Web-Based Project Based Learning (PBL) Activities - A Technogenesis Example using a Senior Design Lab

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Abstract

Education represents one of the largest areas for the application of online Project Based Learning (PBL) activities. But does the use of web based PBL help improve student learning? This question is the subject of this paper.

To examine this hypothesis, student achievement in an Engineering Economic Design course was examined. The Engineering Economic Design course requires students to analyze the economic feasibility of their Senior Design projects and is part of the Technogenesis® theme in the Stevens engineering curriculum that helps students understand how to commercialize technology. The course is required for all senior engineering students and is designed to add a real-world, project-based component to Senior Design Projects. The course has both a lecture and lab component, where the lab portion of the course could be performed as a web-based activity by the team members.

The web-based lab participation was only required three times during the Engineering Economic Design course. Student achievement was used as the dependant variable and the total number of web accesses was the independent variable in this analysis. Data were collected for two semesters to increase the sample size and were not reviewed or analyzed until the end of the second semester to eliminate grading prejudice in the study.

A regression analysis was conducted to compare the frequency of students' web-based access with their grades. Statistical analyses indicate that students who were more active in a web-based activity received higher grades in the course and thus more insight into how to commercialize technology. A positive correlation also existed which supports the conclusion that PBL was effective in this case.

Teaching using only lectures is a labor intensive, high cost teaching method since it involves experienced professors or teaching assistants. Lessons learned from this research could impact the possible restructuring of such classes since the results indicate that those students who actively participate in on-line, lab-based group learning activity achieve better grades than those who do not.

Educational Literature and Background

Literature debates the impact a delivery medium has on learning outcomes. Equally as important is the degree to which the medium is utilized. Some argue that a delivery method for education only impacts the efficiency of delivery and not the effectiveness of the outcome.

Others state that different benefits are delivered through different mediums. This paper assumes the latter.

Learning is about learners using various methods and various media in different social situations working together to produce learning outcomes. This study is to test whether students who participate more in an on-line, team based environment achieve better grades than those who participate less in on-line activities.

This concept is based on the Constructive model of learning described in works by Leidner and Jarvenpaa (1995) and Moursund (2003). The construction of knowledge involves higher levels of Bloom's taxonomy and is typically implemented using "learner centered" approaches involving discovery, control of pace and content, investigation, case analysis and other similar learning experiences. The authors suggest that virtual learning spaces such as the one used in this study are the technology element to support these "deep" learning, project-based, activities in the modern world of education.

Authors, such as Wallace and Mutooni (1997), found similar results in that students participating in web based instruction performed better than those receiving traditional classroom instruction. They stated that such teaching methods could provide more effective and economical engineering education. In addition, they concurred with the theme of this article that providing different teaching methods will accommodate the different learning modes and styles of students.

Altschuler (2001) adds a similar thought when he discusses that e-learning may actually encourage some personality types to get more involved. McGrath (1998) continues by stating that electronic interchange lets the teacher determine the direction of investigation in the classroom, but allows the student to choose the path. Sweeney and Ingram (2001) concur with this finding. They suggest in their research that the best approach to educating students is to combine computers with traditional teaching in order to reap the benefits of both environments. Others such as DeLong (1997) and Creed (1996) also argue the benefits of on-line additions to traditional classroom instruction to extend and enhance the conversation that goes on within the classroom.

Pitman, Gosper and Rich (1999), who studied on-line usage of first year college students, also stated statistically significant results showing that student performance was related to the number of times students accessed the course internet site. And they also concurred that different groups of students access courses in different ways.

This study complements the authors work (Merino and Abel 2003a, 2003b and 2002) on the use of web-based tutorials to supplement the teaching of the fundamentals of Engineering Economics.

Engineering Economic Design Course used as Test Vehicle

The Engineering Economic Design course was initially taught in the fall of 2000 and spring of 2001 with no web-based component. As part of Stevens' ABET 2000 process, comments and suggestions for improvement were collected, considered and the course modified. One modification based on student suggestions was to increase the use of web-based activities.

The Engineering Economic Design class is a required engineering core course for all engineering students that uses Engineering Economy (a prerequisite course) to economically assess their Senior Design projects. The teams develop a five year business plan that shows how their design concept can become a commercial product, process or service. For the class, project teams must gather relevant data, use creative higher order thinking and transfer knowledge gained to perform an authentic assessment of the economic feasibility of their real-world product, process or service. This process is similar to other Project Based Learning activities (Moursund 1999).

Students in the Engineering Economic Design class were required to work in teams throughout the course. These teams were the same teams and for the same projects as used in their Senior Design class. The course was a (1-3-2) class which means the students had 1 hour of class and 3 hours of on-line lab in a 2 credit course. Thus, for the Engineering Economic Design course, students were only required to attend 7 lectures and meet with their TA twice. Grading was based mainly on their Midterm and Final Presentations with some points assigned for three direct participations on-line. Some teams participated more, some less and some the required amount. The course presentations for the Midterm and Final were to be completed as a team during their "lab" time. The on-line lab component was considered a supplement to their overall team lab time.

The three-time, on-line lab participation required of the students consisted of accessing documents and/or creating discussions through WebCT. Discipline specific case studies, reference documents on topics such as Costing and New Product Development, and a discussion room were all available to the students. (Note that the reference documents were also provided to the students at the start of class in hard copy form.) Students were required to go onto WebCT the three times throughout the semester to access the material they felt they needed to complete the project or to add a question or discussion to the postings. The authors argue that the on-line lab component provided assistance beyond the classroom that allowed the teams to produce results above and beyond those teams that participated in the on-line lab the minimum required times.

It should be noted that 85% of the final grade was team based and 10% was individually based. Only the remaining 5 percent of the grade was actually based on the participation in the on-line lab. This is important to note since the authors are *not* trying to state that the students were simply given more points for accessing the on-line lab more times. A relationship such as this would not prove the point of this article. The authors are stating that the on-line lab, though a somewhat insignificant source of points toward the final grade, actually demonstrated a large increase in final score for those who used it more.

Study Population and Conditions

Data from the course was collected for a total population of one hundred and one senior level engineering students over the 2001-2002 academic year. All engineering students regardless of discipline were enrolled in the required core Engineering Economic Design course. Data on web-based access was collected for each student individually on the first day of class and on a weekly basis thereafter until the end of term.

The sample size was relatively large (101). Since N approaches infinity after 120 subjects (i.e. the t value does not vary), there was good statistical power in this study.

Web-based delivery presumes access to online technology and a degree of technical literacy. Stevens students have both. Stevens maintains a complete campus-wide wired network, and at the time a mostly wireless one as well, providing students online access whenever and wherever they want. In addition, Stevens students are required to own computers upon entrance to college in their freshmen year. Thus, all Stevens' students could be considered to be computer fluent during their tenure and extremely computer literate by the start of their senior years. These factors are important since differences in pre-existing computer knowledge or fluency were not considered a factor in this particular study. However, such pre-existing knowledge, if not controlled, could have influenced research such as this.

Hypothesis

It was hypothesized that the frequency of student use of web-based labs would impact their final grade. This is based on the premise that web-based labs provide assistance beyond the classroom.

Recall that it was only required for a student to access the on-line lab 3 times. However, some students accessed the on-line information over 250 times over the course of a semester, though the average was 65 or 4.6 times a week. In essence those students who accessed the on-line lab more should experience additional learning which would translate itself into a higher final grade. Or in other words, the course itself was expected to be completely adequate in relaying the required information. However, combining the course with the supplement of the on-line lab would serve to increase the student's final grade.

Please see Table 1 for an outline of expected results and Figure 1 – Appendix for final grade distributions from the students. Note that three quarters of the class for the 2001 – 2002 academic years received a B or better (i.e. more than adequate grades).

Hypothesis – Those students participating on-line more will do better in the class and achieve a statistically higher final grade.

Null hypothesis: H (o) – no difference in grade based on web access (X = Y)

Two tailed t-test – 95% confidence limit

Table 1 – Hypothesized Results

	Group X – Students who accessed the on-line lab more	**Group Y – Students who did NOT access the lab much**
Final Grade	X – High Final Grade	Y – Lower Final Grade

Note: Grades of B+ were considered middle ground and were not considered high or low. Thus A- and above were to be considered high and B and below were to be considered low.

Results of the Data Analysis

As assumed, the data strongly matched the hypothesized trend outlined in Table 1. See Table 2 below.

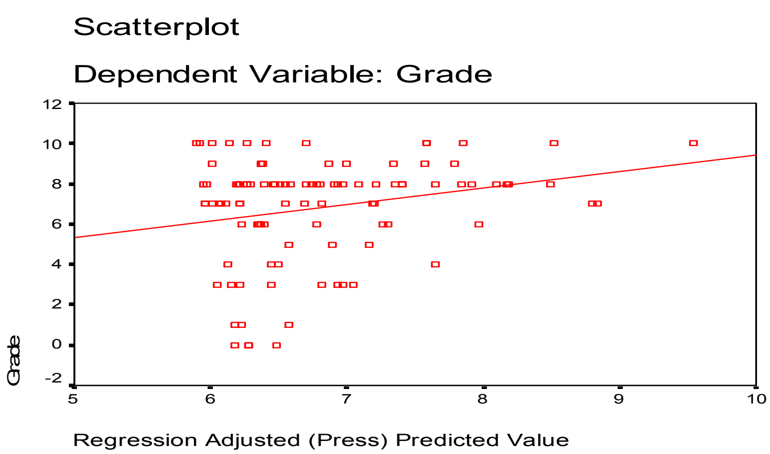
Table 2 – Actual Results -

Group >	**X – Students who accessed the on-line lab more frequently**	**Y – Students who did NOT access the lab as frequently**
Final Grade	8.62	4.98

Note 1. Grade results for both groups were consistent with the hypothesis
Note 2. Coding scheme included the following: A+ = 10, A = 9, A- = 8, B+ = 7, B = 6, B - = 5, C + = 4, etc

To test the hypothesis, a linear regression was performed. The number of web accesses for each student was the independent variable and the student's final grade was the dependent variable. A graph of the data below in Figure 2 demonstrates that as web accesses increase, so does course grade. The statistical results showed significance with $t = 3.046$ and $p < .003$. (See Tables 3A and 3B - Appendix)

Figure 2 – Graph of Data



An additional investigation was conducted to determine if the significant results occurred for all students or only those in the upper half or lower half of the class. The data was split at the B+ course grade level (See Table 1 for justification). Course grade was again used as the dependent variable and total number of accesses was the independent variable. What was found was that on-line lab usage had no significant effect for those students who received an A- or better in the course. However, there was a significant difference in grade with respect to on-line lab usage for those who received a B or lower. The statistical results showed significance with $t = 2.361$ and $p < .023$. (See Tables 4A and 4B - Appendix)

Conclusions

As can be seen from the output in Tables 3A and 3B (Appendix), a significant difference existed in degree of web accesses between those students who achieved high final grades and those who achieved low final grades. And from the output in Tables 4A and 4B of the students in the lower group, higher grades were achieved if the students used the on-line lab significantly more. Thus, the students who accessed the on-line component more often did have an increase in final score over those who did not access it as often.

In addition to determining the significance of this pattern, correlation coefficients between final grade and amount of web access were analyzed. The data showed that a significant positive correlation between final grade and web access did exist ($r = .293$, $p < .01$) for a two tailed test with $N = 101$.

The results were obtained with a relatively large sample size (N approaches infinity after 120 subjects, i.e. the t value does not vary) and, on balance; they showed evidence of a difference. Thus, the number of web accesses did make a difference in final grade. This indicates that the web-based component was successful at conveying concepts of Engineering Economic Design to undergraduate engineering students.

Implications for Educational Research – re PBL

This research is in response to the call from authors, such as Rich, et. al. (2000), who state that the ability to foster collaborative learning is still a "great frontier" in on-line learning. And as Moursund (2003) states, "Although computers have been used in education for more than 50 years, we are just barely getting started in the changes Information Technology will bring to education." Thus, today's campuses are still increasing their use of technology in their teaching environments (Keown, 1999; McLester, 2001). And the consensus thus far is that computer assisted learning can be used in combination with the traditional classroom experience (Merino and Abel 2002, Pitman, Gosper and Rich 1999, Sweeney and Ingram 2001). The results of this research indicate that adding a web-based component as a supplemental form of instruction helps students achieve higher grades indicating higher levels of knowledge.

Students who participated in the web-based component achieved higher grades, but the "why" is still elusive. It could have been that otherwise shy people were provided enough anonymity on-line to make genuine contributions; the technology may have constrained other work group problems such as dominant personalities; or the technology could have also made it easier for students to "meet" as they did not have to be in the same physical space. Whatever the reason, the outcome is consistent with Moursund's (2003) belief that highly active participants in project based learning actually score higher than less active participants.

While pursuing this research, one might ask if the students did better because they participated in the on-line group learning process or if students that participated more, were simply those that would have gotten better grades anyway. Two concepts may help to dispel to this later thought.

In this research, over 85% of the grade was group based and only 5% was based on the web-based lab participation. Thus for the latter statement to be true it would require that every member of the best groups be an active lab participant and every member of the poorer groups be a non-active, on-line lab participant in order to get these same final grades. This divergence of personal characteristic seems unlikely to be split by Senior Design groups. (Note that Senior Design Groups were chosen by the discipline departments of the students. The Engineering Economic Design Course had no say in the way groups were split. However, future research will more fully explore the intelligence and computer fluency issues.) Also to be considered in this argument, is that the lower performing/grade group were the ones that demonstrated a significant difference in grade based on increased lab usage. If those that were higher achievers used the lab extensively as well, those students would have also demonstrated significance.

Second, Ramsden (1992) while discussing deep versus surface learning, states that "It was overwhelmingly clear as well, however, that outcome and process were empirically linked… those who used deep learning processes passed the courses far more frequently than those using surface learning processes." Thus establishing yet another argument that those students who use web-based project based learning environment (i.e. use a deep learning process), are more likely to do better than those who do not. This statement may be recognized in the fact that three-quarters of the students in the Engineering Economic Design class achieved a B or better.

Finally, the authors do not interpret the results to imply that traditional teaching is unsatisfactory. Rather, the web-based project learning environment should be further explored to see if teaching effectiveness can be improved. . Information can be anywhere and teachers and students can find it and use it to create knowledge in non-traditional and arguably better ways. The role of faculty then becomes to facilitate the acquisition of knowledge, or what may be the true goal of education; teaching students to think.

Bibliography

[1)] Altschuler, Glenn C. (August 2001). "The E-Learning Curve", *Education Life*, p. 13.

[2)] Creed, Tom. (Nov. 1996). "Extending the Classroom Walls electronically", www.employees.csbsju.edu/tcreed/techno3.html

[3)] DeLong, Stephen E. (1997). "The Shroud of Lecturing", *First Monday: Peer Reviewed Journal on the Internet*, www.firstmonday.dk/issue2_5/delong/index.html

[4)] Keown, Cherly, "A Learning Curve", *American School and University*; Overland Park, Vol. 71, No. 12, (1999, August), pp. 116 – 119.

[5)] Leidner, D.E. and Jarvenpaa, S.L. (Sept. 1995). "The Use of Information Technology to Enhance Management School Education: A Theoretical View", *MIS Quarterly*, p. 226-291.

[6)] McLester, Susan. (2001, April 26). "Technology and Learning; Taking A New Approach to Education", *The Los Angeles Times*, , pp. T7.

[7)] Merino, Donald N. and Abel, Kate D. (2003a, June). "Evaluating the Effectiveness of Using Computer Tutorials to Teach Basic Accounting", *American Society for Engineering Education (ASEE) Annual Conference and Exposition Proceedings*, Nashville, Tennessee.

[8)] Merino, Donald N. and Abel, Kate D. (2003b, April), "Computer Tutorials vs. Traditional Lecturing: Which is a More Effective Learning Environment?" *Journal of Engineering Education*, Vol. 92, No. 2, pg. 189.

[9)] Merino, Donald N. and Abel, Kate D. (2002, June). "Teaching Basic Accounting to Engineering Economy Students: Are Computer Tutorials More Effective than Traditional Classroom Lectures?", *American Society for Engineering Education (ASEE) Annual Conference & Exposition Proceedings*, Montreal, Canada, Session 2139.

[10)] Moursund, David. (Nov 2003) "ICT-Assisted Project-Based Learning", http://www.uoregon.edu/~moursund/PBL/

[11)] Sweeney, Jillian C and Ingram, Deborah. (2001, April). "A Comparison of Traditional and Web-Based Tutorials in Marketing Education: An Exploratory Study", *Journal of Marketing Education*, Vol. 23, No. 1, pp. 55 – 62.

[12)] Pitman, A.J.; Gosper, M; Rich, D.C. (1999). "Internet Based Teaching in Geography at Macquarie University: An Analysis of Student Use", *Australian Journal of Educational Technology*, Vol. 15, No. 2, p. 167 – 187.

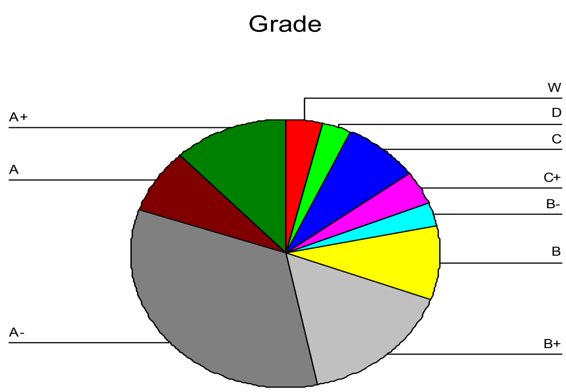
[13)] Ramsden, P. (1992). "Learning to Teach in Higher Education", *Routledge Publishing*, London, pg. 269.

[14)] Rich, David C; Pitman, Andrew J.;' Gosper, Maree V. (Mar 2000). "Integrated IT based Geography Teaching and Learning: A Macquarie University Case Study", *Journal of Geography in Higher Education*, Vol. 24, No.1, p. 109 – 115.

[15)] Wallace, David R. and Mutooni, Philip. (July 1997). "A Comparative Evaluation of World Wide Web-Based and Classroom Teaching", *Journal of Engineering Education*, p.211-219.

Appendix

Figure 1 – Grade Distribution –



Tables 3A and 3B – Regression Results

ANOVA[b]

Model	Sum of Squares	Df	Mean Square	F	Sig
Regression	56.497	1	56.497	9.277	.003[a]
Residual	602.929	99	6.090		
Total	659.426	100			

a: Predictors: (Constant) : total web accesses: note significance at the p< .01 level
b: Dependant Variable : Grade

Coefficients [a]

Model	Unstandardized Beta	Std Error	Standardized Beta	t	Sig
1 (Constant)	5.987	.366		16.379	.000
Total Access	1.273E-02	.004	.293	3.046	.003

a: Dependant Variable: Grade
Note significance at $p< .01$ level

Tables 4A and 4B – Regression Results

ANOVA[b]

Model	Sum of Squares	Df	Mean Square	F	Sig
Regression	26.962	1	26.962	5.573	.023[a]
Residual	208.016	43	4.838		
Total	234.978	44			

a: Predictors: (Constant) : total web accesses: note significance at the $p< .05$ level
b: Dependant Variable : Grade

Coefficients [a]

Model	Unstandardized Beta	Std Error	Standardized Beta	t	Sig
1 (Constant)	4.199	.465		9.029	.000
Total Access	1.406E-02	.006	.339	2.361	.023

a: Dependant Variable: Grade
Note significance at $p< .05$ level

Biographical Information

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Kate Abel serves as the Program Director for the Bachelor of Engineering in Engineering Management Program in the Charles V. Schaefer, Jr. School of Engineering at Stevens Institute of Technology. She teaches courses in Engineering Economy, Engineering Economic Design and Statistics for Engineering Managers. Her research areas include knowledge engineering, as well as, knowledge and information management. She has published over 10 refereed journal articles and conference papers.

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