The VOS Data Manager: Providing Immediate Feedback on Teaching Effectiveness

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Abstract

New classroom assessment technologies produce large amounts of data. However, providing useful information to instructors, who may not be familiar with coding or analytic methods, remains challenging. For the past several years, the VaNTH (Vanderbilt Northwestern Texas Harvard-MIT) Engineering Research Center for Bioengineering Educational Technologies has employed the VaNTH Observational System (VOS). VOS allows minute-by-minute capture of both student and instructor activities during a classroom session via handheld personal data assistants (PDAs) and has been previously described. However, generating useful information for instructors based on this data is time-consuming, and instructors often wait days or weeks for the appropriate reports to be generated on a case-by-case basis. Furthermore, multiple files resulting from these methods have been difficult to organize and maintain.

The VOS Data Manager has been developed to automate the process of importing, organizing, and analyzing VOS data. The import process checks the underlying data for validity, automatically correcting simple artifacts and identifying more complex ones for manual correction. The entire import process, including artifact correction, takes about five minutes for a one-hour classroom session. Once data has been imported, a variety of reports can be generated within seconds that detail instructional methods, student engagement (or lack thereof), and other classroom activities over a particular session. Additional reports show how one session compares to another, or to an average of other sessions given by the same or different teachers. Instructors can now receive feedback within minutes after a class ends, and researchers can more easily compare data across different sessions, instructors, and/or coders.

The VOS Data Manager runs on any computer equipped with Excel (Microsoft Corp., Redmond, WA). Excel was chosen because of its wide install base, familiarity to most instructors and educational researchers, and the fact that it's built-in macro language, Visual Basic for Applications, provides a high degree of functionality and compatibility across recent versions of the Windows (Microsoft) and MacOS (Apple Computer, Inc., Mountain View, CA) platforms. This technology facilitates rapid development and dissemination of the VOS Data Manager, allowing VOS researchers to provide immediate and useful feedback to instructors following a classroom session.

Background

Prior research suggests that professors will use formative feedback to make positive changes in classroom teaching[1], and that self-reflection is an important tool for improving teaching[2,3]. Such improvements might include adopting different classroom management techniques[4,5] or other changes in teaching behavior[6]. Since quality of student learning can be evaluated by observing what occurs within classrooms[7], an observational system that identifies specific elements of the classroom experience as correlated with student learning can be used to evaluate changes in classroom teaching, or to identify areas where change might prove beneficial.

The VOS[8], based in part on the Stallings Observation System[9], was developed in 2000 to evaluate changes in bioengineering classroom instruction implemented as part of various VaNTH-ERC initiatives. Briefly, the VOS records classroom activity in four parts: (1) repeated 5-item code strings capturing student-teacher interactions, (2) numeric records of students' levels of academic engagement, (3) free-text narrative notes describing lesson content and process, and (4) Likert-scale global ratings indicative of effective teaching. General aspects of classroom activities are captured (i.e. what the instructor is doing, if students are paying attention, etc.), as well as specific features of instruction related to elements of *How People Learn*[10] and use of multimedia technology. Observers use PDAs to record data continuously during the classroom session. Following the session data is downloaded from PDAs to a personal computer for analysis. Observations are stored in linked MS Access (Microsoft) tables corresponding to the parts of VOS described above, with each record corresponding to a single observation in a session. Data can be exported from Access to Excel or other programs for generating graphs or additional analysis.

While the VOS is an effective data capture tool, with inter-rater reliability above 85% for observations made almost continuously over one-hour (or longer) classroom sessions[11], data analysis can be cumbersome. Researchers must be familiar with technical tools and methods to create appropriate reports for instructor feedback, in addition to the substantial training and practice needed to code observations[12]. Producing meaningful reports for instructors, who may be unfamiliar with specific coding schemes or general tenants of learning science research, is complex; some coded fields, such as the number of students "on-task", can be graphed over time directly, while others require grouping, normalization, or computation of derived measures based on combinations of coded data[13]. Finally, since recording data with VOS is a continuous process, if a mistake occurs observers usually simply start a new record rather than taking the time to fix the old one, leaving it incomplete. These occasional incomplete records need to be removed, or "cleaned", from the raw data prior to analysis. Instructors often wait days or weeks for reports because substantial effort is required to process the coded observational data.

As such, by the time an instructor receives a VOS report he or she may not recall details of that classroom session, making it difficult to relate observed effects to specific changes in teaching behavior or to other classroom events. Our primary goal in developing the VOS Data Manager was to automate the process of producing graphical reports so that instructors could receive them almost immediately following a classroom session. Delivering reports promptly to instructors increases the potential for VOS feedback to improve teaching and learning in their classrooms,

and automated reports allow for wider use of VOS and realization of improved instruction both within and outside our institution.

Methods: System Development

Development of the VOS Data Manager began with a prioritized list of requirements:

1. Ease of use: Someone having basic familiarity with word processing or spreadsheet applications should be able to use the system without additional instruction.
2. Data repository: All VOS data should be maintained by the system and organized by session and instructor. The system should support shared use of a single data repository by multiple users.
3. Error handling: Any errors in source data (incomplete records, as described above) or program function should be detected and reported to the user. All errors should be automatically corrected if possible, with user confirmation where appropriate.
4. Extensibility: The system should be easily modified to include additional reports or other functionality. Advanced users should be able to define additional custom reports.
5. Windows and MacOS compatibility: The system should be usable on computers running either Windows or MacOS operating systems.
6. Batch data import/export: Data should be able to be imported to, or exported from, the system in a variety of standard formats.
7. Report archive: All reports generated by the system should be archived and accessible for future use.

A number of different technologies were considered for development in light of these specifications, including use of "platform neutral" languages such as Java (Sun Microsystems), or a completely web-based application utilizing PHP (open source) or .net (Microsoft) scripts coupled with a database. Given resource constraints for this project, the most efficient solution was to implement the VOS Data Manager in Excel macros utilizing the Visual Basic for Applications ("VBA" - Microsoft) language. While this choice did not completely satisfy all requirements (see Discussion below), Excel macros had significant advantages including substantial built-in data manipulation and graphing functions, a simple development platform, and compatibility between recent versions of Windows and MacOS.

After selecting the development platform, user workflows were defined. The VOS Data Manager needed to support tasks related to the following: (1) importing raw VOS data, (2) producing reports, and (3) managing stored data. Workflow for importing raw data is straightforward; the user selects a file containing source data, provides ancillary information not captured by VOS such as the coder's name, and instructs the system to proceed. Producing reports is more complex, requiring identifying the type of report, the session(s) to include, and various options for computing report data. For example, a report across multiple sessions might allow grouping results by instructor or date range, or normalization of results according to the number of sessions. Furthermore, once reports are generated the user may wish to edit, print, or save the report to an archive. The last group of tasks relate to managing stored data, as users need to be able to edit session information such as the instructor or coder, delete sessions, and

merge or split sessions. This workflow involves selecting the session(s) and desired operation, with appropriate confirmation before modifying the data store.

Defining user tasks and workflows informed development of the main graphical user interface (GUI), show in Figure 1. The grouping of tasks is reflected in the three tab panels. Since most of the task sequences were short they could be implemented without use of menus, and descriptive "help" text could be included directly on the forms.

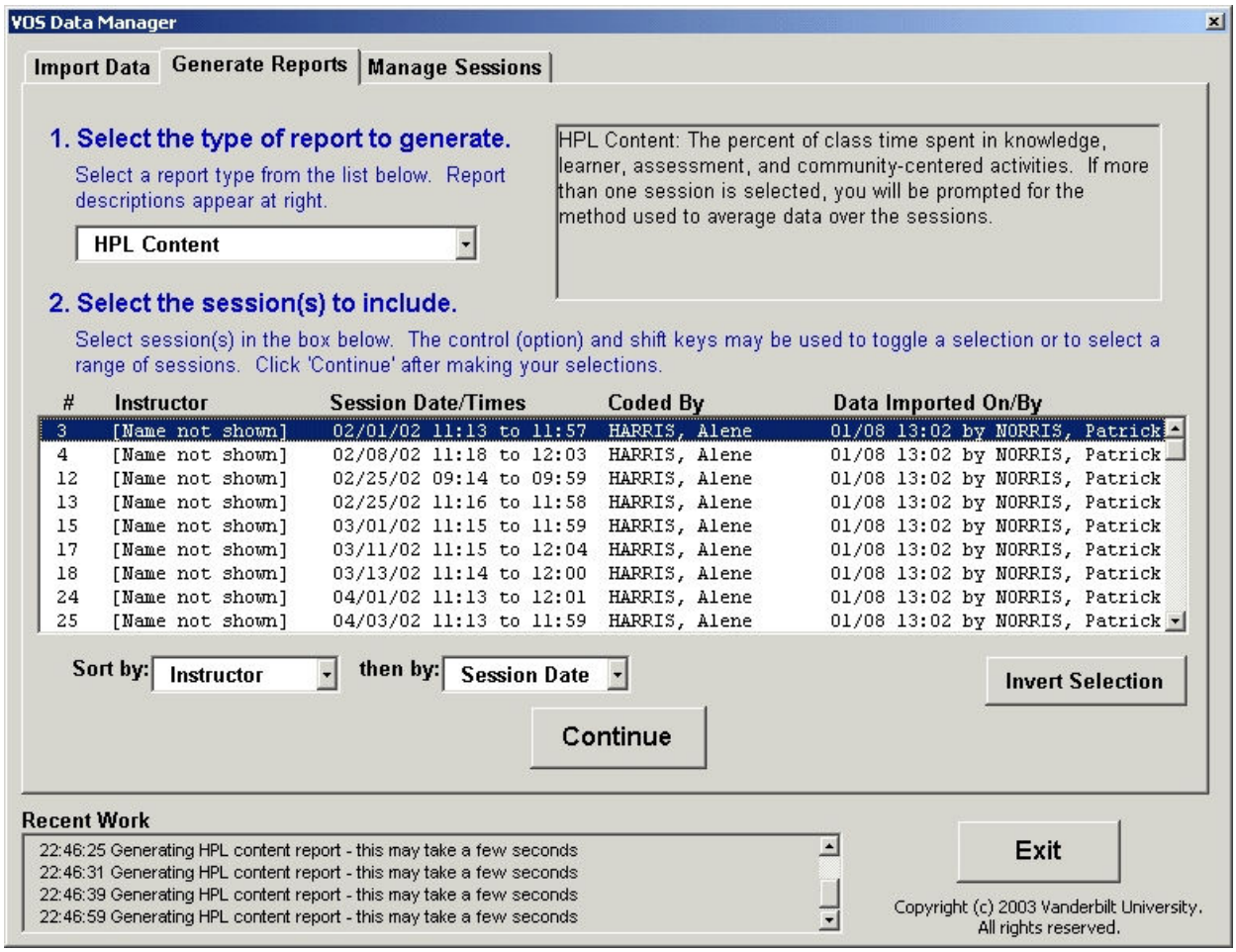

Figure 1 – VOS Data Manager GUI showing screen used to generate reports

The last step in system development was to implement underlying data structures and logic. Data is organized into Excel worksheets. Four sheets store data for each of the four parts of VOS, and additional sheets store session information or provide space for temporary use during data import and report generation. VBA Class Modules were written to encapsulate structures and basic functions for manipulating VOS data and session records. Simple functions related to GUI operation were coded within GUI event handlers, and more complex functions, such as data sorting or analysis for reports, were coded within a single VBA code module. Built-in Excel functions were used as much as possible for data manipulation and graph generation.

Results and Discussion

Initial testing of the VOS Data Manager shows substantial reduction in time and skill required to create reports. Graphs such as the one shown in Figure 2 can be generated in a few seconds once data has been imported. The data import process currently requires that VOS data be properly formatted in an Excel spreadsheet file, with minimal capabilities for automatically correcting errors. However, all errors during import are grouped and listed for the user by line number to facilitate any needed corrections. In addition, since distinct VOS sessions are automatically identified during data import, multiple sessions can be imported at once. A single file containing over 13,500 records in 68 sessions can be parsed and imported by the system in under one minute (1.3GHz processor, 256 MB RAM). The system also reduces the time required to maintain VOS data by locating all data in a single file and by allowing data to be easily manipulated by session.

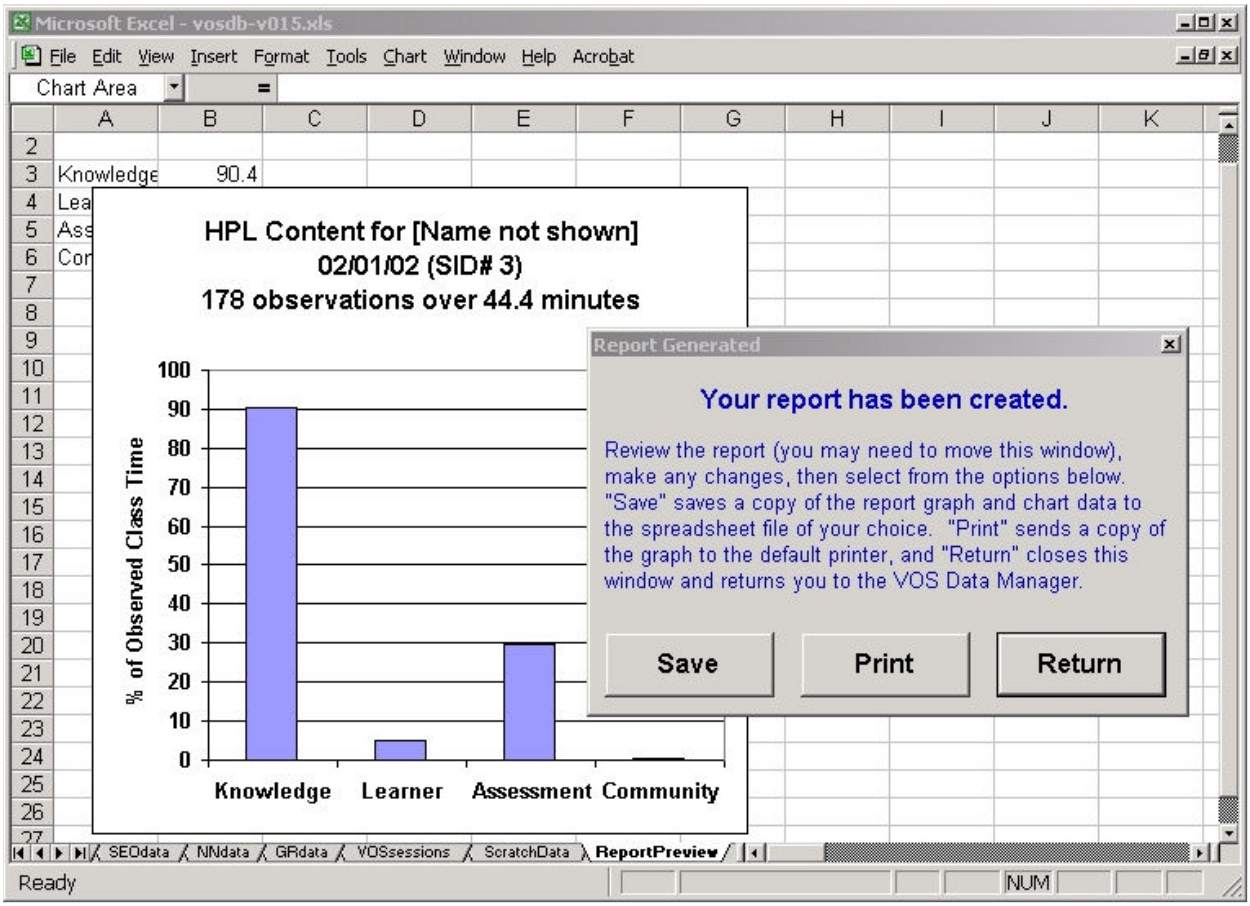

Figure 2 – Report Generated by VOS Data Manager, showing Report Option GUI

The VOS data manager currently provides several types of reports: (1) HPL content distribution (percent of time various HPL categories were present during an entire single classroom session) as shown in Figure 2, (2) average HPL content distribution over any number of user-selected sessions, (3) a comparison of a single session's HPL content distribution to an average of multiple sessions, to facilitate benchmarking, (4) individual HPL content distribution of multiple

sessions displayed simultaneously, to show evolving trends in instructional methods, and (5) display of HPL content distribution over consecutive segments of a single session, for observing differences related to specific classroom events. Future reports will provide similar analyses and comparisons for other kinds of distributions in addition to HPL content, such as the percent of class time spent in various activities and the percent of students on- or off-task.

In terms of usability, no knowledge of Excel functions, macros, or graphs is required to use the system effectively. The program starts automatically when opened, and substantial descriptive text is provided to aid novice users (see Figures). At the same time, advanced users are able to modify graph formatting or work with underlying data directly if they so choose. Error checking and other safeguards such as using Excel's worksheet protection features help prevent accidental alteration of program data. GUI features, such as the ability to sort session displays by instructor, session date, coder, or import date and the running log of recent work (see Figure 1) also enhance usability. The ability to access the system remotely via a network file share means that users can work with the same data from different locations. Finally, VBA for Excel is compatible across recent versions of both Windows and MacOS operating systems, although cross-platform compatibility has not been extensively tested.

The modular program design using Excel macros provides several other benefits outside usability. First, since the macros are stored as text and leverage the substantial data manipulation and graphing functions built into Excel, the size of the file is under 500KB (prior to importing data), allowing for easy distribution of the VOS Data Manager. Another factor facilitating distribution is the lack of need for an install procedure if Excel is already present on the machine. Finally, development and expansion of functionality can be accomplished rapidly, due to the availability of built-in functions, modular design of the code, and an easy-to-use development environment. An experienced Visual Basic programmer planned and developed all current functionality, including the existing report types, in less than 100 hours.

There are also several limitations to the current system. Since data is stored in Excel worksheets, there is an upper limit of about 65,500 records that can be imported, or about 300 sessions' worth of data. Other disadvantages of storing data in Excel include the following: (1) potential for information to be corrupted if accessed outside the program, (2) the need to export individual reports to separate files, as retaining these graphs would eventually impact performance, and (3) inability for multiple users to simultaneously access and manipulate data - while multiple users can use the same system via network shares, only one user at a time can open the file for write access. In addition, some PCs, especially those for shared public use, have Excel macro functionality disabled by users or system administrators due to security concerns. These limitations may become significant if the VOS Data Manager is used on a large scale.

One other limitation is the somewhat cumbersome process of transferring and formatting raw data from VOS PDAs. Ideally, the Data Manager should pull data directly from the PDA via a docking station or network connection. This is currently extremely difficult to implement, in part due to the "hotsync" mechanism required to transfer data and the fact that many PDAs are not yet network-ready. In the short term this should not be an obstacle, as current users are used to exporting and formatting raw VOS data for manual analysis in a way that closely matches the

Data Manager's requirements. In the long term, the five to ten minutes required to do so may seem burdensome compared to the speed and ease-of-use of the data manager.

Conclusion

The VOS Data Manager enhances the utility of the observational system, allowing reports to be rapidly generated for instructors following classroom sessions. Educators may be better able to interpret feedback and adjust teaching strategies accordingly when it is delivered in a timely manner, and reducing both the time and skill required to generate VOS reports potentially allows more instructors to benefit from in-class observational feedback. While developing the system around Excel macros has several limitations that might become significant in the long term, it allowed for rapid production of a system that satisfied nearly all design requirements to a high degree.

Future directions for this work include support for additional report types, investigating several research topics, and improving the ease of data transfer from VOS PDAs. Since it is now possible to provide more complex and detailed reports to instructors with relatively little effort, users may wish to experiment with reports beyond those used routinely thus far. Research is needed to identify the optimal formats and types of data for instructors to use in improving teaching behavior, or in identifying particularly challenging classrooms. Finally, streamlining data transfer from VOS PDAs should allow reports to be generated in only a few minutes following a classroom session. The VOS Data Manager takes a significant step toward achieving these and other goals to improve teaching by providing instructors with timely feedback based on classroom observation data.

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Biography

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