Learning Analytics across Digital and Physical Spaces: Overcoming Challenges in Large Required College Courses

Author(s): Please Leave This Section Blank for Review
Institution
Email

Author(s): Please Leave This Section Blank for Review
Institution
Email

ABSTRACT: This paper describes ongoing efforts to design a required freshmen-level college course that can scale to large numbers. The learning problem we identified pertains to the ability to engage learners, in and outside of class, despite the large number of students enrolled. This paper offers two contributions: a) a set of design principles and meta-requirement for an in-class required introductory college course b) early results from a pilot study implementing the proposed design. Our proposed design leverages the promise of learning analytics and persuasive technology to achieve its dual objective of quality education and efficient implementation. However, our early results point to yet unsolved challenges that must be addressed if the design is to successfully scale to a large number of students.

Keywords: Learning analytics across digital and physical spaces, persuasive technology, college education, large classes.

1 INTRODUCTION

Recent research has increasingly converged toward the consensus position that as class size increases, the learning and teaching experience degrades. Specifically, at the college level larger classes are associated with lower subject matter mastery, as measured by grades (Kokkelenberg et al. 2008), particularly for students who are at the top of the grade distribution (Bandiera et al 2011). Further, interaction and engagement decrease and students in large classes remain anonymous leading to lower motivation for both faculty and students (Chambliss and Tackacs 2014). The most effective teachers carefully motivate student learning by articulating and reinforcing the "payoff" of knowledge acquisition while giving students a sense of control over their achievement (Bain, 2004). Larger classes limit the human interaction that teachers traditionally leverage to motivate students, leading to a regression toward using grades as a motivator. The lack of human interaction also fosters strategic learning, occurring when students concentrate "primarily on doing well in school, avoiding any challenges that will harm their academic performance and record" (Bain 2004, p. 34).

Conceptualizing a semester long college course is an act of design – "engineering an environment in which [students] learn" (Bain 2004, p. 49). Our program of research tackles the challenge of designing an in-class required introductory college course that can scale to large numbers of students, under resource constraint. We report on a pilot study focused on testing the feasibility of the course design prior to scaling it. For those universities where the pressure on efficiency is

irreversible, we propose that learning analytics and persuasive technology serve as important elements of the environment that can combat some of the negative effect of inherent in large classes.

2 INTERVENTION THEORY

The design of our course is based on intervention theory (Argyris 1970). Intervention theory identifies three principles that guide the design of interventions: leveraging valid and useful information, allowing free informed choice by the client,[1] and fostering internal commitment. Previous research (Piccoli et al. 2017) draws on intervention theory to articulate the meta-requirements (Walls et al. 1992) upon which to build and scale a learning environment for required introductory college courses under resource constraint. In this section, we briefly sketch both the theory and the meta-requirements stemming from it.

Valid information is that which can be publicly verified and shown to affect the phenomena the intervenor is seeking to affect. Useful information is that which the client would be able to use to "control their destiny" (Argyris 1970). For example, while students' natural aptitude will reliably predispose them to master specific subject matter (e.g., computer programming), they cannot modify natural ability. From an intervention theory standpoint, natural aptitude provides valid, but not useful information. Study habits are also reliably shown to affect subject matter mastery. An understanding of study habits provides valid and useful information in support of an intervention.

MR1: An in-class required introductory college course that can scale to large numbers of students should record students' behaviors both in class (e.g., attendance) and outside (e.g., study patterns).

Free informed choice points to the centrality of the client in the implementation of the intervention – and therefore in its design. Free and informed choice is particularly important in situations like college learning, where internal commitment is a precondition to the success of the intervention.

MR2: An in-class required introductory college course that can scale to large numbers of students must not conflate behavior with learning. In other words, grades should never be used to enforce behaviors (e.g., attendance points).

MR3: An in-class required introductory college course that can scale to large numbers of students treats students as self-responsible and maximizes learner control.

MR4: An in-class required introductory college course that can scale to large numbers of students exposes all behavioral and performance data as soon as they become available (e.g., providing alerts to at-risk students based on tracked behaviors and performance).

MR5: An in-class required introductory college course that can scale to large numbers of students contextualize behavioral and performance data for students (e.g., in the form of contextualized

[1] In the context of intervention theory, the term "client" refers to the recipient of the intervention. In our case the client is the student.

dashboards enabling students to compare their behavior to the class, previous cohorts, or their own targets).

Internal commitment refers to the degree of ownership and responsibility the client feels with respect to the intervention. The power of internal commitment comes from individuals' sense of purpose for the initiative and their beliefs about the control they exert over their action and the outcome.

MR6: An in-class required introductory college course that can scale to large numbers of students proactively triggers appropriate behaviors (e.g., by engaging students outside of class using conversational interfaces and alerts).

MR7: An in-class required introductory college course that can scale to large numbers of students encourages sustained use by managing triggering risks (e.g., personalizing triggers based on student preferences or characteristics).

The three principles of intervention theory are interdependent. The availability of valid and useful information is necessary for the client to make decisions that are free and informed. At the same time, the outcome of these decisions provides information that contributes to the stock of valid and useful information available to the client and the intervenor. Moreover, to the extent that the results of choices being made by the client are positive, those choices should strengthen internal commitment (Argyris 1970).

3 THE COURSE

Our work focuses on a standard introductory course in a US business school: "Introduction to Management Information Systems." It is required of all first-year business and economics majors and focuses on "the role of information technology in business including the development and use of information systems, hardware and software, the strategic impact of IT for businesses and the nature of the IT career." The course currently throughputs more than 1,500 students per year.

Following a very successful pioneering effort in the late 1990s (Piccoli et al. 2001) the school incrementally migrated the course online and increased class size (Piccoli et al. 2017). The course has been fully online over the last six academic years with average section sizes exceeding 200 students. While the online effort has created considerable efficiencies, saving the college over $5.5M between 2001 and 2016, human interaction between students and faculty has all but disappeared (Piccoli et al. 2017). An analysis of a section of the course in Fall 2017 reveals that only 6% of the enrolled students met at least once face-to-face with the faculty member. With half of these meetings being requested for bureaucratic purposes (signature, medical notes, etc.).

3.1 Pilot Study: Implementation

Following the design principles articulated above, we ran a pilot section of the course in class (39 students), with a second pilot scheduled for Spring 2018 (90 students). All content material was custom-developed and delivered through a responsive Web application written in Node.js (Express framework). MR1 was implemented by requiring the students to individually sign on in order to

access course material ranging from book chapters, course slides, practice assignments, schedule and test data. Attendance data was manually recorded.

MR2 was also implemented by ensuring that students' final grade depended solely on their performance on two exams, five checkups (i.e., quizzes), and a final team project. All behaviors tracked were exposed to the students and no measured activity was assigned a grade or points.

MR3 was implemented by providing nine practice assignments over the course of the semester. None of the assignments required completion. Students were informed that homework represented "a service" to them. Work submitted by each deadline would be evaluated and students received a detailed performance report for each assignment they turned in. However, grades were unaffected by students' decision to complete each assignment or its evaluation.

MR4 and MR5 were only partially implemented in our pilot. Students received two reports, one at the midterm and one prior to the final exam, detailing all the data we had collected about their behaviors. The report was private and individualized, and provided a comparison of individual students' activities with an aggregate (average) of the class. We are in the process of developing a real-time dashboard to expose all data to students on an ongoing basis for the next pilot. MR6 and MR7 have yet to be implemented.

3.2 Pilot Study: Results

The objective of our pilot study consisted primarily in testing the feasibility of the course design prior to scaling to a larger class size. Thus, we did not advance any formal hypotheses. However, we drew a number of interesting observations from the experience.

As with any other behavior in the course, class attendance was not required. Despite the prevailing rhetoric at the school suggesting that unless students are forced they will not go to class, attendance was consistently above 75%. Of the 30 students who completed the course, four attended every class and all but three attended at least two thirds of the sessions.

While they were present and actively engaged during the sessions, in aggregate students did not consistently complete the assignments. On time completion, a condition to receive feedback, steadily declined during the semester – from 69% on the first assignment to 7% on the ninth assignment. When asked for feedback, students' consensus seem to be that the assignments were too long and complex. Once a week, students would start the assignment in class using a flipped classroom pedagogy. However, they rarely completed the work during the allotted class time. A number of students stated that when they sat down to complete the assignment at home, the length and complexity would discourage them. On a follow up survey at the end of the course, 22 out of the 27 respondents agreed with the statement that "shorter practice assignments would be more effective." We also speculate that, as students became increasingly busy during the semester, the lack of points as an incentive to complete the assignment became a decisive factor with students prioritizing courses that forced homework completion.

Also telling was students timing of preparation for the checkups. Each checkup covered one or two chapters of the online book. The material was covered in two sessions, one per week, starting two weeks before the checkup. Students could sign up for the quiz at the testing center on any day

between Monday and Friday during the checkup week (represented by the black horizontal dashed line in Figure 1). While the instructor repeatedly stimulated the students to review material and study after each class, as the figure shows, access to the tested material occurred immediately before the exam. Specifically, as the boxplot in Figure 2 shows on average students prepared for the checkup within a two-day window of taking the test.

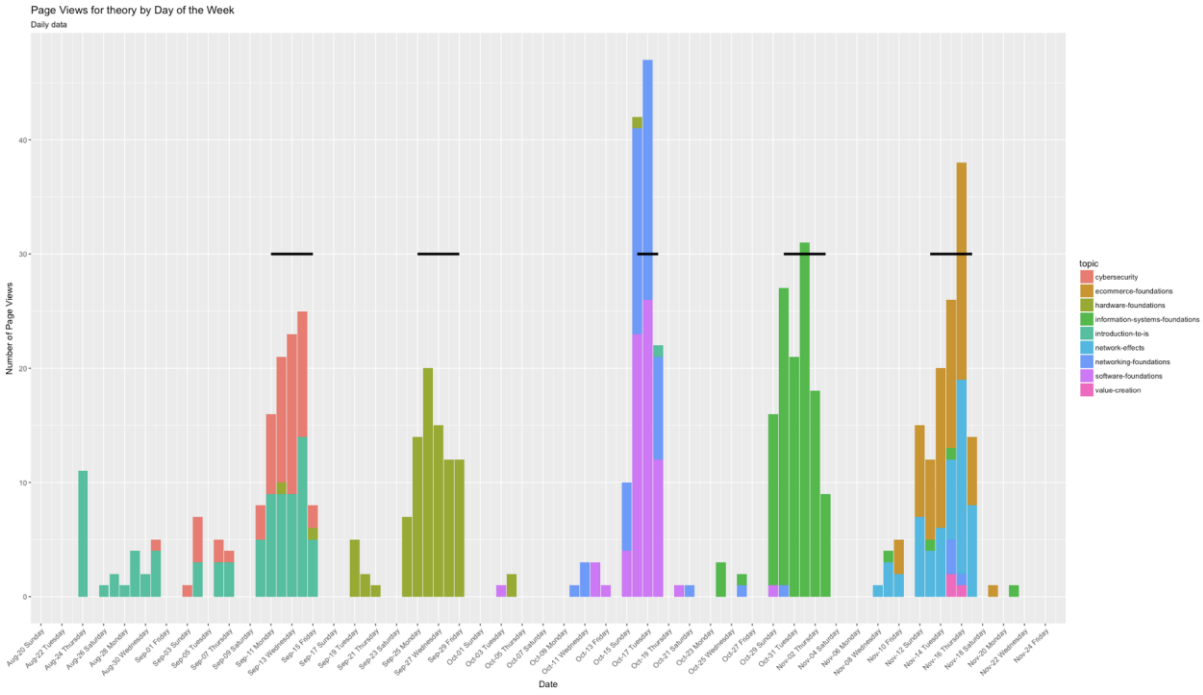

Figure 1: Checkup weeks and content access

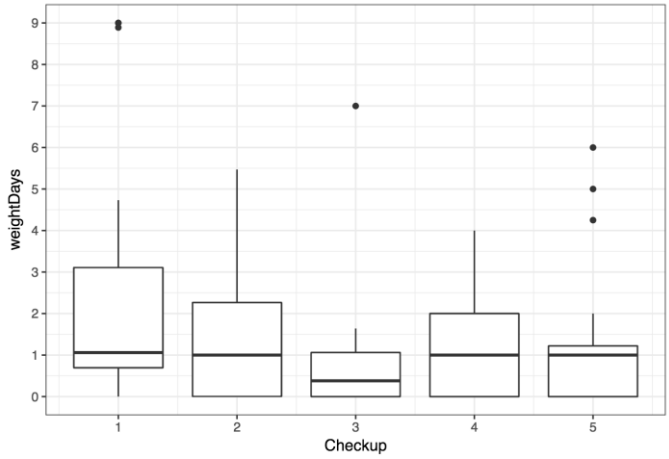

Figure 2: Average days accessing material prior to examinations

4 CHALLENGES AND FUTURE DEVELOPMENT

The above results frame the challenge for our work going forward. Beyond course material changes, such as the “chunking” of large practice exercises, we have designed future improvements along two vectors: Improved data collection beyond logs, and persuasive technology triggers.

While at this point we have relied heavily on log data to capture student behaviors, we intend to leverage multimodal learning analytics (Bilkestein and Worsley, 2016) to improve our collection of valid and useful information. Specifically, we are currently developing an attendance taking system that relies on face recognition. The system is to be used to collect attendance in all co-located learning activities: class sessions, lab sessions, review sessions and office hours. Keeping with our design principles, such system can be used to record student behaviors in an effort to expose them through dashboards and will not be used for grading. We also expect the system to become the basis for real-time student recognition during the class, once augmented reality solutions become viable. We deem such a system as an important instrument to help reduce the feelings of anonymity that pervade students in large classes.

The second challenge we face, as captured by our results, is the need to think creatively about scalable systems that aid in influencing students to practice good learning habits and combat strategic learning. In smaller classes, the best teachers are able to motivate students without resorting to the use of requirements and grades (Bain, 2004). How can the same objective be achieved in larger required courses? We believe that persuasive technology (Fogg, 2009) holds promise. We are developing two types of triggers, through conversational interfaces, for the next iteration of the course: a) Facilitator triggers, designed to reduce barriers to accomplishing the behavior (e.g., a "question of the day" trigger designed to stimulate both interest and reflection on the subject matter covered during the week). Spark trigger, designed to increase motivation (e.g., alert triggers for ensuring that all students stay on task and to raise awareness of at-risk students who are in danger of falling behind).

REFERENCES

Argyris, C. (1970). Intervention Theory and Method: A Behavioral Science View, Reading, MA: AddisonWesley.

Bain, K. (2004). What the Best College Teachers Do (1 edition.), Cambridge, MA: Harvard University Press.

Bandiera, O., & Larcinese, V., Rasul, I. (2010). Heterogeneous Class Size Effects: New Evidence from a Panel of University Students, *The Economic Journal*, 120 (December), 1365-1398. http://dx.doi.org/10.1111/j.1468-0297.2010.02364.x

Bilkstein, P., & Worsley, M. (2016). Multimodal Learning Analytics and Education Data Mining: using computational technologies to measure complex learning tasks. *Journal of Learning Analytics,* 3(2), 220-238. http://dx.doi.org/10.18608/jla.2016.32.11

Chambliss, D. F., & Takacs, C. G. (2014). How College Works (1 edition.), Cambridge, MA: Harvard University Press

Fogg, B. (2009, April). *A Behavior Model for Persuasive Design* in Proceedings of the 4th International Conference on Persuasive Technology Persuasive '09, New York, NY, USA: ACM, 40:1-40:7. http://dx.doi.org/10.1145/1541948.1541999

Kokkelenberg, E. C., Dillon, M., & Christy, S. M. (2008). The effects of class size on student grades at a public university, *Economics of Education Review* (27:2), 221-233. https://doi.org/10.1016/j.econedurev.2006.09.011

Piccoli, G., Ahmad, R., & Ives, B. (2001). Web-Based Virtual Learning Environments: A Research Framework and a Preliminary Assessment of Effectiveness in Basic IT Skills Training,

Management Information Systems Quarterly (25:4) 401-426. https://doi.org/10.2307/3250989

Piccoli, G., Rodriguez, J., Palese, B., & Bartosiak, M. (2017, December). *The Dark Side of Digital Transformation: The Case of Information Systems Education.* In Proceedings of the Thirty Eighth International Conference on Information Systems, Seoul, South Korea, 1-20.

Walls, J. G., Widmeyer, G. R., & El Sawy, O. A. (1992). Building an Information System Design Theory for Vigilant EIS, *Information Systems Research* (3:1), 36-59. https://doi.org/10.1287/isre.3.1.36

Ward, A., & Jenkins, A. (1992). The problems of learning and teaching in large classes. In G. Gibbs & A. Jenkins (Eds.), *Teaching Large Classes in Higher Education: How to Maintain Quality with Reduced Resources* (pp. 23-36), London: Kogan Page.