Leveraging PBL and Game to Redesign an Introductory Computer Applications Course

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ABSTRACT

The purpose of this paper is to discuss one instructional design that leverages problem-based learning and game structures as a means of developing innovative higher education courses for students as responsive, lived experiences. This paper reviews a curricular redesign that stemmed from the evaluation of an introductory course in computer applications that had high drop, failure, and withdrawal (D/F/W) rates. Interviews with students and faculty in this course revealed that students were not engaged with, motivated by, or satisfied with the instructional methods, which were often frustrating and difficult to navigate. Using data collected from students and faculty, we describe the full redesign of the course, which included ill-structured problems for students to solve, multiple forms of learning assessment, and a contextual framing stemming from a digital, alternate reality game design. When comparing the new design to the original, the first iteration research indicated decreased failure rates, increased achievement on standardized assessments, and a range of individual student experiences from high praise of the design to some disappointment.

Categories and Subject Descriptors

K.3.2 [**Computer and Information Science Education**]: Literacy, *computer literacy.*

General Terms

Performance, Design, Experimentation, Human Factors, Theory,

Keywords

Blended learning; Course redesign; Game; Communicative Action; Problem-based learning

1. INTRODUCTION

The original computer applications course was designed to teach the basics of computer parts, Internet use, online security, and using Microsoft Office™ implemented an Adobe Flash™-based computer assisted instruction program called SAMS 2003 Computer Literacy™ [5].

An analysis of course materials and notes from interviews revealed several issues that led to dissatisfaction with the existing curriculum and instructional methods used in the course. The design team identified the following problems:

1. *Functions in one program were not linked to others.* Understanding how the programs can be used in a complementary fashion is an important objective that wasn't addressed in the existing curriculum. Students found learning the same skills in four different programs boring and repetitive, since many students were already familiar with these basic actions from previous computer applications courses in high school.

2. *Computer-based assessments and instruction were too rigid.* There are commonly three to five ways to perform an action in a program; however, the program often recognized only one. In some instances, the practice exercise asked a student to complete a task in one manner, while the assessment compelled another.

3. *Applications of knowledge were decontextualized and unrealistic.* Based on students' current life experiences, the applications of learning expected in both the training practice and exams don't fit well with an undergraduate's life experiences. Students saw little relevance between course content and their future work. They also found the constant drill and practice tedious.

4. *Computer-based instruction provided weak feedback.* The system provided weak feedback during both training and often none during exams. The amount of feedback did not increase or decrease dependent on how many correct or incorrect answers students provided for a specific objective.

2. THE REDESIGNED COURSE

Based on this analysis, the design team determined that the following measures be taken to address the underlying problems:

1. *The number of discrete learning objectives should be revised from 750 to 150.* Given the length of the course, the sheer number of objectives was overwhelming to students, and should be collapsed to eliminate redundancies from unit to unit. For example, the objectives "The learner will be able to open an MS Word document" and "The learner will be able to open an Excel spreadsheet" should be consolidated to read, "The learner will be able to open documents within MS *Office™*."

2. *Requirements for the course should be stable across sections and semesters, but revised yearly to incorporate innovations in the field.* With rapid changes in information technology and differing needs of students, course requirements should be updated regularly. An examination of state technology requirements for K-12 learning should take place yearly to ensure that the course does not simply re-teaching the same concepts students learned in high school.

3. *The course should be centered on larger learning projects and problem solving using the software, not around disembodied learning tasks.* The nature of the computer applications introduced in the course readily lends them to a project-based or contextual learning approach. To better engage students with these tools in the manner for which they're intended, the learning tasks should leverage them as a means to solve an ill-structured problem, design a project, or effectively communicate ideas to others. Development of appropriate, rubric-based assessments rather than multiple-choice tests is also warranted.

The university's retention goals, the research literature, and analysis of the existing course supported a redesign using problem-based learning methods. Furthermore, the use of story-like scenarios typical of problem-based learning (PBL) [3] is a prominent element in digital games, and media products known to engage players for hours on end.

However, given the challenge and cost of designing an immersive game world, alternative media that leverages that both narrative plot and the requisite learning scaffolds to facilitate learning is necessary. One such alternative is to embed game activities and resources in a variety of media, distributed across the Internet using Alternate Reality Game (ARG) structures [2, 4], rather than a fully integrated, stand-alone product. This approach maximizes resources, such as MySpace, generic web logs, Podcasts, YouTube™, and the three-dimensional digital environment of Linden Labs' *Second Life*™.

Students work in small teams of 3-4 students to solve problems posed by fictional clients, similar to those they may encounter in a video game, that last for two weeks during which time they explore the resources provided to them or uncover more as they play they game. This helps create an open system of resource distribution that authentically mirrors the contexts to which learners will transfer the skills and knowledge once they are done with college and working in the real world. This concept also allows designers to exploit many free online resources while merging them with PBL methods to give learners a situated, coherent narrative to contextualize their learning experience while concurrently providing cognitive scaffolds from which to retrieve knowledge and skills necessary to their future work and learning. In order for students to cognitively transition from an acquisition model to knowledge construction requires curricular and instructional innovation.

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2.1 Student Learning Outcomes and Assessment

As noted earlier, student learning outcomes (SLO) were reduced from more than 750 separate outcomes/learning objectives to 150, mainly by eliminating those that were repetitive from a single software program to the next. The objectives that emerged may be found here. These outcomes were only those specifically related to surface-level learning related to either memorization of facts or application of skills based on rote memorization.

2.1.1 Assessment

As with any new instructional methodology, it is as important to discover the specific answers as to why it was more effective than another method as it is to learn that it is effective at modifying behavior, improving achievement, or engaging learners in reflection associated with improvements in critical thinking. This research study employed both qualitative methods to examine student experience as well as a quasi-experimental, posttest comparison design to measure the effect of a digital game-based, problem-based curriculum in a hybrid course on student achievement. The posttest questions used the shared learning objectives for each section of the course.

The participants were quasi-randomly selected as they self-selected to participate in each section with no prior knowledge by the researchers. These participants had no prior knowledge of the instructional style of the course prior to enrolling other than knowing that the comparison section is a hybrid course which meets only partly in a classroom, that the section meets entirely online, or another section meets entirely face-to-face each week.

The research of the quantitative questions differed dependent on the outcomes sought by the questions. In the instance of the achievement questions, students have been randomly assigned to a condition dependent upon the section of the course that they signed up to take with no prior knowledge of the research questions and with no influence by the researchers. Two sections engaged in the existing 1.) online and 2.) face-to-face sections acted as the comparison groups. A third section, developed specifically as a hybrid course with six total face-to-face meetings combined with learning tasks and activities to be completed online using open-source and no-cost Web 2.0 tools. This third section acted as the treatment condition. The following were our main research questions linked to overall goals of the course, including achievement:

> *Question 1.* Can the use of a game-driven, problem-based learning curriculum for post-secondary learners that leverages existing and developed distributed learning resources should improve the achievement of learners at a statistically significant level more than those learners in the existing drill and practice-based course?

In order to address this question, students in the two conditions engaged with either the treatment or comparison curricula over the course of the semester. At two points during the semester (midterm and final), each group completed two exams based on the same learning objectives shared by each curriculum.

> *Question 2.* Can the use of a game-driven, problem-based learning curriculum for post-secondary learners that leverages existing and developed distributed learning resources improve the level of satisfaction expressed by learners more than those learners in the existing drill and practice-based course at a statistically significant level?

This question was addressed by providing students with a survey

of learner satisfaction with the overall course, the means of instruction, means of assessment, and learning activities similar to the means of course quality assessment that will be provided by the College of Education. However, while summative, this survey was more in-depth and asked specific questions about the delivery of instruction by the game and online systems, attitude toward instructor, attitude towards instructional style, self-report of instructional style, attitude towards individual learning components and activities, attitude towards peers, as well as general satisfaction with the course.

2.2 Pedagogical approach

Students in this class met face-to-face four to ten times during the semester, depending on instructor and student preference, to practice the basic skills needed to complete coursework. The remainder of the time, the class met in small groups online in the *Second Life™* digital environment, which is free to download and enter. Visual imagery and audio provide information, tasks to complete, and a larger narrative structure within which students may situate their learning. Rather than listening to lectures and taking large multiple-choice tests, students will hone their technology skills by solving ill-structured problems that they encounter in the 3-D environment. They worked in small groups, using productivity tools to develop products that solve posed problems, and take part in support one another using a complimentary courseware tool called *Moodle.* The goal of this instruction was to provide students with a general set of skills that will allow them to use any word processor, spreadsheet program, or presentation tool and adapt to new versions readily. Problems were contextualized within a larger narrative structure that takes students along through a linear story within which their understanding was be situated. Game structures such as an overarching conflict, objectives to complete, clues to seek out and interpret, and feedback from the 3-D system were expected to increase student engagement with the learning of basic computer skills and knowledge.

Both problem-based learning (PBL) and alternate reality game structures were used to redesign the computer applications course. Rather than listen to lectures, complete practice exercises, and take frequent multiple-choice tests, students hone their technology skills by solving a series of ill-structured problems posed by fictional clients using the very tools they are expected to learn. Students work on each task or problem in small groups of two or three, using a variety of productivity and communication tools. The redesign made use of a hybrid or blended learning format. Face-to-face class time was dedicated to delivering instruction and to facilitate group problem solving. Online resources, support, and collaboration tools were also provided through the free courseware platform, *Moodle.* However, students were encouraged to make use of whatever productivity and communication tools best fit the dynamic of their groups. Emphasis was placed on communicating with peers, in class and online, to develop viable and deliverable solutions, rather than enforcing conformity to a specific version of a designated proprietary software program. The goal of this instruction was to provide students with a general set of skills that would allow them to use any word processor, spreadsheet program, or presentation tool and adapt to new versions readily. It also addressed some of the issues cited previously that frequently accompany online learning and digital collaboration, compelling students to negotiate solutions to issues of

accessibility, software compatibility, and file management in their own teams. For example, if one team member could not afford the latest version of *Office™*, the team might use Sun's *Open Office™* or Google Docs™. These broadened objectives were expected to better prepare students for their future world of work.

2.2.1 Alternate Reality Game course structure

The Door ARG was designed with a two-tiered narrative structure that framed course activities and provided the context for problem solving. The first tier of this narrative engaged students with fictional clients who "hired" student teams to complete authentic tasks — a problem-based narrative approach. The second tier engaged students in game structures that included puzzles, codes, and ciphers that must be solved, retrieved or used correctly in order to gain access to materials, information, and resources that provide additional scaffolding and narrative support to the first tier learning tasks. In essence, each of the clients and characters in the six, PBL scenarios had alternate personas, hidden beneath their client identities, and all of them were embroiled in an underlying conflict with each other as well as the unsuspecting student players. Within the top-level story of *The Door*, students are asked by "clients" to solve complex, ill-structured problems that require them to use all the major components of Microsoft *Office*™. The problems students faced ranged in complexity. In one instance, students had to provide directions to an inept old coach and gym teacher for how to construct a properly functioning grade book spreadsheet in order to allow him to keep his job at a middle school. In another instance, students develop an improved web site for a local nightclub that included appropriate use of basic color theory and space usage.

At the same time, clues appear indicating that a software program called the Autumnal Equinox Firewall has disappeared which may have dire consequences for both the students and the world. Through these clues, the second tier of the story is revealed. The Puppet Master character of the game, Hester, offers students rewards for locating relevant game information. Further, she notes that additional resources to improve their problem solutions will be revealed if they obtain these rewards, such as a video that students can locate in YouTube™ (link here) if they put together a web address correctly. In this way, the Puppet Master, played by the instructor, provides soft scaffolding and additional resources for students who may be struggling either to solve the ill-structured problems or locate game resources. Game characters also act as gatekeepers, judging the quality of student solutions and preventing them from moving to the next problem until the last has been adequately addressed. As students move through the story at both levels, clues and minor puzzles are revealed. If students are successful at piecing this information together, they may discover that the clients are intended to be the ancient Greek gods seeking to reclaim followers and power by harnessing the power of the Internet, a power these students seek to understand.

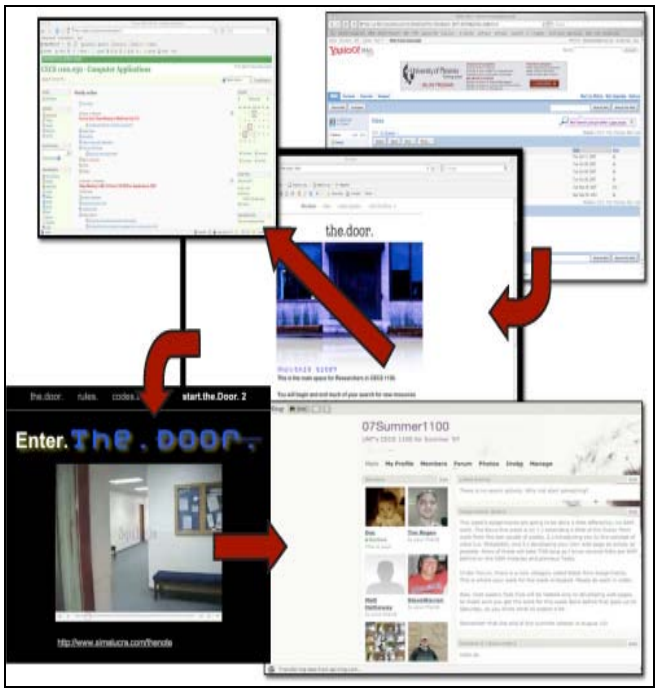

Figure. *Distributed resources, clues, and communication tools for the ARG.*

Visual imagery and audio were used to provide objective information about the ill-structured learning tasks and to spur communications among students, instructors, and game characters. Further, the two-tiered narrative framing provided the means for students to situate their learning in a more meaningful and engaging context [6]. It also encouraged students to interrogate the inconsistencies between the two plotlines and was leveraged to challenge students to rethink their surface-level understandings of what was presented to them by the game.

3. RESULTS

Given that this course redesign stemmed from a university initiative aimed at improving retention, satisfaction, and academic achievement, research into the redesign employed multiple methods: qualitative and quantitative. The quantitative measures included examination of drop, failure, and withdrawal rates, analysis of posttest achievement scores, and a measure of student satisfaction with the course. Qualitative data from semi-structured interviews with students in the pilot implementation was collected and analyzed using constant-comparative methods. This data was triangulated with data from the aforementioned student blogs which were analyzed through computer mediated discourse analysis [1].

3.1 Quantitative findings

The analysis of scores from first, Spring 2007, implementation of the experimental curriculum had mixed, but promising results on measures of retention, satisfaction, and achievement as shown in Table 1.

Table 1. Quantitative results for student retention, satisfaction, and achievement

	Comparison *n*=57	**Treatment** *n*=32	**Differences**
Retention (% DFW)	21.05%	12.50%	- 8.55%
Drops	1	2	
Failures	2	0	
Withdrawals	9	2	
Satisfaction	3.64	4.2	alpha=.05, z(6)=6.86, p=1.64
Achievement	M=78.83	M=85.96	t=3.90, crit=1.67

The results indicate an 8.55% difference in the percent of students who dropped, failed, or withdrew between the comparison course and the treatment. Moreover, satisfaction with the redesigned course, as gauged by the five item college course

evaluation which is the measure used at the university, was statistically significantly higher than in sections using the existing course design. Finally, student achievement, as measured by posttest in both groups, and compared using a two-sample t-test assuming unequal variances showed greater improvement in the treatment group the comparison group.

3.2 Qualitative findings

Although student satisfaction was higher in the redesigned course, qualitative data collected through interviews with students tells a slightly different story. Interviews indicated that students gained a number of insights and understandings from the experience. These included:

1. An appreciation for how the technology skills gained in the course applied to the world of work and would impact their future.
2. An understanding of the significant role that interpersonal communications play in learning and in career success.
3. A sense of empowerment fostered first by access to resources and later by development of the knowledge and skills to become resourceful
4. An increased willingness to play, explore, and experiment with tools, content, and processes that points to potential lifelong learning [7].

4. DISCUSSION AND CONCLUSION

The course continues to be taught in different forms each semester. These differences stem from data collected each semester from students and faculty teaching the course. Upon reviewing the qualitative data collected over the course of the last three years to contextualize the quantitative findings, communication problems among students in their groups was paramount, indicating that this is a skill entering freshman substantially lack. This also had roots in the design of the course that required high levels of communication using digital tools as a means of completing work and asking questions. Problems of communication were further exacerbated by the size of some of the groups that ranged from three to five, depending on student choice. Finally, a lack of student experience with group communication and problem solving that they brought with them to the course from high school and other undergraduate courses further complicated matters. While the problem-based learning component was challenging for some students, they made clear linkages between problems they were solving in the course and those they would have to solve in the future. However, while many students reported disliking working in groups to complete tasks, they did recognize its necessity in their future careers and that excellent interpersonal communications skills are necessary for their future success. The next iteration of this course will undergo a full redesign in order to specifically target each of these communicative goals and allow for the evaluation of student and instructor success at reaching them. We will also redesign the problem-based aspect of the course and the game aspect so that students must complete the game in order to successfully complete the course, which we hope will result in even higher student satisfaction rates amongst students.

While the instructional methods have yielded some mixed results stemming from the use of problem-based learning and its accompanying reliance on students to self-organize and

solve ill-structured problems, it has provided a wealth of data and results related to improving student experience with experimental and innovative instructional methods that push towards the edges of what our students are capable of as they enter college. Overall, the results of the research related to this course redesign leave the researchers hopeful that the hybrid course and use of an ARG to frame the problem-based learning tasks and group interactions were responsible for the improved test scores. While the statistical findings of this study were mixed in terms of student retention, the increased posttest and ratings scores are promising and will be followed up with additional studies on future iterations of the course.

However, the process was not without difficulty. There have been many challenges to the innovation from student, instructor, and technology arenas, causing this course to go through eight iterations over the course of the past three years in response to student and instructor realities [7]. Taking the innovation from a single section of 32 students to seven sections and more than 200 students while coordinating five or more instructors with wildly different pedagogical and epistemological views has been difficult and extremely time consuming. Developing additional materials on a weekly and monthly basis in response to instructor needs and questions or simply answering questions and assuaging fears sometimes takes as much as 25 hours a week in addition to monthly afternoon meetings. While the adjunct faculty teaching the course have been supportive, they have complained often of the increased workload required by the course in terms of the amount of feedback and grading they are required to provide, the level of communication they must maintain with their 32-64 students to respond to questions by e-mail, phone, or other digital structure, and the general lack of student willingness to read directions and do a reasonable level of work in the course.

Students were often not prepared by high school for the innovative curricula they should expect in college. Therefore, we must work more closely with professionals in K-12 settings and at state agencies to better prepare students and instructors for the critical thinking and creative tasks they should expect in college and beyond. Developing innovative curricula in high school that both targets acquisition of knowledge and skills while challenging students to solve ill-structured problems and be prepared for self-direction, ambiguity, and critical thinking will require that instructional designers and educators on both sides of the secondary/post-secondary line challenge the fundamental objectives of schooling. By doing so, we prepare our students for the future world of work in meaningful ways that allow them to be successful in the 21st century Conceptual Age economy rather than be left behind because they are not prepared to adapt to the rapidly changing world around them.

5. REFERENCES

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