse his undergraduate College Algebra students into technology-rich environment; and enormous efforts are being made by investigator's institution in the effort to make online learning as effective or perhaps even more effective than traditional on-ground classroom teaching. Since last two years, the investigator had the opportunity to use various synchronous and asynchronous methods to integrate technologies with the delivery of College Algebra mathematics instruction in hybrid-on-ground as well as totally online courses. In this paper, the author documents whether the technology used has improved student's learning outcomes, self-confidence, and their problem-solving fulfillment in college algebra classroom. The author will present data grounded teaching and learning outcomes findings for on-ground and online College Algebra classes (twelve sections, N=170).

Introduction and Related Research

In this paper, author reports the results from his institution's grant-supported research that addresses the effectiveness of technologies interventions on fully online-College Algebra student's learning outcomes. In the following paragraphs, a brief related research is given to illustrate the rationale of this College Algebra online course selection and need of this research study.

At the outset, the term and concept of online education has been quite confusing and vague. Many freely used terms (e.g. asynchronous learning network, asynchronous online courses, blended courses, distance education, distributed learning, e-learning, fully online, hybrid courses, virtual reality learning, and Web-enhanced courses) are being used today and add to the disorderly use of online teaching concept (Picciano & Seaman, 2007, pp. 1-2). In this paper the author chooses the College Algebra subject area, and as it turns out that the MAA report also suggested that the "support be given to large numbers of institutions to change their College Algebra program (Katz 2007, p.35 CAI)". The author used the opportunity of mini-grant award from his Coppin State University campus– a Historical Black University, to plan and deliver the online College Algebra classes. The award of grant at Coppin was in time of availability of new tools for e-communication on campus, trend when web 1.0 changing to web 2.0. So, this timely online instructional strategy has become part of the 21st century and contributes to new ways of thinking, teaching and learning. The online learning is on the rise in so called the "flat" world, and it is adding value to the traditional on-ground education experience, meeting the needs of specific groups of undergraduate students, and increasing a large variety of course offerings, the College Algebra course included. It is the firm belief of the author that in very near future the online instructional strategies will affect the on-ground teaching set-up, and soon provide an inclusive learning environment that requires little or no face-to-face contact. The related research (Carol 2003, Deubel 2007, Ken 2001) suggests that an online learning environment help build state of the art structured instructional platform and enhance mathematics learning, at undergraduate level in particular. The web 2.0 technology based online instructional design adds diverse functionalities such as synchronized technologies in Virtual Reality environment and solve issues of labor-intensive instructional aspects ranging from classroom managements details to the new learning experiences.

Among the educational pedagogy's components, the total Internet course delivery process has some challenges, and especially the online learning assessment phase that has been a big dilemma. However, thee nine principles for assessing student learning developed by the American Association of Higher Education (AAHE) stresses that assessments should support good instructional practice and enhance mathematics learning opportunities by meeting online course delivery challenges. Notably also, Chickering, A., & Gamson, Z. (1987) outlined seven principles of good online instructional practices in undergraduate education, and the author has employed them to bring into line, his College Algebra online delivery structure. These are in some what modified version: 1) Promoting student-faculty contact by outlining office hours and addressing promptly student's e-mails. 2) The Blog discussions sessions encouraged collaboration among students, 3) The learning team project assignments encouraged students to learn College Algebra concepts in active discovery learning mode, 4) Instructor's prompt feedback in terms of quizzes and tests scores, common errors and information on assignments due dates , 5) The posting weekly overview and deliverables and deadlines allowed students to plan time on task, 6)Learning teams encouraged cooperation in producing challenging and quality projects and College Algebra problem solutions, and meeting high expectations, 7) Blog discussion sessions, Internet researches on Google, working on other math sites and web-graphing tools, and encouraged diverse thinking. The students used different methods and approaches to College Algebra problem solving. So, the principles for assessing student learning developed by the American Association of Higher Education (AAHE) and Chickering, A., & Gamson, Z. (1987) have been useful to the author in designing and carrying out the online instruction for this study.

As indicated earlier, Katz (2007) reported a study on Algebra : Gateway to Technological Future and stated that "Annually 650,000 to 750,000 college students enroll in College Algebra" and "Nationwide more than 45% of students enrolled in College Algebra either withdraw or receive a grade of D or F. (p.34). So, according to this research, clearly a large population of the College Algebra students is at risk. Katz (2007) has also recommended Electronic Library of Exemplary College Algebra Resources in his report entitled "Algebra Gateway to a Technological Future". Furthermore, Katz's College Algebra Guidelines include College Algebra Course goals to "Develop students' ability to use technology for understanding and doing mathematics". Which is in line with NCTM's (1989, 2000, 2006) call for reform in K-16 curriculum, process of instruction and assessment.

Furthermore, from the related research by Katz (2007) and others (Deubel 2007, Twigg 2003, Houston 2001), it is certain that online learning is on the rise for K-16 education system, and all professionals involved in k-16, should have a current knowledge base of effectiveness of new technologies interventions on purely online as well as hybrid courses. The author is involved in using technology in lower and upper level undergraduate courses for over two decades, and has successfully taught on-ground as well as online mathematics courses. The aim of this paper therefore, is to disseminate information about the author's use of new technologies (e.g., Tegrity, Interactive Bb, Web-based graphing technologies etc.) in on-ground and online classes during Fall 2006 to Spring 2007, and reports the data based College Algebra teaching and learning findings of *twelve sections* during this period of *three semesters*. This paper is meaningful for readers and teachers of College Algebra, to be aware of the results of this at risk subjects' study (N= 170). The findings of this paper goes beyond the College Algebra boarder, essentially because the online learning is on the rise in so called "flat" world, and availability of new technologies are adding value to the traditional on-ground undergraduate education experience globally.

Theoretical Prospective and Logistics

What's College Algebra online course at CSU is all about? The author has offered this course at CSU in three modes of instruction. For the purpose of this study design the author adopted with minor modifications, the following course definitions that Picciano and Seaman (2007) used in their *K-12 Online Learning: A survey of U.S. school district administrators.*

- *Online Group*: All of the College Algebra content is delivered online. Only the Cumulative final exam-time being replaced by face-to-face (f2f) exam monitoring time.
- *Blended/Hybrid Group*: College Algebra course blended online and face-to-face delivery system. Substantial proportion (30 percent to 79 percent) of the content is delivered online. Tegirity (www.tegrity.com) class recordings were done for student's later use for review, and for those students who missed the class.
- *Control Group*: Course uses Web-based technology Bb (1 percent to 29 percent of the content) to facilitate what is essentially a face-to-face course.

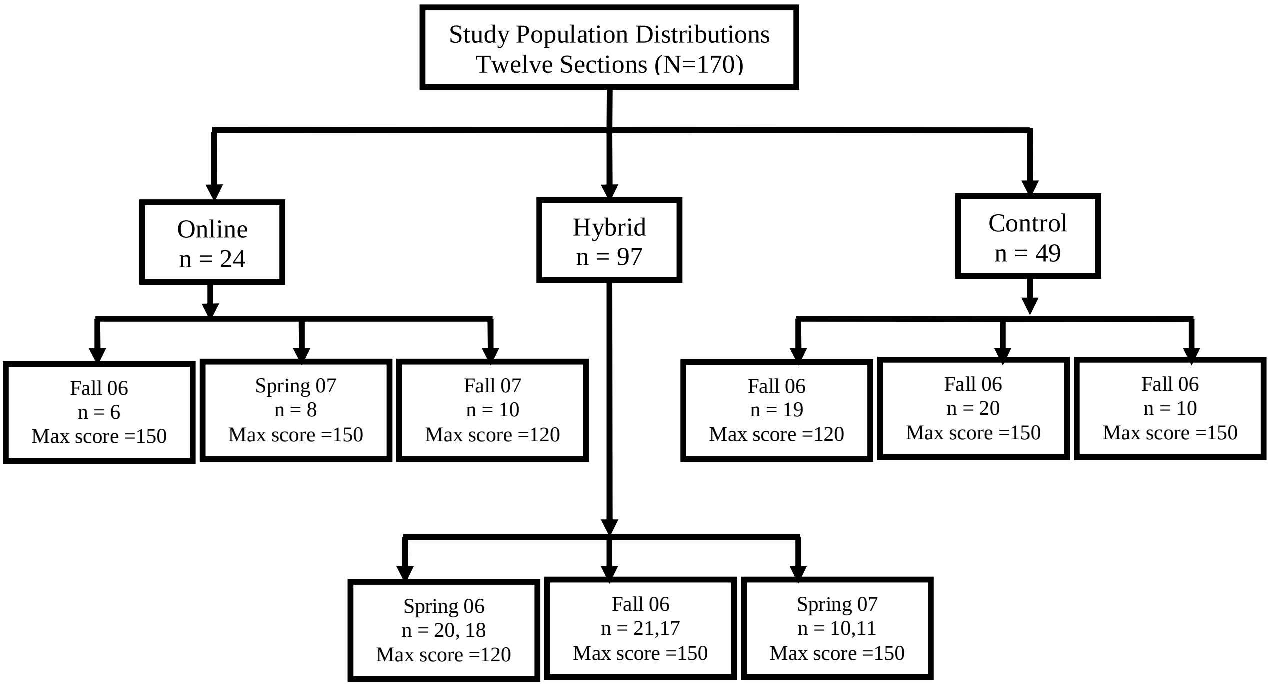
Furthermore, the author increased the access of the online College Algebra course beyond the CSU campus border by blending all benefits of distance and web 2.0 Internet technologies. This increased access of Algebra Class helped a significant student's population consist of working learner, and those students who are required to take this course to graduate. Initially a lot of author's time, skill, training and experience went into designing and organizing the online and hybrid courses, and to decide what these techno-enriched classes should contain. In the light of new technology interventions, the outcome of the course were re-examined .Thus, the assessment tools used were valid and consistent. Some of the strategies used were (Houston 2001) to:

- Inform students about their own learning by—weekly feedback evaluation, grading Quizzes, Discussing Question Online, and chapter quizzes/tests.

- Increased availability by phone, conference calls, office hrs and participating in discussion question online. Thus author learned student's strengths and difficulties. Consequently, the teaching strategies were re-modeled to deliver instruction more interactively, and author became "more" helpful to *all* students.
- Encourage students to take a critical-reflective approach (e.g.,. Polya's problem solving strategies) to everything that they do in the Algebra class, that is, to self-assess the product before submitting.
- Provide the frequent formative and summative feedback and evaluate the student's achievement.

Research Methodology and Study Design

As defined earlier, the three College Algebra groups-types (Online, Hybrid, and control) were identified, and their subject-population distribution is indicated below in the chart:



The online model used in this study is tailored from Twigg, C. A. (2003). As found by her, in the study of *Models for Online Learning*, the capabilities provided by information technology professionals at CSU campus turned out to be the key to the success of the Online/hybrid courses, for the author. She also reported that the other factor in the course re-design strategies is the commitment of faculty members teaching the course.

Data Collection and Data Analysis

Both formative and summative assessment data collection strategies were employed. The details include: a) Formal/Formative Data collection tools (f2f-Cumulative Final, Mid-Term,Quizzes), b) Informal Online Participation Observation (Bb Discussion Questions, Class Participation, Math-Tech Assignments), c)Summative Evaluation Data tools that included Survey and Cumulative Departmental Final Exam.

The following paragraphs discuss the analysis of data gathered from twelve sections (N= 170).

a) Survey Data Analysis

The following main trends in the qualitative survey data emerged:

1) The students' self-esteem enhanced by i) Employing more practice time and keep practicing, and ii) Check and re-check strategy used for whatever student's are doing in the class.
2) The most students were able to resolved their mathematics and new technology used related difficulties by:
a) *Content Related*: Overcoming Challenges in: i) Graphing (functions, inequalities etc.ii) Graphing website's crashes/error messages; iii) Order of operations (signs, exponents, radical..) in algebraic equations.
b) *Pedagogy issues:* Use of instructional materials and Tegrity recordings, "frequent-feedback" and interactions among students in Discussion Questions sessions and with instructor, were some of the helpful instructional strategies for student learning surfaced in the data.

b) ***Quantitative Data Analysis***

The data were cleaned and analyzed first for: A) *Within Semester* Comparison: Two-Sample T Test was used. Also, described below is: B) *Across Semesters* Comparisons analysis.

A. Within Semester Comparison: Two-Sample T Test Analysis Tables.
Data of Cumulative Departmental Exam scores were collected and feed to Mini-Tab software, and Two-Sample T Test procedure was performed. The following notations for the research variables were used:

Notations:

i) First three alphabets definitions

Hybrid	HYB
Control	CTL
Online	ONL

ii) Fist four letters definitions

HYBS	Hybrid Spring
CTLS	Control Spring
ONLS	Online Spring

Similarly, the fourth letter represented label for the semester, for example, S= Spring, F= Fall. The fifth and sixth number represents year, for example: 06= 2006,
07= 2007. And last digit represented section number (see the population distribution chart for more details). The following data analyses tables from Mini-Tab were the output.

Spring 06: HYBS061, HYBS063, CTLS064

HYBS061 vs. CTLS064 : HYB a bit better than CTL

	N	Mean	StDev	SE Mean
HYBS061	20	95.8	11.9	2.7
CTLS064	19	91.9	12.3	2.8

DF =36, T-Value = 1.01,P-Value = 0.321(not significant at α=0.05 level).

HYBS063 vs. CTLS064: HYB a bit better than CTL

	N	Mean	StDev	SE Mean
HYBS063	18	93.9	11.4	2.7
CTLS064	19	91.9	12.3	2.8

DF = 34, T-Value = 0.51, P-Value=0.612(not significant at α=0.05 level).

Fall 06 : HYBF061, HYBF062, CTLF063, ONLF061

HYBF061 vs. CTLF063: HYB a bit better than CTL

	N	Mean	StDev	SE Mean
HYBF061	21	125.5	18.8	4.1
CTLF063	18	119.8	12.3	2.9

DF=34,T-Value=1.15,P-Value=0.260(not significant at α=0.05level).

HYBF062 vs. CTLF063: CTL <u>is better</u> than HYB

	N	Mean	StDev	SE Mean
HYBF062	17	102.7	20.2	4.9
CTLF063	18	119.8	12.3	2.9

DF=26,T-Value=-3.00,P-Value=0.006(**significant at** α=0.05 level).

ONLF061 vs. CTLF063: CTL a bit better than ONL

	N	Mean	StDev	SE Mean
ONLF061	6	106.0	21.1	8.6
CTLF063	18	119.8	12.3	2.9

DF=6, T-Value= -1.51,P-Value=0.181(not significant at α=0.05 level)

HYBF061 vs. ONLF061: HYB is <u>better</u> than ONL

	N	Mean	StDev	SE Mean
HYBF061	21	125.5	18.8	4.1
ONLF061	6	106.0	21.1	8.6

DF = 7,T-Value=2.04,P-Value=0.080(significant at α=0.1 level).

HYBF062 vs. ONLF061: ONL a bit better than HYB

	N	Mean	StDev	SE Mean
HYBF062	17	102.7	20.2	4.9
ONLF061	6	106.0	21.1	8.6

DF = 8,T-Value=-0.33,P-Value=0.748(not significant at α=0.05 level).

Spring 07: HYBS071, HYBS073, CTLS074, ONLS071

HYBS071 vs. CTLS074: CTL a bit better than HYB

	N	Mean	StDev	SE Mean
HYBS071	10	93.6	28.6	9.0
CTLS074	10	105.6	20.7	6.5

DF = 16,T-Value= -1.08,P-Value=0.298(not significant, α=0.05 level).

HYBS073 vs. CTLS074: Almost the same

	N	Mean	StDev	SE Mean
HYBS073	11	105.3	16.7	5.0
CTLS074	10	105.6	20.7	6.5

DF = 17, T-Value = -0.04 P-Value = 0.969 (no difference)

ONLS071 vs. CTLS074:ONL a bit better than CTL

	N	Mean	StDev	SE Mean
ONLS071	8	114.5	16.6	5.9
CTLS074	10	105.6	20.7	6.5

DF = 15,T-Value=1.01,P-Value=0.328(not significant at α=0.05 level).

HYBS071 vs. ONLS071: ONL is <u>better</u> than HYB

	N	Mean	StDev	SE Mean
HYBS071	10	93.6	28.6	9.0
ONLS071	8	114.5	16.6	5.9

DF = 14, T-Value = -1.94 P-Value=0.073 (significant at α=0.1 level).

HYBS073 vs. ONLS071:ONL a bit better than HYB

	N	Mean	StDev	SE Mean
HYBS073	11	105.3	16.7	5.0
ONLS071	8	114.5	16.6	5.9

DF = 15, T-Value=-1.19,P-Value=0.251 (not significant at α=0.05 level).

Fall 07: CTLF074, ONLF071

1.1 ONLF071 vs. CTLF074: CTL a bit better than ONL

	N	Mean	StDev	SE Mean
ONLF071	10	97.8	13.2	4.2
CTLF074	8	102.5	19.5	6.9

DF = 11, T-Value=-0.58, P-Value=0.572 (not significant at α=0.05 level).

B) Across Semester Comparison: HYB (5), CTL (4), ONL (3) :[Spring 06, Fall 06, Spring 07 and Fall 07 all Combined]

HYB vs. CTL : CTL a bit better than HYB

	N	Mean	StDev	SE Mean
HYB	97	0.755	0.140	0.014
CTL	55	0.778	0.120	0.016

DF = 127, T-Value=-1.08, P-Value=0.281(not significant at α=0.05 level).

ONL vs. CTL: CTL a bit better than ONL

	N	Mean	StDev	SE Mean
ONL	24	0.771	0.121	0.025
CTL	55	0.778	0.120	0.016

DF = 43, T-Value=-0.25,P-Value=0.803(not significant at α=0.05 level).

HYB vs. ONL: ONL a bit better than HYB

	N	Mean	StDev	SE Mean
HYB	97	0.755	0.140	0.014

DF = 39,T-Value=-0.55, P-Value=0.583(not significant at α=0.05 level).

The tabulated outputs of 2-sample T-tests show that in "most cases" hybrid group of students perform a bit better than control and online groups. The following paragraphs give a more detailed discussion of data analysis and state the findings based on qualitative and quantitative data.

Discussion of Results

The survey data and author's observational data reveled that variations on the topics of written online Discussion Questions increased "interactivity" in the class among the students as well as with the instructor. These DQs helped students clarify their answers to them, and help them understand concepts of algebra topics. In particular the students' self-esteem enhanced, as they were able to add more practice time at their own pace, and take their time to check and re-check, whatever they were doing in the class. Several real life application (Drug Dosage, bacteria growth and decay, finance, geometry applications etc.) problems were discussed successfully online and students were able to follow problem-solving processes in George Polya's sense.

Students' discussed their tech-related (e.g. Equation editor, Web-graphing etc.) difficulties and resolved them with-in first week of the classes. Some of the content related achievements for students were about overcoming challenges in graphing problems (functions, inequalities etc., and order of operations (signs, exponents, radical etc.), and the pedagogy issues overcome were --- use of instructional materials, "frequent-feedback" and interactions among students in Discussion Questions sessions and with instructor. Overall, the qualitative data show that students' confidence and their participation level was high. Additionally, the author was able encourage student to express their different views in the courses; and also incorporating learning exercises with real life applications, quite-often represented varied perspectives.

On the quantitative data analysis windowpane, the results show some contrasted trends. Nevertheless, for the most part student achievements remain bit better in hybrid classes when contrasted with online and control groups. This finding is in agreement with the Carol A. Twigg's (2003) thirty institutions online model study, as in this College Algebra study design, the students learned College Algebra concepts better in hybrid courses compared to online or control classroom environment. Additionally, the observational and qualitative data analysis substantiates that the student's self-esteem and problem solving skills enhanced during the College Algebra course taken in hybrid *and* online classroom environment.

Conclusions and Future Research Issues

The purpose of this study was to assess the effectiveness of technologies interventions on learning outcomes of online-College Algebra Student. This research study was need-based and allowed author to collect and analyze data and compare fully online, hybrid (part online and part traditional face-to-face instruction) and control-class with little or no technology interventions. The distinction made in the study between fully online and hybrid classes is a most important enhancement of previous studies on this topic of online instructional models, and particularly in College Algebra subject area (Katz 2007). This research paper also addresses the call for Algebra and Problem Solving learning and instructional strategies reforms as recommended by NCTM (1989, 2000, 2006) with regard to K-12 online and technology inspired algebra concepts' learning.

The qualitative and quantitative data are conclusive suggesting that the student achievements remain bit better in hybrid classes than online and controlled class. Additionally, the observational and qualitative data substantiates that the student's self-esteem and problem-solving skills were improved during the College Algebra course taken in hybrid and online classroom environment.

However, further exploration of the successfulness of online learning on large population size, and established base-line data use in online research studies is needed. Issues such as online instructional planning, online assessment, tech-ware operational difficulties, and adoption of new online learning technologies, need an in-depth research study. There are plentiful online education research variables to be considered in extensive future studies, and some of them include---Student-Faculty Contact and Timely Feedback, Online Cooperation Among Students, Algebra Tasks and Time on Task, Student-Faculty New Expectations, Learning Styles, Student-Faculty Diverse Ability and Aptitude, Diverse Methods of Online Instruction and Learning Assessment, Evaluation of New Learning Technologies, Online Course Design and Re-Design Process of Existing Courses, and Delivering Quality Content. These research variables are important that will allow, to some extent, the future online researchers to be more inclusive of online teaching issues and difficulties teachers are facing today.

As we know that the online learning is on the rise, and new tools for e-communication are evolving, for example, web 1.0 changing to web 2.0, and thus the new technology use contribute to many new ways of teaching and learning. It is the firm belief of the author that in very near future the online instructional strategies will involve implementation of Virtual Reality tools (e.g., accessgrid, WebEx, Web 2.0 Internet Technologies etc.), and soon these evolving new VR technologies will facilitate in designing an inclusive learning environment that requires little or no face-to-face contact. Needless to say that there are still disbelievers who are not yet influenced by new technology based teaching innovations. There is a need of a robust online learning assessment research, and it is to be factored into the academic curriculum on universities campuses locally. This robust online learning assessment research plan if implemented will produce base-line data for more innovative teaching developments, and thus skepticism of some teachers will gradually be resolved. For the author, the opportunity of doing research in his own classroom, identifying and selecting good instructional strategies, developing them, evaluating them and then be able to inspire fellow colleagues is stimulating. This inspiring experience revitalized all teachers about their teaching and their students' learning.

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