SESSION 6

EXPERIMENT GENERATOR

Moderator—Bill Lee-Sammons, Washington State University

Student MEL software support for instructors and teaching assistants in research methods course

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A number of common problems plague the teaching of the undergraduate research methods course, from the training of teaching assistants to providing meaningful experimental materials to handling data acquisition and analysis. The Student Micro Experimental Laboratory (MEL) offers a systematic approach to the management of a computerized research methods laboratory course by combining high-quality experiments in many areas of psychology with background materials to help the instructor and teaching assistant. The software presents and collects data from 28 experiments. The data can be analyzed for single subjects and for classes as a whole. Students can rapidly implement new experiments in a variety of paradigms. An expanding library of experiments created by students and instructors should provide an expanding environment for teaching experimental research methods. Instructor's materials provide background information, discussion questions, and data analysis for all experiments. The student workbook provides discussion of the background of the experiment, details of the methodology, and questions addressing various aspects of experimental design and interpretation of data.

Several problems are commonly encountered in teaching the undergraduate course on research methods in psychology. The first is to provide enough research materials for a full semester, plus student projects. The second is to do so without use of specialized equipment that is often not available or is too difficult for teaching assistants to use. Third, teaching assistants, who often have not completed their own methods and statistics courses, may not have sufficient background in the methods or analysis

techniques. Fourth, students may have neither the time nor the background to implement their own experiments in the limited time of the course. Fifth, instructors would like to be able to use a small number of their own experiments. Anyone who has taught the research methods course will agree that providing adequate laboratory experience for students (and adequate training for teaching assistants) is time-consuming and difficult.

The Student Micro Experimental Lab (MEL) was designed to provide a full range of support for instructors and teaching assistants, as well as to provide a wide range of experiments that give students experience with the logic and methods of modern experimental psychology. On most campuses, students have easy access to personal computers in departmental laboratories or in public facilities. Personal computers are adequate for most professional psychological research (Schneider 1988). Personal computers allow millisecond timing accuracy, and statistical analysis software is widely available. Students can

The Micro Experimental Lab (MEL), and *The MEL Lab: Experiments in Perception, Cognition, Social Psychology, and Human Factors* are products of Psychology Software Tools, Inc., 511 Bevington Road, Pittsburgh, PA 15221. Inquiries about MEL should be sent to the address above or to James D. St. James, Millikin University, 1184 W. Main St., Decatur, IL 62522.

Note: One or more of the authors has a direct financial interest in some of the software or hardware described in this paper.—*Editor*

carry out experiments either in or out of class, they can see their own results at the end of a session, and data from all students can be merged to allow analysis of group data.

A SYSTEMS APPROACH

The Student MEL provides a systems approach to the undergraduate research methods course (see Figure 1). MEL goes beyond just providing a set of "canned" experiments. It also provides complete support for data management and analysis, questions and blank graphs for student assignments, questions for discussion in lab, written discussions of the background of the experiments (including references), availability of copies of principal references, and a powerful experiment generator (based on MEL; see Schneider, 1988) that permits students to implement their own experiments or make alterations to most of the experiments. The instructor's manual provides details of data analysis for each experiment, as well as instructions for using the experiment generator.

The Experiments

The Student MEL provides experiments in perception, cognition, social psychology, and human factors. In its initial release, MEL contained 28 experiments that addressed different methodological issues (see St. James, 1989). The current experiments include:

Perception

- Blind spot mapping
- Duration of icon
- Signal detection
- Perceptual matching

Selective attention

Mental rotation of images

Cognition

Lexical decision

Scanning short-term memory

Additive factors

Sentence/picture comparison

Short-term memory

Free recall

Organization in memory

Mnemonics: Aids to memory

Recall and recognition

Spacing and rehearsal

Generation effect

Imagery in problem-solving

Automatic/control processing

Reading comprehension: Linking inferences

Social Psychology

Prisoner's dilemma

Personality tests

Impression formation

Human Factors

Design of telephone systems

Students purchasing the Student MEL (suggested student price, \$19.95) receive a student workbook, which contains the discussion of each experiment along with questions about the variables involved and about the experiment's outcome. Advanced questions and suggestions for extension experiments are provided, along with blank graphs for students to complete with both individual and group data. Students also receive the complete set of ex-

Figure 1. Summary of Student MEL programs, information flow, and text materials. Arrows show the flow of programs or data. The squares represent student floppies. The class data ellipse represents a hard disk file to store the accumulated data from the experiments.

periments on diskettes. The diskettes provide a menu-driven selection of experiments, and they permit a choice of either the normal mode for running the experiment and collecting data or a demonstration mode that permits students to preview and/or review experiments. Most experiments require about 5 min in demonstration mode and average 20 min in normal mode.

Many experiments end with a brief questionnaire designed to draw the students' attention to various aspects of the experiment. These questions are intended to help students make sense of what they just experienced and also to stimulate discussion.

Class time need not be used to run the experiments. Students can be assigned to do the experiments as homework. Also, when students miss a class, they can make up the laboratory without having to schedule a make-up session.

Student MEL Software

The Student MEL software is a specialized version of the MEL RUN program (Schneider, 1988) for running experiments. The current version runs on IBM-compatible PCs with 512K of memory (456K available) with CGA, EGA, VGA, or Hercules graphics cards. Most of the experiments can be run without graphics cards, although in such cases graphs would not be presented. The diskettes contain an experiment execution program, EXPERIMENT, that maintains millisecond timing and can execute MEL-developed experiments. Space is reserved for data files generated while the experiments are run. An initialization program, STARTUP, is used by the student to enter identification information such as name and number. With the STARTUP program, students can make backup copies or transfer their files to other media (e.g., make a working set of 3.5-in. disks).

The student software is menu-driven, with the menus directly mapping to the textbook (e.g., the top level chooses areas; the next level, the specific experiment with the number corresponding to the chapter in the textbook). Students are given instructions for being run as subjects in the experiment, given practice trials, and run through the full experiment (typically requiring 20 min). At the end of the experiment, they are given a table of the main results and a graph of their performance.

A network version of the software will be available in fall 1991. It will allow students to send data at the end of the experiment to a master file for group analysis.

Data Management Tools

The examination of group data is critical in a research methods course. Most psychological research is based on group effects summed over subjects. To learn experimental procedures, students must gain an appreciation for within- and between-subjects variability. The Student MEL shows students their own data. Students can also examine data for the entire class. Students can compare their data to the group averages, examine group variability, and perform statistical procedures. A variety of statistical programs are provided for analyzing the full data set.

Merging data is simple and rapid. Students turn in their data disks at the beginning of class. While the instructor begins discussion of the experiment, a student or assistant can load each student disk and add the student's data file to a master file by pressing a single key.

Descriptive statistics and graphs of data. The instructor using the Student MEL receives an analysis program and data analysis files that are set up to perform the descriptive statistics commonly used for each experiment. Few teaching assistants know what statistics are appropriate for all the procedures involved. Even if they know what methods to use, few assistants have the time to generate statistical procedures for all experiments.

To ease the analysis burden on the instructor, each experiment comes with analysis form files (over 160 pre-generated analyses). Each analysis form includes comments informing both the instructors and the student what the analysis is expected to reveal. The instructor executes most analyses by pressing two keys to perform the analysis and display a graph or table. The descriptive analysis includes mean reaction time or proportion correct graphed or tabled for each main effect and each interaction for the class data. There are also graphs and tables of individual student performance. Graphs are often used to illustrate intersubject variability, with all students' data presented in a single plot. To permit data filtering (e.g., to eliminate subjects with excessive error rates), graphs and tables of accuracy by subject are provided. Reaction time distributions can be graphed to determine filter settings to exclude outlying responses. Graphs include means and standard errors by condition. Tables include means, standard deviations, minima and maxima, and number of observations for each condition. A system of numbering the analyses across experiments facilitates learning to use the data analysis package.

A chapter in the instructor's manual details the data analysis package and how to change analyses as needed. For each experiment, the relevant section of the instructor's manual also includes a complete description of the analyses set up, along with a listing of variable names and coding of the levels of each variable. Analyses are labelled "Basic," "Medium," and "Advanced," to help the instructor choose which analyses to present, depending on the level of the course.

Analysis of variance (ANOVA). Where appropriate, the ANOVA comparing mean reaction time or mean proportion correct is set up and ready to perform. Most of the experiments involve repeated-measures or mixed ANOVAs and produce standard ANOVA summary tables. The forms that control these analyses can be changed if specialized analyses are needed.

Output for external analysis. The Student MEL data analysis package does not support inferential statistics other than the ANOVA. While the ANOVA is the relevant approach for most of the experiments, a few require other analyses. The Student MEL permits exporting of data in a variety of formats. The user designates BMDP, SPSS-X, SAS, or Lotus, and the results are output with the

trial-by-trial data for each subject formatted for the chosen package. With the data definition language, new output formats can be created. Data can be formatted to include means for each condition instead of single-trial data. Data can also be exported to space-delimited files either as single-trial data or with prior processing to filter data or output means for each condition. With minor editing using a text editor, such files can be used with SYSTAT, MYSTAT, or most other statistical packages.

Student and Instructor's Textbook/Manual

Each student receives a written textbook along with the diskettes containing the experiments. Instructors and teaching assistants receive a copy of the textbook, along with the instructor's manual.

The student textbook. The 200-pp. textbook that each student receives contains a narrative discussion of the issues addressed by each experiment (with references) and details of the specific methodology in about 4 pages. Blank graphs are provided for most experiments, to permit students to graph both their individual data (reported to them at the end of each experiment) and the group data from the whole class. The instructor is provided a standard analysis form for the group analyses. With these, the instructor can create a summary table by entering a few keystrokes. A set of five or six questions addresses aspects of design (including dependent, independent, and control variables), the outcome of the experiment, and comparison to published reports in the literature. Advanced questions are included that can serve as discussion topics or as an introduction to further reading by the interested student. Extension experiments are also suggested, most of which can be implemented with the experiment generator.

The textbook contains information about planning and implementing experiments involving reaction time and questionnaire procedures. The textbook also provides instructions on how to initialize and run the software and make back-up copies.

The instructor's manual. The instructor's manual contains answers to the questions from the student textbook, discussion questions for use in class, and an extensive discussion of data analysis for each experiment.

The MEL Experiment Generator

Our teaching experience in methods courses suggests that the most effective way to get students to understand experimental techniques is to have the students design and execute their own experiments. For example, counterbalancing and stimulus selection become very concrete when students design these into an experiment. The applicability of concepts such as mnemonics can be evaluated in student-designed tasks such as the learning of chemical names or the building of human-computer interfaces.

It is critical that students and instructors have support tools to facilitate experiment development on computers. Most undergraduates in methods courses have little, if any, programming experience. Hence it is not feasible to have them program experiments in standardized lan-

guages. The MEL research system (Schneider, 1988) simplifies experiment development but requires more training time than is typically available in an undergraduate methods course.

Our goal in creating the Experiment Generator is to allow students to develop new experiments in preprogrammed paradigms with only about 2 h of class instruction. To do this, we have developed a series of paradigms that can be edited by filling in blanks to specifying the paradigm.

The paradigms include reaction time, list learning, questionnaire, and human factors procedures. Most experiments that present a series of visual stimuli and then collect a response can be implemented. The Experiment Generator requires the instructor or student to designate the events and timing of displays for each trial and block of trials; it then asks for input of instructions (for the whole experiment as well as for each block) and stimulus materials.

The Experiment Generator is easy to use. The initial menu allows the student to read in files and edit displays, experimental parameters, and stimuli and specifications for blocks and trials. For example, in the reaction time paradigm, students can provide a variety of instructional displays, block conditions with up to three independent variables, and specify trials with three independent variables. The dependent variables of response time and accuracy are recorded. The trial procedure includes a "get ready" display, optional study stimulus, focus cross, probe stimulus, and optional masking stimulus. The meaning and acceptable values for all the specifications are presented on a form that the subject edits.¹ Figure 2 illustrates the screen displays from the Experiment Generator for reaction time tasks. The upper form specifies the experimental parameters; the lower form specifies the trial stimuli. The forms are filled in for the Posner and Boies (1971) physical/name match experiment. By entering about 50 keystrokes and typing the specific stimuli, one can convert the matching experiment to other experiments involving tasks such as lexical decision, visual scanning, or mathematical calculation, or to an experiment on the Stroop effect. Similarly, learning, questionnaire, social bargaining, and design experiments can be altered by editing the parameters, instruction displays, and stimulus text.

The source files for many of the Student MEL experiments are included with the instructor's materials, so that these experiments can be modified with either the Experiment Generator or the standard MEL system (not included in the instructor kit). Students can modify most of the experiments in the Student MEL with the Experiment Generator. This makes it easy for students to extend procedures that they have used earlier in the course (e.g., do mnemonics help for learning the vocabulary for chemistry courses?). After the students modify the experiment, they can then run it with their own disks.

Experiments included in the student workbook provide examples of many paradigms that students can consult when setting up their own experiments. Whether students modify existing experiments or set up their own, the Experiment Generator gives them access to a wide range of

File	Displays	Parameters	Block Specs	Trial Specs	Help	Other
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Trial Specs

101 ! Block type 1 stimulus in

102 ! Block type 2 stimulus in

Press the arrow keys to select the options

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FILE: rt.ins      PARAMETERS 1      INSERT #1
Study line - location on the display to show the text (range 1-22) 5
Center the study display in the frame (0-no, 1-yes) 1
Maximum study time 0-32767 milliseconds (0-no study display) 30000
Probe start line 1-22 (use center of display if possible) 12
Center the probe display in the frame (0-no, 1-yes) 1
Maximum Probe duration 14-32767 milliseconds 500
Response keys allowed for probe display 13
Response message for the probe (displayed on the fixation display)
Press the 1 key for a match and the 2 key for a mismatch
Mask duration 0-32767 milliseconds (0-no mask) 1500
(NOTE the probe duration and mask duration must be less than 32767)
Mask Stimulus
***
Randomize blocks (0-no, 1-yes) 0
Randomize trials (0-no, 1-yes) 1
<E> - Edit    <PgDn> - Next insert    <Esc> - Quit form    <Alt-Q> - Quit program
  
```

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FILE: rt.ins      TRIAL 101      INSERT #1
T_IV_X first trial independent variable range 1-9 for response 2
T_IV_Y second trial independent variable, 0-31, use 0 for null 0
T_IV_Z third trial independent variable, 0-31, use 0 for null 0
Study stimulus
A
Probe stimulus
b
<E> - Edit    <PgDn> - Next insert    <Esc> - Quit form    <Alt-Q> - Quit program
  
```

Figure 2. MEL Experiment Generator screen displays. Top panel illustrates the initial menu screen. The middle illustrates the parameter screen for reaction time tasks. The bottom shows the trial specifications for a letter matching task. Students can edit any of the underlined fields.

possibilities for group and individual projects. These experiments may be added to the auxiliary student diskette and referenced through the standard MEL menu structure.

Importing New Research Procedures

The Student MEL system is a system to which instructors and students can add new experiments written in MEL. Many instructors want to add their own experiments. One goal of the Student MEL is to allow instructors to add experiments of their own to the basic set of 28 experiments.

The new experiments can come from many sources. The MEL research system is being used by over a thousand psychologists at 700 sites in 20 countries. As new experiments are created in MEL, student versions can be easily implemented and exchanged. The MEL research system itself provides many support tools and over 45 implemented procedures that can speed development of new experiments.

Public domain library and student experiment competition. To increase the set of available experiments, procedures have been developed to collect and distribute programs across institutions. The MEL student disks include many popular experiments. An auxiliary library will be distributed to provide a wider range of experiments from which the instructor can choose. Instructors can select experiments from the auxiliary library.

Undergraduate and graduate students will be encouraged to submit programs to the MEL auxiliary library. At the end of a class in experimental methods using the Student MEL, a class might have some useful additional experiments created by the students or teaching assistants. To encourage students to submit new experiments, student competitions will be held each semester to find the best experiments. Students submitting the best judged projects will receive cash awards and recognition. The experiments will then be made available to instructors in the following semester.

Data files are also collected and distributed. All data sets are labeled with the ZIP code of the university. The merging of these national data sets will provide statistics classes with data sets to be used for analysis exercises. National data sets will allow classes to compare their results with data from other years and other campuses.

Phone support. Instructors and their assistants can receive phone consulting by MEL support personnel. Help is provided regarding initialization, execution, analysis, and development of new experiments. This help is provided to instructors and teaching assistants but not to the students directly.

CONCLUSION

The Student MEL is intended to go beyond the typical software available for undergraduate instruction (see Hornby & Anderson, 1990, and Butler, 1988, for reviews) by offering a systems approach to the laboratory experience in the undergraduate research methods course in psychology. It includes materials from a wide range of areas within experimental psychology and can serve to acquaint students with many major experiments and associated methodologies. During the development of the Student MEL, attention has been paid to providing support in the areas that have traditionally been the sources

of greatest difficulty in the teaching of the research methods courses. This represents an open approach to computerized instruction in experimental methods.

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NOTE

1. These forms are different from the forms used in the MEL research system. The forms in the Student MEL determine more global parameters of the paradigm and the stimuli. In the MEL research system, the forms determine details of the experimental procedure and allow written code to specify the experiment. The latter is more flexible but requires considerably more learning time.