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Enhancing the Quality of Engineering Graduate Teaching Assistants through Multidimensional Feedback

MONICA F. COX
School of Engineering Education
Purdue University

JEEYEON HAHN
School of Aeronautics and Astronautics
Purdue University

NATHAN MCNEILL
Department of Materials Science and Engineering,
The University of Florida

OSMAN CEKIC
Canakkale Onsekiz Mart University,
School of Education,
Turkey

JIABIN ZHU
School of Engineering Education
Purdue University

JEREMI LONDON
School of Engineering Education
Purdue University

ABSTRACT

This paper describes the Global Real-time Assessment Teaching Tool for Teaching Enhancement (G-RATE). It is a tool framed around the elements of Bransford, Brown, and Cocking's (1999) "How People Learn" framework and informed from data collected via laboratory observations; focus group interviews with engineering supervisors and graduate teaching assistants; and undergraduate student surveys. The G-RATE allows various stakeholders (i.e., classroom observers, administrators, graduate teaching assistants, undergraduates, and students) to provide feedback about the pedagogical practices of graduate teaching assistants within a laboratory session. Future applications of the tool include the creation of pedagogical profiles for instructors and the dissemination of the tool across multiple educational environments.

Keywords: Classroom assessment, engineering pedagogy, observation systems, graduate teaching assistants

INTRODUCTION

Challenges facing graduate education in the United States include narrow disciplinary training of graduate students (COSEPUP, 1995; Nerad, 2004), declining enrollments of domestic students within doctoral engineering programs (COSEPUP, 1995; NRC, 2006; Akay, 2008), and an overwhelming absence of pedagogical training and feedback systems among engineering faculty and postdoctoral researchers (NSB, 2007). In fact, few engineering faculty obtain teaching experience as graduate students (Ruscio, 1987; Boice, 1991; McDermott, 1990; Reinarz, 1991; Shea and Taylor, 1990; Stice, Felder, Woods, and Rugarcia, 2000). Those who obtain teaching assistantships as graduate students often receive no formal pedagogical training (White, 1993; Bomotti, 1994; Cahn, 1994; Rushin et al., 1997; Shannon, Twale, and Moore, 1998; Golde and Dore, 2001), and those who do obtain formal training often receive limited useful information about how to be effective graduate teaching assistants (GTAs) (White, 1993; Tang and Sandell, 2000). Those who participate in training via short and intensive programs, workshops, and courses before beginning of their roles as GTAs typically do not receive formative performance evaluations. Because of this, GTAs who later become faculty often rely upon lecture as their primary method of instruction within engineering courses (Rugarcia, Felder, Woods, and Stice, 2000; Cox, 2005). Numerous studies highlight the benefits of non-lecture pedagogical techniques which result in better student learning, persistence, and attitudes (Cooper and Robinson, 1998; Springer et al., 1998; Cudd and Wasser, 1999; Cabrera et al., 2001).

The roles of engineering graduate teaching assistants vary from grading student assignments to teaching courses or laboratories independently depending on the content and context of the courses in which they are involved (e.g., traditional lecture or laboratory). Similarly, the formative and summative feedback needs of engineering GTAs may vary as well. The authors have developed the Global Real-time Assessment Tool for Teaching Enhancement (G-RATE) to provide feedback to GTAs for their improvement towards effective teaching and to understand the unique roles of engineering GTAs and their relationships with their supervisors (who are the ones most likely to provide them with pedagogical feedback). As an assessment tool that incorporates the pedagogical views of various stakeholders, the G-RATE addresses multiple perspectives by providing feedback from students, observers, administrators, researchers and GTAs. This paper presents the development of the G-RATE and a detailed description about the functionality of G-RATE. More specifically, it (1) reports the development of the G-RATE from observational data collected in engineering laboratory courses using a reliable and valid observational tool, the VaNTH Observation System (VOS) (Harris and Cox, 2003; Cox and Cordray, 2008), (2) addresses what the VOS captures and what it does not capture in an engineering laboratory environment, (3) explores the different types of feedback that GTAs and supervisors need and the perceived roles of GTAs in engineering laboratory environments, and (4)

provides a detailed discussion and demonstration about the function and usability of G-RATE for the purpose of capturing pedagogical practices and providing feedback in engineering laboratories.

LITERATURE REVIEW

Graduate students as teachers and laboratory instructors play a big role in U.S. higher education and as such, spend a significant amount of time engaging with undergraduate engineering students. Since laboratory projects are a prerequisite for understanding engineering practice, it is imperative that individuals who teach or supervise in these laboratories possess the tools to improve their pedagogical practices. The definitions of a laboratory can differ in engineering (e.g., one-on-one troubleshooting sessions or senior design courses).

The roles of GTAs (Allen and Rueter, 1990; Nyquist, Abbott, Wulff, and Sprague, 1991), the improvement of GTAs' teaching, and the feedback given to GTAs (Bond-Robinson, 2000; Black and Kaplan, 1997; Prieto and Meyers, 2001; Prieto and Meyers, 1999) have been studied extensively. In a study across three departments (two in chemistry and one in astronomy), Seymour et al. (2005) explored GTAs' roles in both traditional course environments and in environments implementing innovative pedagogical practices. Within traditional course environments, GTAs reported engaging in five primary activities to: (1) working in small groups with undergraduate students, (2) working with undergraduate students in laboratories, (3) providing academic support for students, particularly during office hours, (4) grading and preparing homework and exams, and (5) serving as a second authority figure in undergraduate courses. Seymour et al. (2005) found that within innovative course environments, GTAs engaged in three roles. The first was that of creative troubleshooter, meaning that GTAs resolved daily problems and alerted faculty to challenges that were out of their control. Second, GTAs acted as consultants who offered faculty information about the classroom interactions and occurrences within the environments in which they work. Finally, GTAs became collegial collaborators, meaning that they worked closely with faculty to facilitate student learning. However, while GTAs fulfill their roles through an extensive array of activities, the training they receive before entering the classroom or laboratory is limited and by no means consistent across departments. Because of the important roles that GTAs play in both traditional and innovative environments, feedback to GTAs about the extent to which they are fulfilling their teaching roles is needed.

To date, most feedback for GTAs has come informally from course coordinators, supervisors, or peers (Prieto and Meyers, 2001), from videotapes of course lessons, self-reflections by the GTAs (Prieto and Meyers, 1999; Bond-Robinson, 2000), or undergraduate student evaluations completed at the end of the term (Black and Kaplan, 1997; Seymour et al., 2005). Student reflections, which

are used most often to give feedback to GTAs about their teaching practices, might occur via group discussions, written course evaluations, or surveys (Black and Kaplan, 1997). Student surveys composed of Likert scale items are the most commonly used method for providing feedback GTAs. The items in these surveys may ask about a variety of issues including GTAs' preparedness, communication skills, approachability, or helpfulness (Black and Kaplan, 1997). When comparing undergraduate students' ratings and graduate students' self-reported ratings of teaching effectiveness, Twale, Shannon, and Moore (1997) found GTAs' self-reported ratings to be higher than their students' ratings. Self-ratings by international GTAs were also higher than self-ratings by U.S. GTAs, although undergraduate students gave U.S. GTAs higher ratings than international GTAs.

CONCEPTUAL FRAMEWORK

The conceptual framework on which this study is based is the "How People Learn" (HPL) Framework (Bransford, Brown, and Cocking, 1999). The HPL framework identifies four dimensions which are essential elements of an effective learning environment: (1) learner-centeredness, (2) knowledge-centeredness, (3) assessment-centeredness, and (4) community-centeredness. Within the learner-centered dimension, instructors recognize and attend to unique backgrounds and experiences that students bring to the classroom. The knowledge-centered dimension includes well-articulated lessons and emphasizes both students' understanding of course content and their abilities to transfer and apply this knowledge accurately in new environments. Two key aspects of the assessment-centered dimension are opportunities for feedback and revision by both instructors and students. The community-centered dimension emphasizes the creation of positive group dynamics among all members of the classroom community and encourages students to learn from one another. The HPL framework has been demonstrated to be a useful tool for measuring levels of these four dimensions in both traditional, lecture-based, and innovative lesson designs (VaNTH, 2010) with innovative lessons specifically incorporating all four dimensions (Greenberg, Smith and Newman, 2003; Pandy et al., 2004). For this reason, the authors have used the HPL framework to evaluate GTAs' instruction across multiple engineering disciplines in engineering laboratory courses.

PREVIOUS DATA COLLECTION

To determine what type of tool is needed to record GTAs' pedagogical experiences in engineering laboratories, pedagogical data were collected in engineering laboratories using the VaNTH

Observation System (VOS) and via focus groups, one composed of GTAs and another composed of the GTAs' supervisors. Overviews of the findings of these activities are provided in the following sections.

Direct Observations Using the VaNTH Observation System (VOS)

Prior to developing a comprehensive GTA feedback tool, the authors used the VaNTH Observation System (VOS) (Harris and Cox, 2003) to collect real-time, in-class data about GTAs' pedagogical practices in first-year engineering laboratory courses at Purdue University during the Fall 2007 and Fall 2008 semesters. This course serves as an introductory engineering course. Annually, the approximate enrollment is about 1600 students with supervision by fifteen GTAs. The course meets four hours per week, which includes two hours of lecture and two hours of laboratory. In this course, both lecture and laboratory components are utilized so that students can engage in teamwork and can hone their problem-solving skills. The Classroom Interaction Observation (CIO) portion of the VOS was used to collect data using *who, to whom, what, how*, and *media* categories of the instrument, with data recorded in four- to six- second intervals. Codes for each category are described in detail in Harris and Cox (2003). The *who* and *to-whom* categories note who is initiating or responding to in-class interactions. The *what* category describes twelve types of in-class interactions that may occur during the four- to six- second observation cycle. The content of the *how* category within the VOS differs from the CIO portions of other similar observational instruments in its identification of the presence of "How People Learn" dimensions in the learning environment. To understand additional information about the types of media that an instructor is using during an observed class session, the VOS contains a *media* category.

The VOS was used to understand what data it was capable of capturing in laboratory course environments and how this data differed from that collected in conventional classroom environments for which the VOS was designed. To collect data using the CIO portion of the VOS, observers sat through three-hour lab course sessions and observed a GTA supervising thirty undergraduate engineering students. The observers recorded approximately 20 to 25 five-minute segments of instruction at regular intervals by selecting corresponding codes under each category, thereby resulting in the creation of hundreds of code strings per course session.

The use of the VOS in laboratory course settings was found to be hampered by several factors (McNeill. et al, 2008). First, the VOS required considerable training to use. Extensive training was required in order to achieve 85% inter-rater reliability accuracy in four- to six- second coding intervals. Second, not all categories were intuitive. While the *who, to whom*, and *media* categories were straightforward, the *what* and *how* categories required additional interpretation by observers, depending on the types of classroom interactions that were occurring. Also, the *how* category, containing the

four HPL dimensions, was difficult to interpret because of the subjective interpretation of observed interactions representing these dimensions. Finally, observational data were collected primarily on handheld computers running software which required users to navigate multiple interfaces.

Undergraduate Student Survey

To complement observations recorded with the VOS, survey data were collected in first-year engineering laboratory courses taught by both U.S. and international GTAs at Purdue University (Cox et al., 2010b). Seventy-eight undergraduate engineering students shared their perceptions of their GTAs using a modified Adjective Generation Technique (Potkay and Allen, 1988). More specifically, students were asked to describe their GTAs using five words. Based upon student feedback, researchers identified three themes of highest concern to undergraduate students about their GTAs: (1) GTAs' knowledge levels, (2) their overall effectiveness, and (3) their approachability.

Focus Group Interviews about the Roles and Experiences of GTAs and Supervisors

During summer 2008 at Purdue University, two focus groups were conducted to assist with the understanding of the roles of GTAs, GTAs' relationship with their supervisors (the person who provided feedback most often), and the feedback needs of both groups. One of the focus groups was comprised of all GTAs and the other was of the GTAs' supervisors. A focus group study is a carefully planned series of discussions designed to obtain perceptions on a defined area of interest in a permissive, nonthreatening environment. Each group is conducted with 5 to 10 people led by a skilled interviewer. The discussions are relaxed and often participants enjoy "sharing their ideas" (Krueger and Casey; 2008; p. 2). Focus groups are commonly used and are an effective method when the researcher wants to obtain varied perceptions on a topic (Morgan, 1996). The participants in the supervisors' focus group represented the disciplines of electrical and computer engineering, chemical engineering, nuclear engineering, and first-year engineering. Participants in the GTA focus group represented the disciplines of engineering education, materials engineering, electrical and computer engineering, and software engineering. Moderators asked the supervisors and the GTAs semi-structured questions about their roles and experiences that varied little between groups (Tables 1 and 2).

Using open coding, the authors made the following conclusions:

- The roles of supervisors and GTAs differed. The participants believed that a supervisor's job was to think explicitly about the purpose of their courses, whereas, the participants thought that the role of the GTA is simply to implement the ideas of their supervisor.
- Supervisors and GTAs acknowledged GTAs to be the liaisons or "conduits" between the undergraduate students and professors.

Please introduce yourself by stating your name and the course(s) that you supervise.
How would you describe the course that you supervise?
What is the role of the TA in the course, or courses, that you supervise?
What criteria do you use to select your TAs?
What expectations do you have of your TAs?
What do think your TAs enjoy about their work?
What do you think your TAs dislike about their work?
Do you have any formal training for your TAs?
Do you conduct any performance evaluations of your TAs?
How often do you interact with your TAs?

Table 1: Questions asked of supervisors.

Please introduce yourself by stating your name and the course that you teach.
Please describe the course that you are a TA for.
How would you describe your role in the course that you are a TA for?
Do you enjoy your work?
If you do, what do you enjoy about it?
What do you dislike about your work?
What are your strengths and weaknesses?
What would you do to improve your teaching?
What kind of relationship do you have with your students?
Please describe the relationship that you had with your supervisor.
What would you do to improve your interactions with your supervisor?
If you all had any type of training what type of training did you have?

Table 2: Questions asked of GTAs.

- Answering questions and giving students feedback, guidance, and assistance were some of the most important roles of GTAs.
- While GTAs were rarely provided with formal or explicit performance evaluations, many supervisors did provide their GTAs with informal feedback.
- Training for GTAs occurred campus-wide, and departments rarely followed up with additional training representing the disciplinary content that would be taught by the GTAs.
- Some GTAs relied on peer observations to learn about teaching.

CONNECTING RESEARCH TO PRACTICE

A synthesis of the findings from the studies above suggests that the following elements be incorporated into a tool that would capture the pedagogical practices of GTAs:

- The tool should be easy to use and should not require extensive observer training.
- A complete description of the codes and what they represent should be integrated into the tool so that users do not have to memorize observational codes and definitions.
- The *who* and *to whom* categories from the VaNTH Observation System (VOS) could be customizable according to the environments (i.e., laboratory or classroom) where the tool is used.
- A help function should be provided to assist users with the operation of the tool.
- GTAs should obtain deliberate, periodic feedback about their pedagogical practices.
- Because GTAs have to understand engineering concepts, the tool might explore the extent to which they are accurately and effectively conveying pedagogical concepts to their students.
- The student observation piece should allow students to assess formatively their laboratory experiences.
- A common code or identifier should be used to connect all elements of the tool.

DEVELOPMENT OF THE GLOBAL REAL-TIME ASSESSMENT TOOL FOR TEACHING ENHANCEMENT (G-RATE)

In response to the aforementioned needs, the G-RATE, an adaptation of the VaNTH Observation System, was developed to provide multidimensional (e.g., quantitative/qualitative, student/supervisor) feedback to GTAs about their instructional interactions in a classroom. The G-RATE has a flexible and easy-to-use interface that may be used in both lecture and laboratory course environments and may be used to collect data from a variety of stakeholders (including undergraduate students, GTAs, researchers, and administrators). The G-RATE is a piece of software that was designed using the Microsoft Visual C# programming language and runs on the Windows XP or Vista operating system and requires 3 MB of hard disk space and an eight inch or larger computer screen. Data produced by the G-RATE is stored using Microsoft Access, and Microsoft Excel is needed for generating observation reports.

The graphical user interface of the G-RATE has five working environments, or functions, which correspond to the *Observer, Student, Graduate Teaching Assistant, Researcher*, and *Administrator*. Training materials can be accessed on the main page of the user interface where the functions are

Function	Description
Administrator	This function allows a lab coordinator to modify the data collection parameters of the G-RATE (e.g., adding the name of observed GTAs; tailoring self-reflective questions for the GTAs; selecting appropriate questions for undergraduate students). This occurs at the **beginning** of the lab session.
Observer	This function produces several time- or event-sampled codes that reflect observed instructional practices of GTAs **during** lab sessions. Codes represent elements of the "How People Learn" framework (Bransford, Brown, and Cocking, 1999)
Student	This function contains open-ended and closed-ended questions to be completed by undergraduate students enrolled in the observed lab session. These questions will be formative and summative and will be answered **during the last ten minutes** of the lab session.
Graduate Teaching Assistant	This function contains open-ended items about GTAs' pedagogical practices during lab sessions. The GTA will complete this reflection **after** the lab session.
Researcher	This function gives a researcher access to data from the other G-RATE functions without overriding modifications made by the lab coordination. This function houses the profiles given to GTAs and faculty about GTAs' pedagogical practices. The researcher accesses these profiles **after** all other data have been collected.

Table 3: G-RATE functions and descriptions.

located. These materials provide tutorials about system operation as well as an overview of the "How People Learn" framework (Bransford, Brown, and Cocking, 1999), the conceptual framework on which the G-RATE is based.

Table 3 provides descriptions of the five functions of the G-RATE and Figure 1 displays the observational cycle suggested for the use of the G-RATE. More detailed descriptions of each function are described in subsequent parts of this paper.

Administrator (*Admin*) Function Page

The *Admin* function page is intended for the use of GTA supervisors who will use the instrument to provide feedback from the courses that they supervise. In the *Admin* function, a supervisor is able to modify some cosntents of the Observer, Student, and GTA functions. An administrator account must be created in order for the G-RATE to be used. A private database, which will store data collected from the Observer, Student, and GTA functions, is automatically generated when creating the administrator account.

The *Admin* function page contains four tabs- Observer, GTA, Student, and User page (Figure 2). On the Observer tab the administrator can change the *who* and *to whom code* string categories

Function	*Admin* (5min)	*Observer* (Quantitative Outcome)	*Student* (Qualitative and Quantitative Outcome) (10min)	*Graduate Teaching Assistant* (Qualitative Outcome) (10 min)	*Researcher*
Time	Before class	Lab session (Duration of the class)		After class	

Figure 1: Observational cycle for the G-RATE.

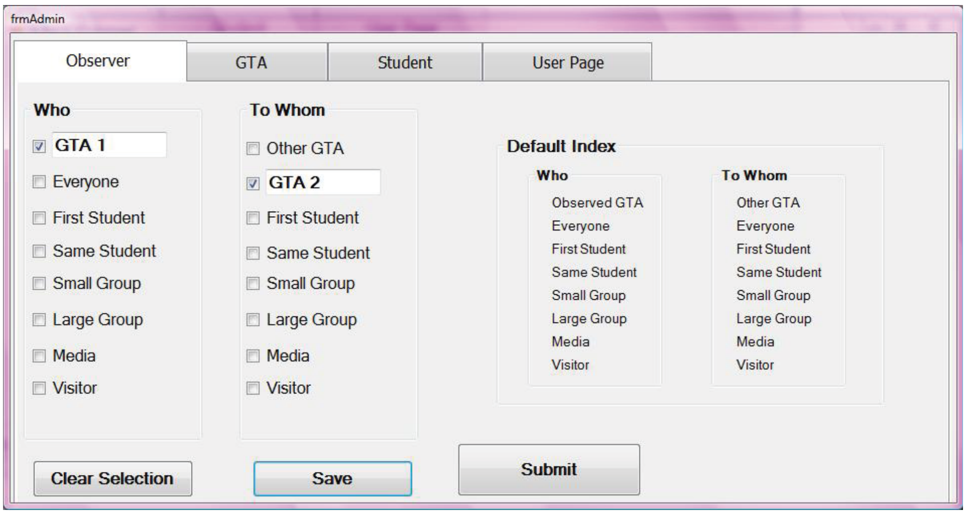


Figure 2: Admin function page of the G-RATE.

of the Observer function. Similarly, the questionnaires for the GTA and Student functions can be altered on the GTA and Student tabs, respectively. All of these modifications are stored in the private database.

Since security and anonymity are important concerns when collecting data using the G-RATE, a user has two possible data store options- a public database or a private database (Figure 3). A public database saves the data in a default file that can be read in the Researcher function and stored in the Observer, Student, and GTA functions. Only authorized administrators, observers, students, GTAs, and researchers can read and store data in a private database. In order to grant access to a private database, security options can be applied by accessing the User page tab in the Admin

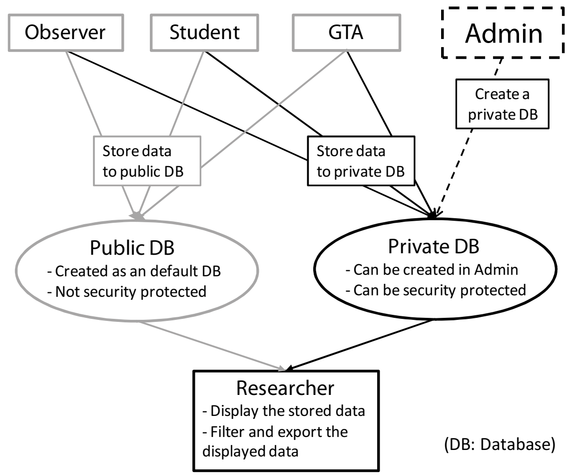


Figure 3: Public and private database options in the G-RATE.

function. By setting up the passwords, the administrator can control (1) who may use the contents of the private database, (2) who may store data in the private database, and (3) who may read data in the private database.

Observer Function Page

The *Observer* function page is used by observers to record observational data of GTAs' instructional practices in laboratory course settings. Figure 4 shows a screen shot of the Observer function page which is a modified version of the Classroom Interaction Observation (CIO) portion of the VaNTH Observation System (VOS) instrument (Harris and Cox, 2003).

Rather than using abbreviated codes as the VOS does, the G-RATE's *Observer* function displays entire descriptive codes (e.g., "instruction" or "guidance"). To help observers learn and recall codes quickly, tooltip functions are located beside each code, and *Help* functions are provided in the upper corner of the page to remind observers of the definitions of the "How People Learn" dimensions and other observational elements.

There are two code string saving options in the *Observer* function. Users may choose whether they want to save observation code strings manually or automatically. If saving codes manually, an observer must select one code each representing the *who*, *to whom* and *what* categories and at least one code representing the *how* category and then press the "submit" button to save the data. If a category is not represented, a warning message will appear in a pop-up window informing the user of the unselected categories. If automatically saving codes, the observer can select a recording time interval that will save codes at regular time intervals regardless of categories selected or

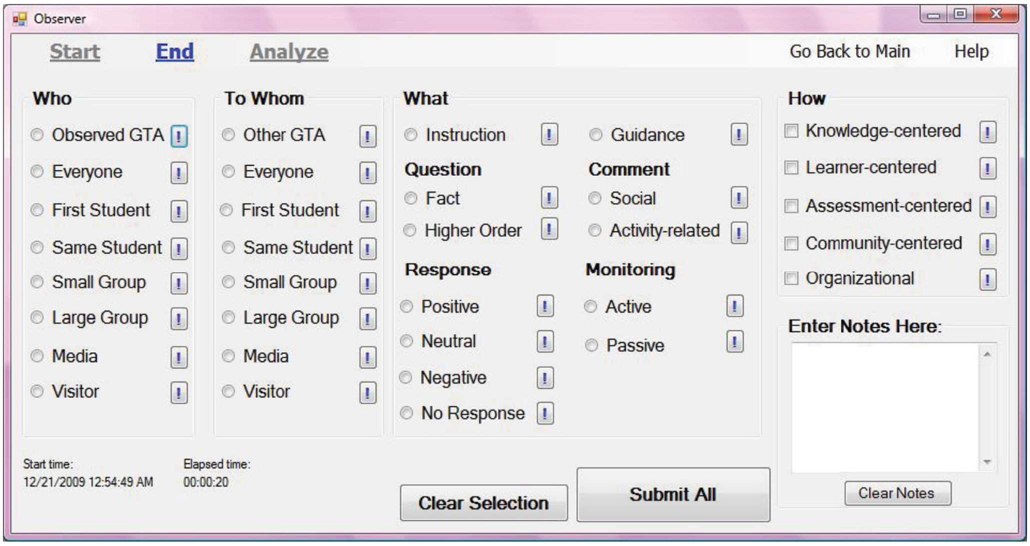


Figure 4: Observer function page of the G-RATE (Cox et al., 2010a).

other parameters. Within the database, any category without selected codes will display the word '*miss*' under the selected category.

In addition to collecting code string data, observers may write notes at anytime during an observation session. Notes are saved with corresponding code strings regardless of whether data is being stored manually or automatically.

Student and GTA Function Pages

Both the *Student* and *GTA* function pages contain enumerated questions which may be completed by students and GTAs, respectively. The *Student* function contains open-ended and Likert scale items and the format of this function is similar to a regular classroom evaluation form. A comment section is provided for each Likert item. The *GTA* function contains open-ended self-reflective items on GTAs' pedagogical practices.

Researcher Function Page

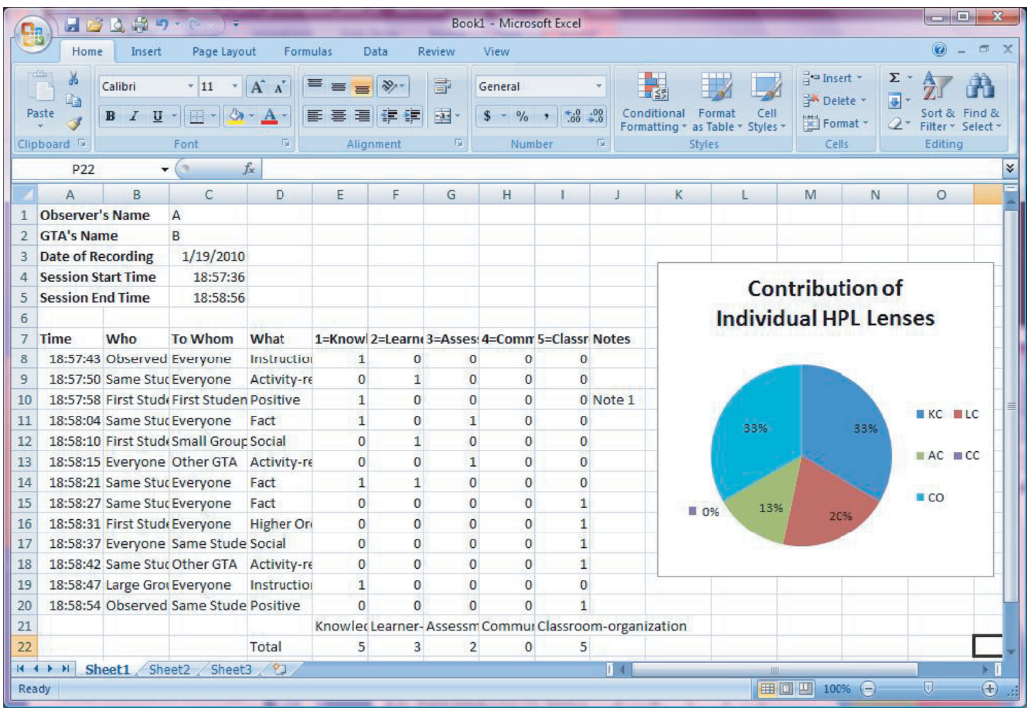
The primary role of the *Researcher* function page is to display data from both the public and private databases for use by a researcher. As stated in the previous section, any data produced by other functions of G-RATE is stored as a Microsoft Access database file. Thus, there may be a chance that the file may be deleted, that the data may be modified by accident, or that other people

who are not authorized may open and read the data. For these reasons, all databases are created as a password protected file by default, and the file cannot be opened directly. In other words, the database can only be read using the *Researcher* function.

The *Researcher* function page also contains data filtering options. There could be hundreds or even thousands of code strings of data if observations are performed for a long period of time or if multiple GTAs are observed under a group database. In this case, a researcher may have difficulty finding necessary information among the enormous amounts of data. Using a filter, a user can extract data from any function using multiple options (e.g., key words: observer names, GTA names, or dates). The researcher can then export this data as an Excel file, and may copy the database file to load it on another computer.

An Example

As an example, demonstration of data generated by the Observer function is located in Figure 5. At different times during the class, the observer submitted observational data in real time. The observer chose different codes under the *who*, *to whom*, and *what* categories. Meanwhile, the



Observer's Name	A								
GTA's Name	B								
Date of Recording	1/19/2010								
Session Start Time	18:57:36								
Session End Time	18:58:56								
Time	Who	To Whom	What	1=Knowl	2=Learn	3=Asses	4=Comm	5=Classr	Notes
18:57:43	Observed	Everyone	Instructio	1	0	0	0	0	
18:57:50	Same Stu	Everyone	Activity-re	0	1	0	0	0	
18:57:58	First Stud	First Studen	Positive	1	0	0	0	0	Note 1
18:58:04	Same Stu	Everyone	Fact	1	0	1	0	0	
18:58:10	First Stud	Small Group	Social	0	1	0	0	0	
18:58:15	Everyone	Other GTA	Activity-re	0	0	1	0	0	
18:58:21	Same Stu	Everyone	Fact	1	1	0	0	0	
18:58:27	Same Stu	Everyone	Fact	0	0	0	0	1	
18:58:31	First Stud	Everyone	Higher Or	0	0	0	0	1	
18:58:37	Everyone	Same Stude	Social	0	0	0	0	1	
18:58:42	Same Stu	Other GTA	Activity-re	0	0	0	0	1	
18:58:47	Large Gro	Everyone	Instructio	1	0	0	0	0	
18:58:54	Observed	Same Stude	Positive	0	0	0	0	1	
				Knowle	Learner-	Assessm	Commu	Classroom-organization	
			Total	5	3	2	0	5	

Figure 5: Sample screenshot of observer data.

observer also documented the dimension of the HPL framework at that particular time point and wrote notes in the note box. The data are presented in a pie-chart that summarizes the overall distribution of the teaching practices in the context of the HPL framework. This information can be used later as feedback to the instructor or as part of data sources for further research about effective pedagogical practices.

DISCUSSION AND IMPLICATIONS

Although many GTAs may receive feedback about their teaching in semester-long courses via several activities (e.g., journaling and evaluation of critical incidents via video) (Chavela et al., 2008; McClure, 2007), such courses are not offered at every university, and faculty are not always available to give GTAs pedagogical feedback that is grounded in theory and effective practices. Training for GTAs is often inconsistent (Prieto et al., 2001). For this reason, a tool such as the G-RATE is needed. Unlike instruments which may provide graduate students with feedback once during the semester, if at all, the G-RATE provides GTAs with formative and summative feedback from supervisors, researchers, and from their students. In addition, rather than obtaining this feedback via primarily quantitative methods (e.g., end-of-semester surveys), graduate students observed using the G-RATE will obtain quantitative and qualitative feedback that engages them in effective pedagogical practices, particularly practices related to the dimensions of Bransford, Brown, and Cocking's (1999) "How People Learn" framework.

Within engineering laboratory environments, metrics of interest include student retention, student satisfaction, and the efficacy of laboratory simulations (Feisel and Rosa, 2005). Researchers anticipate that the G-RATE can be used to explore these and other metrics related to student outcomes. Furthermore, the tool can be used to create and to extend research studies about relationships between GTAs and their supervisors or relationships between GTAs and their undergraduate students (Cox et al., 2010a; Commander, Hart, and Singer, 2000). One may also explore the impact of G-RATE feedback upon graduate students' professional development experiences in engineering or even use it to identify the most effective ways to give beneficial feedback to GTAs about their teaching. A focus on graduate students' professional development has strong implications for the creation of formal, standardized training for engineering GTAs regardless of discipline. Furthermore, the implications can also assist with the development of workshops and/or other resources for supervisors who are expected to provide formative and summative feedback to engineering GTAs, and data collected via the G-RATE may be used to explore ways that the tool might be revised to enhance the feedback given to GTAs.

FUTURE WORK

Creation of Pedagogical Profiles from G-RATE Data

Once data have been collected, graduate students' professional development may be enhanced via the generation of comprehensive profiles of GTA instruction. Sample profiles from the *Observer* function will include graphical representations of classroom occurrences and events. More specifically, at the end of an observation, each GTA will receive an individual report and analysis, graphs representing observations, survey output from undergraduate students about their GTAs (e.g., general feelings about GTAs' teaching, ideas of how GTAs are doing, and perceptions of GTAs' disciplinary content knowledge), and a summary of pedagogical information (framed within the context of the HPL framework) over the course of the semester.

Large-Scale Distribution of the G-RATE

The G-RATE research team has received feedback about the tool via an external consultant and from engineering audiences at two public universities housing several engineering departments. Members of these audiences offered various suggestions. Among these include (1) the creation of an awareness brochure to inform audiences about the G-RATE and its potential to enhance the feedback experiences of GTAs in engineering, (2) a collaboration between the research team and universities that support engineering graduate students within the National Science Foundation's GK-12 program, (3) translation of the *Student* and *Graduate Teaching Assistant* functions of the G-RATE to virtual learning environment systems (e.g., Blackboard) that may be used currently in laboratory environments so that students do not have to become familiar with new systems and interfaces, and (4) the modification of the G-RATE for new faculty, K-12 in-service teachers, and pre-service teachers during student teaching. Suggestions related to the practical use of the instrument include limiting the number of student response items to ten so that students do not feel overwhelmed by the assessment and providing five to eight sentence stems for GTAs to complete at the end of the lab to prompt their thinking (e.g., The most difficult aspects of today's lab was ___________).

Testing of the G-RATE is occurring in several ways. As the final version of the G-RATE is being developed, the team is collecting data via IRB-approved video sessions of bioengineering classrooms and of electrical and computer engineering laboratories. The team plans to pilot the finished tool among engineering students in fall 2010. From here, revisions will be made, and the final tool will be distributed for use in spring 2011. As part of a larger evaluation effort, data from students across multiple institutions will be collected to confirm the reliability and validity among targeted populations.

CONCLUSIONS

The G-RATE is a new tool that is informed from observations and empirical studies exploring the needs of engineering GTAs and that minimizes the limitations of current professional development practices for GTAs. Comprised of five functions that collect multidimensional feedback from laboratory observers, the G-RATE provides feedback about GTAs' pedagogical practices to not only the GTA, but to supervisors and to researchers who are interested in the long-term professional development of these graduate students. Such development is needed, since most GTAs do not receive consistent feedback about their teaching. Future implications of this work include the use of G-RATE data in conjunction with student learning outcomes within the laboratory and the translation of the G-RATE to multiple audiences that might benefit from multidimensional feedback.

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AUTHORS

Monica F. Cox, Ph.D., is an Assistant Professor in the School of Engineering Education at Purdue University. She obtained a B.S. in mathematics from Spelman College, a M.S. in industrial engineering from the University of Alabama, and a Ph.D. in Leadership and Policy Studies from Peabody College of Vanderbilt University. Teaching interests relate to the professional development of graduate engineering students and to leadership, policy, and change in science, technology, engineering, and mathematics education. Primary research projects explore the preparation of engineering doctoral students for careers in academia and industry and the development of engineering education assessment tools. She is a NSF Faculty Early Career (CAREER) award winner and is a recipient of a Presidential Early Career Award for Scientists and Engineers (PECASE).

Jeeyeon Hahn is a Ph.D. student in the School of Aeronautics and Astronautics at Purdue University. She obtained B.S. and M.S. in Aeronautical and Astronautical Engineering from Purdue University. Her primary research interests relate to the Fatigue of Structures and Materials.

Nathan McNeill is a post doctoral associate in the Department of Materials Science and Engineering at the University of Florida where he is studying the factors that contribute to success in open-ended problem solving. He has a Ph.D. in engineering education from Purdue University, an M.S. in mechanical engineering from The Georgia Institute of Technology, and a B.S. in engineering from Walla Walla University.

Osman Cekic holds a Ph.D. in higher education and student affairs from Indiana University at Bloomington and a master's degree in secondary school administration from the University of Arkansas at Fayetteville and a Bachelor's degree in educational administration and planning from Ankara University in Turkey. Dr. Cekic's research interests include higher education policy, finance and the linkages between budget and organizational culture, and college student retention. Currently, Dr. Cekic works as a research assistant at Canakkale Onsekiz Mart University, Faculty of Education in Turkey, where he continues to explore issues related to science and engineering at the graduate level.

Jiabin Zhu is a Ph.D. student in the School of Engineering Education at Purdue University. She obtained a M.S. in Optics from the Chinese Academy of Sciences (CAS), a second M.S. in Biomedical Engineering from Purdue University and a B.S. in Physics from East China Normal University. Her primary research interests relate to comparative study methods and frameworks in engineering education, global engineering and mentoring of engineering graduate students.

Jeremi London is a graduate student in the College of Engineering at Purdue University where she is pursuing a Ph.D. in engineering education and a M.S. in industrial engineering. Her research interests include K-12 engineering education and engineering faculty development. Jeremi has a B.S. in industrial engineering from Purdue University.