Toward Predicting Test Score Gains With Online Behavior Data of Teachers

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ABSTRACT

As technology continues to disrupt education at nearly all levels from K–12 to college and beyond, the challenges of understanding the impact technology has on teaching continue to mount. One critical area that yet remains open, is examining teachers' usage of technology by specifically collecting detailed data of their technology use, developing techniques to analyze that data and then finding meaningful connections that may show the value of that technology. In this research, we will present a model for predicting test score gains using data points drawn from typical educational data sources such as teacher experience, student demographics and classroom dynamics, as well as from the online usage behaviors of teachers. Building upon prior work in developing a usage typology of teachers using an online curriculum planning system, the Curriculum Customization Service (CCS), to assist in the development of their instruction and planning for an Earth systems curriculum, we apply the results of this typology to add new information to a model for predicting test score gains on a district-level Earth systems subject area exam. Using both multinomial logistic regression and Naïve Bayes algorithms on the proposed model, we show that even with a simplification of the highly complex tapestry of variables that go into teacher and student performance, teacher usage of the CCS proved valuable to the predictive capability in average and above average test score gains cases.

Keywords

online user behavior, teaching, pedagogy, learner gain prediction, instructional planning support

1. BACKGROUND

Within the past 20 years, the use of technology in the classroom has grown at an unimaginable pace. From K–12, to college and lifelong learning, students and teachers alike are now using a vast array of tools in their educational endeavors. Teachers, especially, are using tools in many interesting ways with the hope that these tools improve their teaching productivity, better engage their learners, and ultimately provide optimizations that make their jobs less difficult so that they can maximize their value and skill in teaching. Tools that educators once relied on to enter grades and organize lesson plans, have transformed into the now-diverse online ecosystem of intra-, extra- and Inter-net based platforms that allow them to do a multitude of activities like collaborate with like-minded educators located anywhere in the world, find digital resources relevant to their curricular objectives, find out how state and national standards are tied to specific resources prepared for use in their classroom, examine the progress their students are making through those lessons and even manage all these things in a single portal. These technologies are affecting everyone in education – administrators, educators, learners, parents, etc. – and as the state of the art pushes policy and pedagogy forward, in its wake a mounting number of challenges must be sorted out, including whether or not these technology tools are facilitating educational productivity or hindering it.

It is widely recognized that teachers matter a great deal in the learning process of students, and many studies suggest that teacher skill is one of the key predictive forces in learner success. Even with large efforts such as The Gate's Foundation $45 million dollar, multi-year study to understand the factors that might accurately predict teacher effectiveness, it still remains unclear from these and many other studies, what impact technology and specifically online tools designed to impact pedagogy, are having on the toolkits, skillsets and patterns of productivity employed by effective teachers, where effectiveness in this context is measured by learner gains. This research aims to explore the mechanisms and models of understanding how teacher utilization of online tools might be linked with learner gains. By studying the usage of the Curriculum Customization Service (CCS), we will try to bridge the gaps between the online behaviors of teachers and learner gains, while at the same time utilizing common educational data, such as teacher experience, class demographics and class dynamics variables.

2. RESEARCH CONTEXT

The research presented here examines the online usage behaviors of teachers within the context of the learning gains observed over the course of a single year of data. Earth systems teachers within a large urban public school district within the U.S. were trained and given the Curriculum Customization Service (CCS) to use for their planning

and instructional tasks during the 2009-2010 school year. The CCS has been described elsewhere in detail [2], but summarily, the CCS is an online instructional and curriculum planning tool designed to provide teachers access to an array of materials to support them throughout the school year. It contains publisher materials (e.g. digital versions of publisher books, student handouts), including instructional supports for classroom activities, as well as digital library resources that have been vetted and aligned to the curricular goals and objectives of the district. The content and structure of the CCS closely match the goals of objectives of the district-designed curriculum, and for this research the curricular focus of the CCS materials was the grade 9 Earth systems curriculum.

As previously reported in [1], the usage patterns of the CCS users have been automatically explored using unsupervised clustering techniques yielding a user typology representing different kinds of aggregate use of the CCS over the span of a single year of use. It was found that five categories of usage emerged from the data, briefly described in Table 1. These usage categories form the basis for the online component of this research, and these automatically generated categories do not in any way represent fixed, or even definitive categories in all instances and users of the CCS (or any other system). The usage types discovered by these methods, however, were studied further through qualitative analysis of teacher surveys, interview and in-class observations, and have been given additional support and validation through other research [2].

Typology Label	**User Characteristics**
Limited Use	Lower overall use of the system.
Interactive Resources specialist	Heavier relative use of the Interactive Resources components of the system.
Power user	Heavy robust use of the CCS.
Moderate generalist	Overall moderate use of the system.
Community-seeker	Heavier relative use of the community and sharing features of the CCS.

Table 1: User typology for CCS users in this research.

The impetus of this research is therefore to explore whether the CCS can be shown to have a predictive association with *classroom learner gains* through the user typology give above. In particular, this research examines how the typology designations along with three crucial inputs (1) the demographic composition of the learners within each teacher's classroom, (2) the dynamics of each classroom in this research, and (3) the skill level of the teachers, might be used to build a model to predict learner gains.

3. METHOD

By using the pre- and post-test scores of the district-wide Earth science Benchmark exam administered to students at the beginning and end of the school year, this research aims to build and apply a model (see section 4) that examines the linkages between CCS usage and the other variables collected in this research. Two years (2008–09 and 2009–10) of standardized test and Benchmark exam score data, teacher experience and class data (class size and demographic makeup) were examined to determine if there were any significant differences in the population characteristics and student test score performance. For the first year data of data (2008–09) the CCS was not used, yet in the successive year (2009–10) the CCS was used. Though there were significant differences between the Benchmark exam score gains ($\alpha < .001$; $df = 2$; $\chi^2 = 1039$; $p = 2.2e^{-16}$), where the mean letter grade gain in 2008–09 Benchmark exam was 0.29 and the mean letter gain in 2009–10 was 1.04, the other variables such as demographic makeup, class size and teacher experience, show no significant differences.

4. DATA & MODEL

Classroom and teacher data were segmented and binned for 27 teachers for which there was complete, comparable data sets as well as CCS usage data in the 2009–10 school year. These data represented 81 total class sections of students for that year. To explore the role the CCS may have played in the Benchmark exam gains of the 2009–10 school year, a model was created to predict learner gains with demographic, class size and teacher skill variables, in addition to the CCS usage typology category previously discovered in section 2. This model for predicting gain $G_{s,t}$ is given by $G_{s,t} \sim E+D+N+U$, where E is the teacher experience category, D is the demographic category, N the class size category and U the CCS usage category. The output variable $G_{s,t}$ was predicted along three outcomes : below average, average and above average gains. Data sets and outcomes were further grouped into the gains for all sections and gains for individual sections.

5. INVESTIGATION & RESULTS

Two classifiers were compared, Naïve Bayes and multinomial logistic regression, in several different configurations to study the predictive capability of model with and without CCS usage. The best model sensitivity (true positive rate) achieved by all models examined was 0.67 for the average and above average gains, corresponding to $G_(s,t) \sim U + N$ and $G_(s,t) \sim U + D$ – CCS usage category + class size and CCS usage + demographic category, respectively. The model performed poorly at predicting below average gains for the individual section gain grouping.

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7. REFERENCES

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