Using eLearning Systems to Scale-Up Educational Research:
The Networked Education Database (NED) Project

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Abstract: Course management systems (CMS) play a critical role in supporting learning and teaching in online degree programs and virtual high schools, as well as augmenting traditional classroom environments. Simultaneously, they provide a tremendous amount of system data about user activity in online spaces, and a unique technology for collecting custom educational data asynchronously and confidentially. From highlighting diverse instructional strategies to elucidating student evaluation practices, CMS can help researchers understand the processes by which learning happens in both online and offline environments. This paper will detail an innovative course management data collection project called the Networked Education Database (NED). As part of NED, during the 2006-2007 school year, 732 students and 19 teachers in 37 classrooms across three secondary schools will be using their school's e-Learning system to submit anonymous socio-metric, social psychological, and student performance information, longitudinally, to a central database. The paper will report on the logistical issues in operating a networked data gathering system, as well as the results from the pilot data collection activities.

1. Introduction and Literature Review

The cost and complexity of data collection in schools remains high, even as efforts to base educational innovations on research evidence increases. For example, the rise in accountability systems has made securing precious classroom time to collect data more difficult. Concerns over privacy have made "informed consent" requirements more stringent for any data collection involving non-anonymous minors. The laborious process of keypunching and coding paper-based data inhibits the sharing and re-use of datasets. Advances in information technology have enabled significant innovations and efficiencies in the work of education researchers. These advances include: easy to use and powerful software packages for quantitative and qualitative analyses; online communication and collaboration tools that enable researchers to engage with colleagues anytime and anyplace; and "data warehouses" that allow for central access to a wide range of information on education resources, processes and outcomes. Despite these innovations, however, the work of collecting original data is still in many cases decidedly "low tech." The prevailing use of paper-based research instruments, delivered manually and synchronously, to collect information that oftentimes already exists in a school's information system, continues to make large-scale original data collection expensive for the researcher and burdensome for the participant.

Indeed, "low tech" data collection costs continue to remain high. For example, the National Science Foundation (2003) maintains recurring surveys, or "infrastructure surveys",

which have been found to be "rising in cost, and declining in response rate" (p. 10). The reasons for rising costs include the difficulty of re-contacting participants in longitudinal studies, the cost of incentives for participants, and the cost of developing contextualized surveys. As well, the requirements of Institutional Review Boards (IRBs) have become a significant factor. The NSF recently found that "many IRBs are increasing the cost of social science inquiries" because they "require written, signed consent for voluntary surveys, have limited callbacks to sample cases, have constrained refusal conversions, and have limited the use of incentives" (p. 10-11). In addition to cost, the NSF found a number of reasons for the declining response rate. The primary reason is that people "are harder to reach than they used to be," possibly because of reduced free time and the perceived burden of participating in a survey.

While large-scale government and private datasets certainly exist, they are relatively small in number and focus on nationally representative samples that span classrooms and schools (as opposed to full classroom and teacher data sets). Those that are longitudinal are limited in their frequency of administration given the cost and complexity issues described above. Finally, because these surveys are administered manually, they are "static" in the sense that they fail to adapt to each human subject in terms of asking relevant questions using local contextual information (e.g. a class roster to prompt for grade sharing, friendship or seating patterns). The net result of these inefficiencies is that few large-scale datasets exist that contain whole-classroom data, including rich sociometric information, across many classrooms, schools and geographies. And no large-scale datasets exist that are refreshed and updated longitudinally month-to-month, semester-to-semester, year-over-year, in the way that so many substantive research problems require.

Today's student "subjects" are more literate, open and technology oriented in the way they share information with others (Lenhart, Madden, & Hitlin, 2005; Madden, 2005; Robert, 2005). Additionally, over the past ten years, school districts across the country have expanded their use of information systems beyond "back-office" administrative functions (Norris, Soloway, & Sullivan, 2002). Further, there has been tremendous growth in the number of schools with access to the Internet. According to the U.S. Department of Education (2001), by the fall of 2000, 98 percent of public schools in the U.S. had access to the Internet. This figure stands in stark contrast to the number of schools in 1994 with network access: 35 percent. With increased Internet access, teachers and their students are increasingly adopting "eLearning systems" – software that allows teachers to create and manage class Web sites. As students become more comfortable with the tools and features of class Web sites, and teachers store more classroom data in their eLearning system (e.g. performance information in the online gradebook), an opportunity may exist to use school district eLearning systems as a vehicle for: (1) collecting customized survey data online without using classroom time; (2) matching it with electronic student demographic and performance data through automated software routines; and (3) reporting whole-classroom datasets anonymously to a central database using secure Internet transmission protocols.

In this paper we report results from the pilot of an innovative data collection project called the Networked Education Database (NED). NED was designed to test the use of eLearning systems as data collection vehicles. As part of NED, during the 2006-2007 school year, approximately 732 students and 19 teachers in 37 classrooms were eligible to use their

school's eLearning system to submit anonymous sociometric, social psychological and student performance information, longitudinally, to a central database. We think of NED as a data collection utility that connects school information systems and reports data centrally and anonymously. While NED uses eLearning systems to collect data, it is intended to collect data for a wide variety of educational research concerns, not just those related to eLearning. Over time, NED has the capacity to grow to thousands of classrooms across hundreds of schools, making available a rich new longitudinal dataset for education researchers collected at scale with dramatic cost efficiencies. As such, the results of the pilot we report in this paper provide much needed empirical insight into the strengths, weaknesses and unresolved issues involved in networking school information systems together as a new model for data collection.

2. Research Question

Given the literature discussed in the previous section, we are optimistic that NED is a viable data collection model. At this stage in our pilot, we have an opportunity to test this optimism by reviewing the project's progress to date and analyzing data from the first two (of three) administrations. Specifically, we address the following three questions:

1. What technical and social implementation issues arise when implementing a networked data collection system?

2. How do teachers and students participate in a networked data collection system; will participation vary by school setting, and do participant characteristics such as race and gender have an impact?

While we propose these research questions to help frame the paper, our report is descriptive in nature. What we are attempting to assess is the strength of NED along eight design objectives. This paper is the beginning of that process.

Table 1. NED Design Objectives

Objective	Example
Asynchronous	Will participants complete surveys outside of class time?
Automatic	Will the system stay up-to-date as enrollments change and control access appropriately? Will it generate the right survey at the right time?
Contextual	Will the system deliver customized questions based on system data (e.g. use class roster to ask about friendships)
Non-duplicative	Will assembling data from multiple sources work?
Complete	Will participants complete the full survey?
Anonymous	Will weaknesses in anonymity protection arise?
Efficient	Will the data arrive in a usable form?
Sustainable	Will NED work across classes, sites and school years?

3. The Network Education Database System

Before addressing these questions, it is worth briefly describing the general design and functionality of NED. Specifically, we review the type of data NED collects, the way in which

data are collected, and the central repository and transport method that aggregates data anonymously. We should note that during the implementation of the pilot, certain details of NED's design were altered for various reasons. These alterations are reported later in the paper as part of our discussion of findings from the pilot.

3.1 Data Categories

NED was configured to collect two distinct data categories. The first data category, "custom data," is data not collected through ordinary use of an eLearning system (e.g., student interest in a topic, student friendship patterns). Custom data in NED are collected through Web-based survey instruments generated by the same eLearning system "assessment engine" participants use as part of their typical instruction. Assessment engines typically support the major question types required to collect social science data. What is notable about custom data is that participants must do something above and beyond their ordinary usage of the eLearning system to provide the data (e.g. complete a survey). Importantly, custom data collected through NED do benefit from several efficiencies. For example, NED can use system data to dynamically personalize questions based on context, such as the student's gender. This eliminates the need to create multiple permutations of the same basic survey instruments for different participant groups and different time periods.

The second data category, "system data," is data collected though a participant's ordinary use of the eLearning system (e.g. gradebook data, demographic data, classroom assignment data). The breadth and depth of system data vary based on how a school uses their eLearning system. System data include both structured data for which a predefined taxonomy is enforced (e.g. # of students in class), and unstructured data in which the data stored by the system follows whatever taxonomy the teacher prefers (e.g. gradebook assessment type entries). In an ideal case, NED will collect a meaningful set of data with no additional effort by participants above and beyond their ordinary use of the system. As will be discussed, custom data and system data are linked through a randomly generated unique ID. In this way, the researcher receives a complete data file while participants need not provide data already stored in the system.

3.2 Data Collection Module

To collect data, NED requires installing a software extension to the school's local eLearning system. Once updated for NED, the eLearning system is able to: (1) assemble classroom-level data already in the system's database (e.g. gradebook data, student demographic information, classmate associations); (2) automatically post Web surveys to students and teachers that collect more specialized classroom-level data; (3) replace individual names with anonymous IDs; and (4) post all relevant data anonymously to a central database using secure transmission over the Internet. For the NED pilot, the extension was developed specifically for the Blackboard Learning System. The Blackboard Learning System is a popular eLearning system that while predominantly used in higher education, has approximately 400 schools and school district installations as well. NED is intended to work with multiple eLearning systems. The decision to focus on one system for the pilot was based on our familiarity with Blackboard and the pragmatic need to move quickly to test the concept.

The NED software extension was developed using the Java programming language. Among its functionality, the NED extension: (1) imports a bundled custom survey XML file into Blackboard; (2) configures the schedule that dictates when the custom surveys appear in Blackboard; (3) creates the necessary encrypted tables to temporarily store survey responses before posting them to the central repository; (4) generates unique IDs for each relevant site, course and user of the system; (5) queries the appropriate Blackboard database tables for previously-specified system data; and (6) posts all collected data, tagged with IDs and encrypted, to the central repository. The NED extension also adds a "NED Tool" icon to the Blackboard user interface. By clicking on the NED Tool, the participant gains access to the custom survey. NED allows the tool to be turned on for specific participating classes only.

3.3 Survey Delivery

As mentioned, NED surveys are bundled with the NED system extension. This means that once installed survey questions cannot be changed without installing an updated file. In the future, our goal is for survey XML files to be pulled down immediately prior to an administration to provide maximum flexibility. Multiple surveys can be imported and scheduled in advance. When the specified date arrives, an announcement automatically appears in the Blackboard user interface and a link for accessing the appropriate survey appears in the NED Tool. Each time a participant starts a survey, he or she is provided with an Informed Consent page. The page can display whatever informed consent text is appropriate, as well as contact links for requesting additional information. A participant must type "I Agree" into a text box in order to release the survey. NED surveys can require participants to complete all questions on a page before moving forward. Responses are saved for each page of questions. Access to the survey automatically turns off based on the schedule programmed in advance.

A nice feature of NED is its ability to track transfers into and out of the classroom. Students who are added to a class after the survey administration period can be automatically "caught up" with the full, or a basic, version of the survey taken by the rest of the class. NED is anonymous, so data on which students completed a survey is not stored or reported. However, teachers do have access to a report on the total number of completions in order to help encourage participation.

COURSES > NED TEST COURSE 1 > TOOLS > NED QUESTIONNAIRE

NED Questionnaire: Background

1. What is your birthdate?

2. Please indicate your sex. (Choose One)

3. Which of the following best describes your race? (Choose one)

4. Please indicate the grade you received in this class subject last year. (i.e. the class you took last year most similar in topic to the current class, such as social studies if you are taking a Government class).

5. Please provide the number of "honors" or advanced classes, if any, you are taking this year.

Submit

Contact Information | Instructions

Figure 1. Sample NED Survey screen

3.4 Data Reporting and Aggregation

Data collected through NED are reported to the central database using random unique identifiers for the school, class, and participant (e.g. teacher or student). The unique identifier does not provide the name of the individual or their school. Without information about the school from which the record was sent, or the name of the student/teacher, the privacy of each individual is protected. No human being is ever involved in collecting and linking data, nor posting the data to the NED repository. In effect, the data arrives to NED as secondary data. System data are reported monthly, while custom data are reported two days after the end of the administration period. Data are encrypted and transmitted over the commercial Internet using a secure FTP protocol. Through the unique IDs, data can be correlated to further maximize efficiency. For example, the teacher's description of course subject and age-grade can automatically populate the appropriate variables for each student in that class.

ned_id	ned_course_ic	ned_questions	ned_answer	role
1	6395	1	C9F0F895FB98AB9159F51FD0297E236D	P
1	6395	2	B38A9DE63E6BA841FA6AD56AF95431FC	P
1	6395	3	20D3DC7E7E8014DC92BD81AD0AE37B83	P
1	6395	4	86E89BF7F214F556284F8577DA3ED1B8	P
1	6395	5	0DB377921F4CE762C62526131097968F	P
1	6395	6	63889CFB9D3CBE05D1BD2BE5CC9953FD	P

Figure 2. Sample Data Feed from NED to Repository

3.5 Anonymity

One specific component of NED's design worth additional discussion is its safeguards for participant anonymity. The entire premise of NED is that eLearning systems can enable a data

collection model sufficiently automated that data arrive as secondary datasets. In doing so, NED can benefit from expedited IRB reviews and less extensive informed consent processes (e.g. "click-wrap"). As discussed, data are sent to the NED Repository using randomly generated codes that identify the record anonymously. Anonymity through random ID codes generated by the software eliminates any ability for project staff to know the region, school or classroom from which the data was posted; the codes still allow for data to be grouped by school and classroom). All data are encrypted and local school staff does not have access to the data tables in which the responses are stored.

4. Method

To address the three questions described earlier, we administered a pilot of NED during the 2006-07 school year (the pilot is still underway). To assess implementation issues, project staff kept detailed notes about their experience and system changes were documented. To assess participation rates, approximately eight Blackboard K-12 clients who expressed early interest in the project were invited to participate. Of the eight, three ultimately participated. While each of the five schools that declined participation had its own reasons, a common concern expressed was skepticism as to the degree of anonymity the system ultimately ensured. Of the three participating sites, two were private schools, one of which served grades 9-12 and the other grades K-12. The third site was an urban public school district; we do not know how many different schools in the district had classrooms that participated. In order to ensure participant anonymity, staff at each site recruited participating teachers. We were then provided with the total number of classrooms, teachers and students that agreed to participate from that site. Participating classrooms were given access to NED by the site's technical staff.

To help each site select teachers, we recommended that they focus on middle or high school teachers who teach multiple class periods. Our intent was to maximize the number of participating classrooms while keeping the number of teachers to a minimum in case technical issues arose. Each site was given documentation that they could use to explain the project to teachers and inform them of the time and effort involved. Based on this recruitment process, Table 2 describes the total number of participants.

Table 2. Participating Sites

Site	Teachers	Students	Classrooms
1	4	429	16
2	11	200	15
3	4	103	8
Total	19	732	37

For the purpose of the pilot, we programmed NED to deliver two types of surveys. Both expired two weeks after being initially made available in the system user interface. The first type was a simple survey and was administered in October. It consisted of between 5 and 10 questions that required only one page for display. The questions were basic, including participant's demographic characteristics, class subject matter, number of honors classes taken, and so on.

Table 3: Summary of Basic Survey

1	What is your birthdate?
2	Please indicate your sex?
3	Which of the following best describes your race?
4	Please indicate the grade you received in this class subject last year. (i.e. the class you took last year most similar in topic to the current class, such as social studies if you are taking a Government class).
5	Please provide the number of "honors" or advanced classes, if any, you are taking this year.

The second type was a complex survey and was administered in February, 2007, and will be administered again in May, 2007. It consisted of as many as 30 questions that required 5 or more Web pages to display and complete. Questions posed were more thought intensive, including classroom environment questions (e.g. classroom behavior, teaching methods, student competitiveness), and student relationship questions (e.g. friendships, grade sharing).

Table 4: Summary of Complex Survey

1	What final grade do you think you will get in this class's subject this year?
2	Is the grade you expect in this class better than what you expect in other classes?
3	How important is it TO YOU to do well in this subject? Use the following scale to answer this question, (1) Not at all important . . . . Very important (7)
4	How important is it TO YOUR TEACHER for you to do well in this subject? Use the following scale to answer this question, (1) Not at all important . . . . Very important (7)
5	How important is it TO YOU PARENTS for you to do well in this subject? Use the following scale to answer this questions, (1) Not at all important . . . . Very important (7).

The pilot is primarily focused on the technology involved in using eLearning systems as research platforms, not collecting data for use in particular empirical studies. Our rationale for designing two types of surveys was simply to assess the sensitivity of participation rates to length and complexity of questions.

Through the site coordinators, teachers were given a script to read to their students on the days the NED surveys were scheduled to activate. The text of this script is provided in appendix 1. To date, the first two administrations have been completed. Data from those administrations and from our project notes provide the basis of our current analysis.

5. Findings and Discussion

5.1 NED Design and Implementation Experience

To assess lessons learned from the pilot implementation, the design team shared notes taken during the process, reviewed the circumstances behind all system design changes, and discussed their own experiences. We expect to augment these data sources with feedback from the participants and site coordinators at the end of the project. We identified a number of challenges and issues fundamental to networked data collection projects:

Table 5: Summary of Design and Implementation Issues

Issue	Examples
School usage patterns	Teachers use one class Web site for all class periods, eliminating ability to segment by class Teachers often do not use eLearning system gradebook Schools often do not load eLearning system with demographic data
Time / cost developing system extension using eLearning system APIs	Required school run "enterprise license" of Blackboard Reverted to custom coding, which negating some of the efficiencies
Heterogeneity in local eLearning system configurations	Preprogrammed file paths did not work given different install directories. Data transmission had to be changed to local SQL scripts, manually executed, not a Web service.
Appropriateness of assessment engine as survey tool	Lacked certain question types, particularly sociometric Need to develop independent survey generator meant lower ease of use and absence of functionality such as adaptive questioning, fixed time for responding, etc.
Anonymity weaknesses	IP address of sending site could allow for matching of school name with unique ID schema. Small number of pilot sites also made site identification possible, with the exception of specific schools in the urban district.

Reviewing Table 5, two basic insights emerge. First, the way schools use their eLearning system varies. This variation makes designing NED survey instruments based on an assumption of particular data being stored in the system difficult. Selection criteria need to be developed to ensure consistency among sites. The most significant example of this variation was our discovery that many teachers use one class Web site to support all of their class periods that share the same subject and track. By doing so, they eliminate any potential for NED to distinguish which students belong to which specific class period. Second, the heterogeneous nature of eLearning system platforms and implementations makes developing a single NED extension that taps the built-in functionality of the system difficult (e.g. assessment engine to deliver survey). In our case, the time pressures of the pilot and our limited resources meant that we sacrificed much of the design and developed a freestanding survey engine and manual reporting scripts. Without clear standards across eLearning systems, and more information about the specific configurations of participating sites, the installation of NED extensions will require site-specific support. On the upside, once installed NED can operate automatically, although even then site upgrades to eLearning system will likely create new issues.

5.2 Participation Rates

Equally critical to the success of NED-like systems is the willingness of participants to complete the surveys on their own time. Our first administration of NED revealed a 43% completion rate. It is significant to point out that due to a technical problem at one of the school sites, the research team was forced to preclude all data from Site 2. Therefore, the 43% completion rate was computed based on the total number of students at Site 1 and 3 who completed the survey. We recognize that in order to create a powerful data system we must increase the level of user participation. Although we provided an incentive for students to participate--we informed students that they would be entered into a drawing to win an iPod--it may not have been sufficient to raise interest in the survey.

Student participation in the system appears to have dropped significantly for the second administration. Table 6 below reveals a nearly 60% drop-off in total respondent participation. There are several possible reasons for this phenomenon. First, the complexity of the survey could have been a deterrent. At T1, the survey was composed of 5 brief demographic questions (see Table 3 above). However, the second administration asked users to expend more time and effort to respond to the 15 total questions. Students could have started the survey and then become discouraged by its length or question type. Future versions of NED will enable us to track survey "drop out" rate--the proportion of students who start a survey but quit prematurely. Another cause for the drop in participation could have been waning interest in the survey between administrations. Students who were initially enticed by the novelty of an online school survey or the prospect of a prize may have lost their motivation. Follow-up interviews with the teachers and students will help to clarify the reasons for the variation in participation between T1 and T2.

Table 6. Total student responses for Simple Survey (T1) and Complex Survey (T2), N=532

	Simple (T1)	**Complex (T2)**
Site 1	72	26
Site 3	155	66

Additionally, we observed no new participation in NED. A student who did not participate at T1, did not suddenly participate at T2. This highlights the importance of seriously engaging participants in NED-like systems from the onset and/or the importance of encouraging involvement among users who did not participate initially.

We also found that males and females dropped out of NED participation at similar rates between T1 and T2 (see Table 7 below). Specifically, 58 percent of males who completed T1 did not complete T2; 61 percent of females who completed T1 did not complete T2. Although we were disappointed with the overall lack of participation at T2, this trend did not appear to be exacerbated by gender. Currently, it is not possible for us to determine the total rates of participation among males and females since we do not know the gender breakdown at each of the sites. It may be worth pre-filling this type of information from existing school databases or classroom rosters for future deployments of NED.

Table 7: Total student responses varied by Simple Survey (T1) and Complex Survey (T2), and varied by gender, N=227

	Simple (T1)	Complex (T2)
Male	112	47
Female	115	45

We also observed falling rate of participation according to racial background (see Table 8). Specifically, 66 percent of White students who completed T1 did not complete T2; 57 percent of Black/African American who completed T1 did not complete T2. Similar to gender, the overall lack of participation at T2 does not appear to be exacerbated by racial background.

Table 8. Total student responses varied by Simple Survey (T1) and Complex Survey (T2), and varied by race/ethnicity.

	Simple (T1)	Complex (T2)
American Indian or Alaska Native	2	0
Asian	3	1
Black/African American	142	61
Hispanic or Latino/Latina	4	2
White	71	24
Other	6	4

A further finding is that when a student submits the survey, they answer all questions at a high rate. For T1, there was a 100% question completion rate, and for T2, 92% (85 students) completed the entire survey. For the 7 students (8%) who did not respond to all fifteen questions, they each did not answer one question.

6. Conclusion

The long-term goal of NED is to provide researchers, policymakers and practitioners with a sustainable, low-cost source of longitudinal classroom-level data by networking Internet-enabled school information systems that already contain much of the data of interest to educational researchers. NED is designed to do this in a manner that ensures anonymity for the student, minimal effort and disruption for the teacher, and significant efficiency for the researcher. The focus of NED is on data that have traditionally been the most difficult to collect: whole-classroom datasets that include sociometric information about the social relations that obtain among students and between students and the teacher. By building on the rapid adoption of instructional and administrative software systems by school districts – systems which are based on relational databases – NED seeks to overcome many of the cost and quality challenges that have limited researchers in their efforts to study critical issues in education.

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Appendix

Appendix 1: Teacher classroom script

[School Name] has agreed to test pilot a new feature that Blackboard – the company that makes our class Web site software -- is considering adding to its product. What this means for us is that we are going to use Blackboard to take a short 25 question survey online that asks questions about this class. The survey is short and interesting. It gives you a chance to share your opinions. It's important for you to know that when you answer the questions, your responses are saved with a random code. So your answers are completely anonymous. I don't see your answers. The school does not see your answers. And the researchers who do see your answers won't ever see your name, or know the classroom or school that the answers came from.
The survey is delivered in Blackboard, so you can complete it on your own time using any computer with Internet access. Everyone needs to complete the survey by [instructor's deadline, no later than one month following the announcement].
You access the survey by clicking on the link that says NED Survey on the announcements page, or by clicking on NED Survey in the Tools menu of Blackboard. From there, just follow the instructions presented on the screen.
As you go through the survey, there are five important instructions to be mindful of:

1.   Please complete the entire survey all at once.

2.   Do not use the browser "back" button once you have started the questionnaire. It may seem like it is working, but it is not. If you were to change your answers by going back one page your changes would not register. And going back a page affects the rest of the survey when you move forward again. So please make sure you are comfortable with your answers before hitting "submit."

3.   Do not use the general Blackboard navigation once you have started the questionnaire. You move from page to page in the survey by clicking the "Submit" button. Also, do not leave the survey to explore other parts of the Blackboard site or the Web. Again, its best to complete the entire survey all at once.

4.   At any point in time while completing the questions you may click either the "Contact Information" or "Instructions" links at the bottom of the page. Once clicking either of these links you will be presented with an additional window containing the appropriate information. Other than these two links, as already stated, do not navigate outside of the survey.

5.   Every time the submit button is clicked within the survey, your answers are stored and there is no going back to change them. However, if you are working on a page of questions and the browser or internet connection drops before you click the submit button, you will start off at the point where you left off the next time you log-in.

Thank you!