Programmed Instruction and Interteaching Applications to Information Technology Education

Henry H. Emurian

Information Systems Department

College of Engineering and Information Technology

UMBC

1000 Hilltop Circle
Baltimore, Maryland 21250

Programmed Instruction and Interteaching Applications to Information Technology Education

Henry H. Emurian
UMBC
&
Ashley G. Durham
Centers for Medicare and Medicaid Services
&
Miji Mathews, Jingli Wang,
Amy Hu, Valeri Scott, Peng Zhang
John Goodall, Xin Li, Diana Wang, & Lidan Ha
UMBC
&
Heather Holden & Amy Abarbanel
UMBC

Programmed Instruction and Interteaching Applications to Information Technology Education: From Novice to Journeyman… and Beyond

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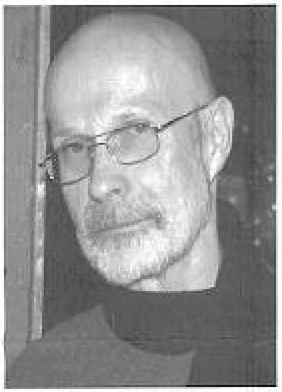
For President-Elect



Richard W. Malott

Professor of Psychology, Western Michigan University

Ph.D. in Experimental Psychology, Columbia University

Recent Publications

Malott, R. W. (2007) Principles of behavior (6th ed.). Upper Saddle River, NJ: Prentice Hall.

Malott, R.W. (2007). Are women, people of color, Asians, and southern Europeans inherently inferior to north-European males? A history of biological determinism—A cultural, spiritual and intellectual disgrace—and the implications for understanding "mental illness." *Behavior and Social Issues*, 16, 134 - 169.

Other Professional Positions and Activities

Award for Public Service in Behavior Analysis (2002).

Founder and Co-Chair: Teaching Behavior Analysis Special Interest Group of the ABAI (1993 - 1997).

Chair: Education Board of the ABA (1993 - 1997).

Chair: ABAI Program Committee (1978 - 1980).

Secretary-Treasurer for the ABA (1974 - 1978).

One of the four co-founders of ABA (now known as ABAI, previously known as MABA) (1974).

And, most important, originator of the Performing Arts (aka the Behavioral Bash).

Statement of Goals

Like everyone who's ever run for president of ABAI, I'd encourage our continued, active support of the experimental and applied analysis of behavior and the practice of behavior analysis. I'd actively support consumer involvement in ABAI and our heavy emphasis on autism research and practice, seeing this heavy emphasis as supporting, not threatening EAB. I'd actively support ABAI's Practice Board and its working with the Association of Professional Behavior Analysts and the Behavior Analysis Certification Board, seeing the BCBA as a major contributor to the impressive growth of ABAI's attendance and the impressive growth in the number of behavior analysis M.A. programs throughout the USA and the rest of the world. I'd actively support ABAI's efforts at the internationalization of behavior analysis, seeing that these efforts do not detract either financially or organizationally from our efforts at promoting the practice and the science of behavior analysis in the USA. I'd try to make attendance at the Behavioral Bash mandatory and forbid ABAI's presenters' from boring their audiences by reading their presentations, especially word-for-word from Power Points. And, I'd require/encourage all superstar invited speakers to spend 2 hours at a poster session admiring student posters and giving feedback to their creators—really.

Content Management Powered by CuteNews

• WHEN EVERYBODY KNEW A POET (NEW YORK TIMES OP-ED)

JANUARY 1, 2003

Letters to the Editor

To the Editor:
Re "A Lost Eloquence," by Carol Muske-Dukes (Op-Ed, Dec.29):

The balking of students to putting verse to heart by rote memorization is not limited to poetry. There is almost a pedagogical malaise that decries rote learning in disciplines like science, mathematics and engineering. And critical analysis and scholarship are being replaced by searching the Web.

There is a growing contempt for the hard work of achieving mastery.

But the beauty of a poem, once learned, is not in the recitation of words. The poem, committed to memory, becomes a vehicle of communion for the self and the soul. Rote learning of the tools of thought has similar benefits in all fields.

HENRY H. EMURIAN
Baltimore, Dec. 29, 2002

To the Editor:
As a 22-year-old recent college graduate, I applaud "A Lost Eloquence," by Carol Muske-Dukes (Op-Ed, Dec.29), about the lost tradition of learning poems through memorization.

In this day and age, I was lucky enough to have a high school French teacher who demanded that we memorize and recite French poetry and fables. As students, we were given extra points for dramatic effusion.

Although, I am sad to say, my French skills are no longer stellar, the poems of Jacques Prevert and others still live in my blood.

I only wish that my English teachers had done the same.

KATE FILMORE
Brooklyn, Dec. 29, 2002

Navigation

The New York Times

May 1, 2009
Op-Ed Columnist
Genius: The Modern View
By DAVID BROOKS

The latest research suggests a more prosaic, democratic, even puritanical view of the world. The key factor separating geniuses from the merely accomplished is not a divine spark. It's not I.Q., a generally bad predictor of success, even in realms like chess. Instead, it's deliberate practice. Top performers spend more hours (many more hours) rigorously practicing their craft.

We construct ourselves through behavior. As Coyle observes, it's not who you are, it's what you do.

http://www.nytimes.com/2009/05/01/opinion/01brooks.html

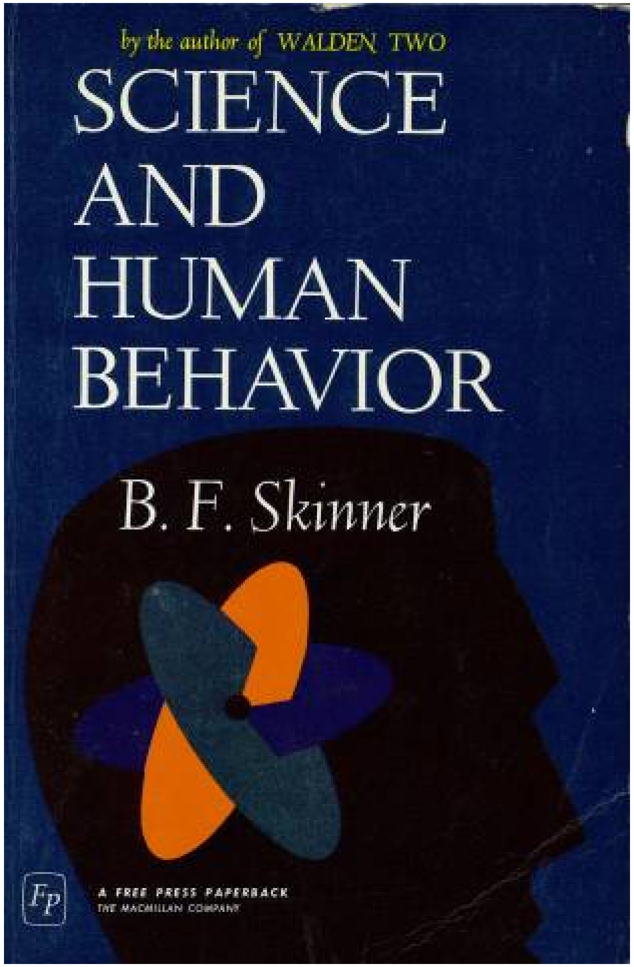
I am right.

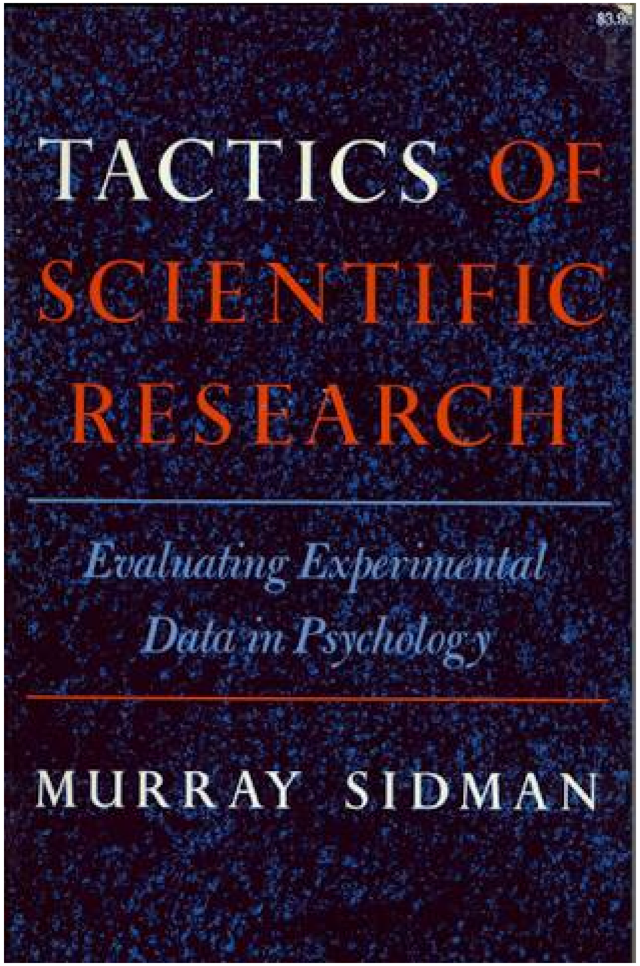
The organism is always right.

The student is always right.

The organism is always right.

1953

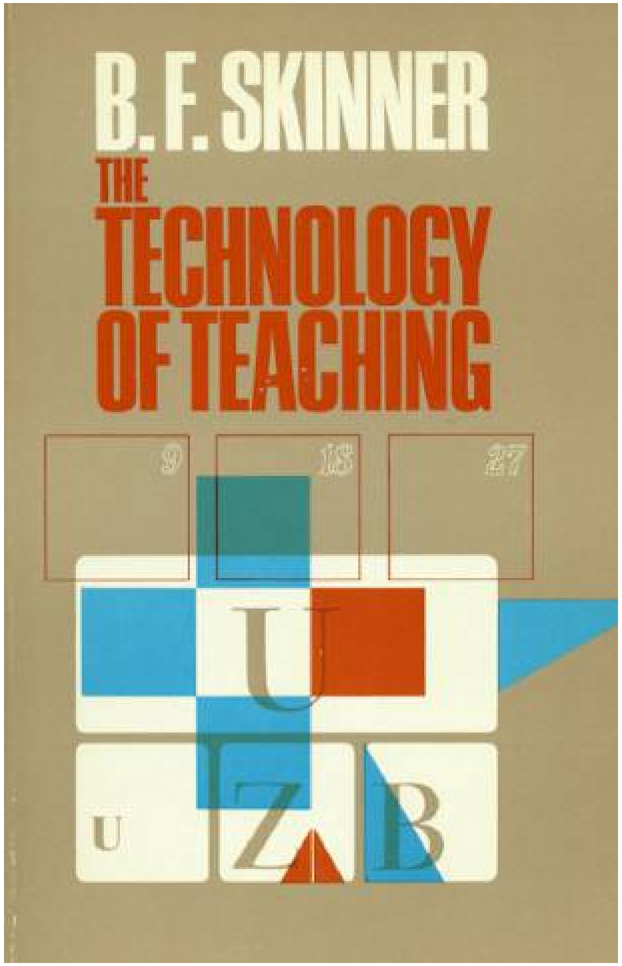


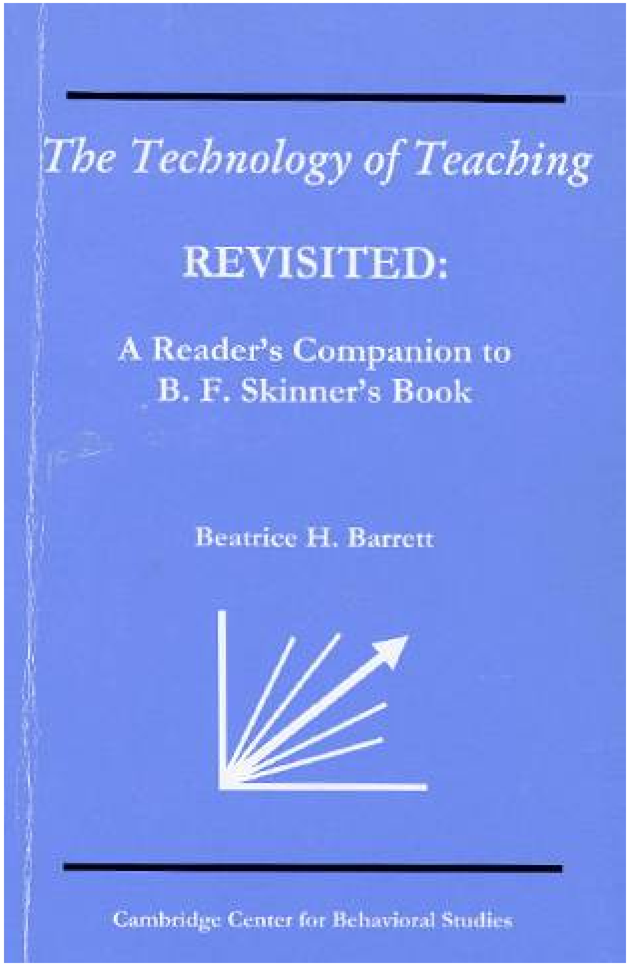


1960

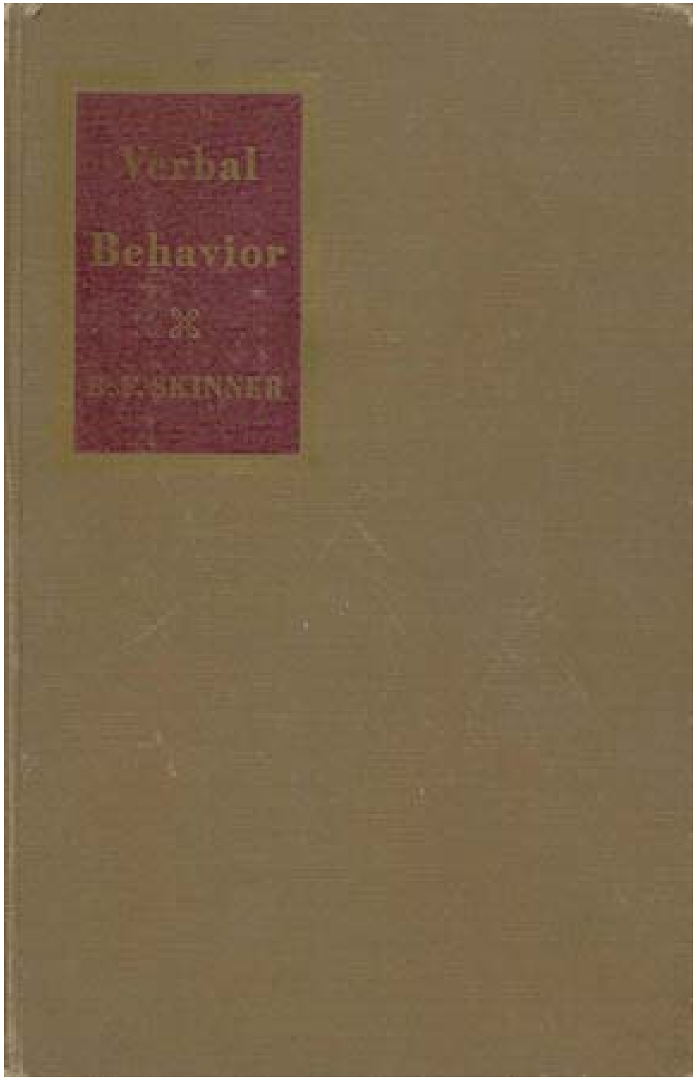
The *student* is always right.

1968

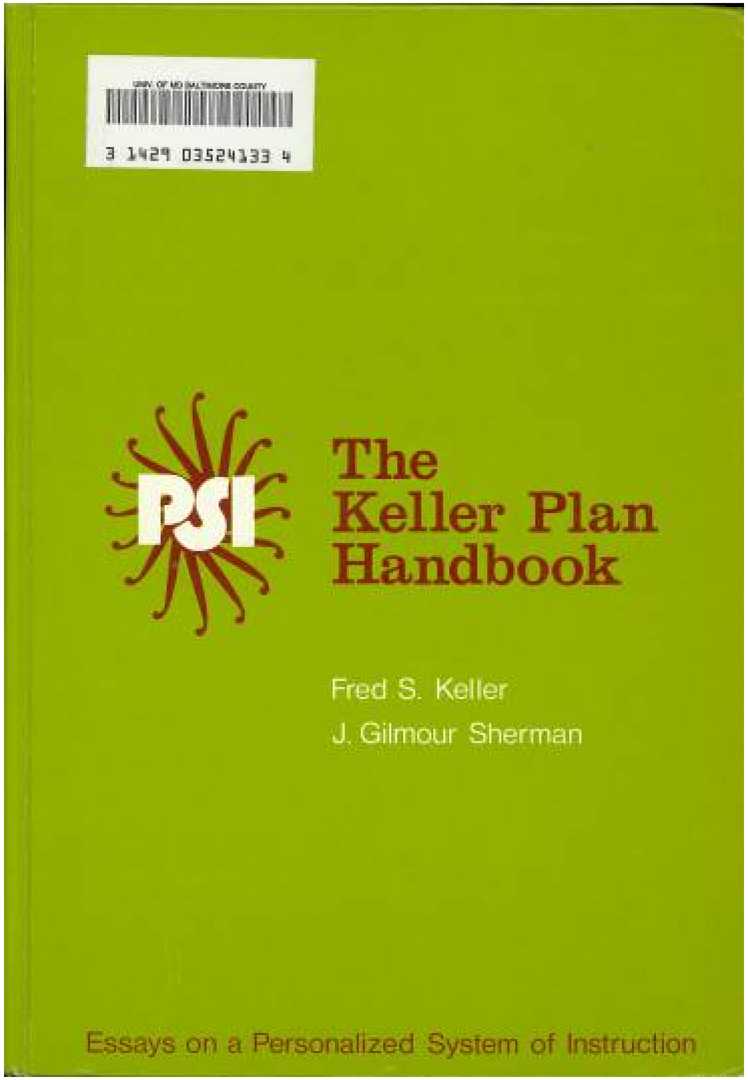




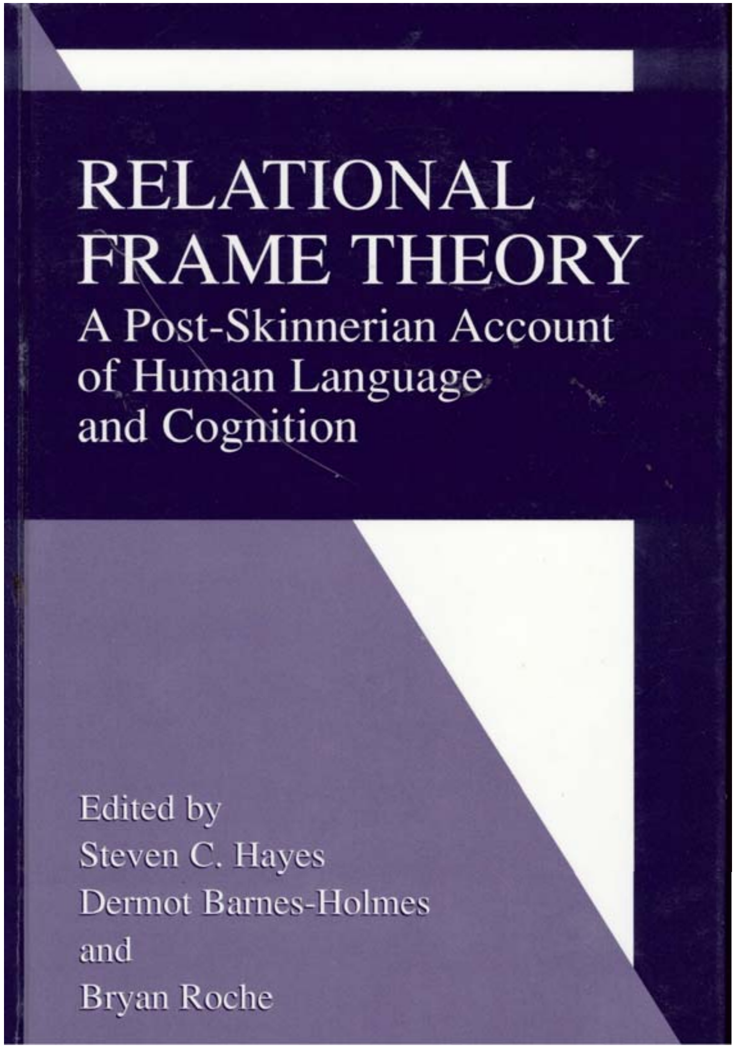
2002


Verbal
Behavior
B. F. SKINNER

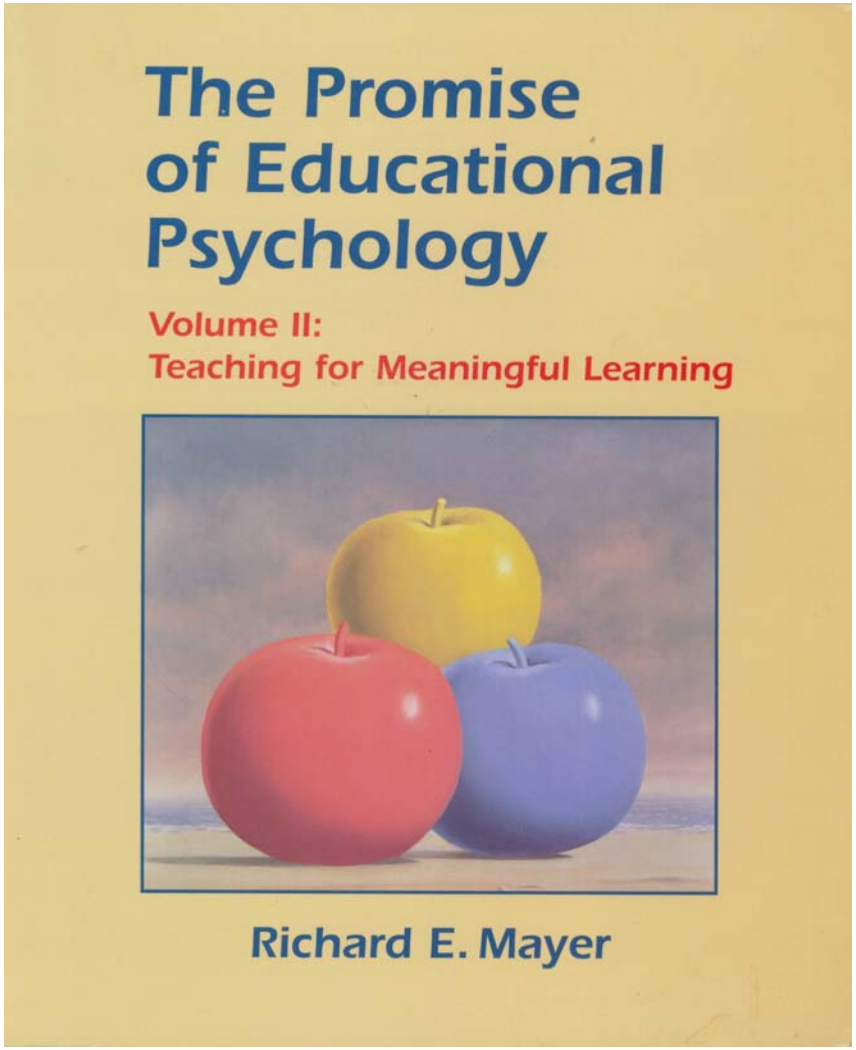
1957


The
Keller Plan
Handbook
Fred S. Keller
J. Gilmour Sherman
Essays on a Personalized System of Instruction

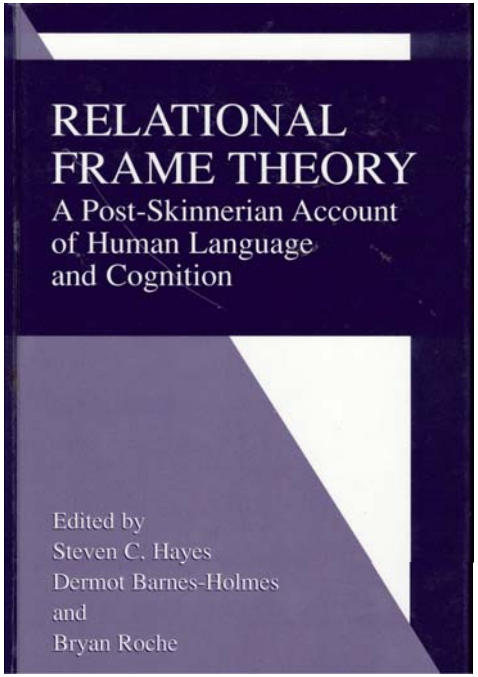
1974


RELATIONAL
FRAME THEORY
A Post-Skinnerian Account
of Human Language
and Cognition
Edited by
Steven C. Hayes
Dermot Barnes-Holmes
and
Bryan Roche

2001


The Promise
of Educational
Psychology
Volume II:
Teaching for Meaningful Learning
Richard E. Mayer

2002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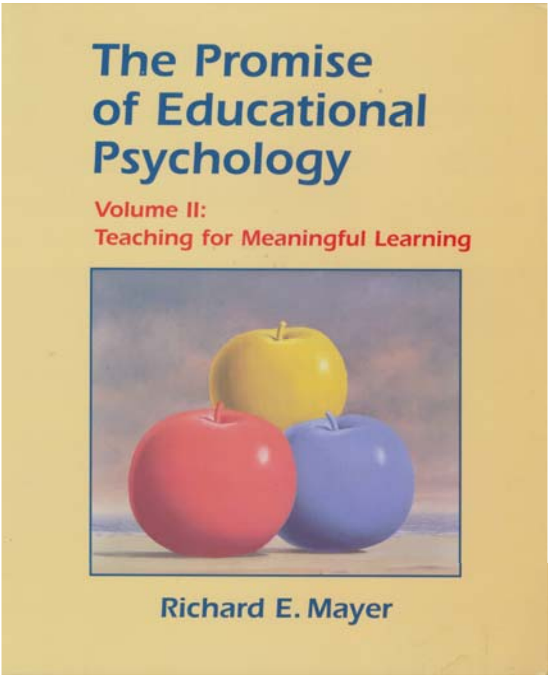
The Promise
of Educational
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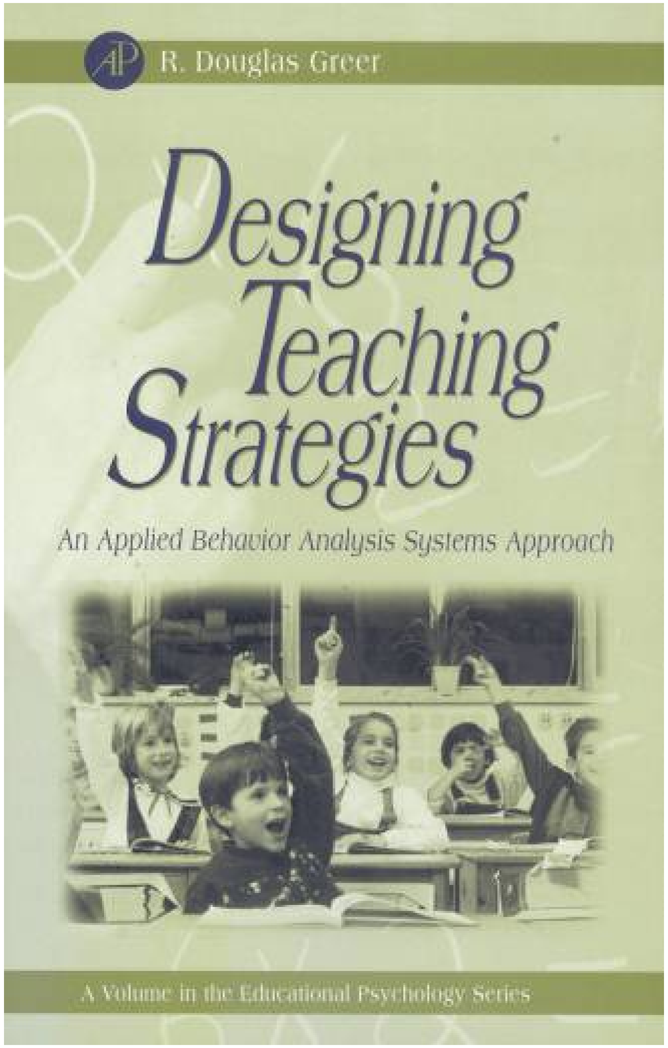
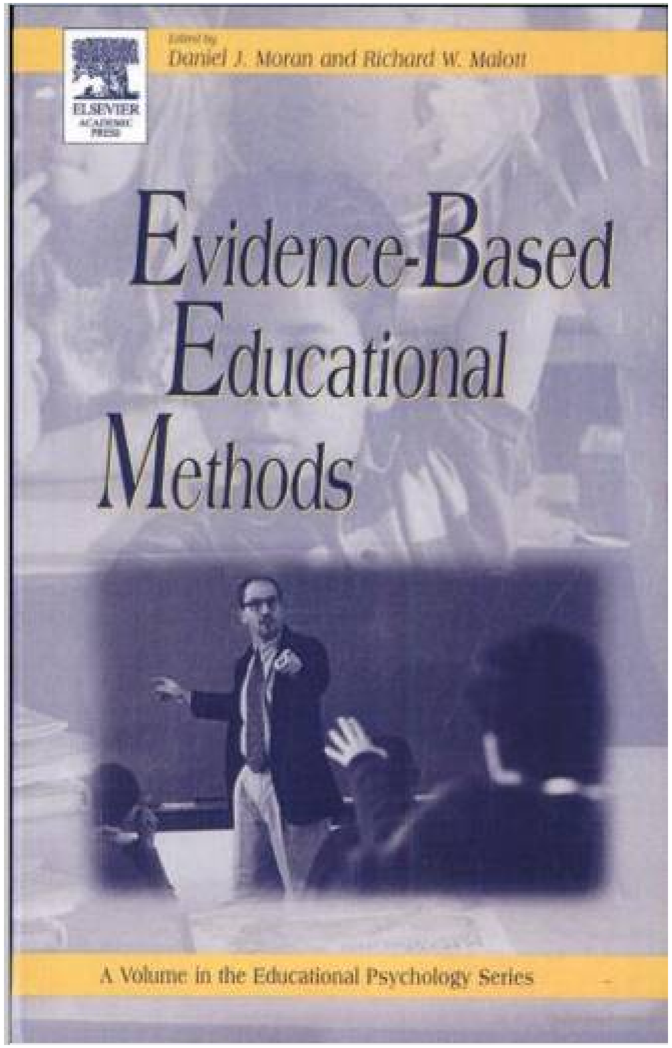
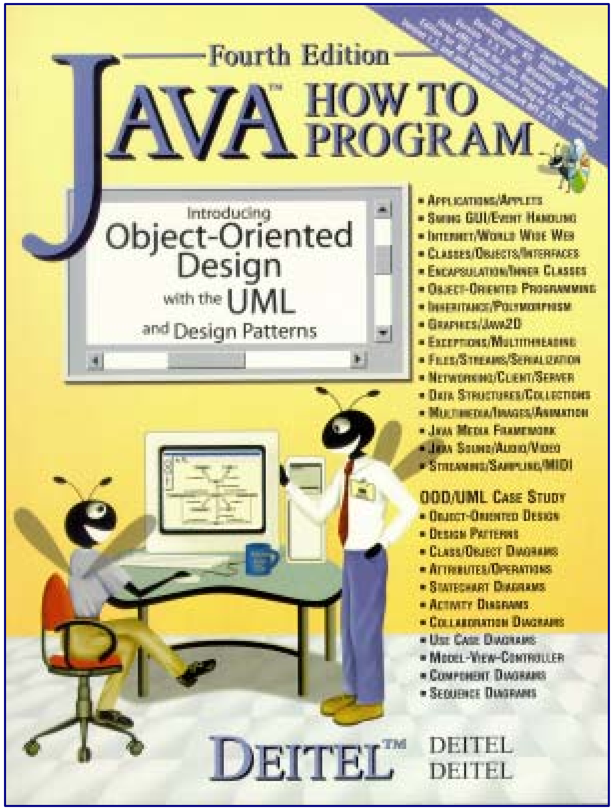

R. Douglas Greer
Designing Teaching Strategies
An Applied Behavior Analysis Systems Approach
A Volume in the Educational Psychology Series

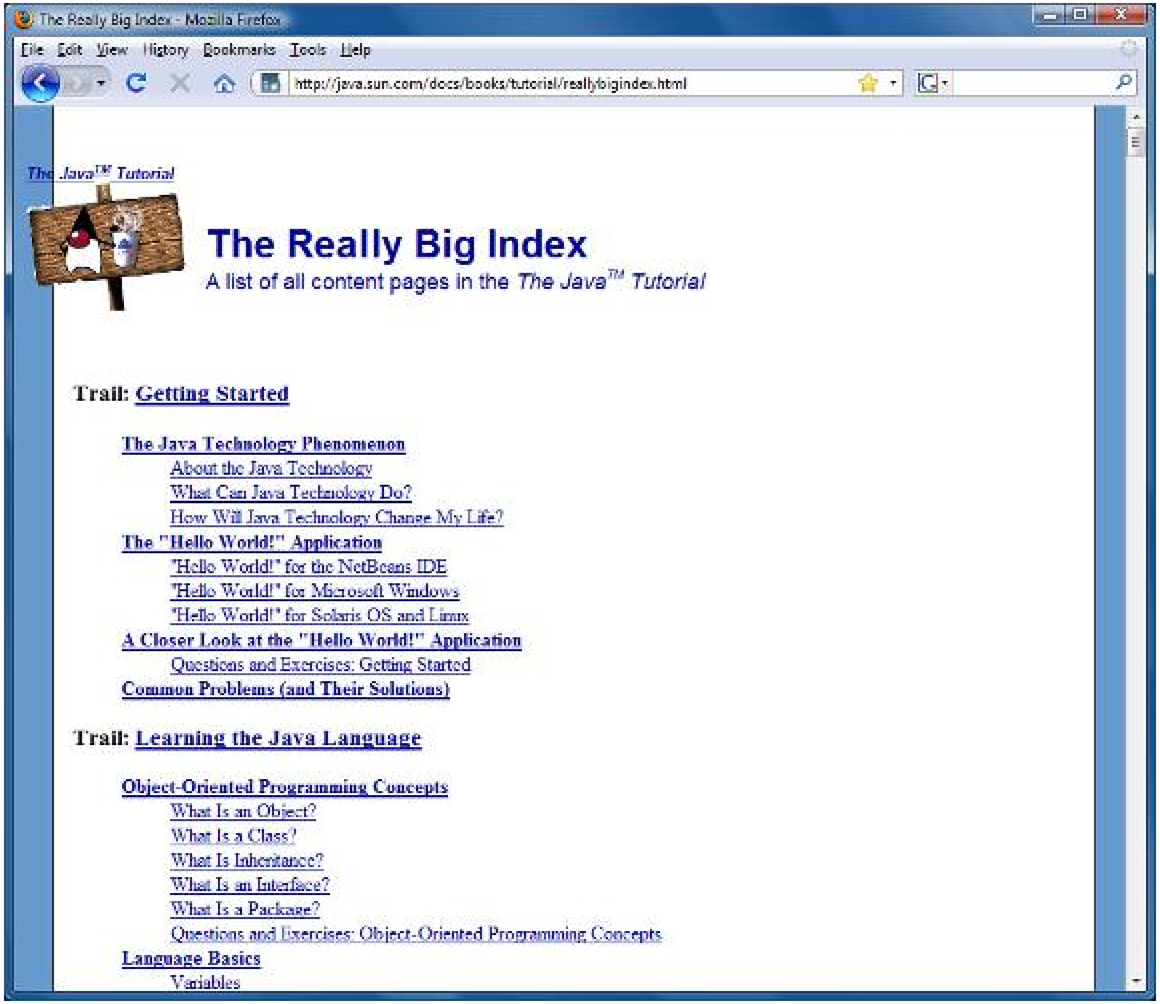
2002


Edited by
Daniel J. Moran and Richard W. Malott
ELSEVIER
ACADEMIC PRESS
Evidence-Based Educational Methods
A Volume in the Educational Psychology Series

2004


Fourth Edition
JAVA HOW TO PROGRAM
Introducing Object-Oriented Design with the UML and Design Patterns
DEITEL
DEITEL
DEITEL

2002


The Really Big Index - Mozilla Firefox
http://java.sun.com/docs/books/tutorial/reallybigindex.html
The Java™ Tutorial
The Really Big Index
A list of all content pages in the The Java™ Tutorial
Trail: Getting Started
The Java Technology Phenomenon
About the Java Technology
What Can Java Technology Do?
How Will Java Technology Change My Life?
The "Hello World!" Application
"Hello World!" for the NetBeans IDE
"Hello World!" for Microsoft Windows
"Hello World!" for Solaris OS and Linux
A Closer Look at the "Hello World!" Application
Questions and Exercises: Getting Started
Common Problems (and Their Solutions)
Trail: Learning the Java Language
Object-Oriented Programming Concepts
What Is an Object?
What Is a Class?
What Is Inheritance?
What Is an Interface?
What Is a Package?
Questions and Exercises: Object-Oriented Programming Concepts
Language Basics
Variables

2009

EDITORIAL

Making a Science of Education

Bruce Alberts is the Editor-in-Chief of Science.

FOR SUCCESS IN AN INCREASINGLY COMPLEX, CROWDED, AND DANGEROUS WORLD, A NATION must strive to be a meritocracy: Its education and social systems should be structured to select those with the most talent, energy, wisdom, and character as the next generation of leaders for each segment of society. When I was young, I was taught that providing equal opportunities for everyone was a matter of social justice—part of the social contract in the United States. Now, I believe that it is also a matter of national survival. Any country that fails to encourage and develop the talent in each individual through its public school system will suffer greatly, because the quality of a nation depends on the collective wisdom of both its leaders and its citizens.

An outstanding education system imparts values that support good citizenship, while empowering adults to be life-long learners and problem solvers who can make wise decisions for their families, for their communities, and for their workplaces. Such an education system must continually evolve to remain relevant to the interests and needs of each new generation. To achieve these ambitious goals, we will need much more emphasis on both science education and the "science of education." It is my hope that *Science* can help to promote progress on both scores.

In 2006, *Science* began a monthly Education Forum. We now plan to build on this strong beginning by recruiting high-quality articles on education from the world's best experts for every section of the magazine. Thus, we will be publishing important work in education as Perspectives, Policy Forums, Reviews, or as original Research Reports and Articles, while continuing to cover education in the News section. This first issue of 2009, with its focus on Education and Technology (see page 53), represents a start that will hopefully inspire many more articles to come.

As this special issue explains, the computer and communication technologies that have profoundly altered many other aspects of our lives seem to hold great promise for improving education as well. But technology is only a tool. To fulfill its promise for education will require a great deal of high-quality research, focused on its utilization and effects in both school and non-school settings. Only by collecting and analyzing data on student learning can we hope to sort out the many variables that determine effectiveness.

The same type of scientific research is also needed to explore, analyze, and improve each of the many other components of educational systems. For example, the most important element of any education system is a highly skilled teacher. Teacher recruitment, preparation, retention, and professional development all need to be informed by scientific research in education. Curricula, pedagogy, assessment, and school system management similarly require focused research. We hope that what scientists are learning about each of these important aspects of education will be reported and reviewed in *Science*.

Research in the social sciences is especially challenging because of the conditionality of its findings: The effects of an intervention are likely to depend on many variables that need to be studied and understood. Some readers may therefore question whether the science of education deserves a prominent place in this prestigious journal. For them, I offer the wisdom of Alfred North Whitehead, who wrote 80 years ago: "The art of education is never easy. To surmount its difficulties, especially those of elementary education, is a task worthy of the highest genius." [But] "when one considers…the importance of this question of the education of a nation's young, the broken lives, the defeated hopes, the national failures, which result from the frivolous inertia with which it is treated, it is difficult to restrain within oneself a savage rage. In the conditions of modern life the rule is absolute, [a country] that does not value trained intelligence is doomed."

The sense of rage is every bit as appropriate today. But we now recognize that we must look at the "art" of education through the critical lens of science if we are to survive.

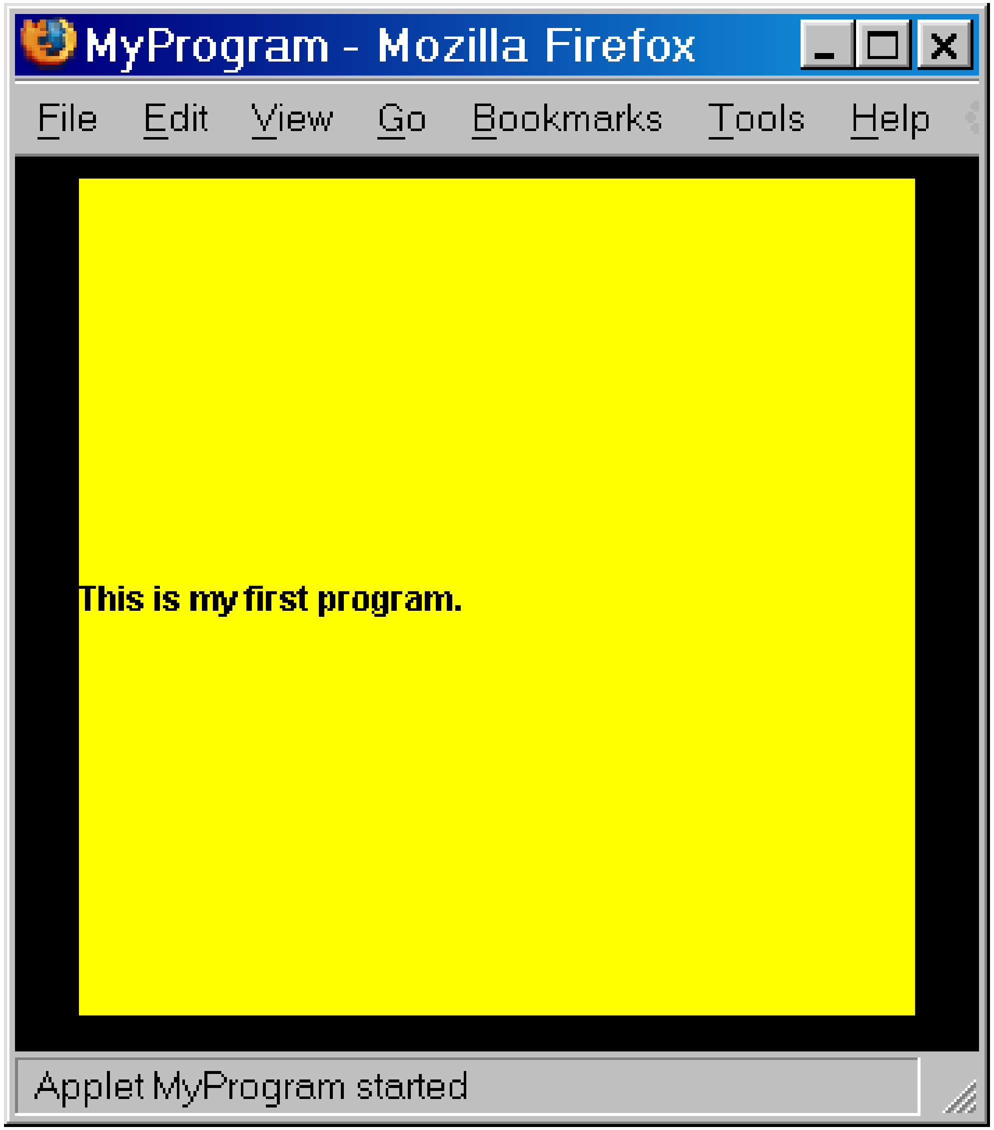
–Bruce Alberts

10.1126/science.1169941

www.sciencemag.org SCIENCE VOL 323 2 JANUARY 2009 15

- Among other things, I teach Java to Information Systems (IS) majors.

```java
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel=new JLabel("This is my first program.");
getContentPane().setBackground(Color.YELLOW);
getContentPane().add(myLabel);
}
}
```


MyProgram - Mozilla Firefox
File Edit View Go Bookmarks Tools Help
This is my first program.
Applet MyProgram started

1. import javax.swing.JApplet;
2. import javax.swing.JLabel;
3. import java.awt.Color;
4. public class MyProgram extends JApplet {
5. JLabel myLabel;
6. public void init() {
7. myLabel=new JLabel(“This is my first program.”);
8. getContentPane().setBackground(Color.YELLOW);
9. getContentPane().add(myLabel);
10. }
11. }

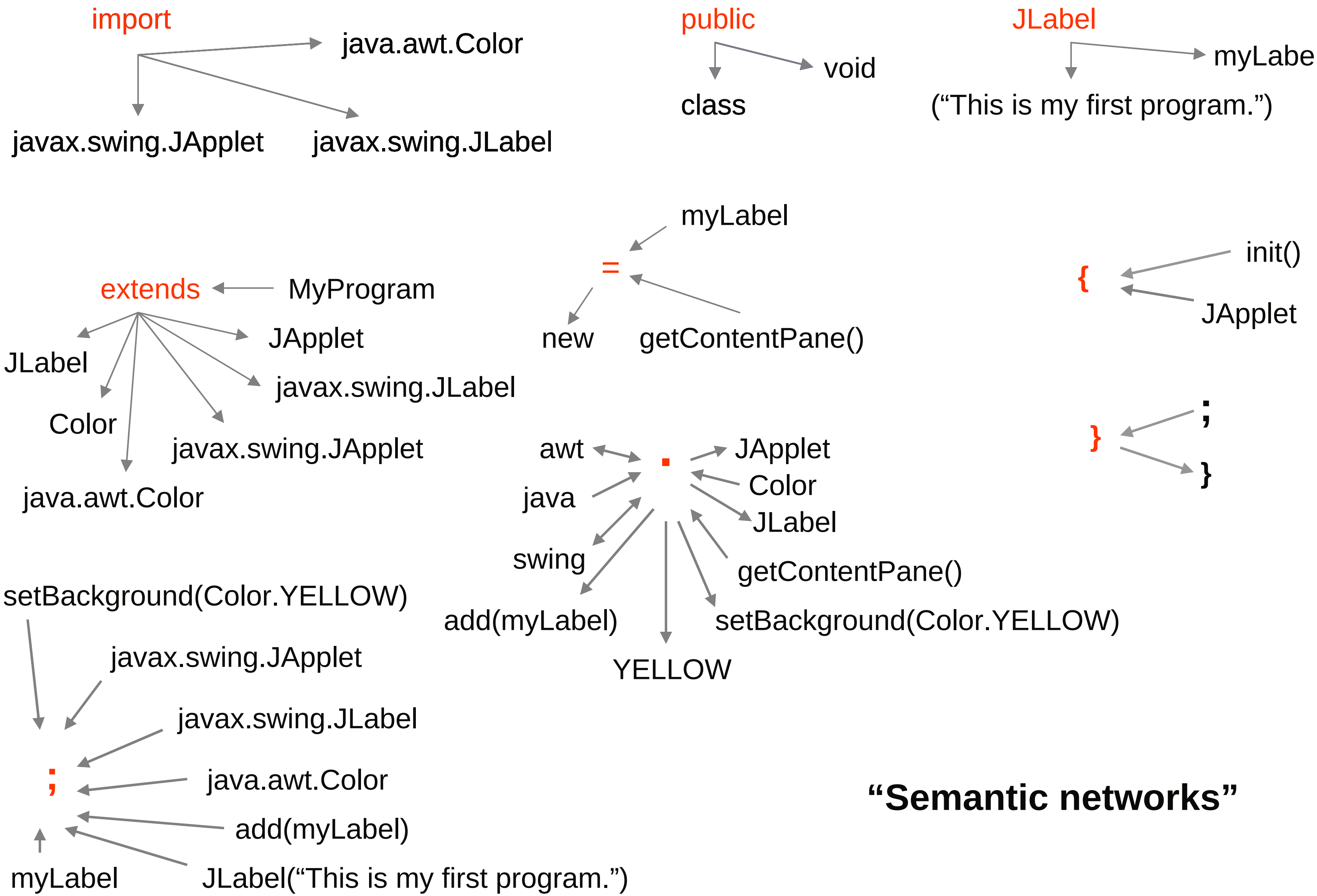
- **Near transfer (recite & “understand”)**
- **Far transfer (meaningful learning → solve novel problems)**
  - **12 “rules” questions**

```
import
javax.swing.JApplet
;
import
javax.swing.JLabel
;
import
java.awt.Color
;
public
class
MyProgram
extends
JApplet
{
JLabel
myLabel
;
public
void
init()
{
myLabel
=
new
JLabel("This is my first program.")
;
getContentPane()
.
setBackground(Color.YELLOW)
;
getContentPane()
.
add(myLabel)
;
}
}
```

Intraverbal performances

"Ordered Tuple"

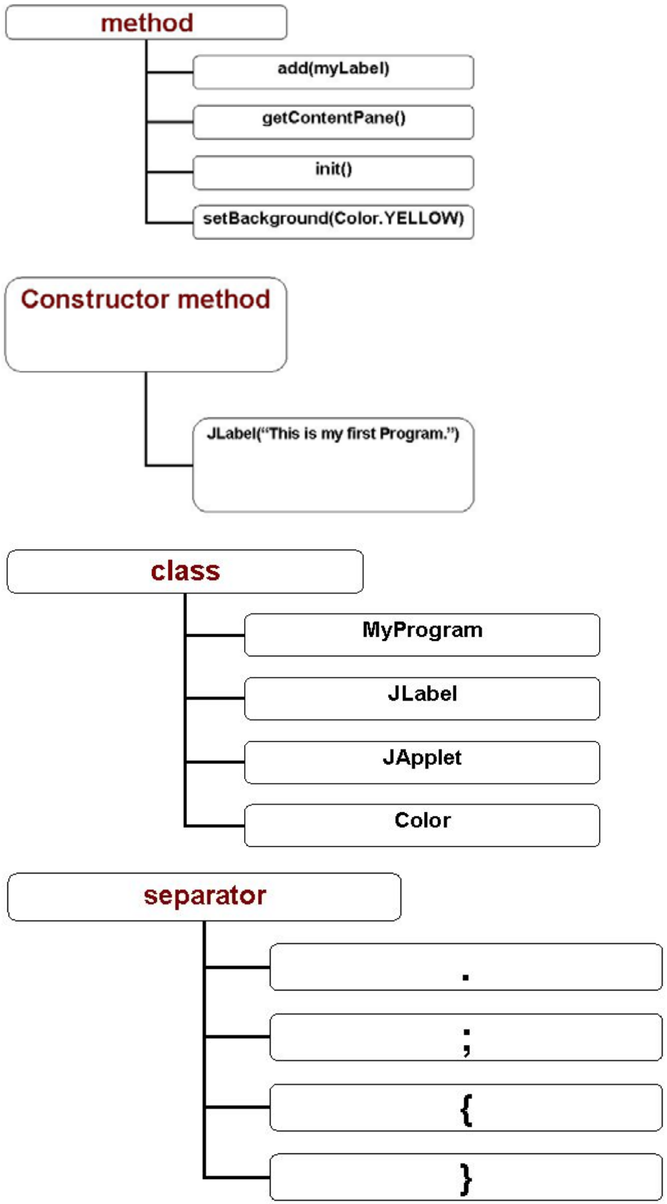
Chain

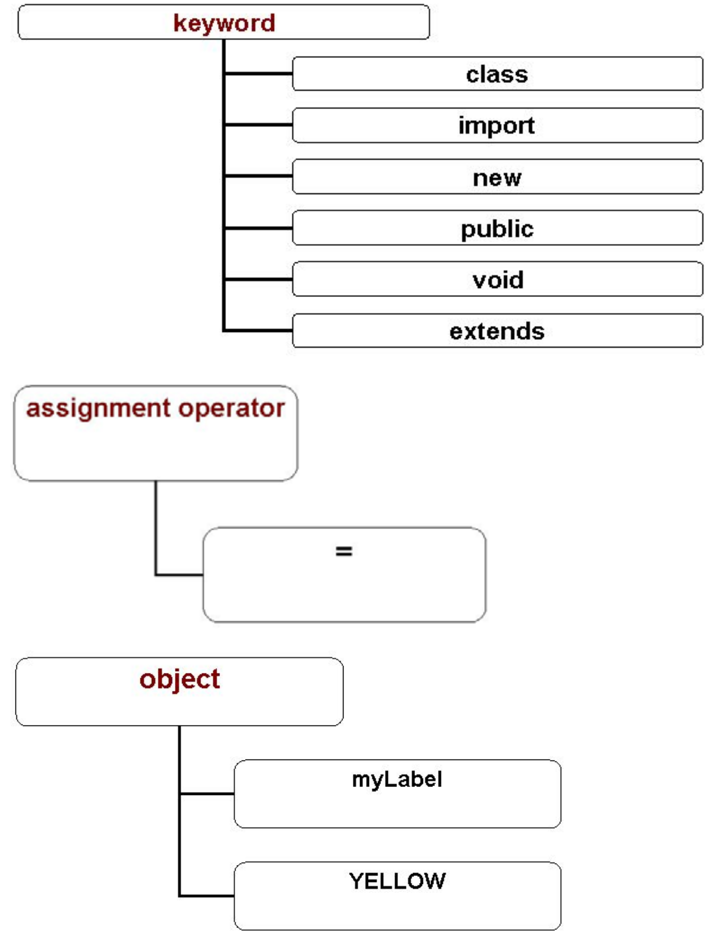


"Semantic networks"

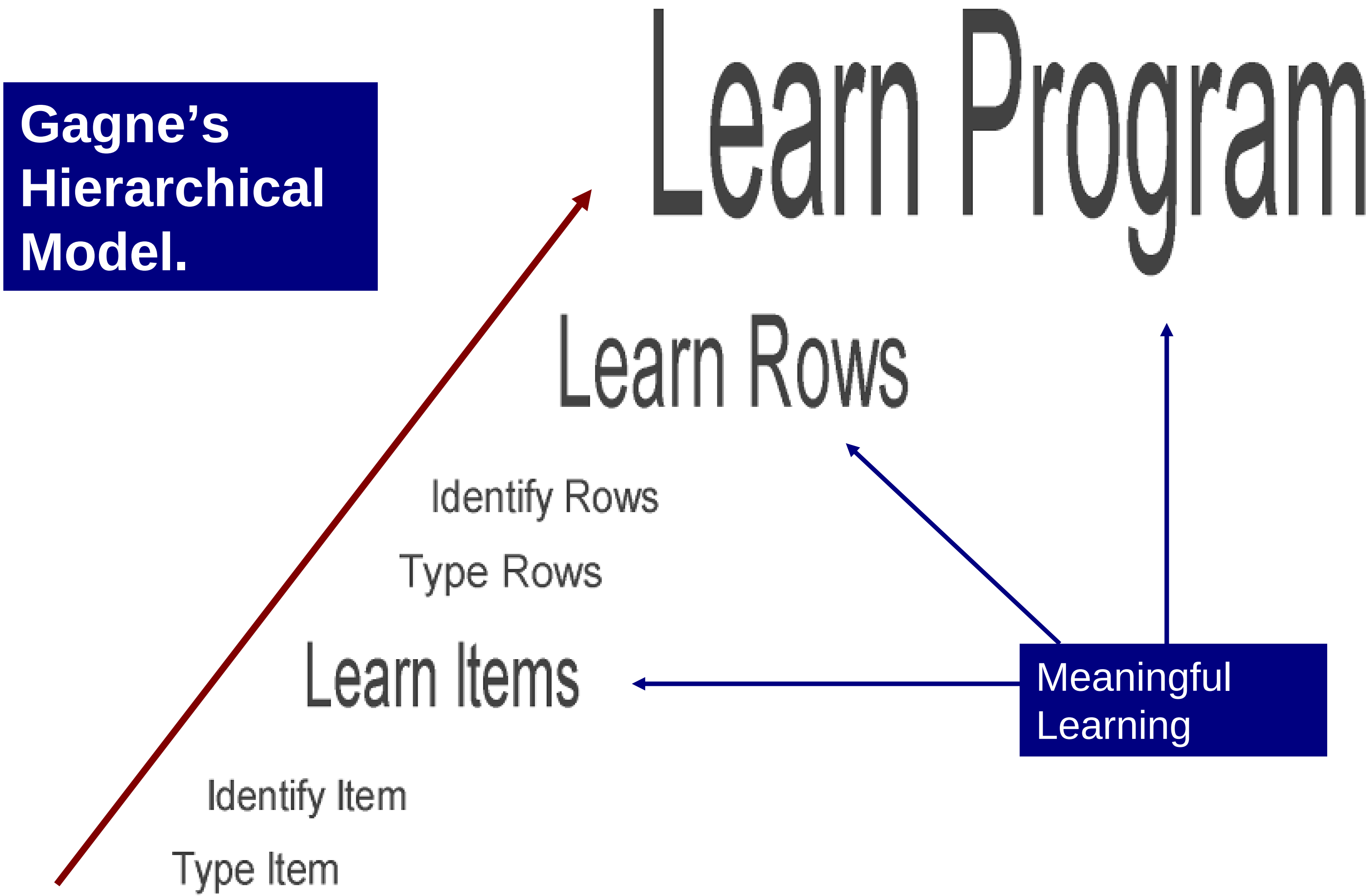
Hierarchical Relational Frames

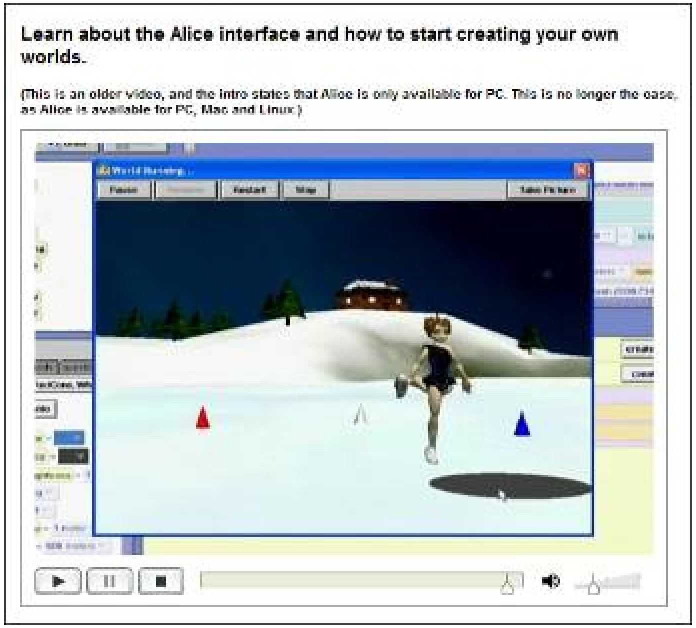
Combinatorial Entailment



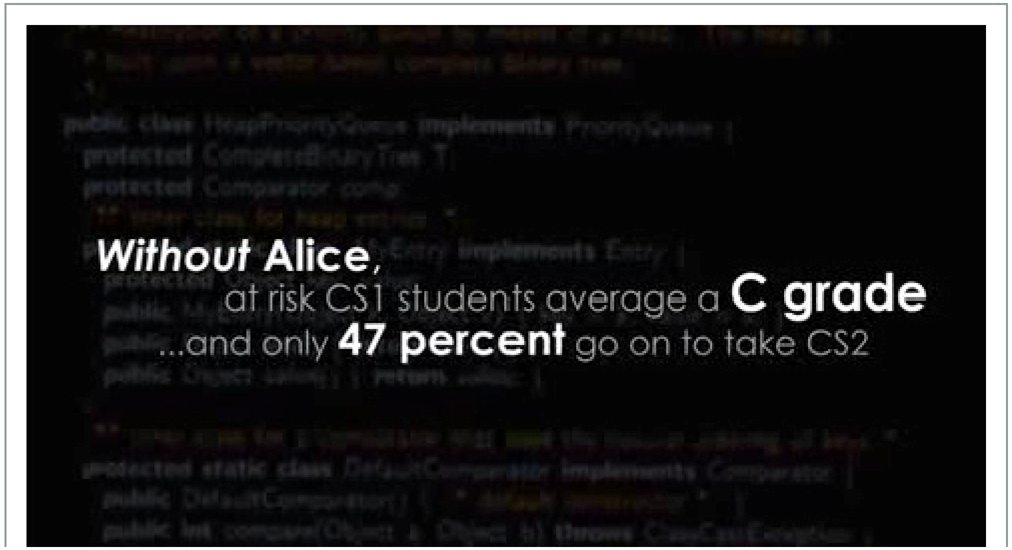


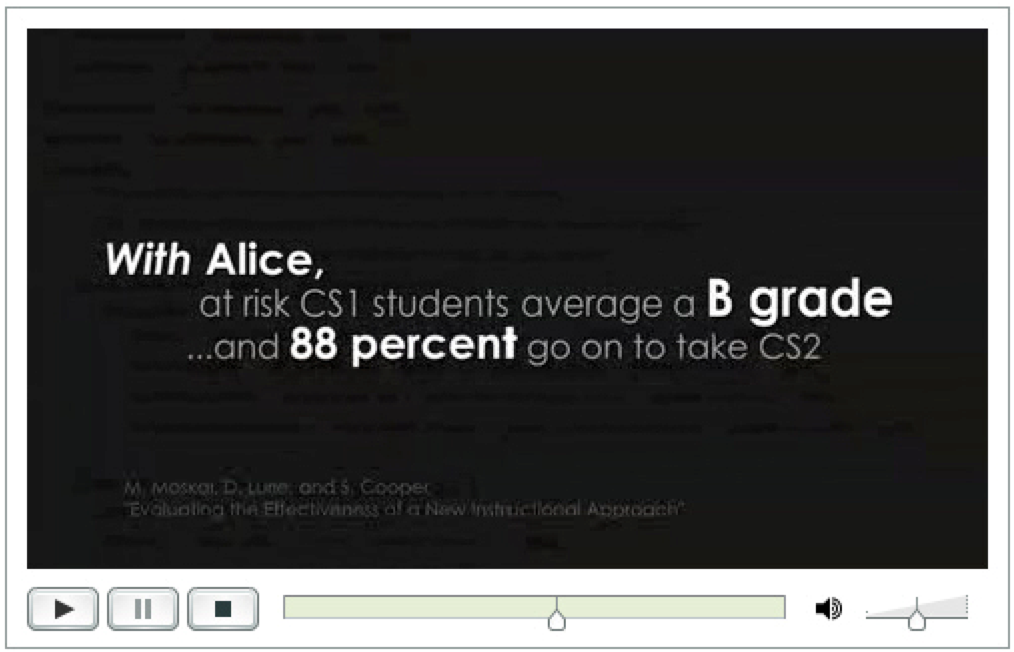
Learn Unit: Greer & McDonough (1999)





http://www.alice.org/


Without Alice,
at risk CS1 students average a C grade
...and only 47 percent go on to take CS2


With Alice,
at risk CS1 students average a B grade
...and 88 percent go on to take CS2
M. Moskal, D. Lurie, and S. Cooper
"Evaluating the Effectiveness of a New Instructional Approach"

1981

Tutorials for the First-Time Computer User

JANAN AL-AWAR, ALPHONSE CHAPANIS, AND W. RANDOLPH FORD

Abstract—This paper describes a general methodology and principles for the preparation of tutorials, or computer-assisted instructional courses, to introduce first-time users to computer terminals. The methodology and principles are especially designed to prepare tutorials that will make computers seem friendly and that will motivate casual or discretionary users to learn more about computers. Examples are drawn from a tutorial prepared for the IBM 3277 Display Station.

users that they can communicate with a computer easily and effectively. Our tutorial uses the computer as an adaptive teaching system. It is adaptive in the sense that it (a) allows students, or users, to proceed at their own pace, and (b) introduces variations in the presentation of materials according to the student's performance. Variations are made through

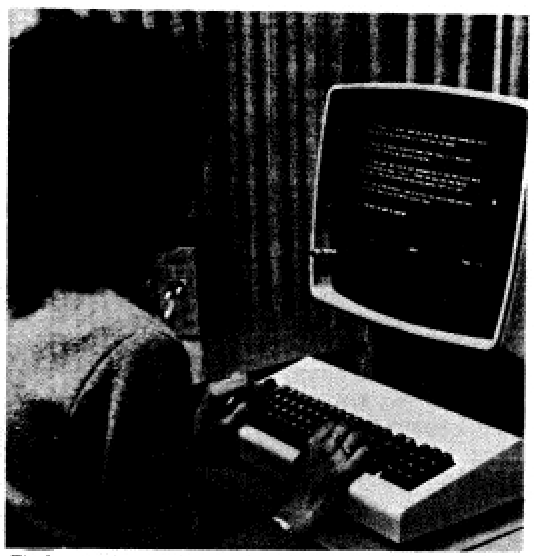


Fig. 2. Operator at the terminal used in testing the tutorial program.

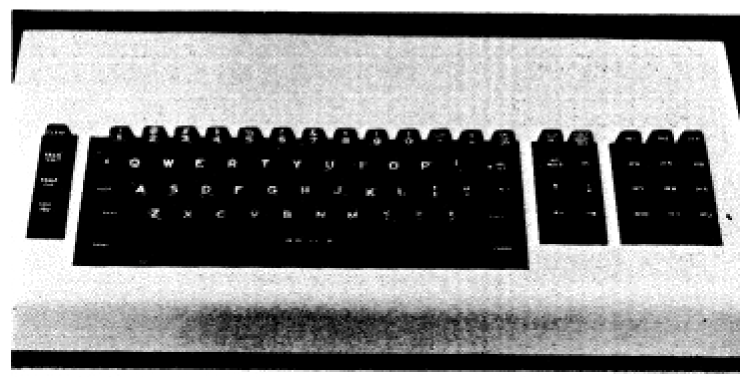
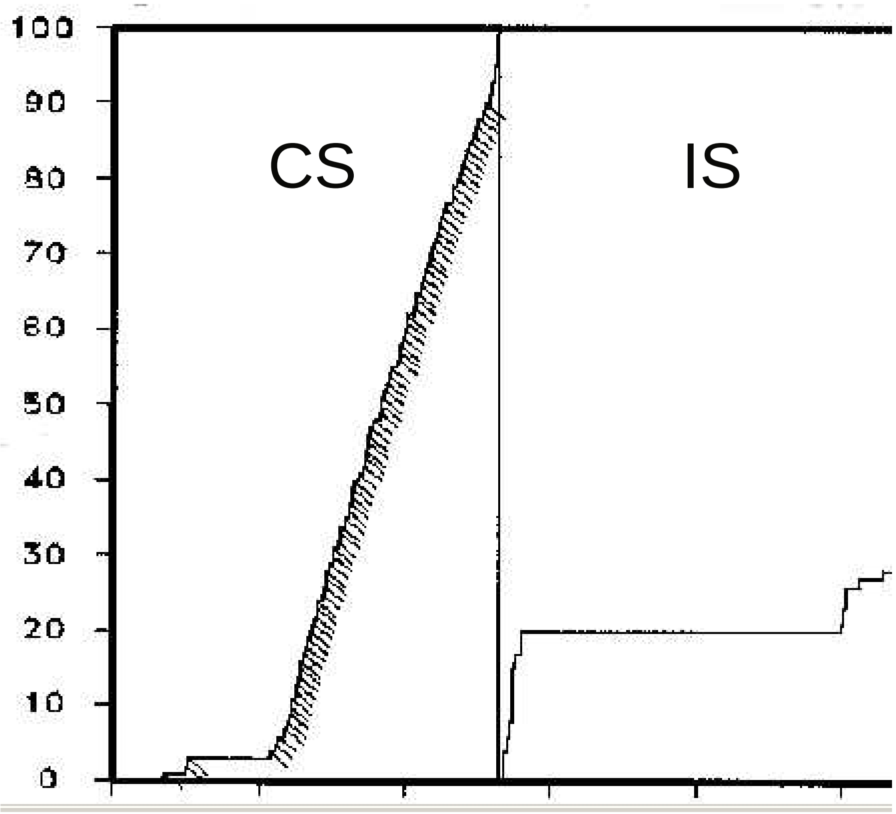


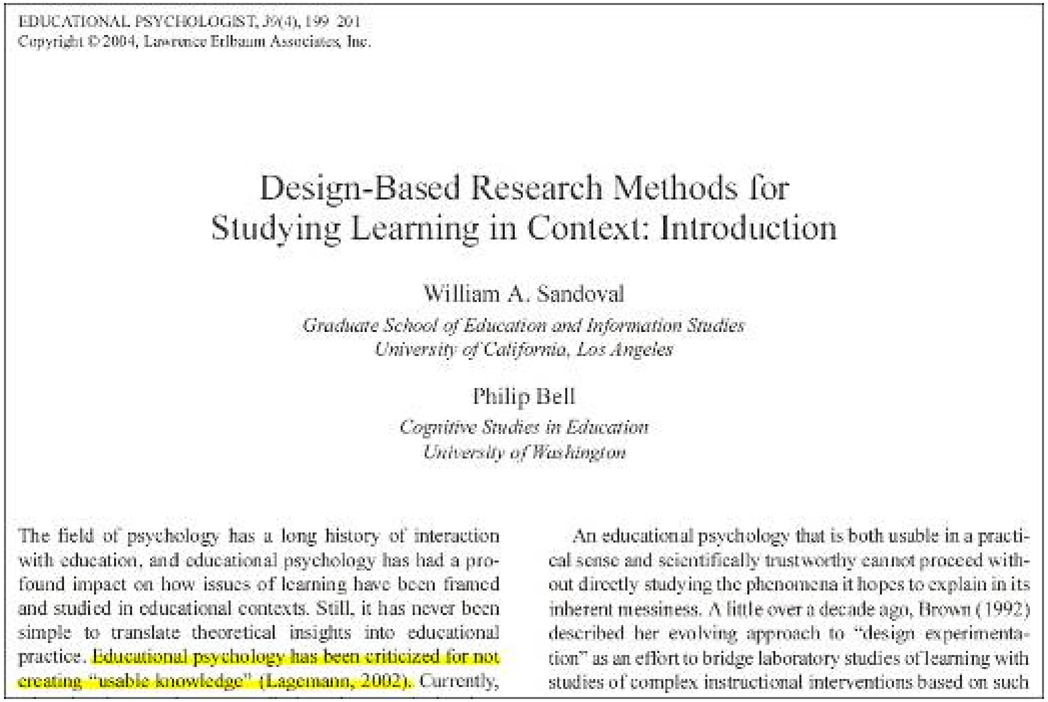
Fig. 1. Keyboard of the IBM 3277 Display Station, Model 2.

- In comparison to Computer Science (CS) students, Information Systems (IS) students exhibit a low rate of computer programming.



- Students in Information Systems (IS) do **not** like to write computer programs.
- IS students have **minimal coursework** in computer programming and programming languages.
- IS students **need** a fundamental mastery of programming principles, especially related to the object-oriented paradigm.
- IS students are often **demoralized** by taking courses with computer science majors taught by computer science faculty.
- How can we best **help** IS students achieve the objective?

Design-Based Research Methodology



EDUCATIONAL PSYCHOLOGIST, 39(4), 199–201

Design-Based Research Methods for Studying Learning in Context: Introduction

William A. Sandoval
Graduate School of Education and Information Studies
University of California, Los Angeles

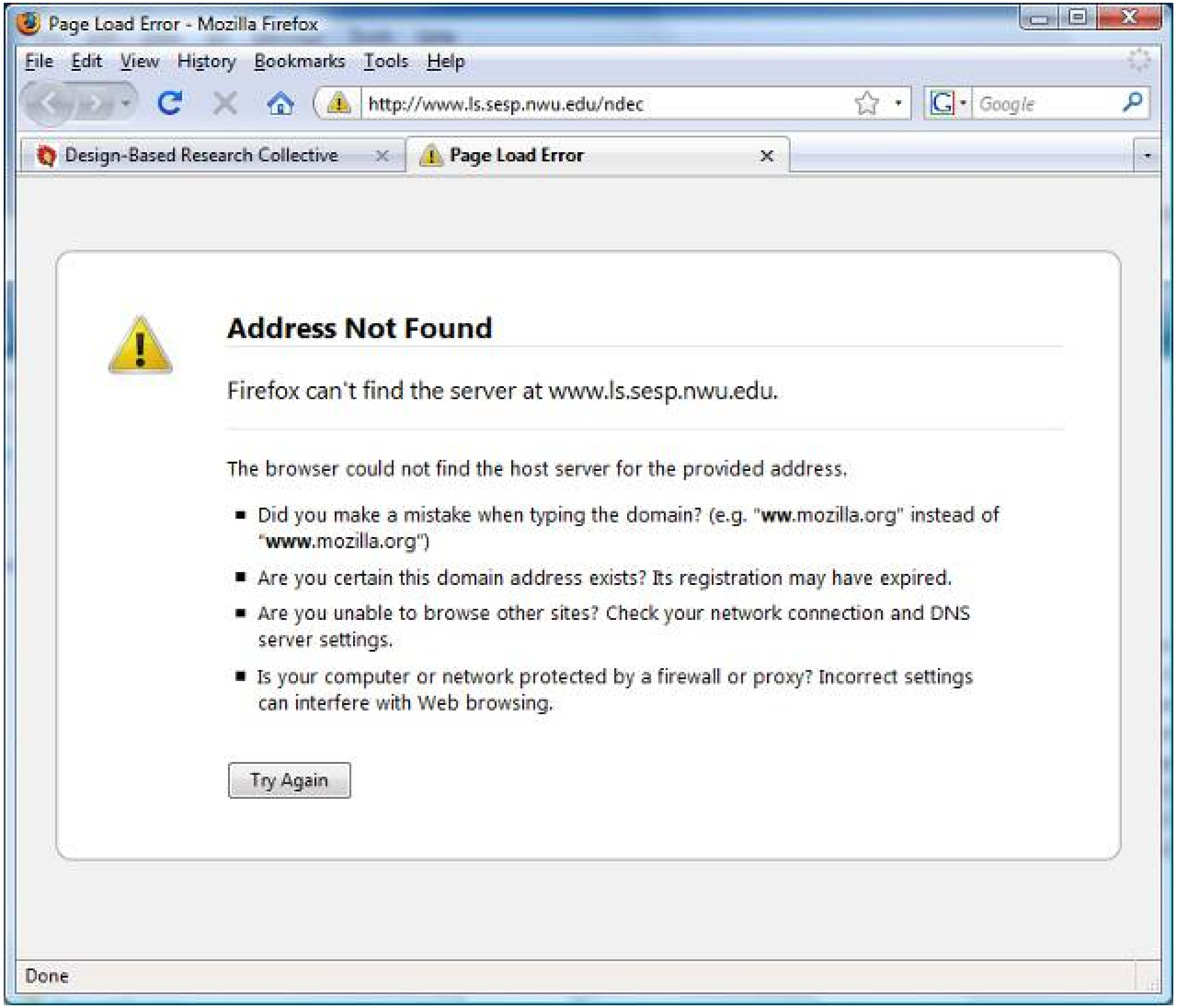
Philip Bell
Cognitive Studies in Education
University of Washington

The field of psychology has a long history of interaction with education, and educational psychology has had a profound impact on how issues of learning have been framed and studied in educational contexts. Still, it has never been simple to translate theoretical insights into educational practice. Educational psychology has been criticized for not creating "usable knowledge" (Lagemann, 2002). Currently,

An educational psychology that is both usable in a practical sense and scientifically trustworthy cannot proceed without directly studying the phenomena it hopes to explain in its inherent messiness. A little over a decade ago, Brown (1992) described her evolving approach to "design experimentation" as an effort to bridge laboratory studies of learning with studies of complex instructional interventions based on such

http://www.designbasedresearch.org/

Extinction?

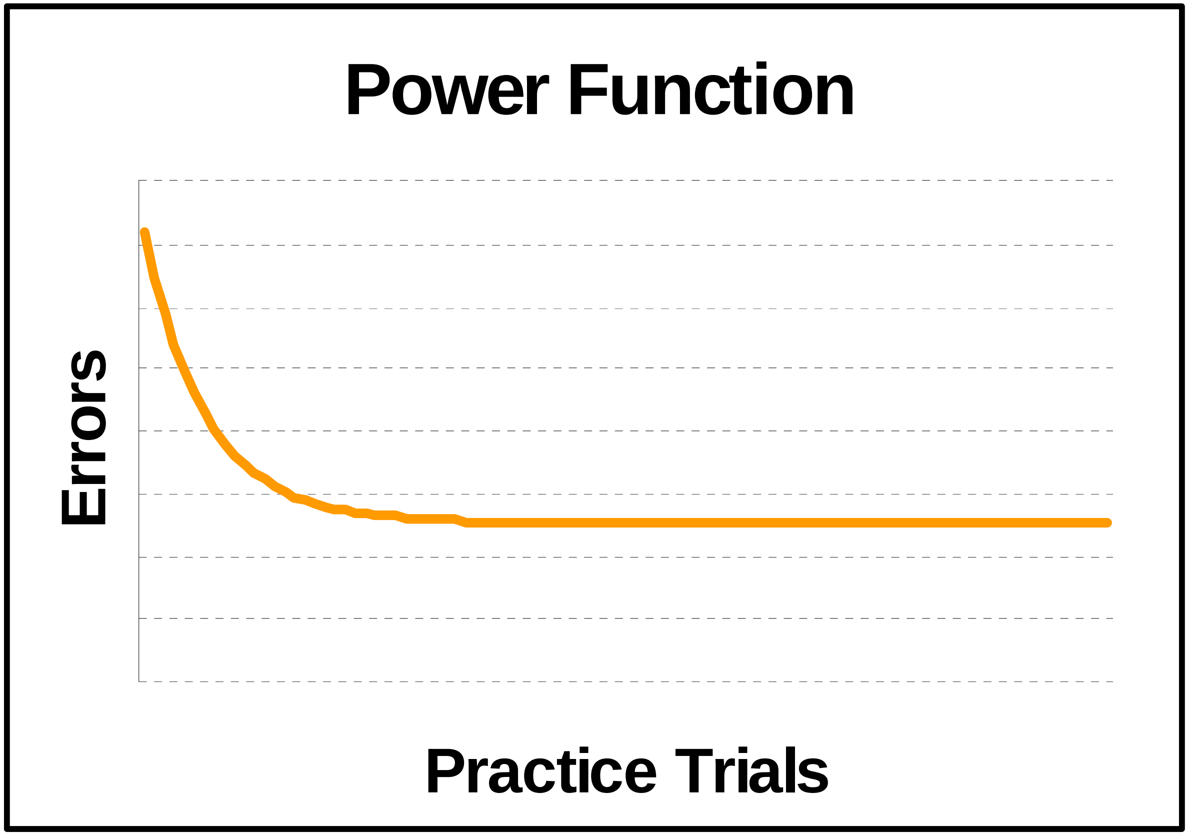

Page Load Error - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://www.ls.sesp.nwu.edu/ndec
Google
Design-Based Research Collective
Page Load Error
Address Not Found
Firefox can't find the server at www.ls.sesp.nwu.edu.
The browser could not find the host server for the provided address.
Did you make a mistake when typing the domain? (e.g. "ww.mozilla.org" instead of "www.mozilla.org")
Are you certain this domain address exists? Its registration may have expired.
Are you unable to browse other sites? Check your network connection and DNS server settings.
Is your computer or network protected by a firewall or proxy? Incorrect settings can interfere with Web browsing.
Try Again
Done

- Observe students in context
  - Repeated observations in one classroom with one group of students and one instructor
- Improve the instructional design over successive replications
  - Systematic replication (Sidman, 1960)
- Emphasizes movement of all students to a common learning outcome (***True Gain***)
  - Contrasts with between-group studies concerned with effect size differences

- Anderson, J.R., Corbett, A.T., Koedinger, K.R., & Pelletier, R. (1995). Cognitive tutors: Lessons learned. *Journal of Learning Science*, *4*, 167-207.

- *It is more meaningful to hold constant the level of mastery required and look at differences in time to achieve that level. This reflects the* ***true gain*** *of an educational technique* (p. 185).

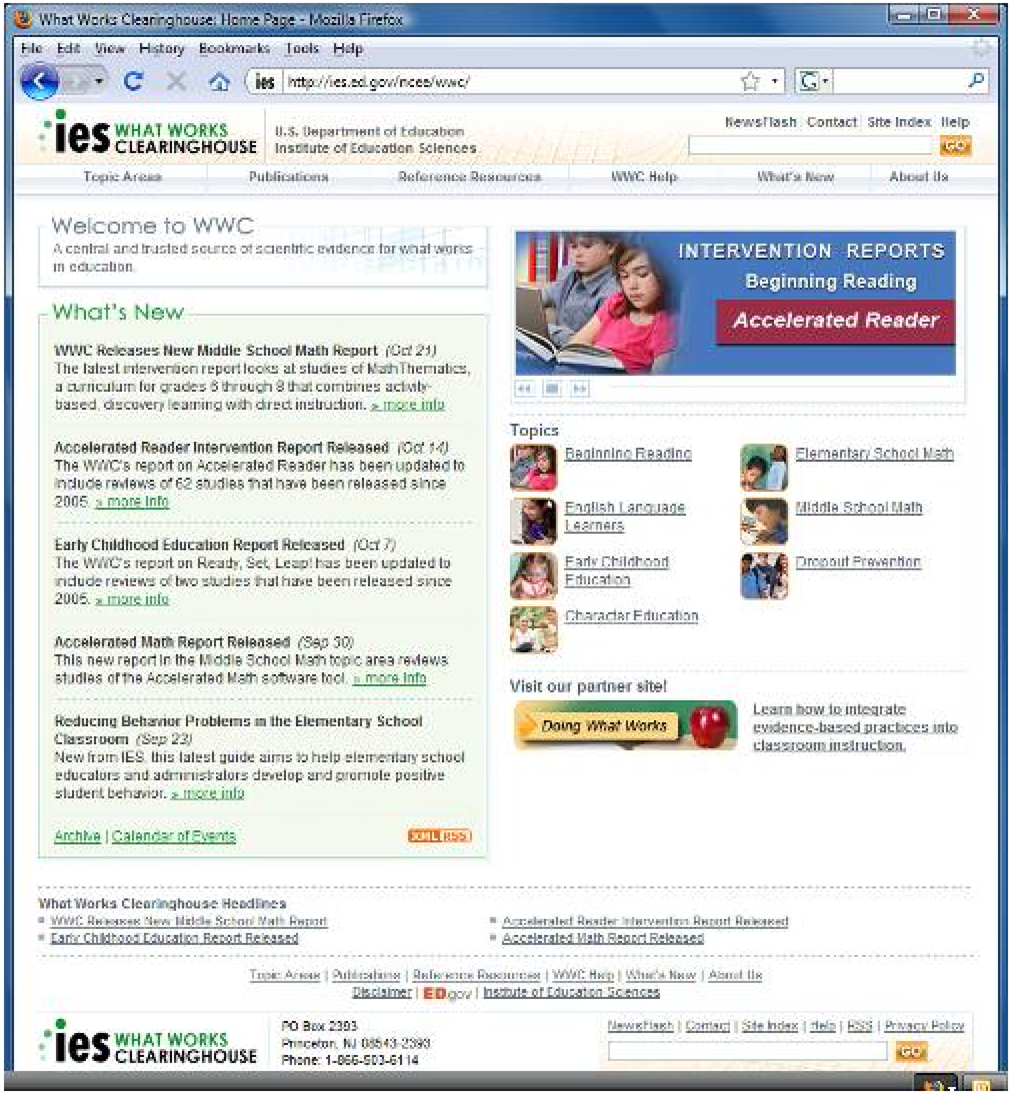
What state is steady? (When is the gain true?)



- *Analytic behavioral application is the process of applying sometimes tentative principles of behavior to the improvement of specific behaviors* (Baer, Wolf, & Risley, 1968, p. 91).
- Baer, D.M., Wolf, M.M. & Risley, T.R. (1968). Some current dimensions of applied behavior analysis. *Journal of Applied Behavior Analysis*, 1, 91-97.
- http://seab.envmed.rochester.edu/jaba/articles/1968/jaba-01-01-0091.pdf

“Competing Responses”

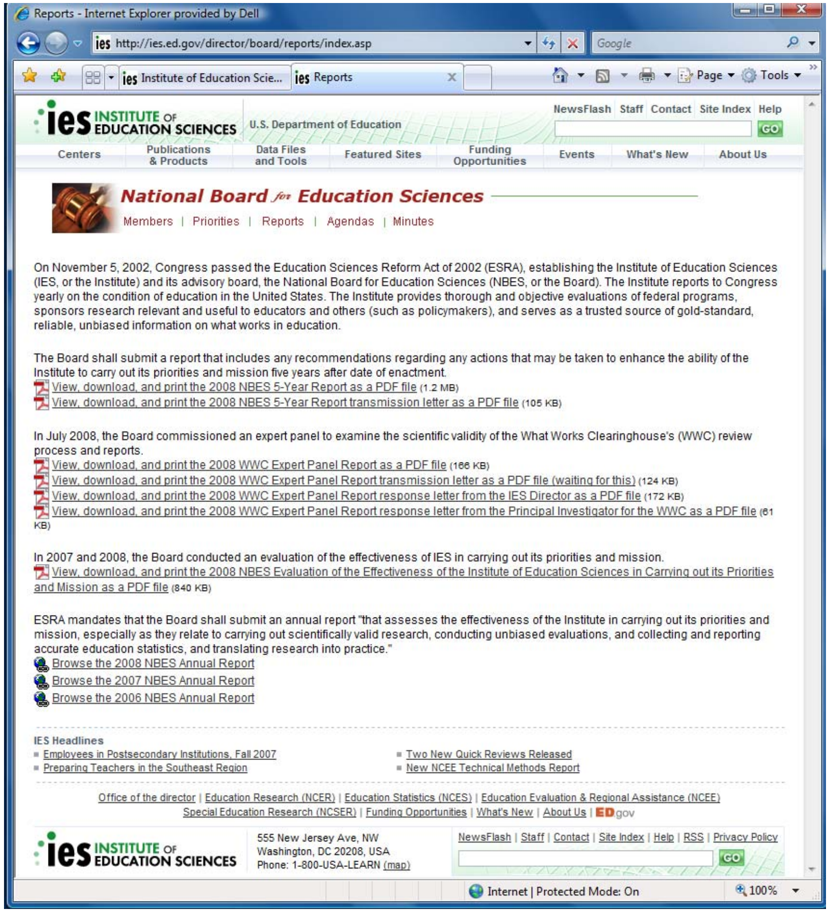
Randomized Field Trial



http://ies.ed.gov/ncee/wwc/

http://www.nifdi.org/

Counter-Counterpoint: July 2008



Report of the What Works Clearinghouse Expert Panel

To: National Board for Education Sciences

From: Hendricks Brown, Ph.D.
David Card, Ph.D. (chair)
Kay Dickersin, Ph.D.
Joel Greenhouse, Ph.D.
Jeffrey Kling, Ph.D.
Julia Littell, Ph.D.

Re: Expert Report on the What Works Clearinghouse

Date: October 21, 2008

<u>I. Introduction and Summary</u>

We have been charged with the task of conducting a "…focused study addressing the fundamental question of whether the Clearinghouse's evidence review process and reports are scientifically valid-that is, provide accurate information about the strength of evidence of meaningful effects on important educational outcomes." (Our complete charge is reproduced as Appendix A, below).

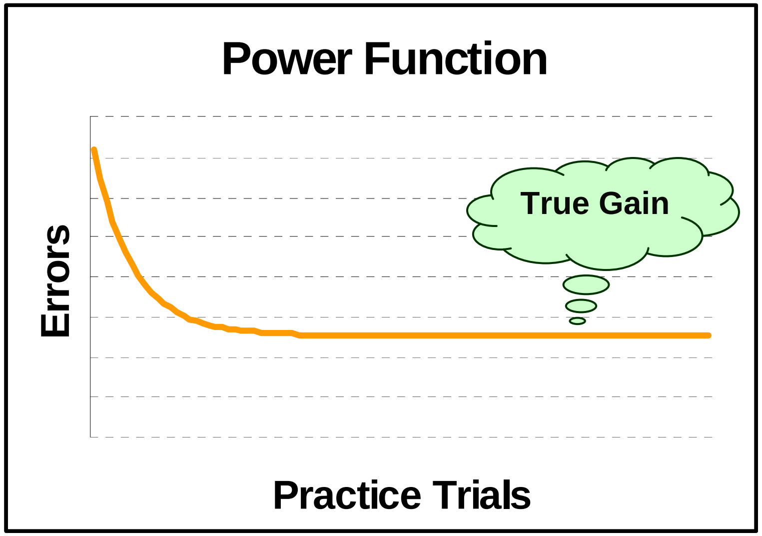
Based on our investigation and analysis of the What Works Clearinghouse (hereafter, WWC), we have concluded that:

(1) WWC procedures and processes for identifying and extracting information from intervention studies are generally well documented and follow reasonable standards and practices for systematic reviews;

(2) WWC Intervention and Topic Area Reports provide succinct and meaningful summaries of the evidence on the effectiveness of specific education interventions.

Support for these conclusions is detailed in the remainder of the report. We have also formed a number of specific recommendations for the continued enhancement and improvement of WWC procedures, which are summarized in section IV. Primary among these recommendations is that the Department of Education commission a comprehensive review of the full range of WWC activities and procedures, with a time frame to allow a complete consideration of a number of issues we have not been able to fully evaluate in this report.

http://ies.ed.gov/director/board/pdf/panelreport.pdf



- Principles to promote retention and transfer:
  - **Repeated practice** with different instructional modalities (Halpern & Hakel, 2003)
  - **Socially supported interactions** (Fox & Hackerman, 2003)

What Instructional Modalities Make Sense?

1. A set of **structured interactions** between a learner and a tutor.
2. Occasions **disciplined study behavior** that is focused on the individual learner.
3. Manages the **moment-by-moment interactions** between a learner and a tutor: *learn units*.
4. A **step-wise progression** from elementary facts to the achievement of meaningful learning.

Java Tutor

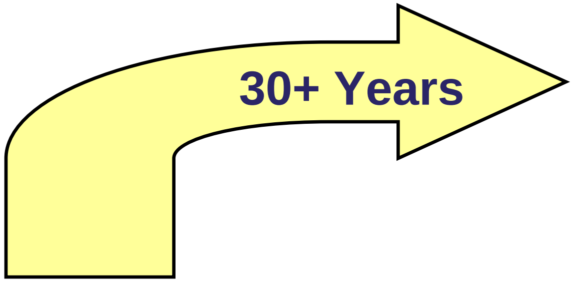
http://nasa1.ifsm.umbc.edu/learnJava/tutorLinks/SwingTutorLinksV2.html

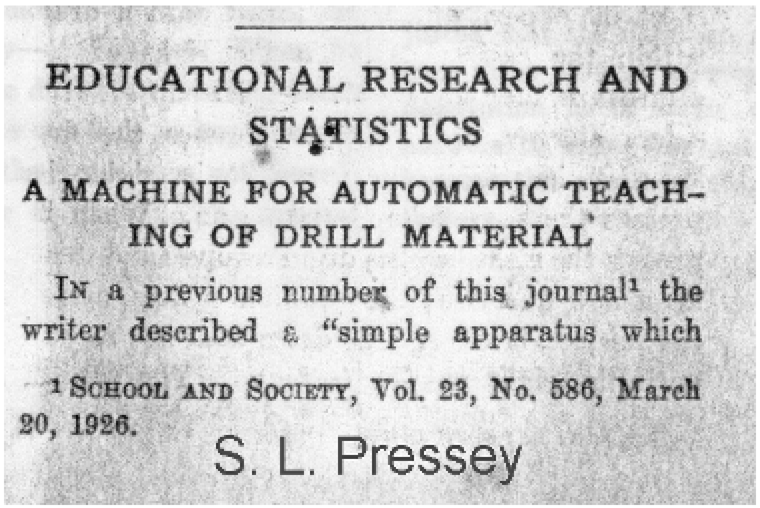
Ten Features of PI
(Holland, 1960; Scriven, 1969; Skinner, 1958; Vargas & Vargas, 1991)

1. Comprehensibility of each unit or “frame,”
2. Tested effectiveness of a set of frames,
3. Skip-proof frames,
4. Self-correcting tests,
5. Automatic encouragement for learning,

Ten Features of PI
(Holland, 1960; Scriven, 1969; Skinner, 1958; Vargas & Vargas, 1991)

6. Diagnosis of misunderstandings,
7. Adaptations to errors by hints, prompts, and suggestions,
8. Learner constructed responses based on recall,
9. Immediate feedback, successive approximations to a terminal objective, and
10. Student-paced progress.





EDUCATIONAL RESEARCH AND STATISTICS

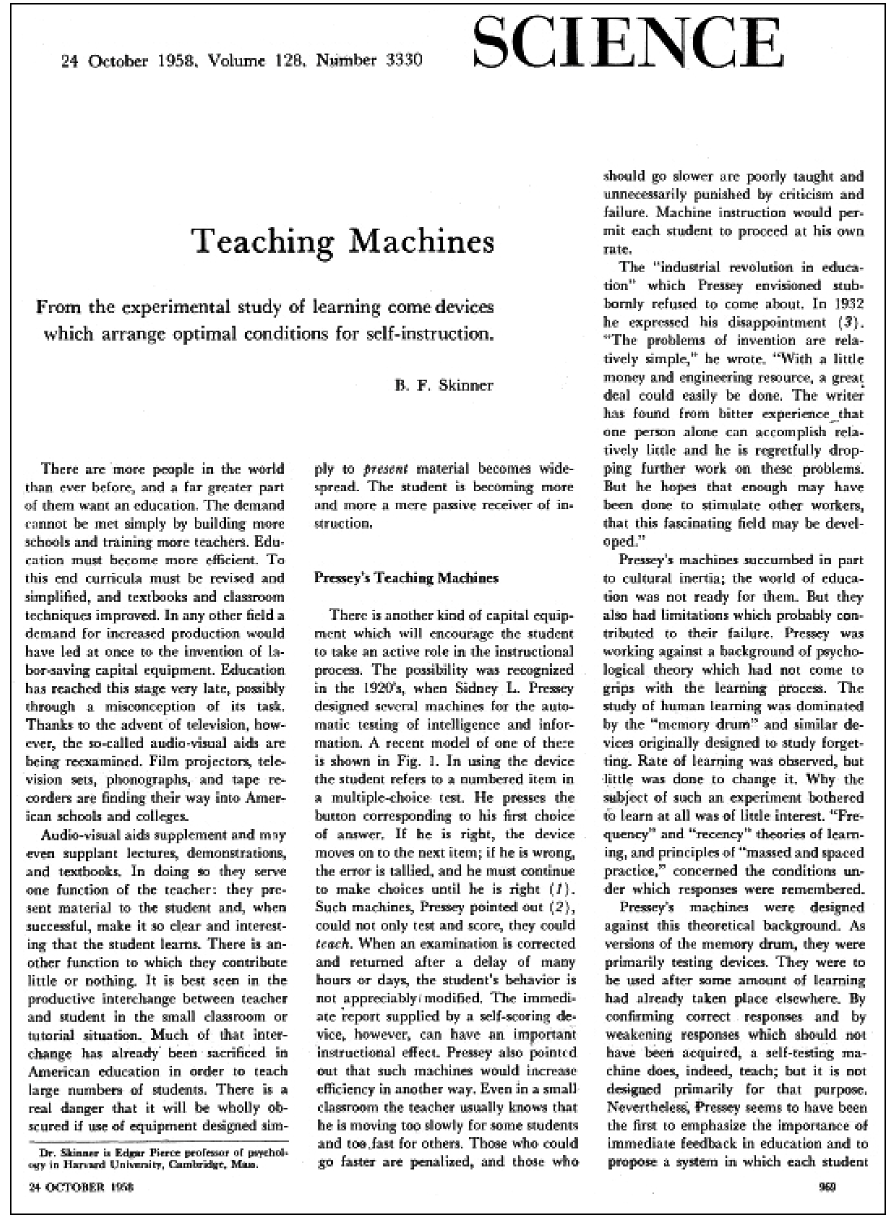
A MACHINE FOR AUTOMATIC TEACHING OF DRILL MATERIAL

IN a previous number of this journal[1] the writer described a "simple apparatus which

[1] SCHOOL AND SOCIETY, Vol. 23, No. 586, March 20, 1926.

S. L. Pressey

1926



24 October 1958, Volume 128, Number 3330 SCIENCE

Teaching Machines

From the experimental study of learning come devices which arrange optimal conditions for self-instruction.

B. F. Skinner

There are more people in the world than ever before, and a far greater part of them want an education. The demand cannot be met simply by building more schools and training more teachers. Education must become more efficient. To this end curricula must be revised and simplified, and textbooks and classroom techniques improved. In any other field a demand for increased production would have led at once to the invention of labor-saving capital equipment. Education has reached this stage very late, possibly through a misconception of its task. Thanks to the advent of television, however, the so-called audio-visual aids are being reexamined. Film projectors, television sets, phonographs, and tape recorders are finding their way into American schools and colleges.

Audio-visual aids supplement and may even supplant lectures, demonstrations, and textbooks. In doing so they serve one function of the teacher: they present material to the student and, when successful, make it so clear and interesting that the student learns. There is another function to which they contribute little or nothing. It is best seen in the productive interchange between teacher and student in the small classroom or tutorial situation. Much of that interchange has already been sacrificed in American education in order to teach large numbers of students. There is a real danger that it will be wholly obscured if use of equipment designed simply to *present* material becomes widespread. The student is becoming more and more a mere passive receiver of instruction.

Pressey's Teaching Machines

There is another kind of capital equipment which will encourage the student to take an active role in the instructional process. The possibility was recognized in the 1920's, when Sidney L. Pressey designed several machines for the automatic testing of intelligence and information. A recent model of one of these is shown in Fig. 1. In using the device the student refers to a numbered item in a multiple-choice test. He presses the button corresponding to his first choice of answer. If he is right, the device moves on to the next item; if he is wrong, the error is tallied, and he must continue to make choices until he is right (*1*). Such machines, Pressey pointed out (*2*), could not only test and score, they could *teach*. When an examination is corrected and returned after a delay of many hours or days, the student's behavior is not appreciably modified. The immediate report supplied by a self-scoring device, however, can have an important instructional effect. Pressey also pointed out that such machines would increase efficiency in another way. Even in a small classroom the teacher usually knows that he is moving too slowly for some students and too fast for others. Those who could go faster are penalized, and those who should go slower are poorly taught and unnecessarily punished by criticism and failure. Machine instruction would permit each student to proceed at his own rate.

The "industrial revolution in education" which Pressey envisioned stubbornly refused to come about. In 1932 he expressed his disappointment (*3*). "The problems of invention are relatively simple," he wrote. "With a little money and engineering resource, a great deal could easily be done. The writer has found from bitter experience that one person alone can accomplish relatively little and he is regretfully dropping further work on these problems. But he hopes that enough may have been done to stimulate other workers, that this fascinating field may be developed."

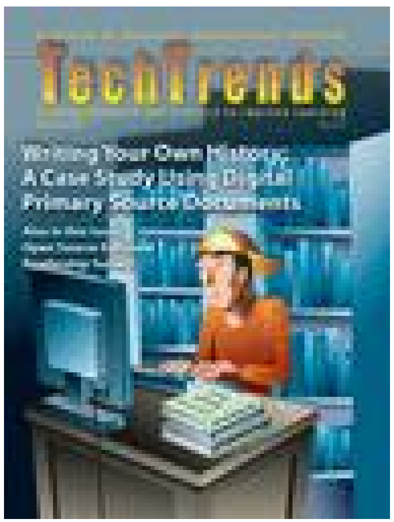
Pressey's machines succumbed in part to cultural inertia; the world of education was not ready for them. But they also had limitations which probably contributed to their failure. Pressey was working against a background of psychological theory which had not come to grips with the learning process. The study of human learning was dominated by the "memory drum" and similar devices originally designed to study forgetting. Rate of learning was observed, but little was done to change it. Why the subject of such an experiment bothered to learn at all was of little interest. "Frequency" and "recency" theories of learning, and principles of "massed and spaced practice," concerned the conditions under which responses were remembered.

Pressey's machines were designed against this theoretical background. As versions of the memory drum, they were primarily testing devices. They were to be used after some amount of learning had already taken place elsewhere. By confirming correct responses and by weakening responses which should not have been acquired, a self-testing machine does, indeed, teach; but it is not designed primarily for that purpose. Nevertheless, Pressey seems to have been the first to emphasize the importance of immediate feedback in education and to propose a system in which each student

Dr. Skinner is Edgar Pierce professor of psychology in Harvard University, Cambridge, Mass.

1958

As public purse strings tighten, the day may come when learning time and learning costs are subjected to close accountability in public schools and university education also.



2008

The Programmed Instruction Era:

When Effectiveness Mattered

By Michael Molenda

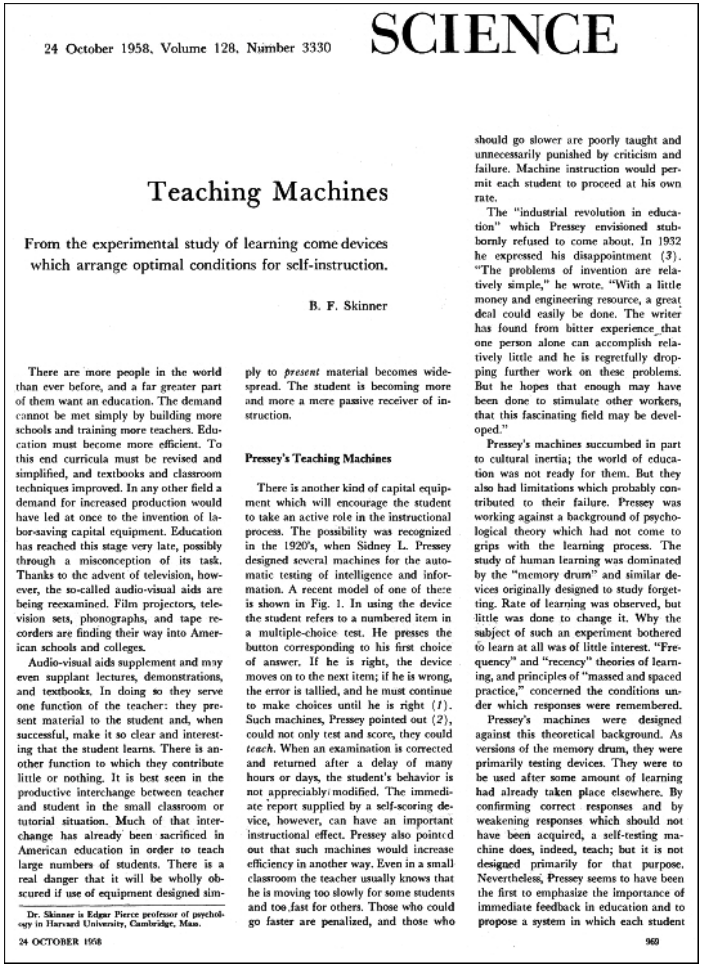
Programmed instruction (PI) was devised to make the teaching-learning process more humane by making it more effective and customized to individual differences. B.F. Skinner's original prescription, although it met with some success, had serious limitations. Later innovators improved upon the original notion by incorporating more human interaction, social reinforcers and other forms of feedback, larger and more flexible chunks of instruction, and more attention to learner appeal. Although PI itself has receded from the spotlight, technologies derived from PI, such as programmed tutoring, Direct Instruction, and Personalized System of Instruction have compiled an impressive track record of success when compared to so-called conventional instruction. They paved the way for computer-based instruction and distance learning. The success of the PI movement can be attributed largely to the commitment of its proponents to relentless, objective measurement of effectiveness.

> *"The original AutoTutor, released in the early 1960s, provided individualized instruction long before general-purpose desktop computers were feasible."*

Origins of the Programmed Instruction Movement

During the first half of the 20th century, research and theory in American psychology tended to revolve around the perspective of behaviorism, and Thorndike's (1911) theorems—the law of recency, the law of effect, and the law of exercise—remained at the center of discussion for decades. In the 1920s Sidney Pressey, a psychology professor at Ohio State University, invented a mechanical device based on a typewriter drum, designed primarily to automate testing of simple informational material (1926). As he experimented with the device he realized that it could also provide control over drill-and-practice exercises, teaching as well as testing. In explaining why his device was successful he explicitly drew upon Thorndike's laws of recency, effect, and exercise as theoretical rationales (Pressey, 1927). Unfortunately, despite the fact that Pressey continued to develop successful self-teaching devices, including punchboards, that had all the qualities of later "teaching machines," his efforts were essentially a dead end in terms of a lasting effect on education. However, Pressey lived and worked long enough to participate in the discussions surrounding the new generation of teaching machines that came along in the 1950s.

The movement that had a more enduring impact on education and training was animated by a reframing of Thorndike's behaviorist principles under the label of radical behaviorism. This school of thought proposed a more rigorous definition of the law of effect, adopting the term *reinforcer* to refer to any event that increases the frequency of a preceding behavior. Operant conditioning, the major operationalization of this theory, involves the relationships among stimuli, the responses, and the consequences that follow a response (Burton, Moore & Magliaro, 2004, p. 10). The leading proponent of radical behaviorism, B. F. Skinner, demonstrated that by manipulating these three variables experimenters



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24 OCTOBER 1958

969

50+ Years

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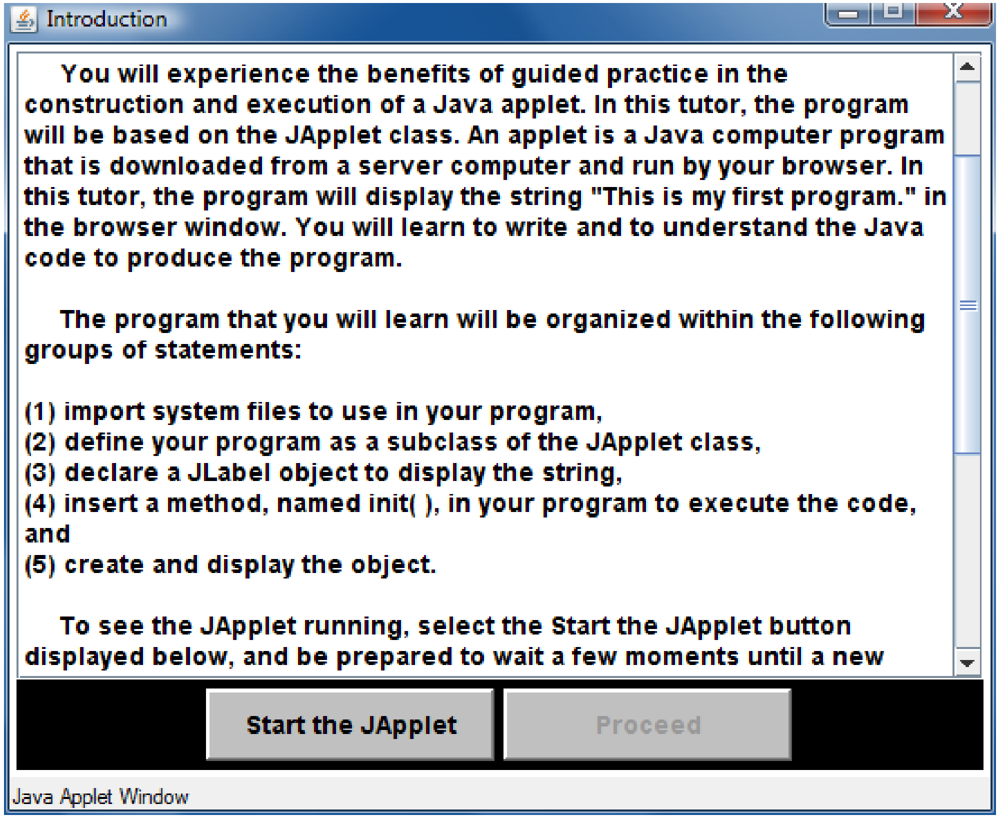
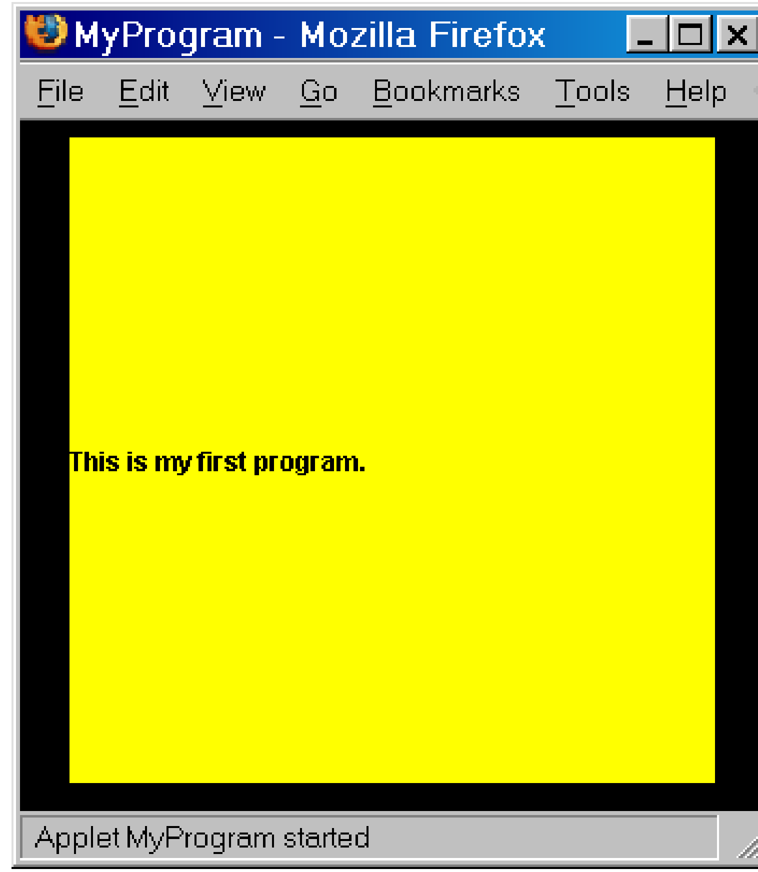
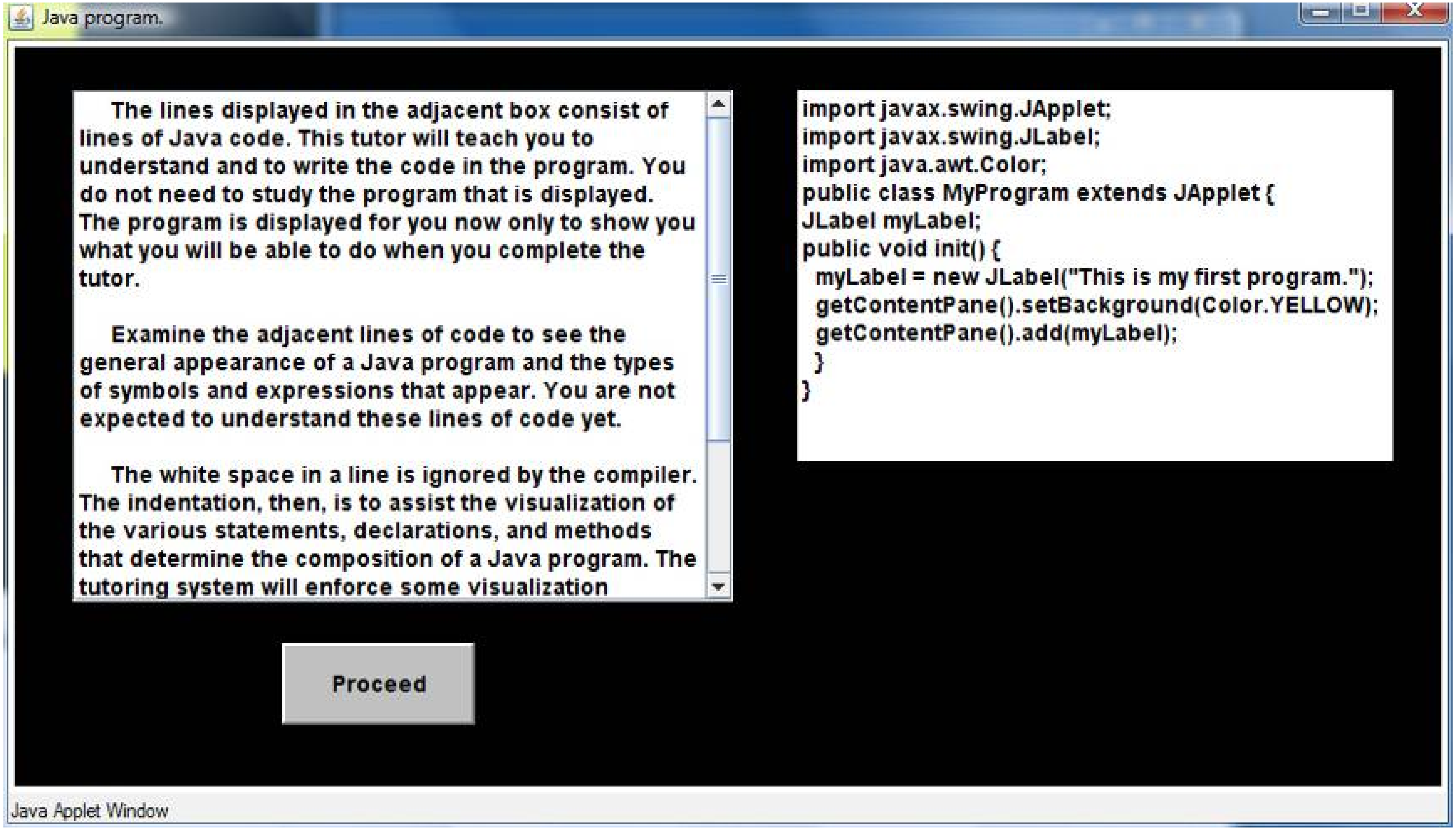
Programmed Instruction
Tutoring System

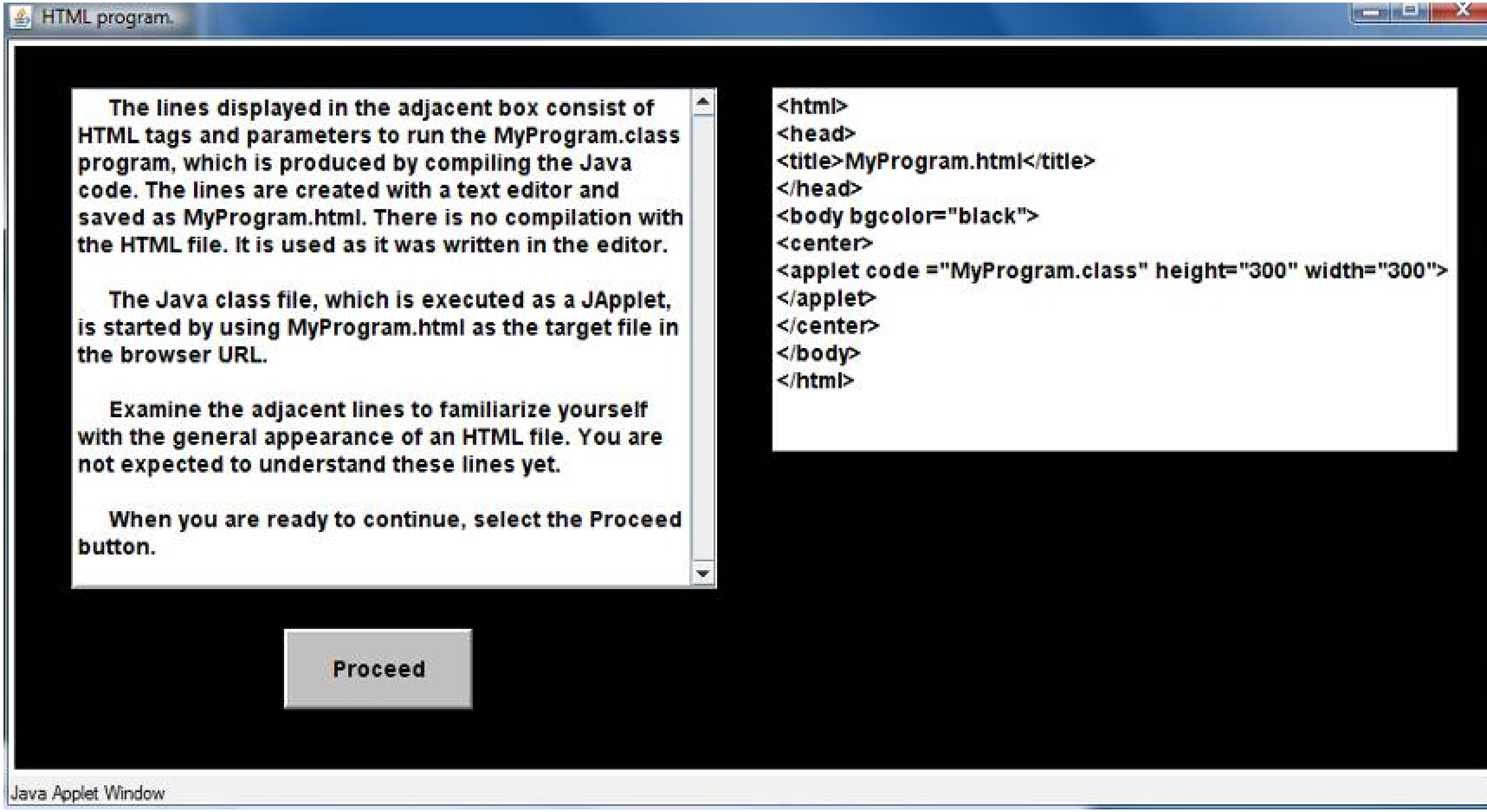
Introduction

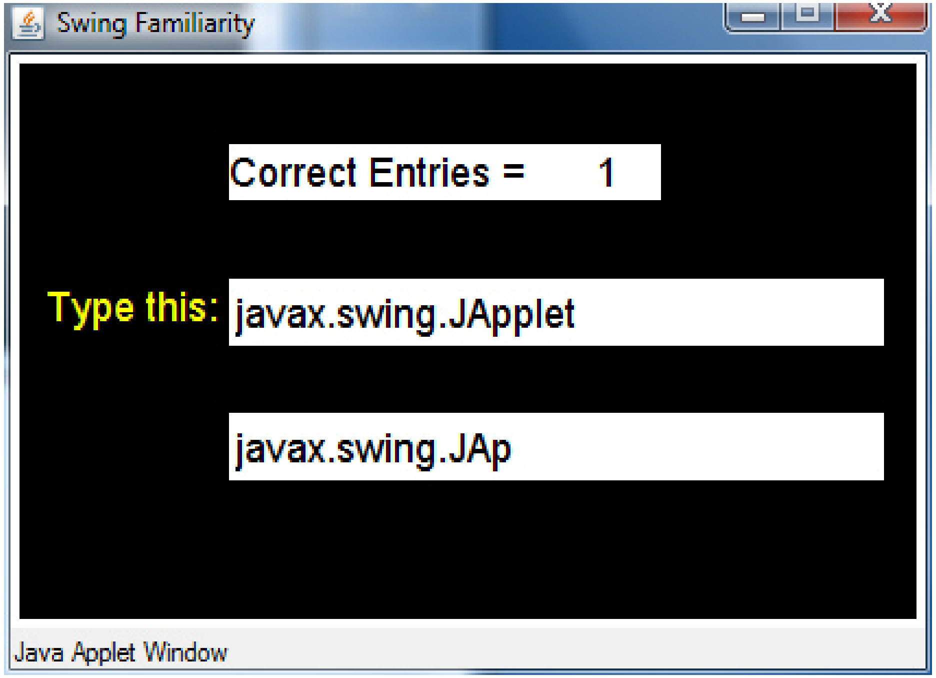


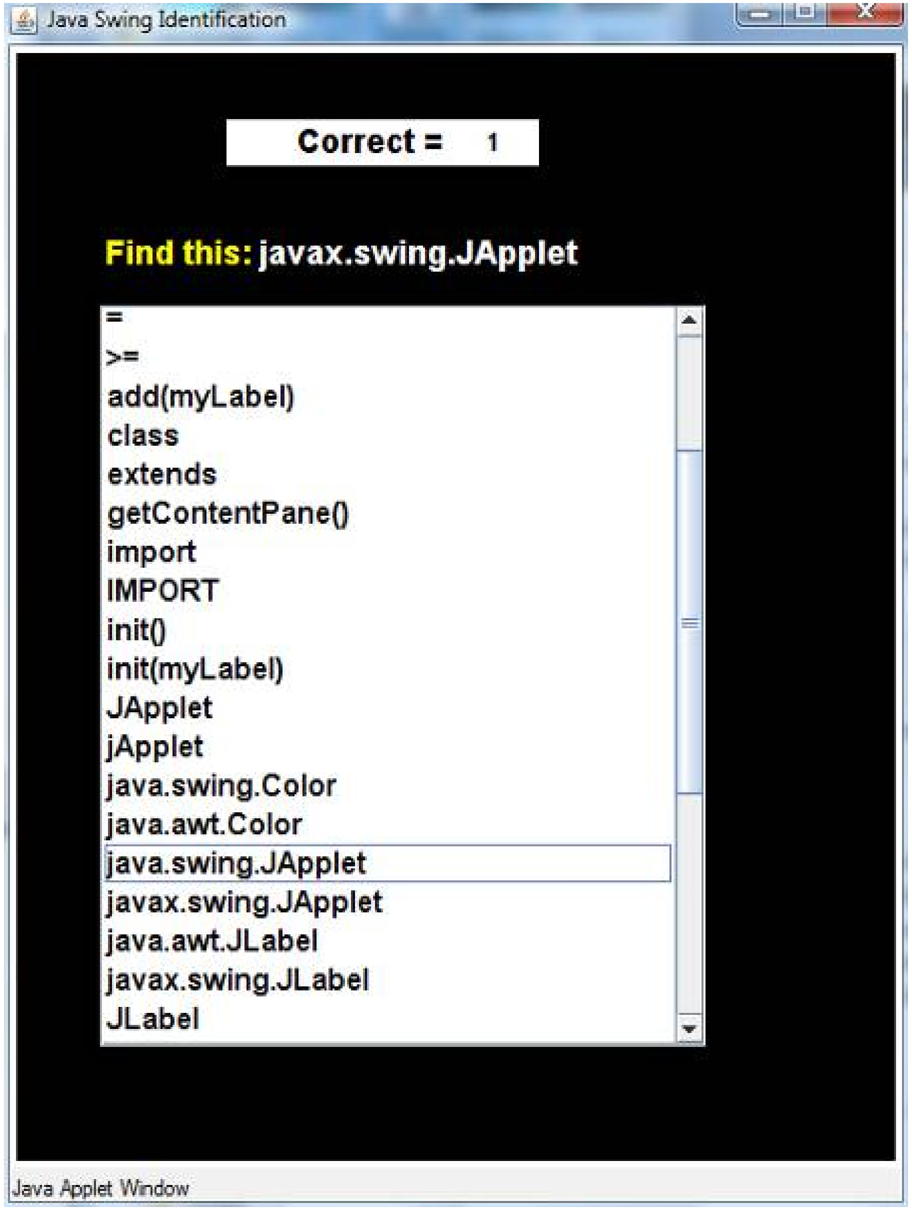


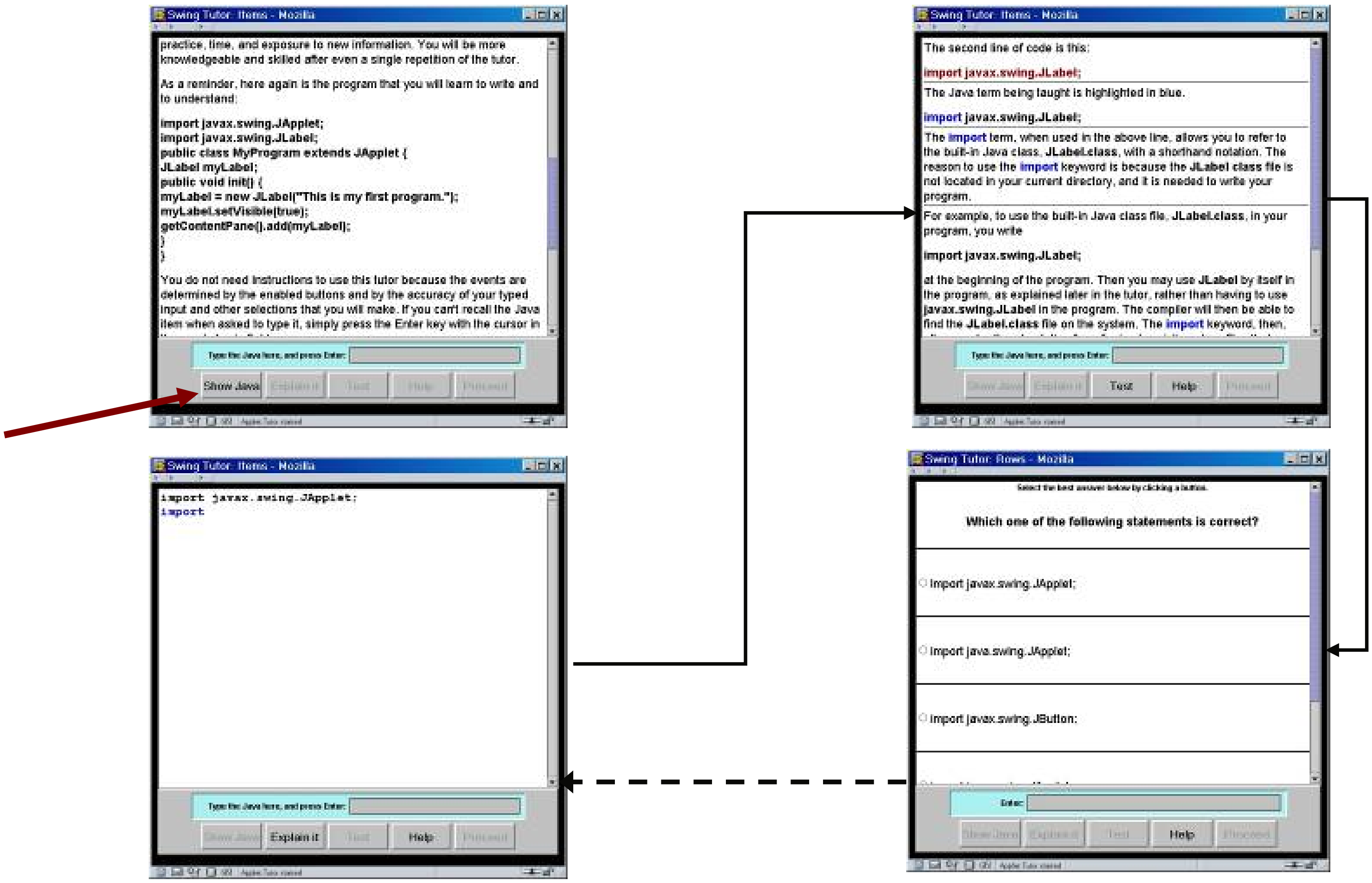
- Advance organizers
  - Template of a Java Applet
- Observe the applet in action

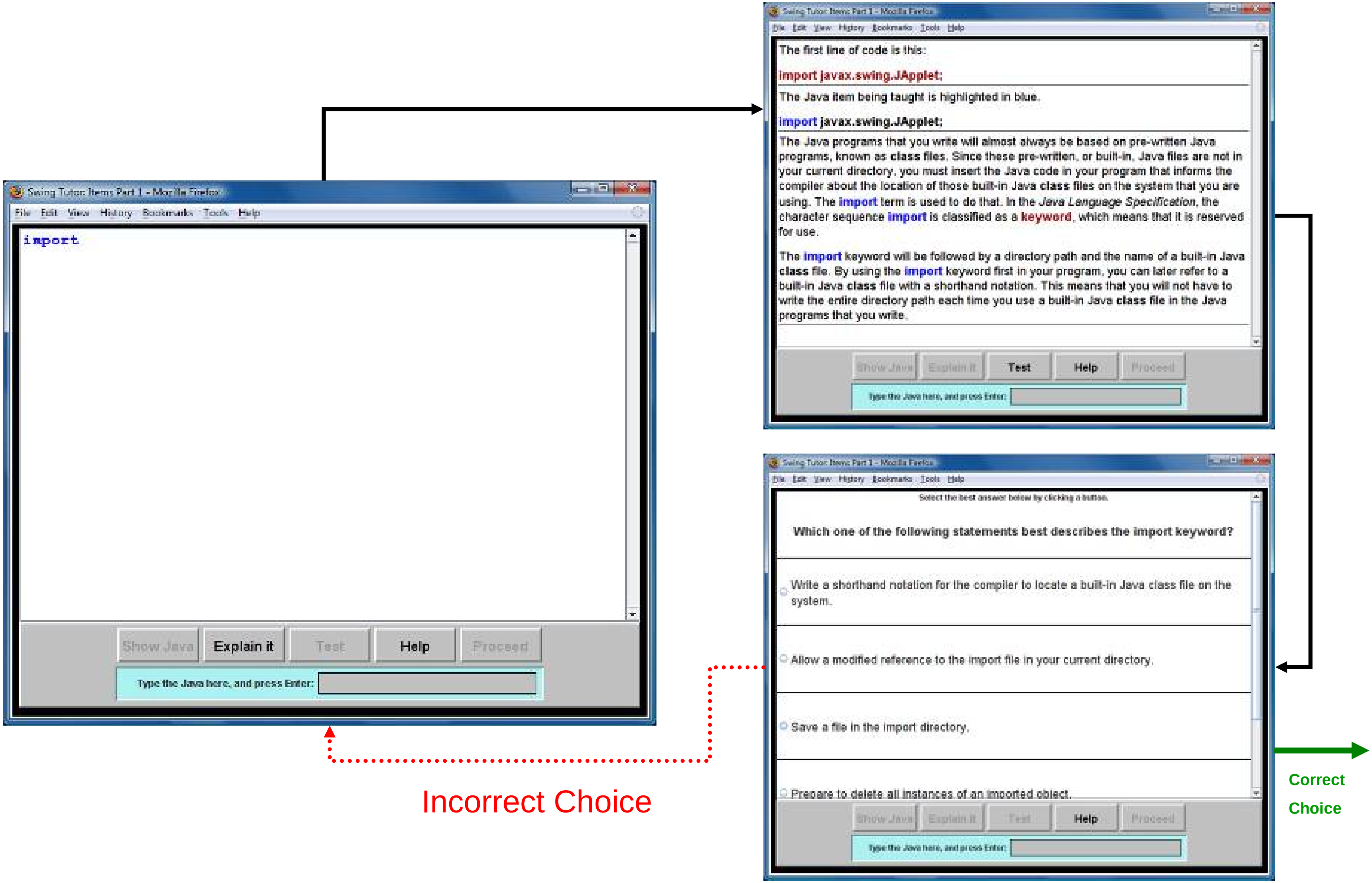

Java program.
The lines displayed in the adjacent box consist of lines of Java code. This tutor will teach you to understand and to write the code in the program. You do not need to study the program that is displayed. The program is displayed for you now only to show you what you will be able to do when you complete the tutor.
Examine the adjacent lines of code to see the general appearance of a Java program and the types of symbols and expressions that appear. You are not expected to understand these lines of code yet.
The white space in a line is ignored by the compiler. The indentation, then, is to assist the visualization of the various statements, declarations, and methods that determine the composition of a Java program. The tutoring system will enforce some visualization
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel = new JLabel("This is my first program.");
getContentPane().setBackground(Color.YELLOW);
getContentPane().add(myLabel);
}
}
Proceed
Java Applet Window


HTML program.
The lines displayed in the adjacent box consist of HTML tags and parameters to run the MyProgram.class program, which is produced by compiling the Java code. The lines are created with a text editor and saved as MyProgram.html. There is no compilation with the HTML file. It is used as it was written in the editor.
The Java class file, which is executed as a JApplet, is started by using MyProgram.html as the target file in the browser URL.
Examine the adjacent lines to familiarize yourself with the general appearance of an HTML file. You are not expected to understand these lines yet.
When you are ready to continue, select the Proceed button.
<html>
<head>
<title>MyProgram.html</title>
</head>
<body bgcolor="black">
<center>
<applet code ="MyProgram.class" height="300" width="300">
</applet>
</center>
</body>
</html>
Proceed
Java Applet Window


Swing Familiarity
Correct Entries = 1
Type this:
javax.swing.JApplet
javax.swing.JAp
Java Applet Window

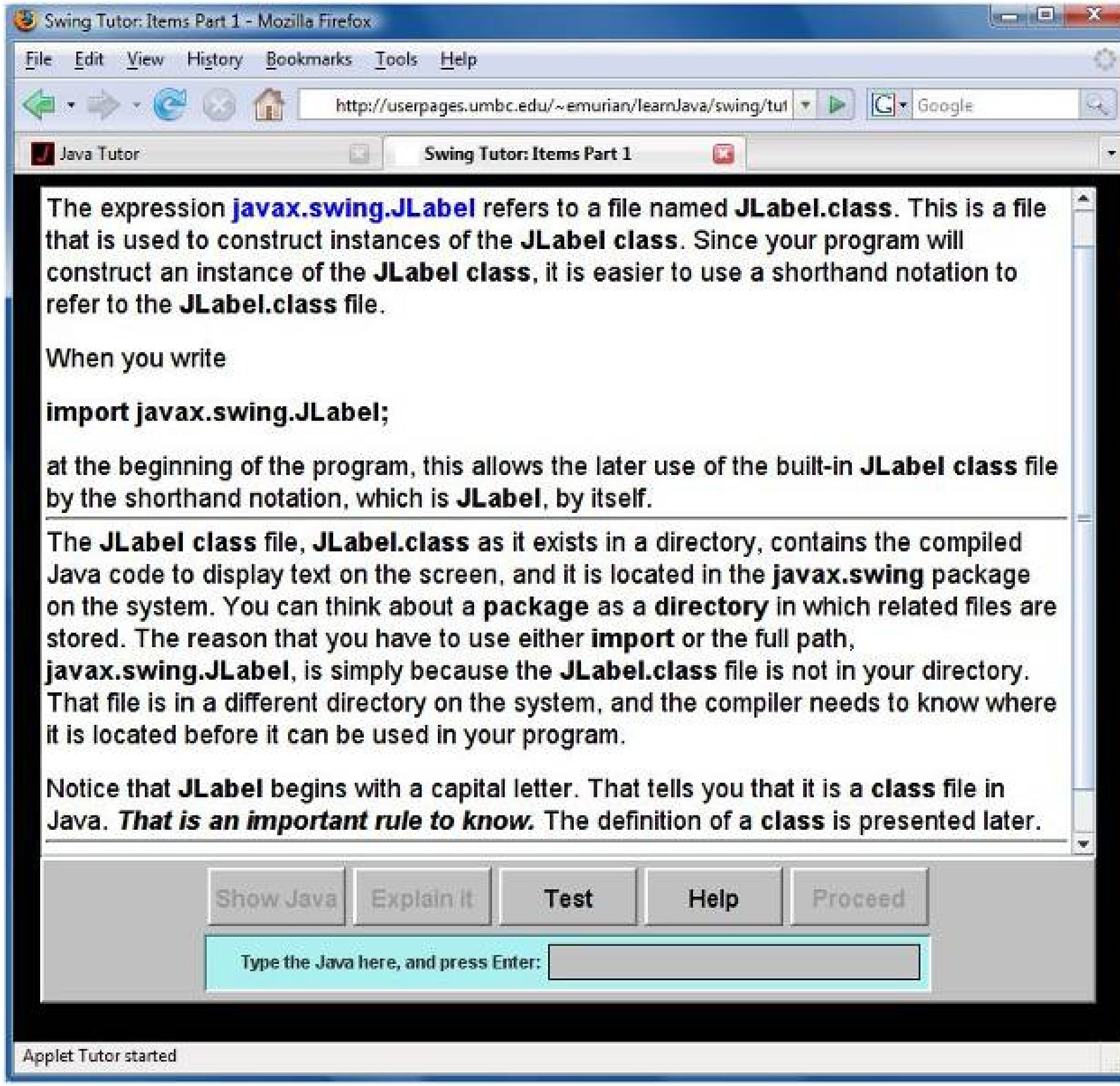

Java Swing Identification
Correct = 1
Find this: javax.swing.JApplet
=
>=
add(myLabel)
class
extends
getContentPane()
import
IMPORT
init()
init(myLabel)
JApplet
jApplet
java.swing.Color
java.awt.Color
java.swing.JApplet
javax.swing.JApplet
java.awt.JLabel
javax.swing.JLabel
JLabel
Java Applet Window


Swing Tutor: Items - Mozilla
practice, time, and exposure to new information. You will be more knowledgeable and skilled after even a single repetition of the tutor.
As a reminder, here again is the program that you will learn to write and to understand:
import javax.swing.JApplet;
import javax.swing.JLabel;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel = new JLabel("This is my first program.");
myLabel.setVisible(true);
getContentPane().add(myLabel);
}
}
You do not need instructions to use this tutor because the events are determined by the enabled buttons and by the accuracy of your typed input and other selections that you will make. If you can't recall the Java item when asked to type it, simply press the Enter key with the cursor in
Type the Java here, and press Enter:
Show Java
Explain it
Test
Help
Proceed
Swing Tutor: Items - Mozilla
The second line of code is this:
import javax.swing.JLabel;
The Java term being taught is highlighted in blue.
import javax.swing.JLabel;
The import term, when used in the above line, allows you to refer to the built-in Java class, JLabel.class, with a shorthand notation. The reason to use the import keyword is because the JLabel class file is not located in your current directory, and it is needed to write your program.
For example, to use the built-in Java class file, JLabel.class, in your program, you write
import javax.swing.JLabel;
at the beginning of the program. Then you may use JLabel by itself in the program, as explained later in the tutor, rather than having to use javax.swing.JLabel in the program. The compiler will then be able to find the JLabel.class file on the system. The import keyword, then,
Type the Java here, and press Enter:
Test
Help
Swing Tutor: Items - Mozilla
import javax.swing.JApplet;
import
Type the Java here, and press Enter:
Explain it
Help
Swing Tutor: Rows - Mozilla
Select the best answer below by clicking a button.
Which one of the following statements is correct?
import javax.swing.JApplet;
import java.swing.JApplet;
import javax.swing.JButton;
Enter:
Help

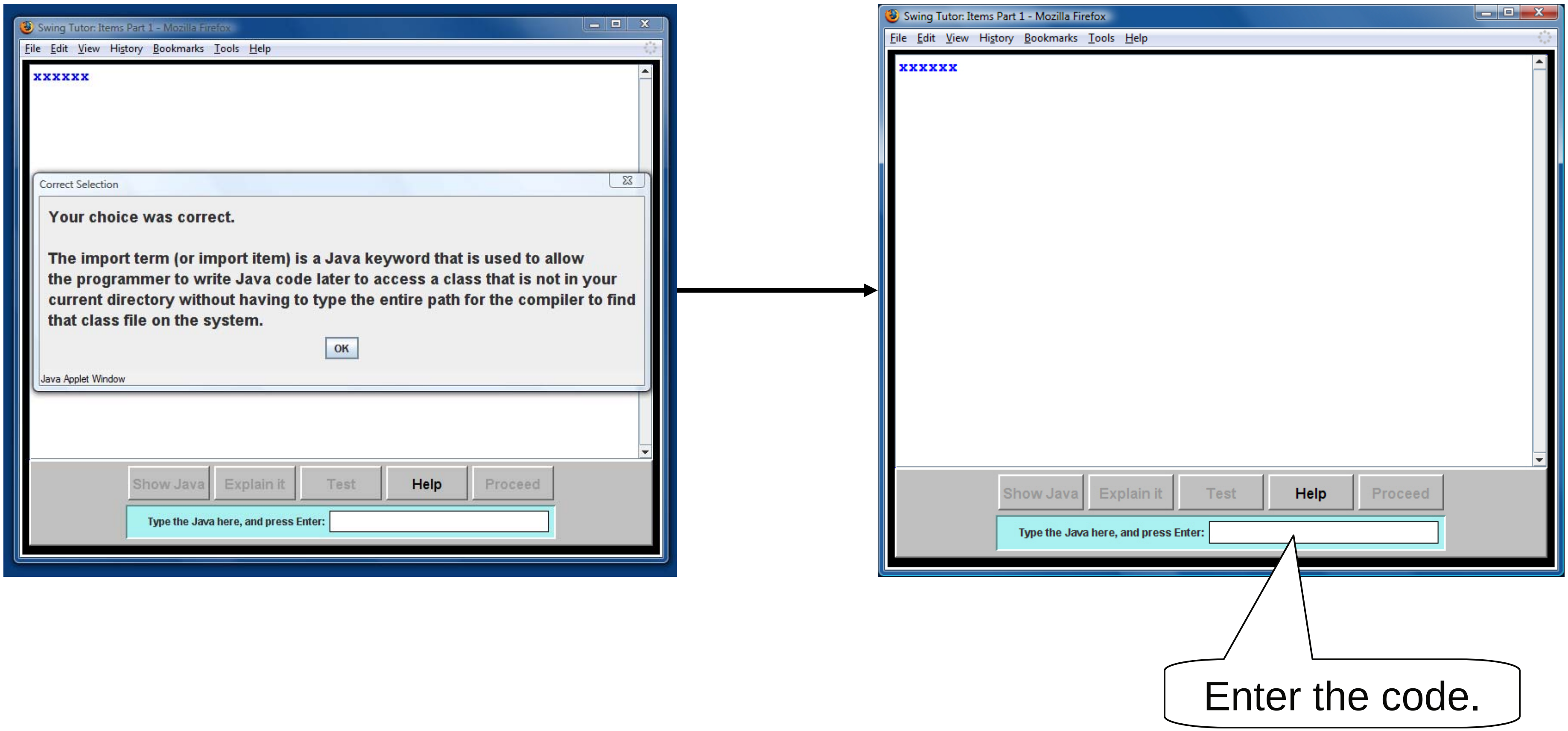

Swing Tutor Items Part 1 - Mozilla Firefox
File Edit View History Bookmarks Tools Help
import
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:
The first line of code is this:
import javax.swing.JApplet;
The Java item being taught is highlighted in blue.
import javax.swing.JApplet;
The Java programs that you write will almost always be based on pre-written Java programs, known as class files. Since these pre-written, or built-in, Java files are not in your current directory, you must insert the Java code in your program that informs the compiler about the location of those built-in Java class files on the system that you are using. The import term is used to do that. In the Java Language Specification, the character sequence import is classified as a keyword, which means that it is reserved for use.
The import keyword will be followed by a directory path and the name of a built-in Java class file. By using the import keyword first in your program, you can later refer to a built-in Java class file with a shorthand notation. This means that you will not have to write the entire directory path each time you use a built-in Java class file in the Java programs that you write.
Select the best answer below by clicking a button.
Which one of the following statements best describes the import keyword?
Write a shorthand notation for the compiler to locate a built-in Java class file on the system.
Allow a modified reference to the import file in your current directory.
Save a file in the import directory.
Prepare to delete all instances of an imported object.
Incorrect Choice
Correct Choice

- Davis, Bostow, and Heimisson (2007) reported the inclusion of abstract statements of a behavioral relation (a “rule”) in many frames of a programmed instruction tutor designed to promote generalization of what was taught in the tutor.
- Davis, D.R., Bostow, D.E., & Heimisson, G.T. (2007). Strengthening scientific verbal behavior: An experimental comparison of progressively prompted and unprompted programmed instruction and prose tutorials. *Journal of Applied Behavior Analysis*, *40*(1), 179-184.

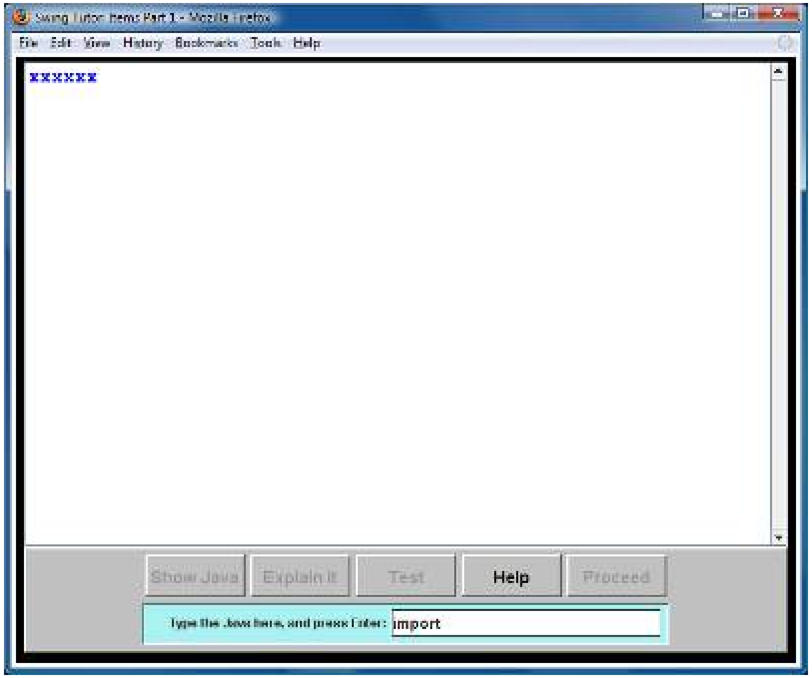
A “Rule”

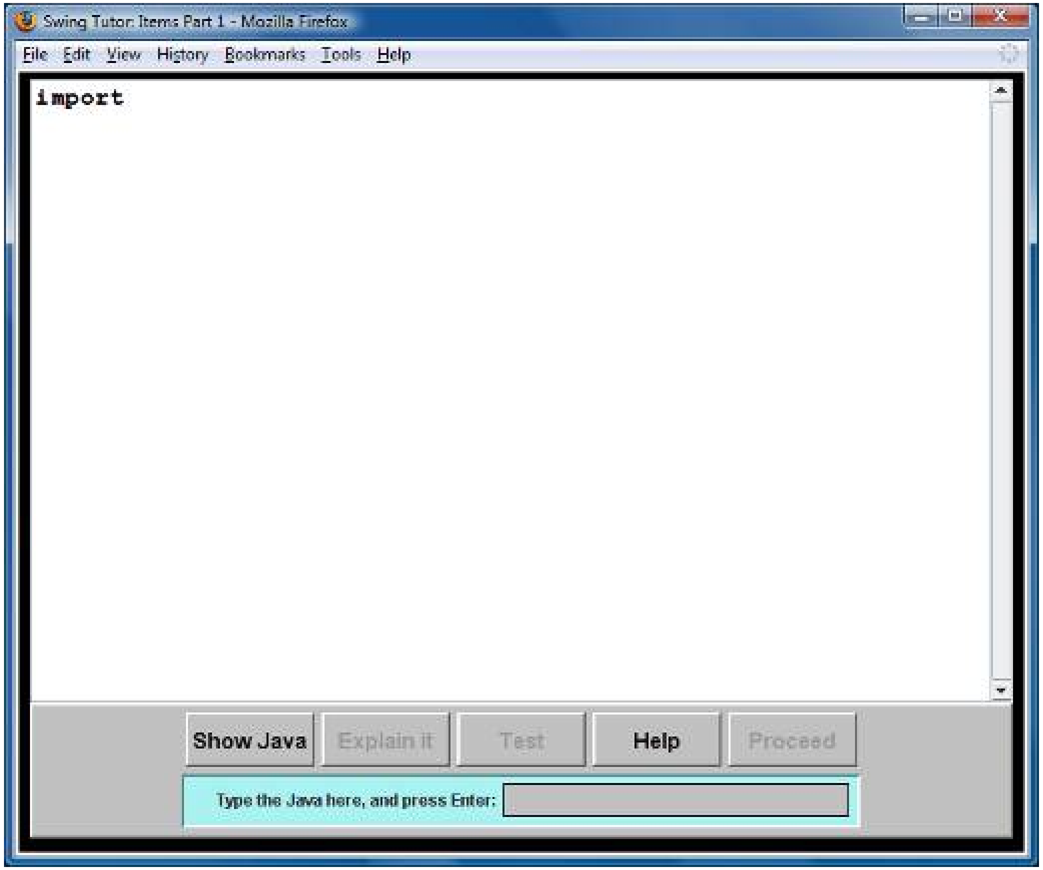

Swing Tutor: Items Part 1 - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://userpages.umbc.edu/~emurian/learnJava/swing/tut
Google
Java Tutor
Swing Tutor: Items Part 1
The expression javax.swing.JLabel refers to a file named JLabel.class. This is a file that is used to construct instances of the JLabel class. Since your program will construct an instance of the JLabel class, it is easier to use a shorthand notation to refer to the JLabel.class file.
When you write
import javax.swing.JLabel;
at the beginning of the program, this allows the later use of the built-in JLabel class file by the shorthand notation, which is JLabel, by itself.
The JLabel class file, JLabel.class as it exists in a directory, contains the compiled Java code to display text on the screen, and it is located in the javax.swing package on the system. You can think about a package as a directory in which related files are stored. The reason that you have to use either import or the full path, javax.swing.JLabel, is simply because the JLabel.class file is not in your directory. That file is in a different directory on the system, and the compiler needs to know where it is located before it can be used in your program.
Notice that JLabel begins with a capital letter. That tells you that it is a class file in Java. That is an important rule to know. The definition of a class is presented later.
Show Java
Explain It
Test
Help
Proceed
Type the Java here, and press Enter:
Applet Tutor started

- **An ongoing challenge relates to the optimal design of the content of frames – the "explanations"** (Wittwer & Renkl, 2008). A challenge for programmed instruction is to develop frames of information that are effective for learning, and that requires a conceptual framework for understanding the effectiveness of instructional explanations.
- Wittwer, J., & Renkl, A. (2008). Why instructional explanations often do not work: A framework for understanding the effectiveness of instructional explanations. *Educational Psychologist*, *43*(1), 49-64.


Swing Tutor: Items Part 1 - Mozilla Firefox
File Edit View History Bookmarks Tools Help
xxxxxx
Correct Selection
Your choice was correct.
The import term (or import item) is a Java keyword that is used to allow the programmer to write Java code later to access a class that is not in your current directory without having to type the entire path for the compiler to find that class file on the system.
OK
Java Applet Window
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:
Swing Tutor: Items Part 1 - Mozilla Firefox
File Edit View History Bookmarks Tools Help
xxxxxx
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:
Enter the code.

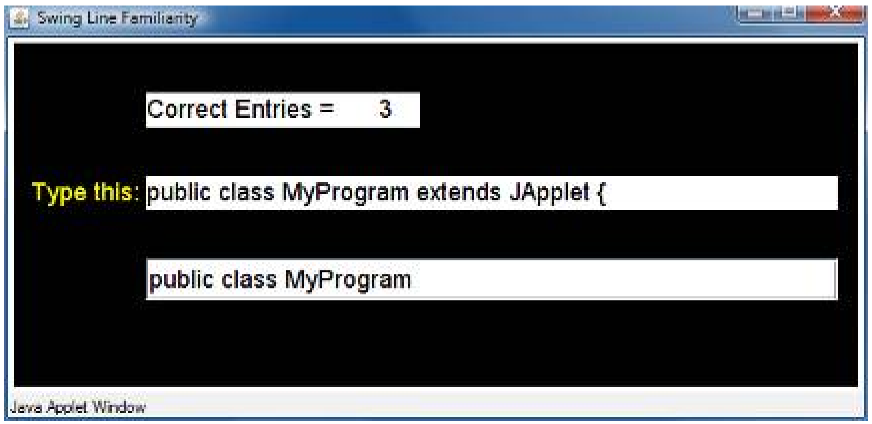

File Edit View History Bookmarks Tools Help
xxxxxx
Incorrect Input
The correct input is:
import
Try again.
OK
Java Applet Window
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:

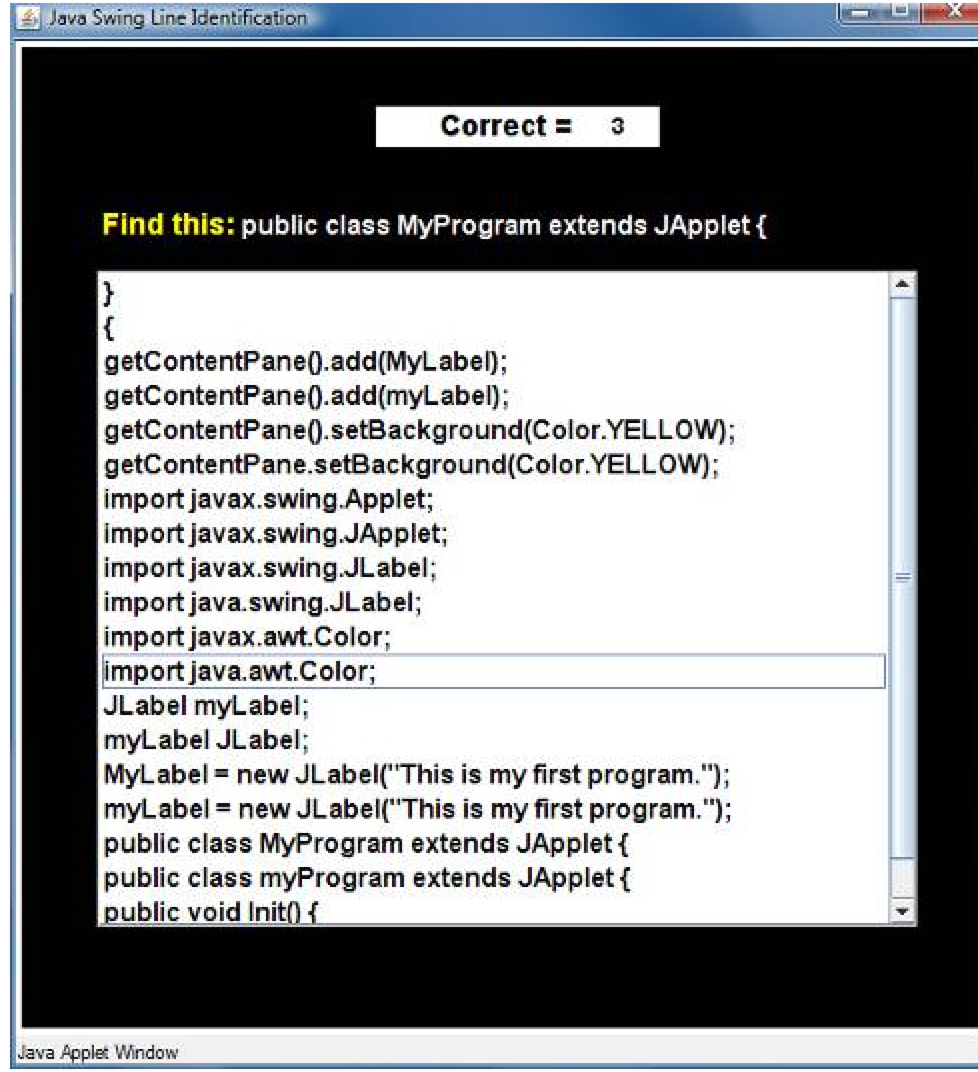

File Edit View History Bookmarks Tools Help
xxxxxx
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:
import

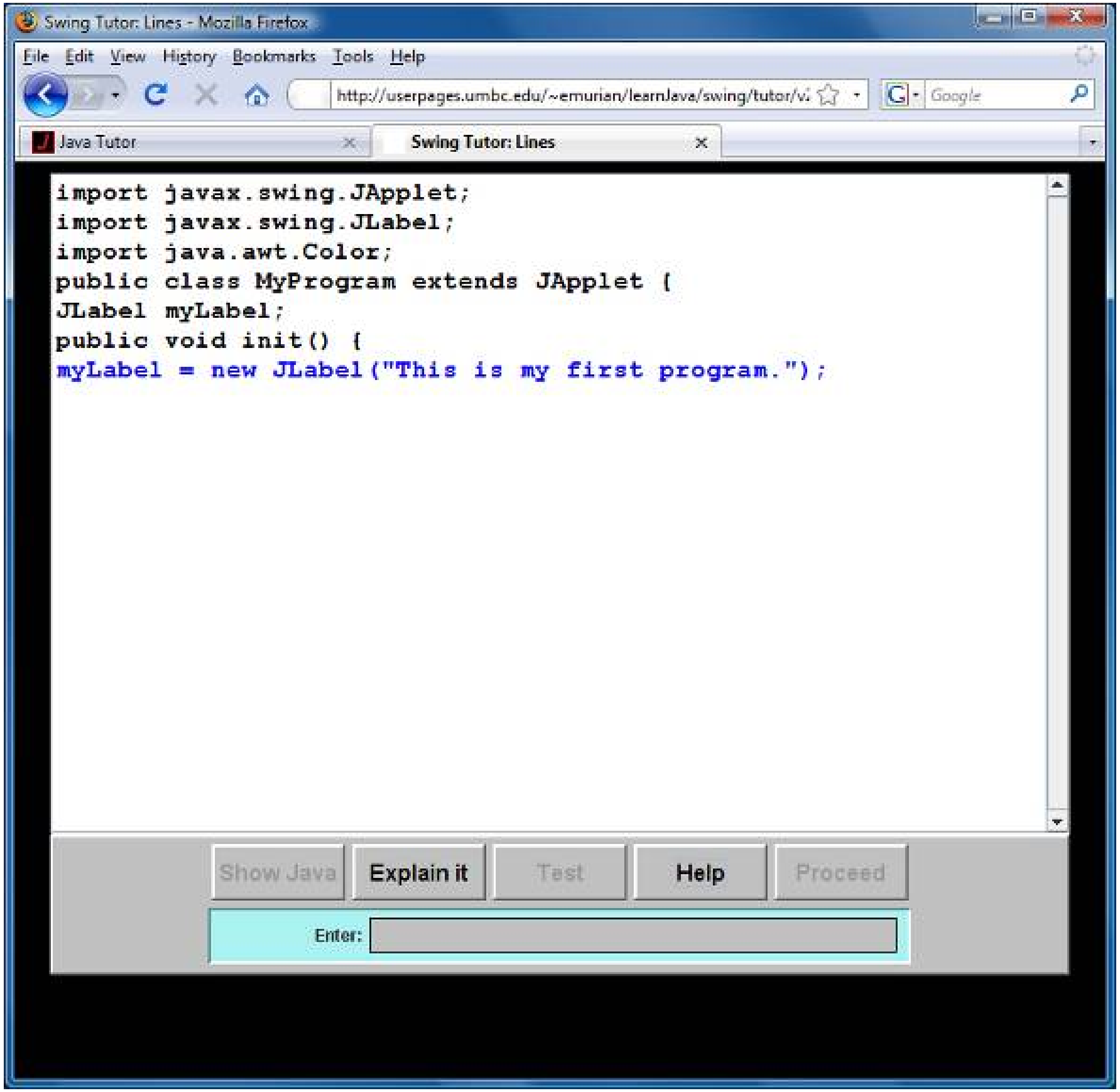

Swing Tutor: Items Part 1 - Mozilla Firefox
File Edit View History Bookmarks Tools Help
import
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:

- **method**
  - add(myLabel)
  - getContentPane()
  - init()
  - setBackground(Color.YELLOW)
- **Constructor method**
  - JLabel("This is my first Program.")
- **class**
  - MyProgram
  - JLabel
  - JApplet
  - Color
- **separator**
  - .
  - ;
  - {
  - }
- **keyword**
  - class
  - import
  - new
  - public
  - void
  - extends
- **assignment operator**
  - =
- **object**
  - myLabel
  - YELLOW

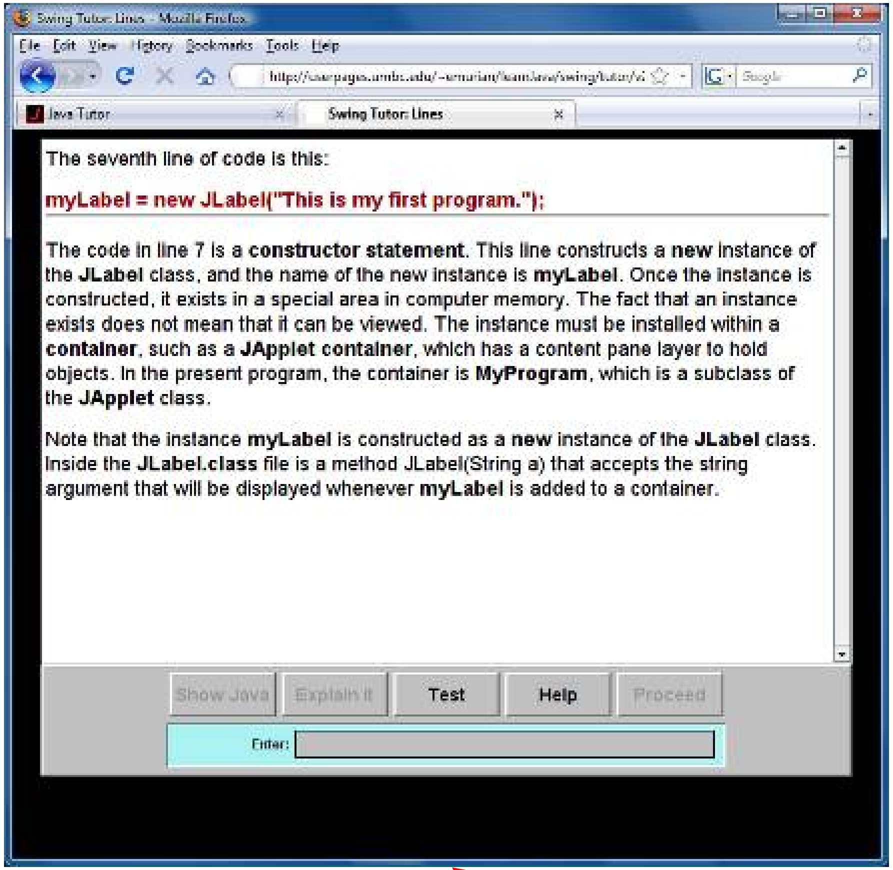
Line familiarity and identification.

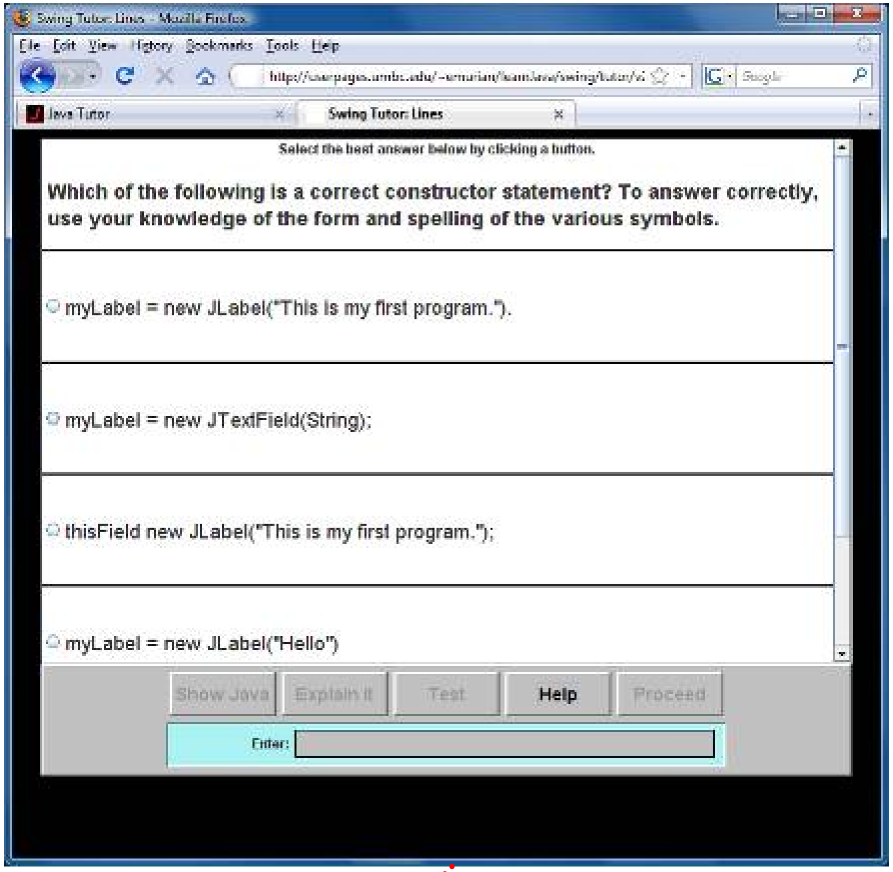





Swing Tutor: Lines - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v
Java Tutor
Swing Tutor: Lines
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel = new JLabel("This is my first program.");
Show Java
Explain it
Test
Help
Proceed
Enter:

Correct





Incorrect

Journal of Further and Higher Education
Vol. 31, No. 1, February 2007, pp. 53–64

Routledge

E-assessment by design: using multiple-choice tests to good effect

David Nicol*
University of Strathclyde, UK

Over the last decade, larger student numbers, reduced resources and increasing use of new technologies have led to the increased use of multiple-choice questions (MCQs) as a method of assessment in higher education courses. This paper identifies some limitations associated with MCQs from a pedagogical standpoint. It then provides an assessment framework and a set of feedback principles that, if implemented, would support the development of learner self-regulation. The different uses of MCQs are then mapped out in relation to this framework using case studies of assessment practice drawn from published research. This analysis shows the different ways in which MCQs can be used to support the development of learner self-regulation. The framework and principles are offered as a way of helping teachers design the use of MCQs in their courses and of evaluating their effectiveness in supporting the development of learner autonomy. A key message from this analysis is that the power of MCQs (to enhance learning) is not increased merely by better test construction. Power is also achieved by manipulating the context within which these tests are used.

Psychonomic Bulletin & Review
2007, 14 (2), 194-199

The memorial consequences of multiple-choice testing

Elizabeth J. Marsh
Duke University, Durham, North Carolina

Henry L. Roediger III
Washington University, St. Louis, Missouri

and

Robert A. Bjork and Elizabeth L. Bjork
University of California, Los Angeles, California

The present article addresses whether multiple-choice tests may change knowledge even as they attempt to measure it. Overall, taking a multiple-choice test boosts performance on later tests, as compared with non-tested control conditions. This benefit is not limited to simple definitional questions, but holds true for SAT II questions and for items designed to tap concepts at a higher level in Bloom's (1956) taxonomy of educational objectives. Students, however, can also learn false facts from multiple-choice tests; testing leads to persistence of some multiple-choice lures on later general knowledge tests. Such persistence appears due to faulty reasoning rather than to an increase in the familiarity of lures. Even though students may learn false facts from multiple-choice tests, the positive effects of testing outweigh this cost.

2007

Perspectives on Psychological Science

The Power of Testing Memory

Basic Research and Implications for Educational Practice

Henry L. Roediger, III, and Jeffrey D. Karpicke
Washington University in St. Louis

Psychological Science

Research Article

Test-Enhanced Learning

Taking Memory Tests Improves Long-Term Retention

Henry L. Roediger, III, and Jeffrey D. Karpicke
Washington University in St. Louis

2006

2008

PERSPECTIVES ON PSYCHOLOGICAL SCIENCE

Styles of Learning and Thinking Matter in Instruction and Assessment

Robert J. Sternberg,[1] Elena L. Grigorenko,[2] and Li-fang Zhang[3]

[1]Tufts University, [2]Yale University, and [3]University of Hong Kong

ABSTRACT—*There are two styles of learning and thinking: ability based and personality based. The former are assessed by maximum-performance tests, and the latter are assessed by typical-performance tests. We argue that both kinds of styles matter for instruction and assessment in school. In particular, shaping lessons based on an awareness that people learn and think in different ways can lead to improved instructional outcomes. We describe one ability-based theory and one personality-based theory and present supporting data from multiple studies relevant to each.*

People learn and think in different ways. That statement at first seems obvious. For example, two students whose knowledge and understanding of the material learned in school are identical may nevertheless manifest their achievements differently. One may do better on a multiple-choice test measuring memory of facts, the other may do better on an essay test that encourages creative use of the material that has been learned. This may be a result of skill-based differences between the two students taking the two different kinds of tests, preference-based differences for the two kinds of tests, or both.

The thesis of this article is that there are both ability-based and personality-based styles that matter for instruction and assessment. Taking these styles into account can improve instruction and assessment. Not taking them into account prevents students from capitalizing on strengths and/or compensating for or correcting weaknesses and thus is suboptimal.

In this article, we discuss styles as a basis for understanding individual differences in how people learn and think. First, we define what styles are. Then we describe how styles apply to two theories (Sternberg, 1997a, 1997b) and draw our conclusions.

DEFINING STYLES

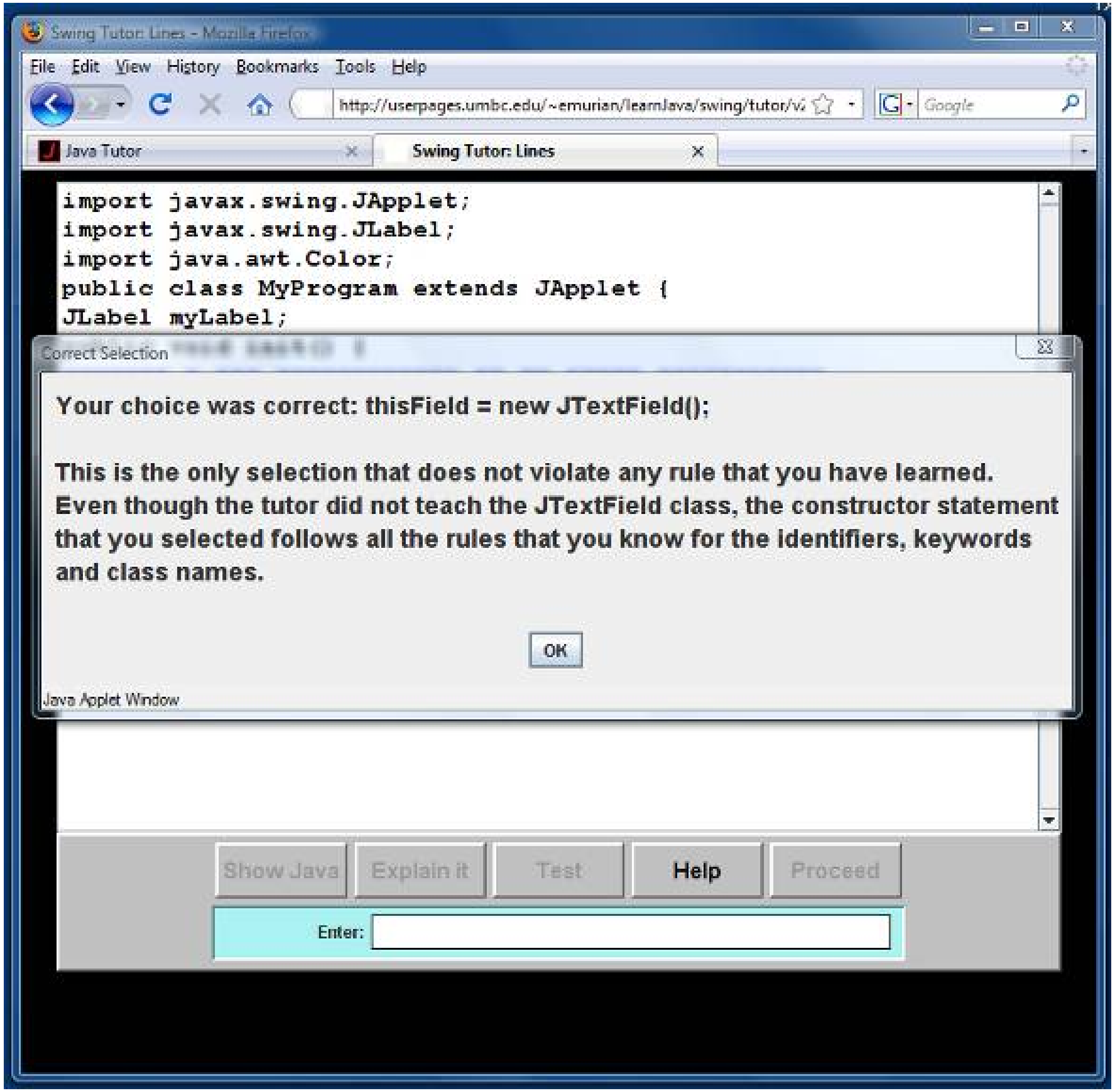
We define styles here as individual differences in approaches to tasks that can make a difference in the way in which and, potentially, in the efficacy with which a person perceives, learns, or thinks. We limit our definition of styles to those that matter for cognition because, in our view, that was the original intention of the "cognitive styles movement"—identifying styles of processing information that are consequential for cognition (e.g., Gregorc, 1979, 1985; Kagan, Rosman, Day, Albert, & Philips, 1964; Kirton, 1976; Kogan, 1973; Marton, 1976; Marton & Booth, 1997; Witkin, Dyk, Faterson, Goodenough, & Karp, 1962).

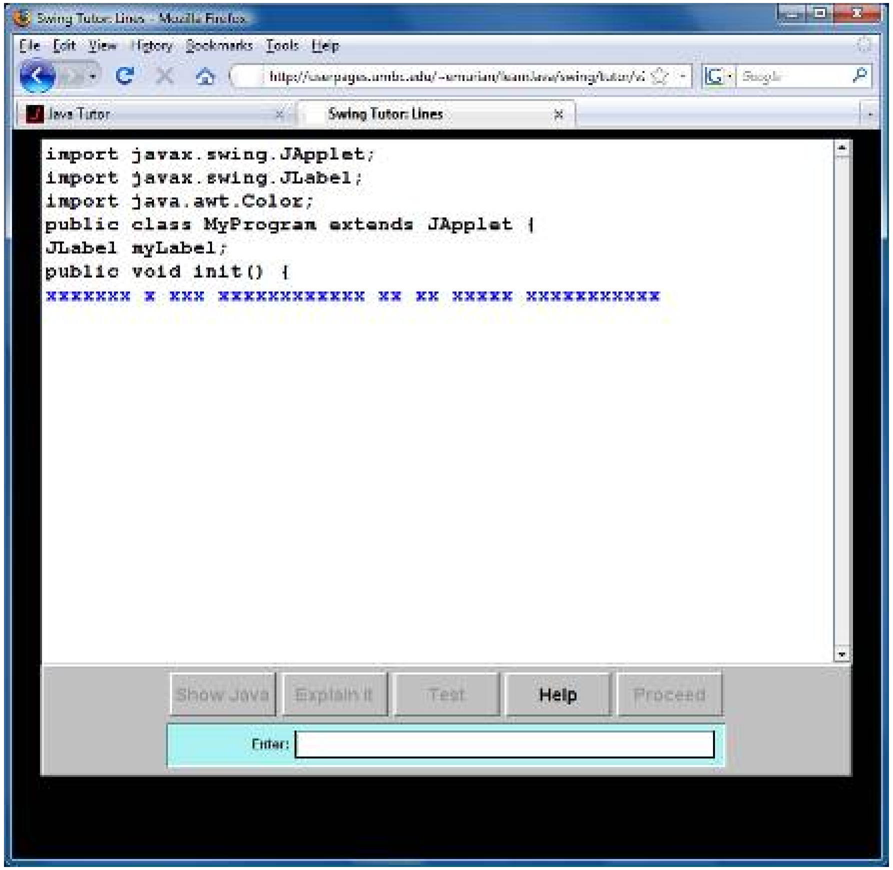
The styles literature focuses on two specific aspects, sometimes referred to as "ability-based" and "personality-based" theories of styles (Sternberg, 1997b; Zhang & Sternberg, 2005, 2006).[1] Styles also may be measured by either ability-based or personality-based measures, much as emotional intelligence is measured in both ways (see Mayer, Salovey, & Caruso, 2000). As in the case of emotional intelligence, the styles measured by ability-based and personality-based assessments are not the same constructs. We label the former as ability-based styles and the latter as personality-based styles, although these terms do not totally capture the difference between them. Styles traditionally have been viewed as being at the interface between cognition and personality (Sternberg, 1997b), and it probably stands to reason that their formulation and measurement have drawn on both the cognitive and personality literatures.

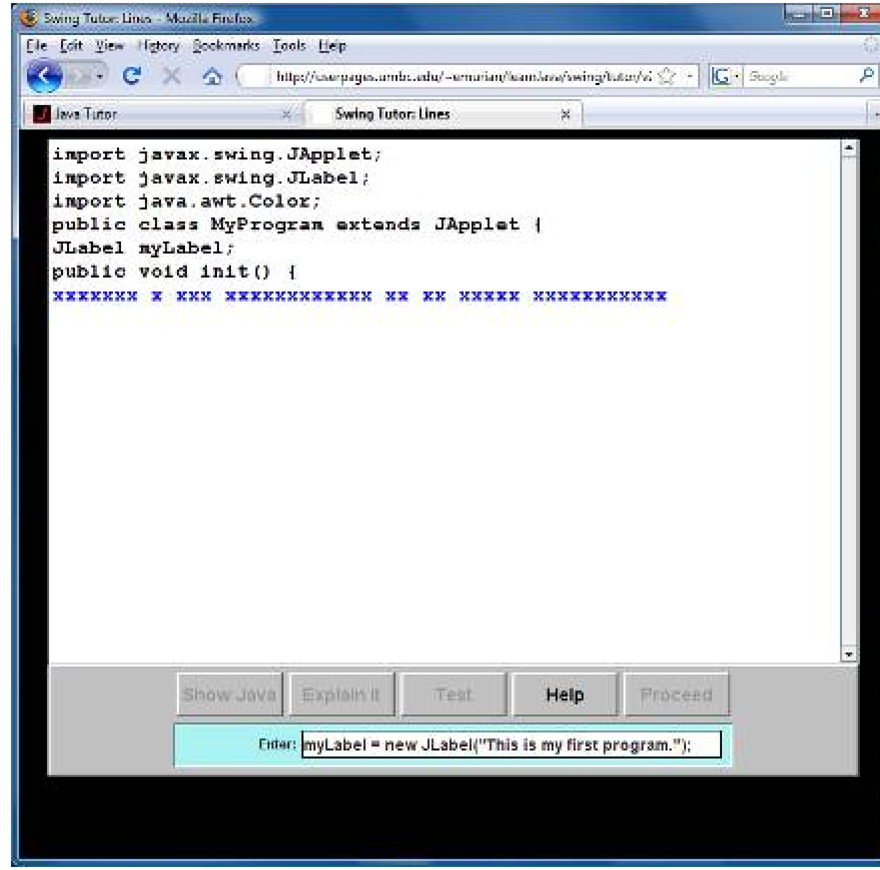
According to our definition, abilities and attributes measured by maximum-performance tests or by typical-performance tests

Address correspondence to Robert J. Sternberg, Office of the Dean of the School of Arts and Sciences, Ballou Hall, 3rd Floor, Tufts University, Medford, MA 02155; e-mail: Robert.Sternberg@tufts.edu.

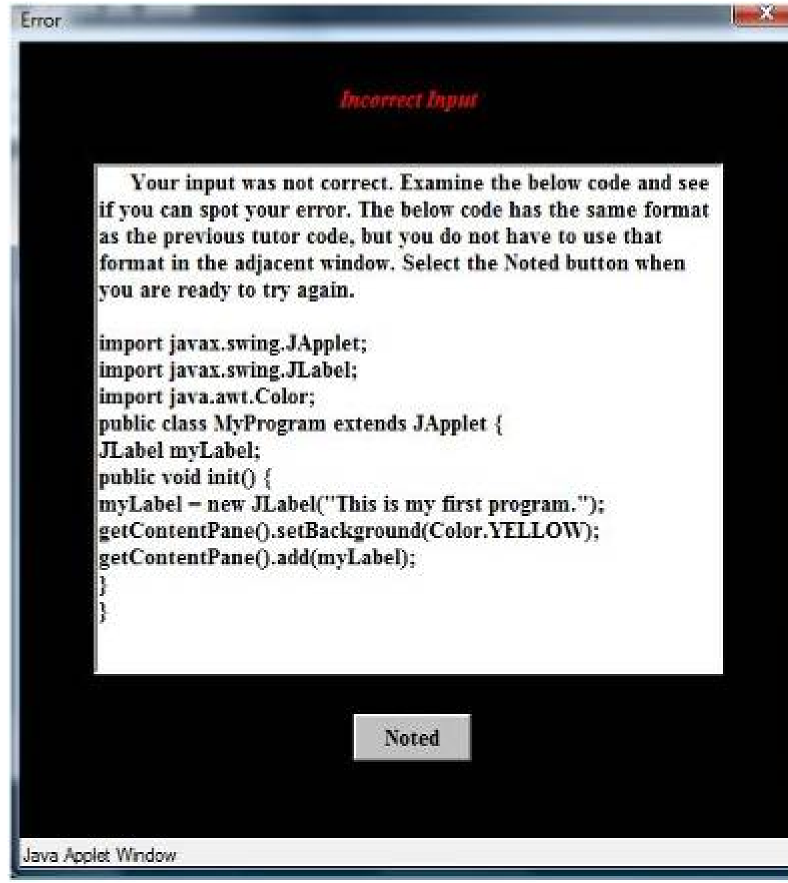
[1]In this article, we use the term *style* somewhat differently from the way we have used it in our past writings. Here, we use it to refer either to a maximum-performance ("ability-based") or typical-performance ("personality-based") difference or preference in learning or thinking that can lead to differential outcomes in instruction and assessment.

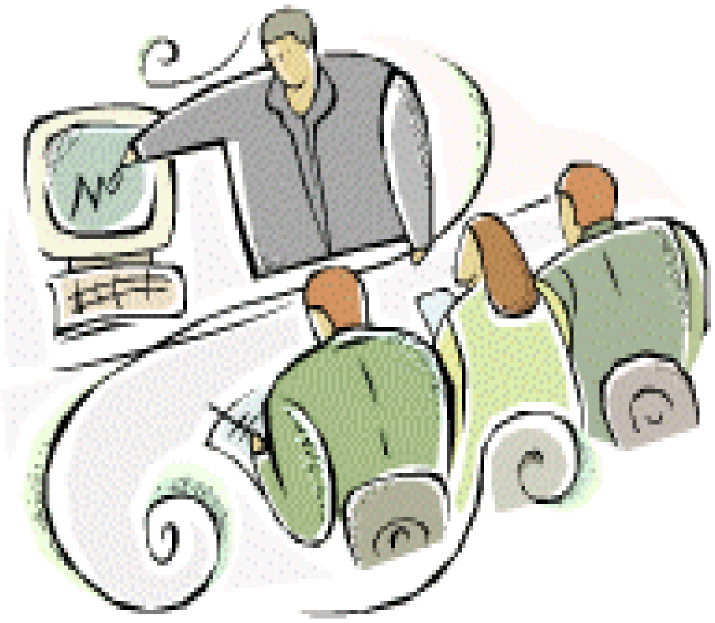

Swing Tutor: Lines - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v
Java Tutor
Swing Tutor: Lines
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
Correct Selection
Your choice was correct: thisField = new JTextField();
This is the only selection that does not violate any rule that you have learned. Even though the tutor did not teach the JTextField class, the constructor statement that you selected follows all the rules that you know for the identifiers, keywords and class names.
OK
Java Applet Window
Show Java
Explain it
Test
Help
Proceed
Enter:


Swing Tutor: Lines - Mozilla Firefox
File Edit View History Bookmarks Tools Help
Java Tutor
Swing Tutor: Lines
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
******* * *** ************ ** ** ***** ***********
Show Java
Explain it
Test
Help
Proceed
Enter:

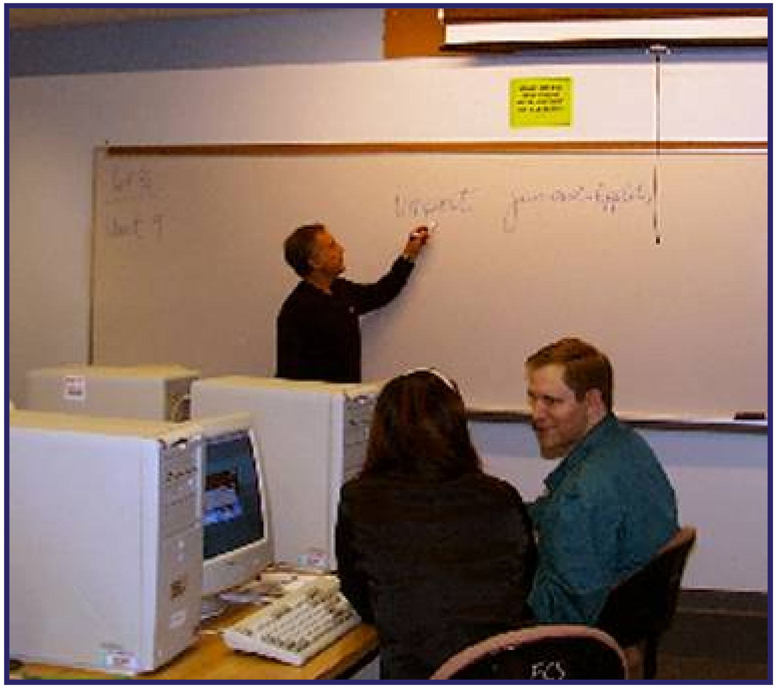

Swing Tutor: Lines - Mozilla Firefox
File Edit View History Bookmarks Tools Help
Java Tutor
Swing Tutor: Lines
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
******* * *** ************ ** ** ***** ***********
Show Java
Explain it
Test
Help
Proceed
Enter: myLabel = new JLabel("This is my first program.");


Enter the Java Program
Type the program in the white space below, and select the Submit button. Do not use the Tab key. Please do not use notes. Try to enter the program from your memory. If you can't remember the program, just select Submit, and you can see the code again.
import java.swing.JApplet;
Submit
Clear
Java Applet Window


Error
Incorrect Input
Your input was not correct. Examine the below code and see if you can spot your error. The below code has the same format as the previous tutor code, but you do not have to use that format in the adjacent window. Select the Noted button when you are ready to try again.
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel = new JLabel("This is my first program.");
getContentPane().setBackground(Color.YELLOW);
getContentPane().add(myLabel);
}
}
Noted
Java Applet Window



1. **Lecture**
   - Repeat the tutor material while students write the code
2. Run the applet on the web



1. A **mutually probing, mutually informing conversation between two people** (Boyce & Hineline, 2002)
2. The questions on a topic to be addressed by the participants during a dialogue are prepared in advance by the teacher, and the **students come prepared to interteach**
3. Has the objective of insuring, by the participants as a team, that **each member of the dyad** can answer the questions with understanding

The Behavior Analyst 2002, 25, 215–226 No. 2 (Fall)

Interteaching: A Strategy for Enhancing the User-Friendliness of Behavioral Arrangements in the College Classroom

Thomas E. Boyce
University of Nevada, Reno

Philip N. Hineline
Temple University

"Interteaching" is an arrangement for college classroom instruction that departs from the standard lecture format and offers an answer to criticisms commonly directed at behavioral teaching techniques. This approach evolved from exploratory use of small-group arrangements and Ferster and Perrott's (1968) "interview technique," leading ultimately to a format that is organized around focused dyadic discussion. Specific suggestions are offered that might enable both seasoned and novice instructors to incorporate this or similar arrangements into their classrooms. This approach retains some key characteristics of Keller's personalized system of instruction and precision teaching, but offers greater flexibility for strategies that are based on behavioral principles.

Key words: applied behavior analysis, education, instruction, interviewing, PSI, precision teaching, reciprocal peer tutoring

1968

JOURNAL OF APPLIED BEHAVIOR ANALYSIS 1968, 1, 79-89 NUMBER 1 (SPRING, 1968)

"GOOD-BYE, TEACHER . . ."[1]

FRED S. KELLER

ARIZONA STATE UNIVERSITY[2]

When I was a boy, and school "let out" for the summer, we used to celebrate our freedom from educational control by chanting:

> Good-bye scholars, good-bye school;
> Good-bye teacher, darned old fool!

We really didn't think of our teacher as deficient in judgment, or as a clown or jester. We were simply escaping from restraint, dinner pail in one hand and shoes in the other, with all the delights of summer before us. At that moment, we might even have been well-disposed toward our teacher and might have felt a touch of compassion as we completed the rhyme.

"Teacher" was usually a woman, not always young and not always pretty. She was frequently demanding and sometimes sharp of tongue, ever ready to pounce when we got out of line. But, occasionally, if one did especially well in home-work or in recitation, he could detect a flicker of approval or affection that made the hour in class worthwhile. At such times, we loved our teacher and felt that school was fun.

It was not fun enough, however, to keep me there when I grew older. Then I turned to another kind of education, in which the reinforcements were sometimes just as scarce as in the schoolroom. I became a Western Union messenger boy and, between deliveries of telegrams, I learned Morse code by memorizing dots and dashes from a sheet of paper and listening to a relay on the wall. As I look back on those days, I conclude that I am the only living reinforcement theorist who ever learned Morse code in the absence of reinforcement.

It was a long, frustrating job. It taught me that drop-out learning could be just as difficult as in-school learning and it led me to wonder about easier possible ways of mastering a skill. Years later, after returning to school and finishing my formal education, I came back to this classical learning problem, with the aim of making International Morse code less painful for beginners than American Morse had been for me (Keller, 1943).

During World War II, with the aid of a number of students and colleagues, I tried to apply the principle of immediate reinforcement to the early training of Signal Corps personnel in the reception of Morse-code signals. At the same time, I had a chance to observe, at close hand and for many months, the operation of a military training center. I learned something from both experiences, but I should have learned more. I should have seen many things that I didn't see at all, or saw very dimly.

I could have noted, for example, that instruction in such a center was highly individualized, in spite of large classes, sometimes permitting students to advance at their own speed throughout a course of study. I could have seen the clear specification of terminal skills for each course, together with the carefully graded steps leading to this end. I could have seen the demand for perfection at every level of training and for every student; the employment of classroom instructors who were little more than the successful graduates of earlier classes; the minimizing of the lecture as a teaching device and the maximizing of student participation. I could have seen, especially, an interesting division of labor in the educational process, wherein the non-commissioned, classroom teacher was restricted to duties of guiding, clarifying, demonstrating,

[1]President's Invited Address, Division 2, Amer. Psychol. Ass., Washington, D.C., Sept., 1967.

[2]Currently on leave of absence at the Institute for Behavioral Research, 2426 Linden Lane, Silver Spring, Maryland. Reprints may be obtained from the author, 5829 Park View Road, Chevy Chase, Maryland.

79

Computer Science Education
2002, Vol. 12, No. 3, pp. 197–212

0899-3408/02/1203-197$16.00
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In Support of Pair Programming in the Introductory Computer Science Course

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North Carolina State University, Raleigh, NC, USA, [1]Department of Computer Science, and [2]Department of Math, Science and Technology Education

ABSTRACT

A formal pair programming experiment was run at North Carolina to empirically assess the educational efficacy of the technique in a CS1 course. Results indicate that students who practice pair programming perform better on programming projects and are more likely to succeed by completing the class with a C or better. Student pairs are more self-sufficient which reduces their reliance on the teaching staff. Qualitatively, paired students demonstrate higher order thinking skills than students who work alone. These results are supportive of pair programming as a collaborative learning technique.

2002

J. EDUCATIONAL COMPUTING RESEARCH, Vol. 17(1) 19-46, 1997

THE PSYCHO-SOCIAL PROCESSES AND COGNITIVE EFFECTS OF PEER-BASED COLLABORATIVE INTERACTIONS WITH COMPUTERS*

JIHN-CHANG J. JEHNG
National Central University

ABSTRACT

This research project consists of two related studies involving first- and second-year university students learning to write recursive programs. The first employed a micro-structure analysis that examined the psycho-social processes underlying peer-based interactions in two different computer-based collaborative learning environments: face-to-face vs. distributed context. These processes may be viewed as knowledge building activities that occur in three key collaborative situations: communication, negotiation, and consolidation. Results of this study demonstrated the two collaborative learning environments produced two distinct psycho-social behaviors manifested by the students. In the second study, 130 students were divided into four groups, three participated in collaborative learning environments; the fourth made up a control group whose members learned in isolation from one another. All the students learned to write recursive programs for designing geometric patterns. Although results indicated the four groups of students did not show significant differences in their program evaluation and completion abilities, students who had participated in three collaborative learning environments demonstrated superior program generation abilities on the posttest compared to those who had learned to solve problems individually.

An increasing number of educational and psychological studies are focusing on forms of peer-based interactions with computers [1-6]. Approaches for peer-based interactions with computers differ little from those for any other peer-based group

*This research project was supported by a grant from the National Science Council, Taiwan, under the contract NSC83-0111OS-032-004. The author is grateful to Dr. Tak-Wai Chan for his assistance with part of this research.

1997

2009

MIS Quarterly

RESEARCH ARTICLE

ARE TWO HEADS BETTER THAN ONE FOR SOFTWARE DEVELOPMENT? THE PRODUCTIVITY PARADOX OF PAIR PROGRAMMING[1]

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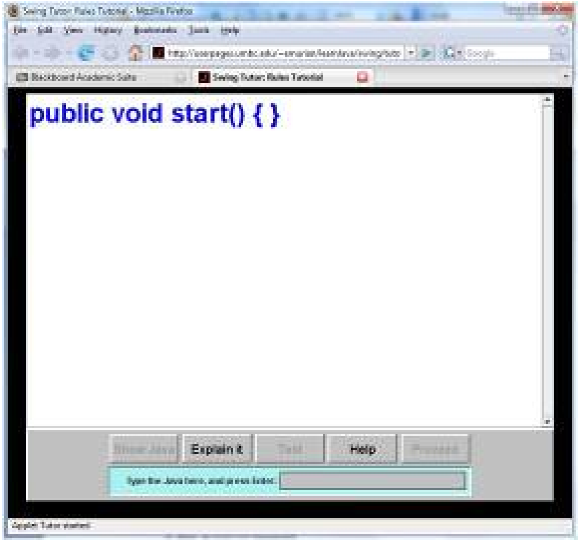
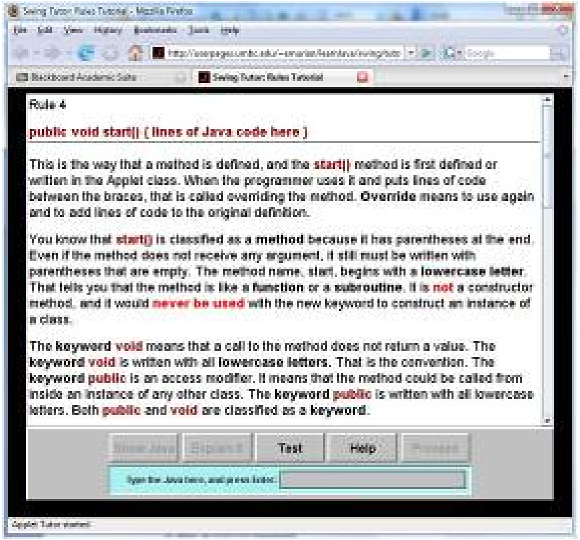
Abstract

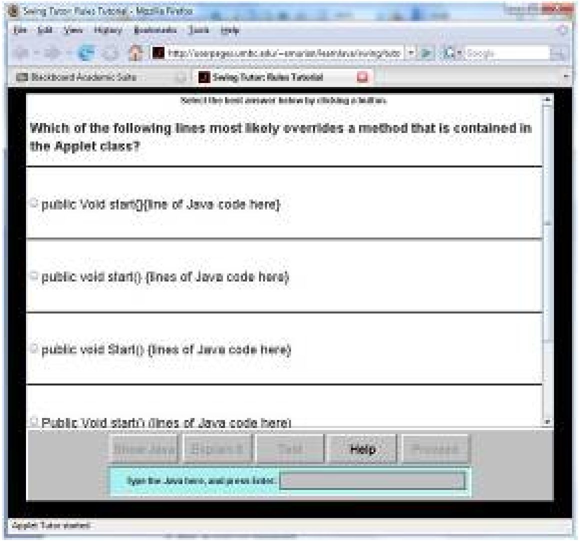
Extreme programming is currently gaining popularity as an alternate software development methodology. Pair programming, a core practice of this methodology, involves two programmers working collaboratively to develop software. This study examined the efficacy of pair programming by comparing the performance effectiveness and affective responses of collaborating pairs with those of individual programmers treated as nominal pairs. In a controlled laboratory experiment involving student subjects, proxies for entry level programmers working on entry level tasks, two factors were manipulated: programming setting (collaborative pair versus individuals) and programming task complexity (high versus low). Participants who worked in the individual condition were randomly combined into nominal pairs. The performance and affective responses of the collaborating pairs were then compared with those of the best performers and the second best performers of each nominal pair. Results indicated that programming pairs performed at the level above the second best performers and at the level of the best performers in each nominal pair. This relationship was found to be consistent across both levels of task complexity. Consequently, there was no evidence of an "assembly bonus effect," where the performance of a collaborating pair exceeds the performance of its best member working alone. While this finding may appear counterintuitive due to the general perception of two heads being better than one, it is consistent with the findings in small group research. When affective responses were considered, programming pairs reported higher levels of satisfaction than those of the best and second-best performing members in nominal pairs. They also showed higher levels of confidence in their performance

[1] Carol Saunders was the accepting senior editor for this paper.

MIS Quarterly Vol. 33 No. 1, pp. 91-118/March 2009 91







http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/rules/Tutor.html

Table 2: An example of a rule test question across the two types of assessments. The underlying principle required to solve the problem is identical, and the principle was emphasized in the brief rule tutorial.

Pre-Tutor, Post-Tutor, and Quiz	Brief Rule Tutorial and Interteaching

Which of the following lines would most likely add a JScrollPane object to a JPanel object?
a. JPanel.add(JScrollPane);
b. JPanel.add(myJScrollPane);
c. myJPanel.add(JScrollPane);
d. JScrollPane.add(JPanelObject);
e. myJPanel2.add(myJScrollPane1);
	Which of the following lines would most likely add a JList object to a JPanel object?
	
	a. myBigJPanel5.add(JList);
	b. myBigJPanel5.add(myLittleJList1);
	c. JPanel.add(myLittleJList1);
	d. JList.add(JPanelObject);
	e. JPanel.add(JList);

IT-1 Preparation Guide 1

Interteaching is a Collaboration Session with Two Students Participating

Interteaching Objectives

Before the next class meets, you must complete the brief Rules Tutorial for credit (20 points). The tutorial may take 30 minutes to complete. You may repeat the tutorial as often as you want. The link to the Rules Tutorial is given in the Assignments folder on the course Bb site.

The below questions may appear on the next quiz. The questions embedded in the Java tutor are also eligible to appear on the next quiz.

You should understand the components of the below program at a level given in the Java Tutor. Also read the material posted in Unit 1 and Unit 2 (1-4) of the online course material.

You should prepare for the interteaching session to discuss these components with the intention to understand the specific item and any general principle that is reflected in an item or collection of items. An example of a general principle would be to begin the name of a class with a capital letter.

```
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel = new JLabel("This is my first program.");
getContentPane().setBackground(Color.YELLOW);
getContentPane().add(myLabel);
}
}
```

IT-1 Preparation Guide 2

You should be able to answer the following questions:

1. What is a class?
2. What is a statement? Give an example.
3. What is a separator? Give an example.
4. What is an operator? Give an example.
5. What is a keyword? Give an example.
6. What is an identifier?
7. What does it mean that methods may be inherited from a superclass?
8. What is the meaning of override?
9. How can you identify a series of characters as the name of a method?
10. What is a constructor method? What properties of the syntax make it a constructor method?
11. Describe the position and functions of the terms in a statement that uses a method to change a property of an object.

During the interteaching session, you may have access to the explanations of items that were presented in the tutor:

http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/explanations/Explanations.html

You also may have access to the explanations of the rules in the brief tutorial:

http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/rules/explanations/

http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/explanations/Explanations.html

http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/rules/explanations/

Interteaching Report #1

Date:
Your name:
Your partner's name:
If you have questions about the below material during your discussion, post them in the Discussion Board area.

Interteaching Objectives

The below questions may appear on the next quiz. The questions embedded in the Java tutor are also eligible to appear on the next quiz.

You should understand the components of the below program at a level given in the Java Tutor.

Discuss the program with your partner with the intention to understand the specific item and any general principle that is reflected in an item or collection of items. An example of a general principle would be to begin the name of a class with a capital letter.

```
import javax.swing.JApplet;
import javax.swing.JLabel;
import java.awt.Color;
public class MyProgram extends JApplet {
JLabel myLabel;
public void init() {
myLabel = new JLabel("This is my first program.");
getContentPane().setBackground(Color.YELLOW);
getContentPane().add(myLabel);
}
}
```

You should be able to answer the following questions:

1. What is a class?
2. What is a statement? Give an example.
3. What is a separator? Give an example.
4. What is an operator? Give an example.
5. What is a keyword? Give an example.
6. What is an identifier?
7. What does it mean that methods may be inherited from a superclass?
8. What is the meaning of override?
9. How can you identify a series of characters as the name of a method?
10. What is a constructor method? What properties of the syntax make it a constructor method?
11. Describe the position and functions of the terms in a statement that uses a method to change a property of an object.

During the interteaching, you may use the explanations of items and rules that were presented in the tutors:

http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/explanations/Explanations.html

http://userpages.umbc.edu/~emurian/learnJava/swing/tutor/v2/rules/vii/explanations/

You may discuss the below questions with your partner during the interteaching discussion. The multiple-choice questions are eligible to appear on the next quiz. Your answers here do not have to be the same for each partner, in case you disagree.

Please circle the correct answer for the below multiple-choice questions. Circle the best choice that you can at this point in your learning.

1. Which of the following lines most likely would be used to create a shorthand notation for the compiler to locate the JFrame class, which is built-in to Java?

   a. import ../class/JFrame;
   b. access JFrame.class;
   c. import java.awt.JFrame.class;
   d. append javax.swing.JFrame;
   e. import javax.swing.JFrame;

How confident are you that you selected the correct answer?
Not at all confident 1 2 3 4 5 6 7 8 9 10 Totally confident

2. Which one of the following lines most likely would be used to create a shorthand notation for the compiler to locate the JScrollPane class, which is built-in to Java?

   a. import ../class/JScrollPane;
   b. import javax.swing.JScrollPane;
   c. access JScrollPane.class;
   d. import java.awt.JScrollPane;
   e. append javax.swing.JScrollPane;

How confident are you that you selected the correct answer?
Not at all confident 1 2 3 4 5 6 7 8 9 10 Totally confident

3. Which of the following lines most likely would be used to add a JCheckBox object to a content pane?

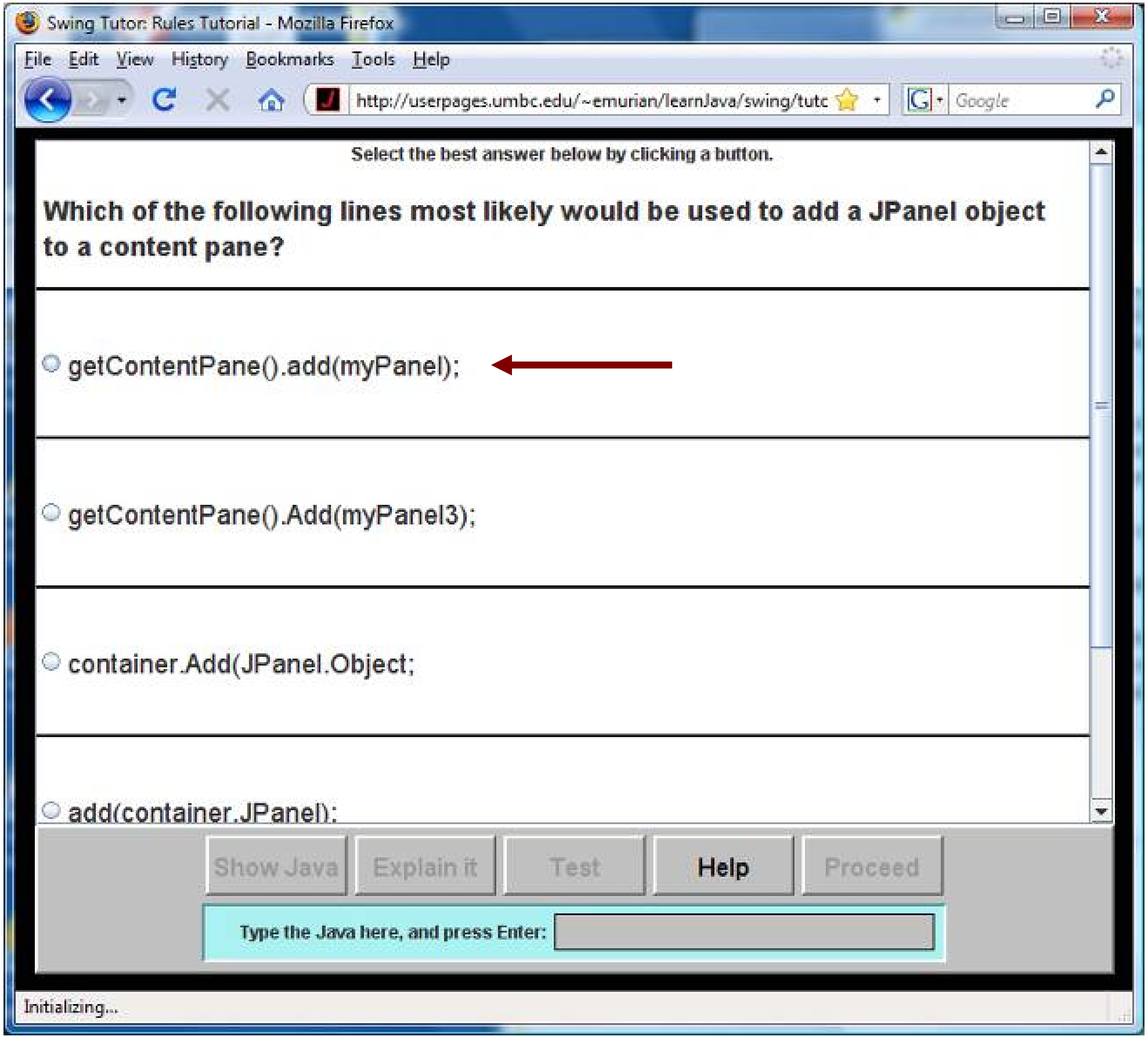
   a. getContentPane.Add(myJCheckBox);
   b. container.Add(JCheckBox.Object);
   c. add(container.JCheckBox);
   d. getContentPane().add(myBox);
   e. Add(myJCheckBox);

Enter a letter here:

How confident are you that you selected the correct answer?

Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

Enter a number here:


Swing Tutor: Rules Tutorial - Mozilla Firefox
File Edit View History Bookmarks Tools Help
http://userpages.umbc.edu/~emurian/learnJava/swing/tutc
Google
Select the best answer below by clicking a button.
Which of the following lines most likely would be used to add a JPanel object to a content pane?
getContentPane().add(myPanel);
getContentPane().Add(myPanel3);
container.Add(JPanel.Object;
add(container.JPanel);
Show Java
Explain it
Test
Help
Proceed
Type the Java here, and press Enter:
Initializing...

Answer at the end of the session.
How effective was this interteaching session in helping you to learn the material?

1 = Not at all effective. The session did not contribute to my learning of the material.
10 = Totally effective. The session contributed to my learning of the material.

(Not effective) **1 2 3 4 5 6 7 8 9 10** (Totally effective)

Enter one number that describes the effectiveness for you: ____.

Answer at the end of the session.
How confident are you that you could answer all questions correctly if you were tested on this program right now?

1 = Not at all confident. I could not answer any question correctly.
10 = Totally confident. I could answer all the questions correctly.

(Not confident) **1 2 3 4 5 6 7 8 9 10** (Totally confident)

Enter one number that describes your confidence: _____.

Software Self-Efficacy Ratings: 23 Items

Question 4

How confident are you that you can use the following symbol now to write a Java program?

JApplet

Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

Enter a number here:

Question 5

How confident are you that you can use the following symbol now to write a Java program?

JLabel

Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

Enter a number here:

Question 6

How confident are you that you can use the following symbol now to write a Java program?

MyProgram

Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

Enter a number here:

Interteachers in Action

Interteachers in Action

At M.I.T., Large Lectures Are Going the Way of the Blackboard

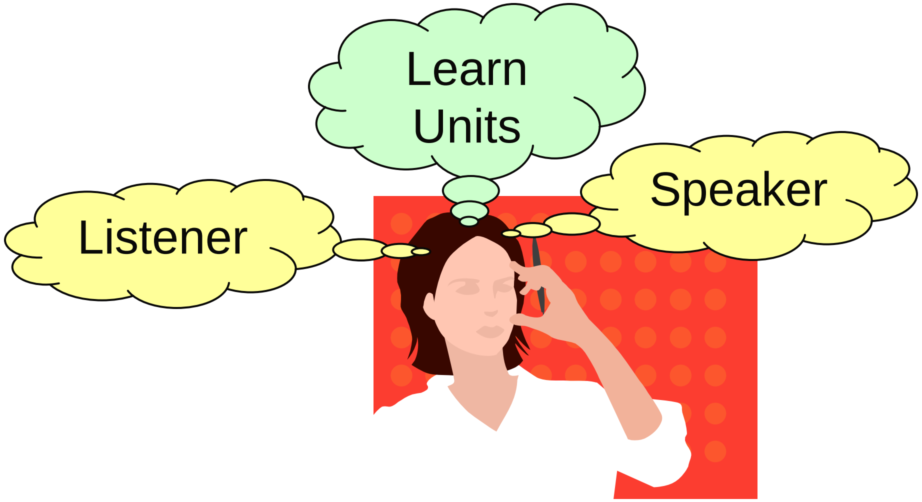
The Massachusetts Institute of Technology has changed the way it offers some introductory classes. Prof. Gabriella Sciolla at a class on electricity and magnetism.

By SARA RIMER

Published: January 12, 2009

http://www.nytimes.com/2009/01/13/us/13physics.html?_r=1&em#

Equivalence Relations



Procedure

- **Fall 2007 (2.5 hr Class)**
  - **Class 1**
    - Pre-Tutor Questionnaires
    - **Programmed Instruction Tutor**
    - Post-Tutor Questionnaires
  - **Homework**
    - Prepare for Interteaching
  - **Class 2**
    - **Lecture**
    - **Interteaching**
      - Questionnaires
  - **Class 3**
    - **Quiz**
      - Includes Rule Test Questions from the Questionnaires

- **Spring 2008 (2.5 hr Class)**
  - **Class 1**
    - Pre-Tutor Questionnaires
    - **Programmed Instruction Tutor**
    - Post-Tutor Questionnaires
  - **Homework**
    - **Brief Rule Tutor**
    - Prepare for Interteaching
  - **Class 2**
    - **Lecture**
    - **Interteaching**
      - Questionnaires (Brief Tutor)
  - **Class 3**
    - **Quiz**
      - Includes Rule Test Questions from the Class 1 Questionnaires

http://userpages.umbc.edu/~emurian/2008study/

Fall 2007

15 M (Mean age = 23.5, range = 20 – 30.

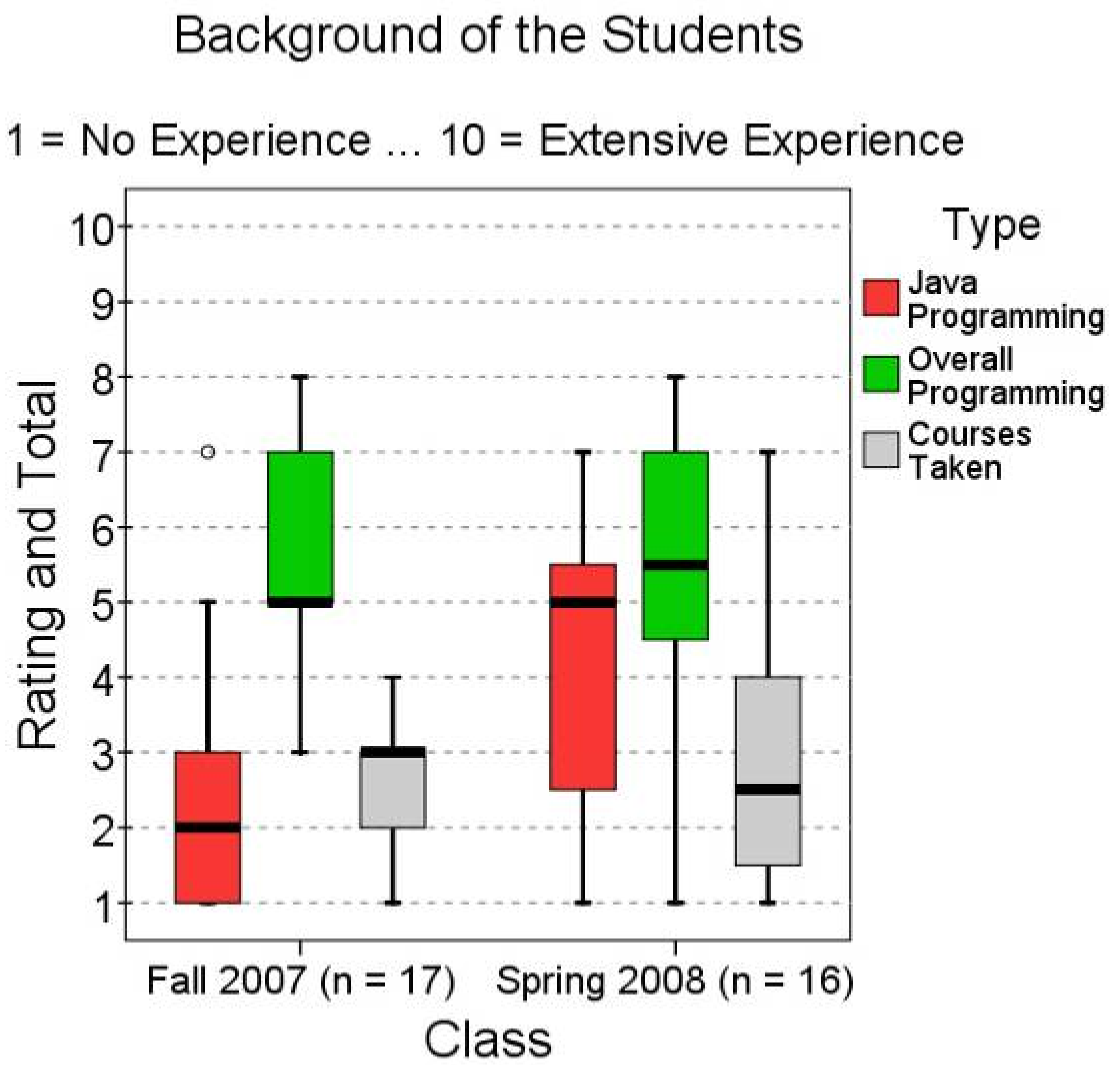
2 F (Mean age = 21.5, range = 21 – 22.

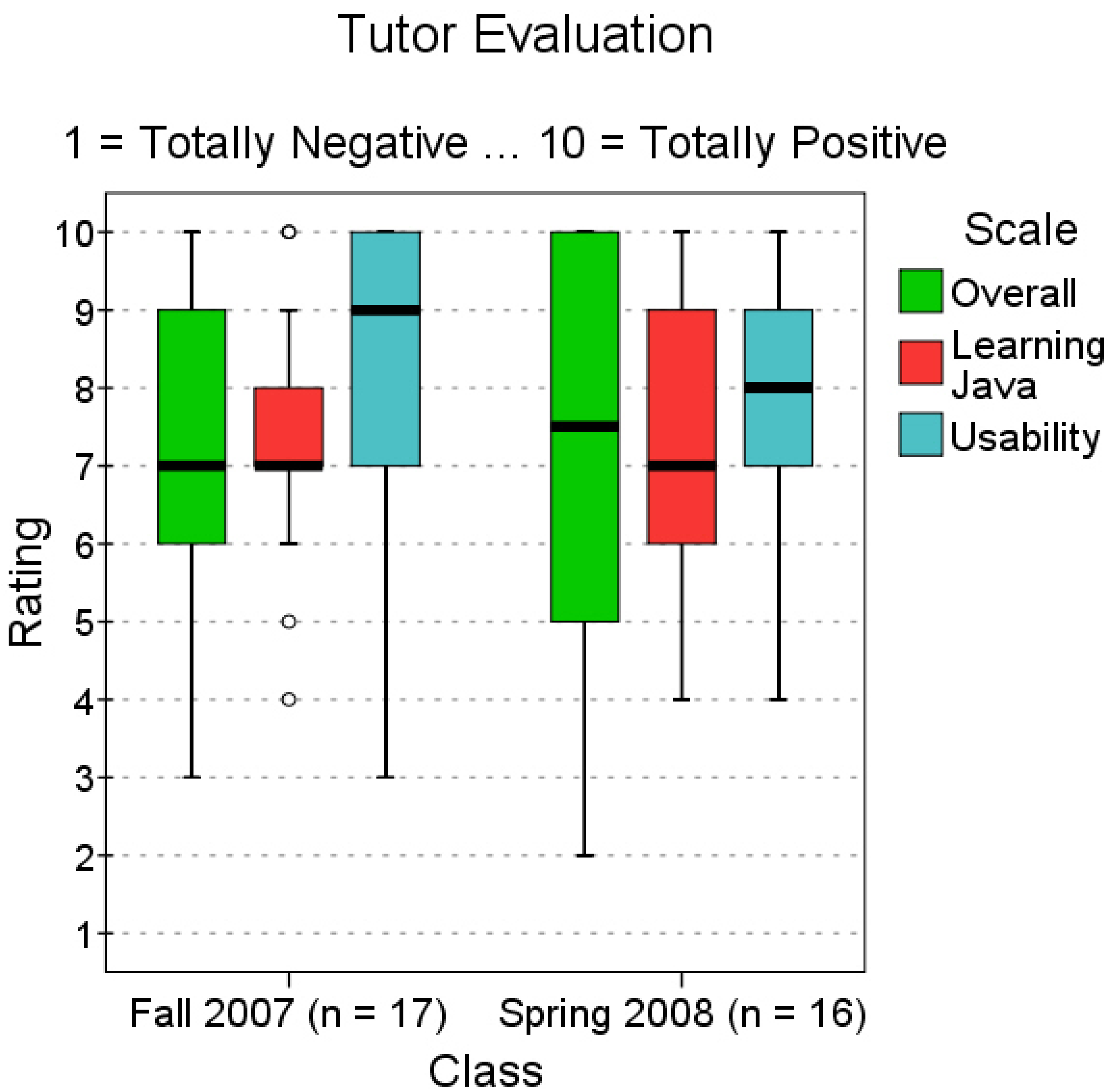
Spring 2008

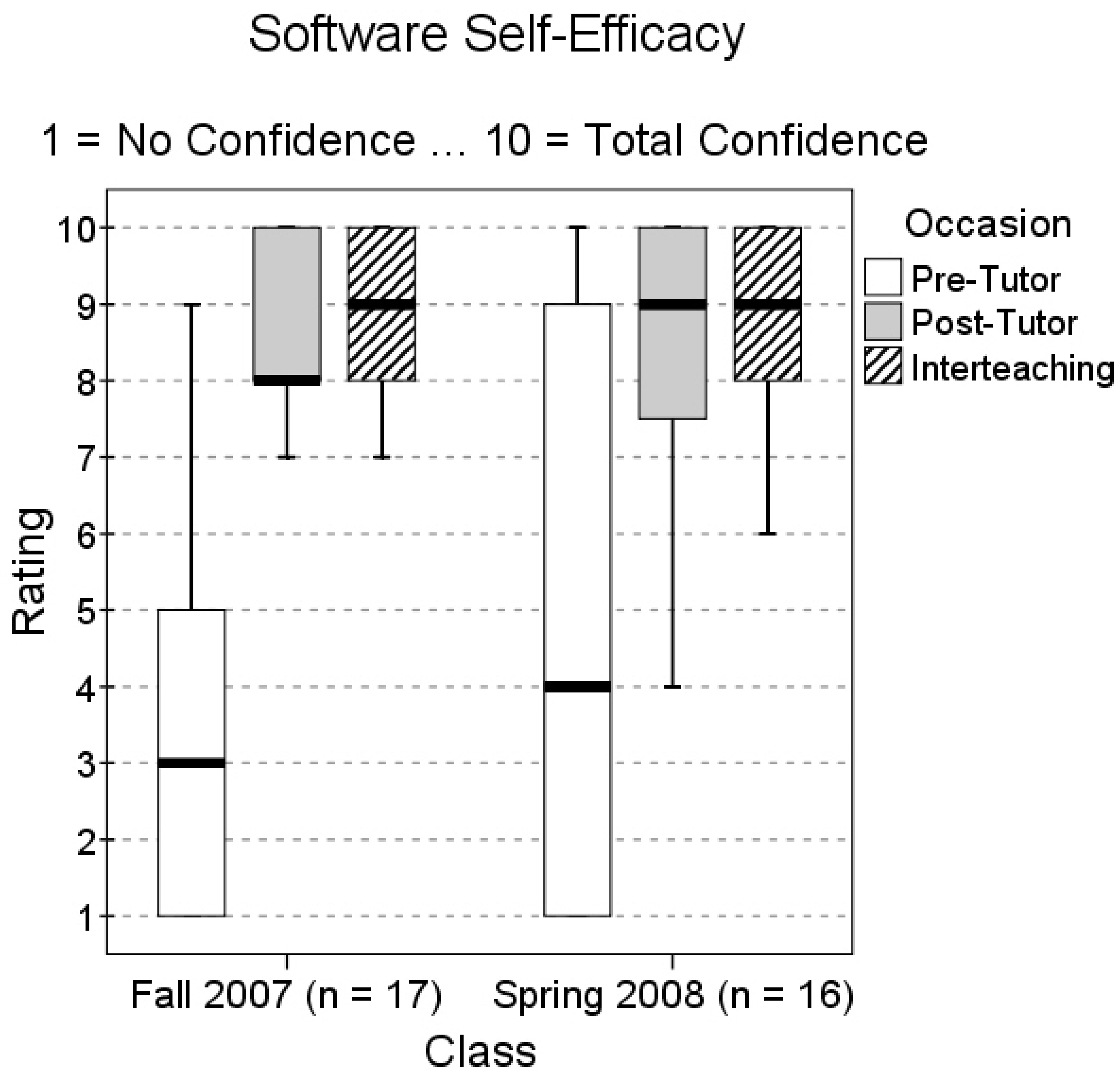
12 M (Mean age = 22.3, range = 18 – 27.

4 F (Mean age = 20, range = 19 – 21.

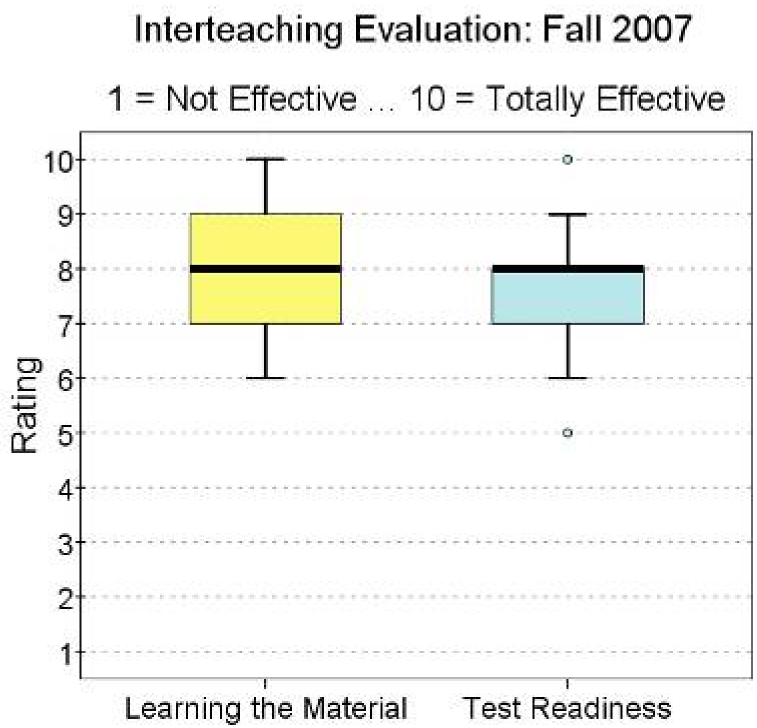
A Mann Whitney U test was marginally significant for reported **Java programming experience** between the two classes (Z = -1.933, p = 0.053).

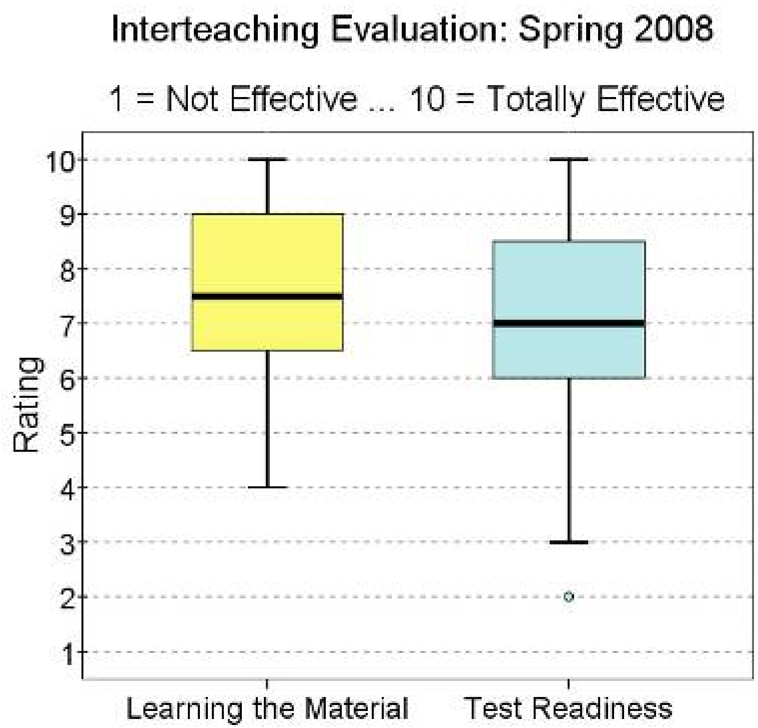



Tutor Evaluation
1 = Totally Negative … 10 = Totally Positive
Rating
10
9
8
7
6
5
4
3
2
1
Fall 2007 (n = 17)
Spring 2008 (n = 16)
Class
Scale
Overall
Learning Java
Usability

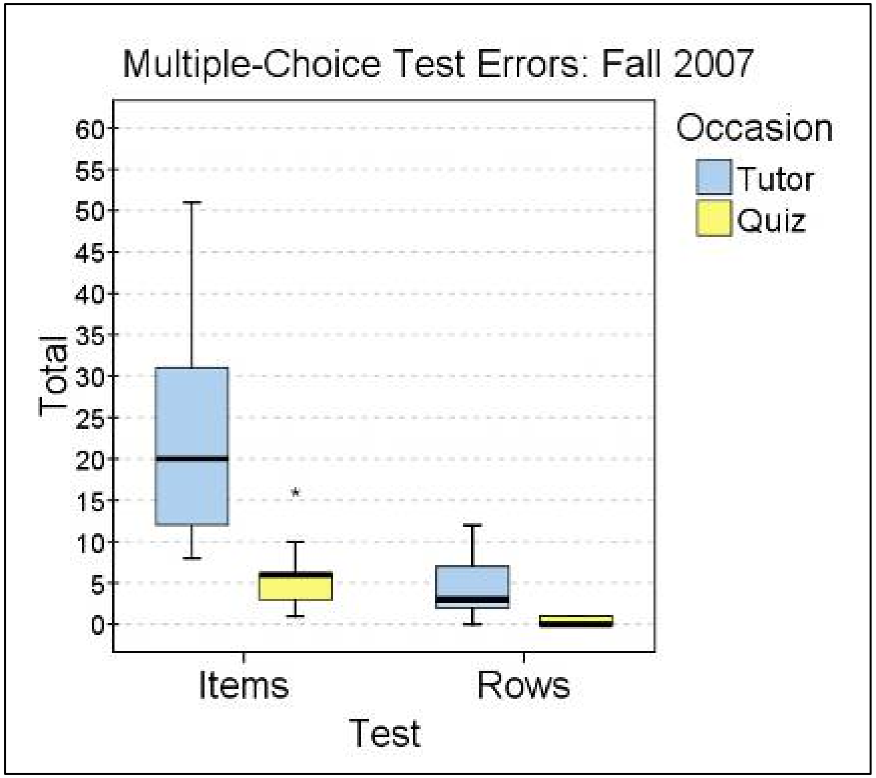

Software Self-Efficacy
1 = No Confidence ... 10 = Total Confidence
Rating
10
9
8
7
6
5
4
3
2
1
Occasion
Pre-Tutor
Post-Tutor
Interteaching
Fall 2007 (n = 17)
Spring 2008 (n = 16)
Class

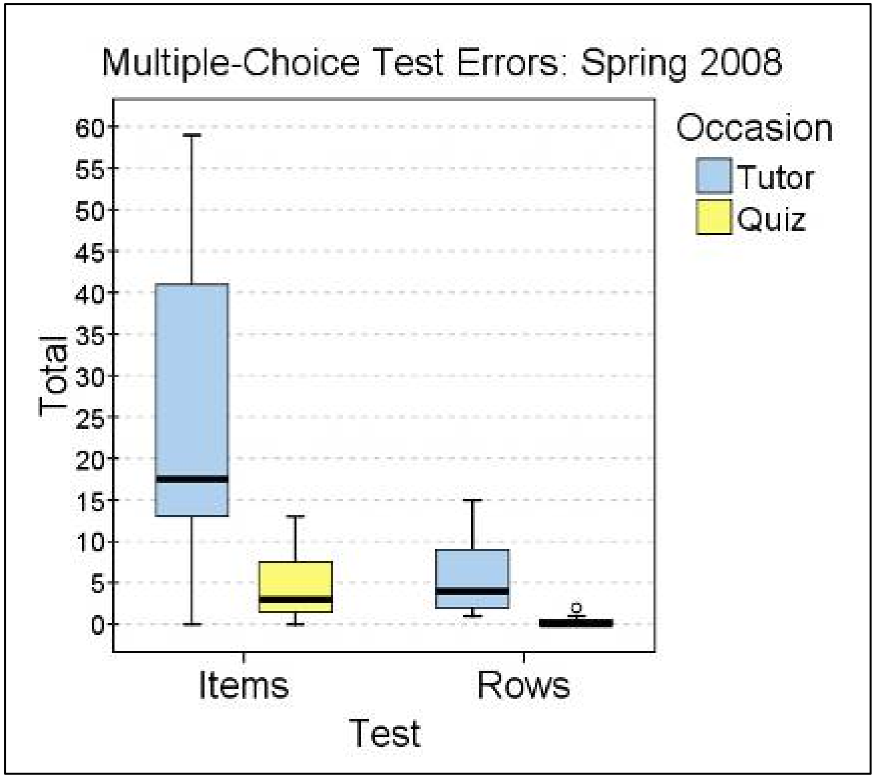
Interteaching Evaluation





Multiple-Choice Test Errors: Tutor → Quiz





Items: r = 0.551, p = 0.022

Rows: r = 0.039, p = 0.881

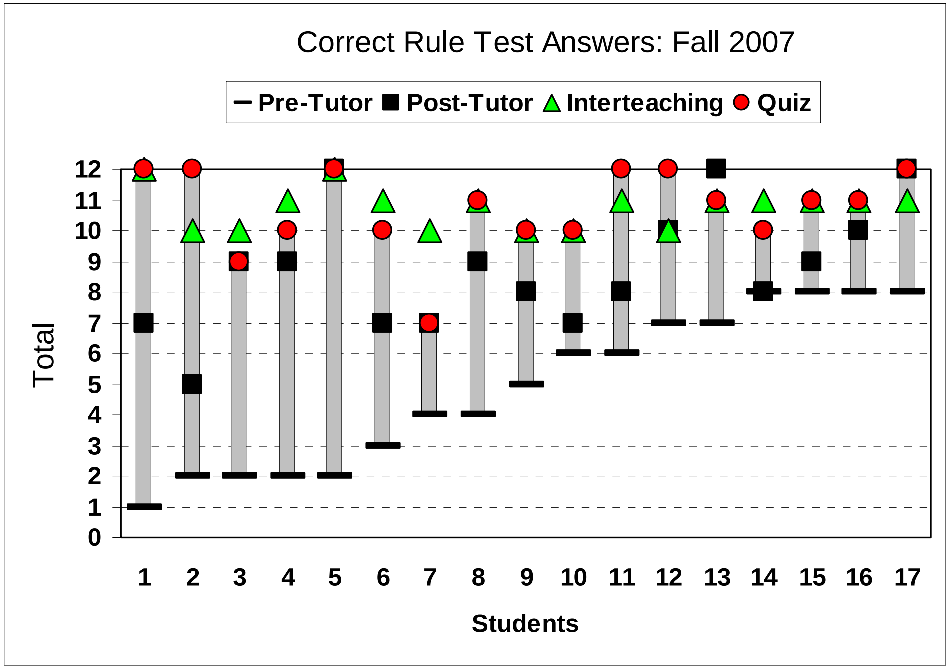
n = 17

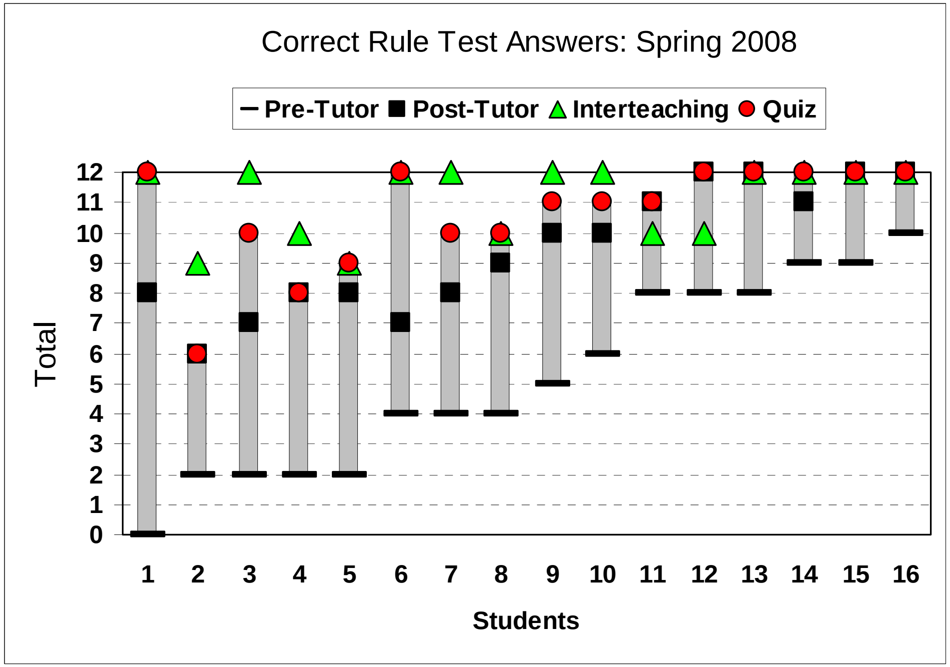
Items: r = 0.837, p = 0.000

Rows: r = 0.649, p = 0.007

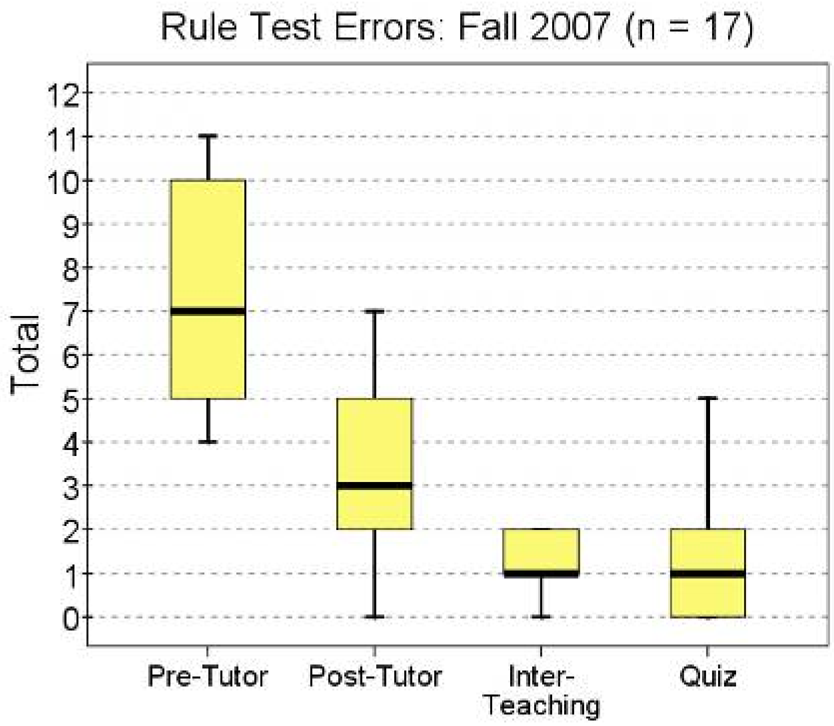
n = 16

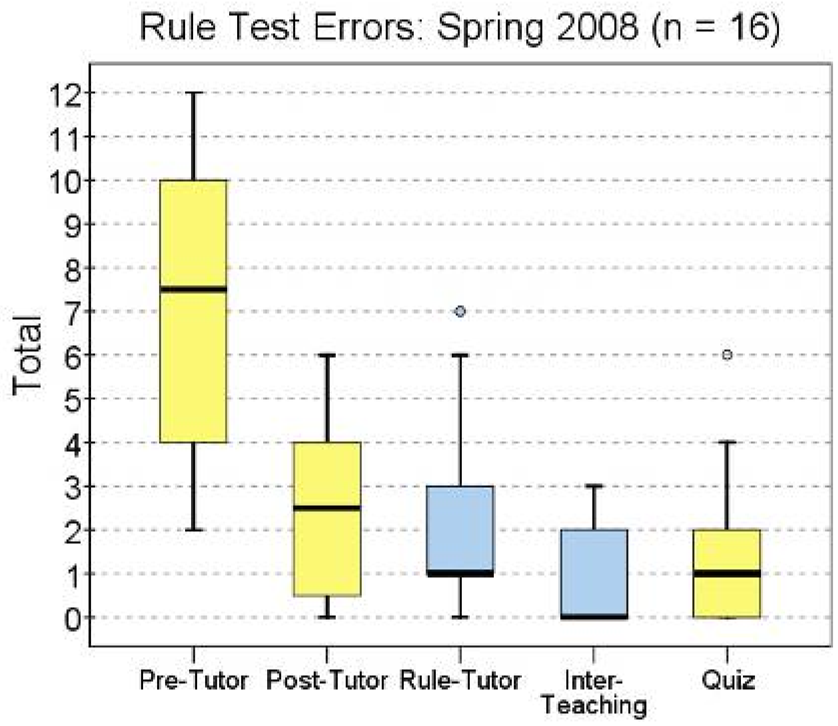
Correct Rule Test Answers: Individuals



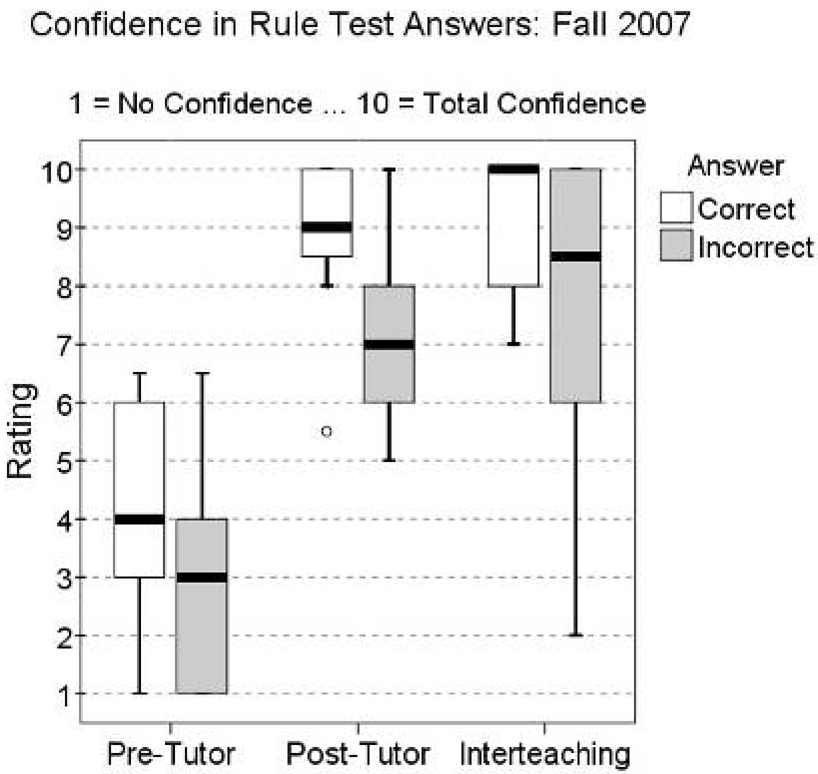


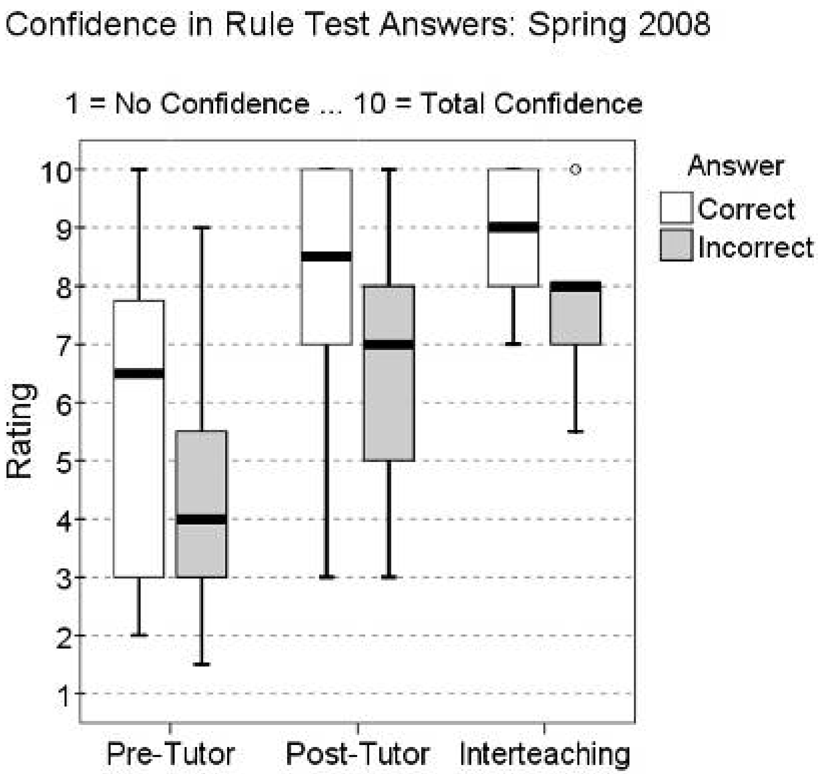
Rule Test Errors





Self-Reports of Confidence in Answers





4. Which of the following lines most likely overrides a method that is contained in the Applet class?

a. public Void stop{} { lines of Java code here }
b. public void Stop(){ lines of Java code here }
c. public void stop() {lines of Java code here }
d. Public Void Stop() (lines of Java code here)
e. Public void stop() { lines of Java code here }

Enter a letter here:
How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.
Enter a number here:

- public void init() {} == public void stop() {}
- How was **public void stop() {}** recognized as a valid form for a method when that particular form did not appear in the tutor?

Applet class methods

1. public void init() { }
2. public void start() { }
3. public void stop() { }
4. public void destroy() { }

public void init() { }

public void stop() { }

Override

Hierarchical Combinatorial Entailment

Interteaching Report 1 6

11. Given the line, **public class MyTextArea extends JTextArea {**, which of the following statements is correct?

a. JTextArea is a subclass of MyTextArea.
b. MyTextArea is a superclass of the extends class.
c. JTextArea is a superclass of MyTextArea.
d. MyTextArea is a subclass of the JText class.
e. JTextArea is a class of MyTextArea.

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

12. Given the line, **public class MyJButton extends JButton {**, which of the following statements is correct?

a. JButton is a superclass of MyJButton.
b. JButton is a subclass of MyJButton.
c. MyJButton is a superclass of the extends class.
d. JButton is a class of MyJButton.
e. MyJButton is a subclass of the Button class.

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

13. Which one of the below lines declares myList as a potential instance of the JList class?

a. myList JList;
b. JList myJList;
c. myJList JList;
d. JList myList;
e. JList myList.

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

Interteaching Report 1 6

11. Given the line, **public class MyTextArea extends JTextArea {**, which of the following statements is correct?

a. JTextArea is a subclass of MyTextArea.
b. MyTextArea is a superclass of the extends class.
c. JTextArea is a superclass of MyTextArea.
d. MyTextArea is a subclass of the JText class.
e. JTextArea is a class of MyTextArea.

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d. JButton is a class of MyJButton.
e. MyJButton is a subclass of the Button class.

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

13. Which one of the below lines declares myList as a potential instance of the JList class?

a. myList JList;
b. JList myJList;
c. myJList JList;
d. JList myList;
e. JList myList.

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

17. Which of the following lines would most likely add a JScrollPane object to a JPanel object?

a. myJPanel2.add(myJScrollPane1);
b. JPanel.add(JScrollPane);
c. JPanel.add(myJScrollPane);
d. myJPanel.add(JScrollPane);
e. JScrollPane.add(JPanelObject);

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

18. Which of the following lines would most likely add a JList object to a JPanel object?

a. myBigJPanel5.add(JList);
b. myBigJPanel5.add(myLittleJList1);
c. JPanel.add(myLittleJList1);
d. JList.add(JPanelObject);
e. JPanel.add(JList);

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

19. A Java JApplet program has two methods written in the class. The methods are not nested. What is the total number of braces, { and } added together, that are needed for this program.

a. 9
b. 6
c. 3
d. 4
e. 2

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident

17. Which of the following lines would most likely add a JScrollPane object to a JPanel object?

a. myJPanel2.add(myJScrollPane1);
b. JPanel.add(JScrollPane);
c. JPanel.add(myJScrollPane);
d. myJPanel.add(JScrollPane);
e. JScrollPane.add(JPanelObject);

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

18. Which of the following lines would most likely add a JList object to a JPanel object?

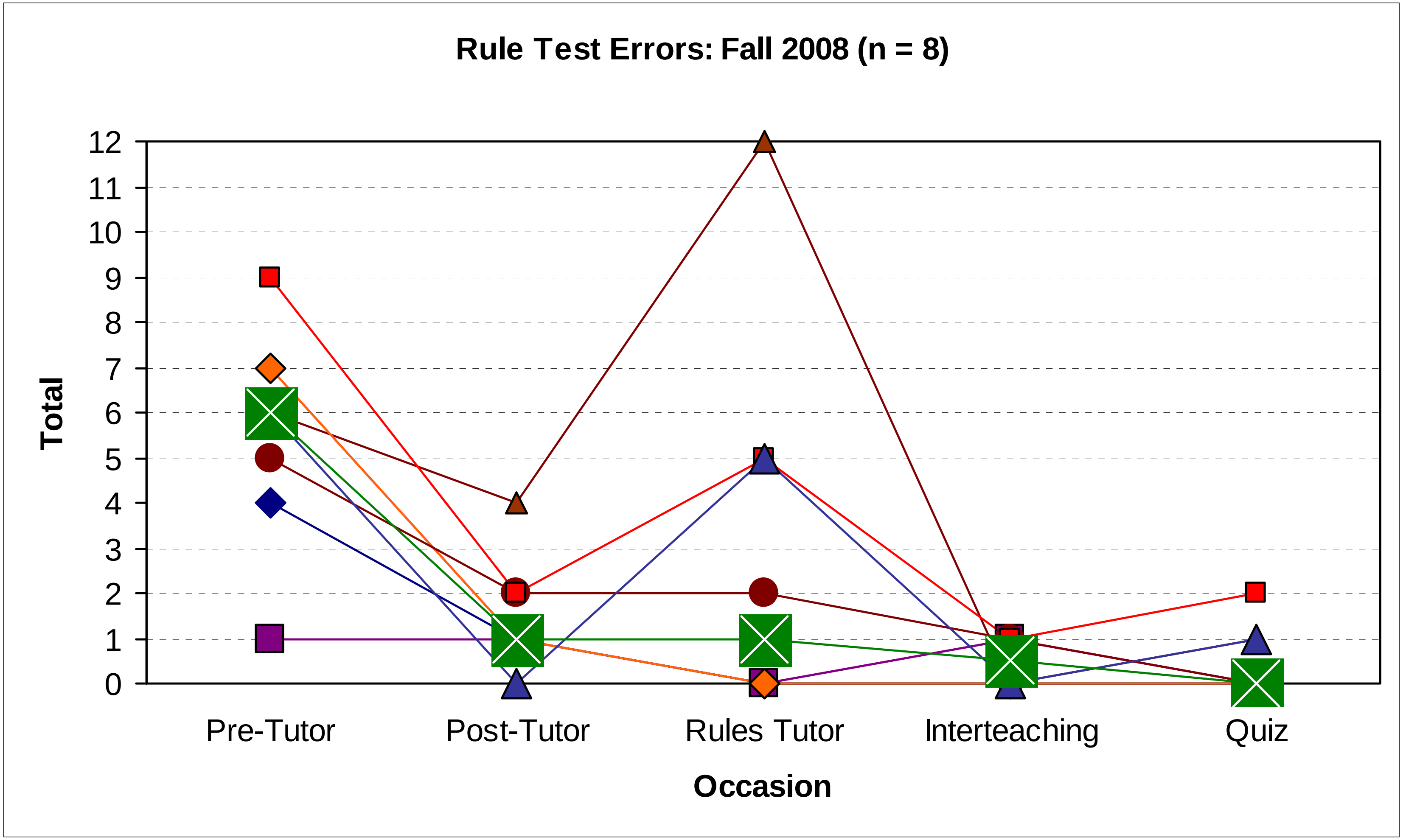
a. myBigJPanel5.add(JList);
b. myBigJPanel5.add(myLittleJList1);
c. JPanel.add(myLittleJList1);
d. JList.add(JPanelObject);
e. JPanel.add(JList);

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident.

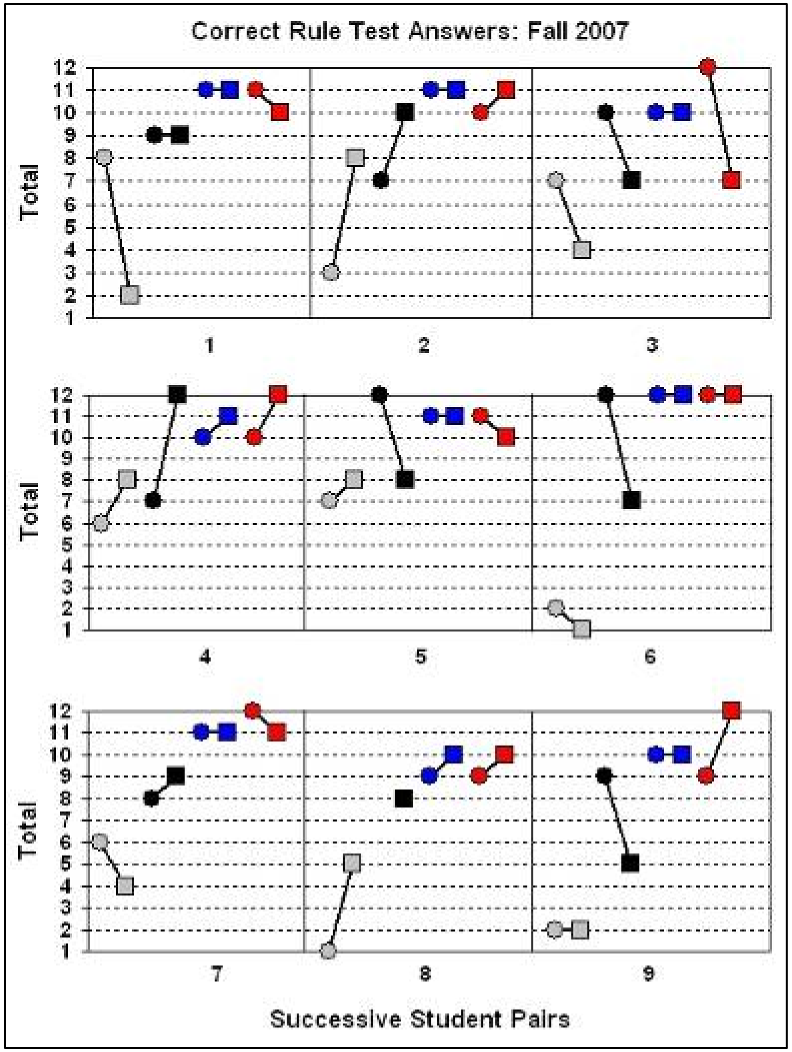
19. A Java JApplet program has two methods written in the class. The methods are not nested. What is the total number of braces, { and } added together, that are needed for this program.

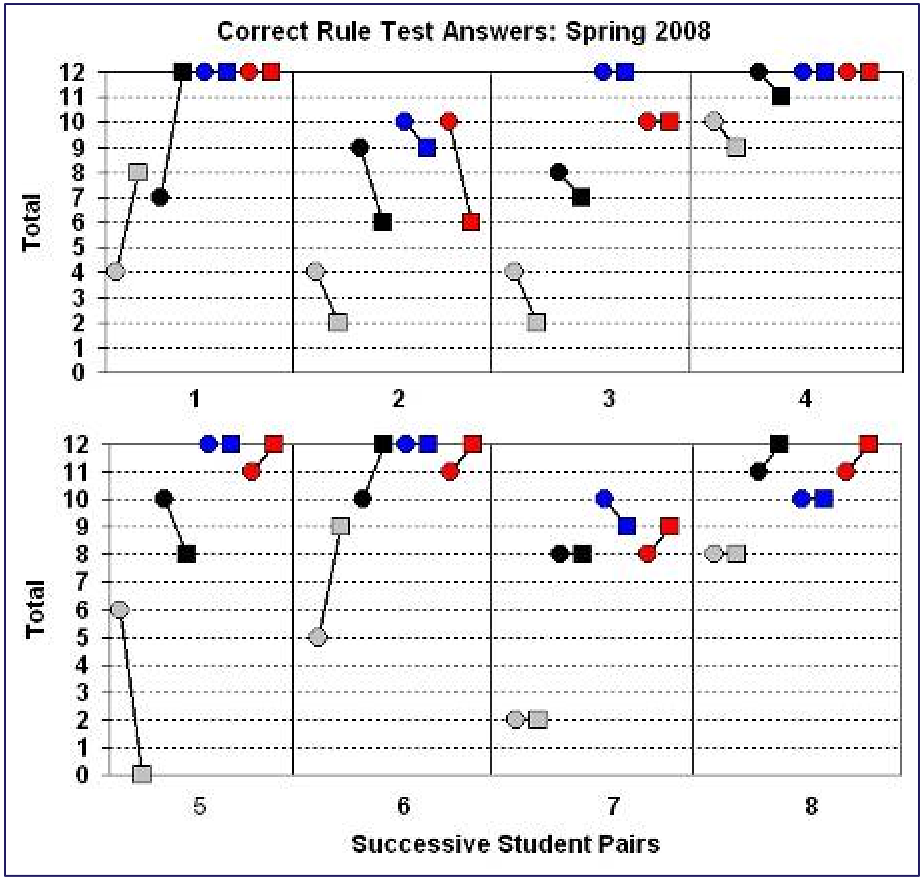
a. 9
b. 6
c. 3
d. 4
e. 2

How confident are you that you selected the correct answer?
Not at all confident. 1 2 3 4 5 6 7 8 9 10 Totally confident



Rules Tutor: Identical Multiple Choice Questions



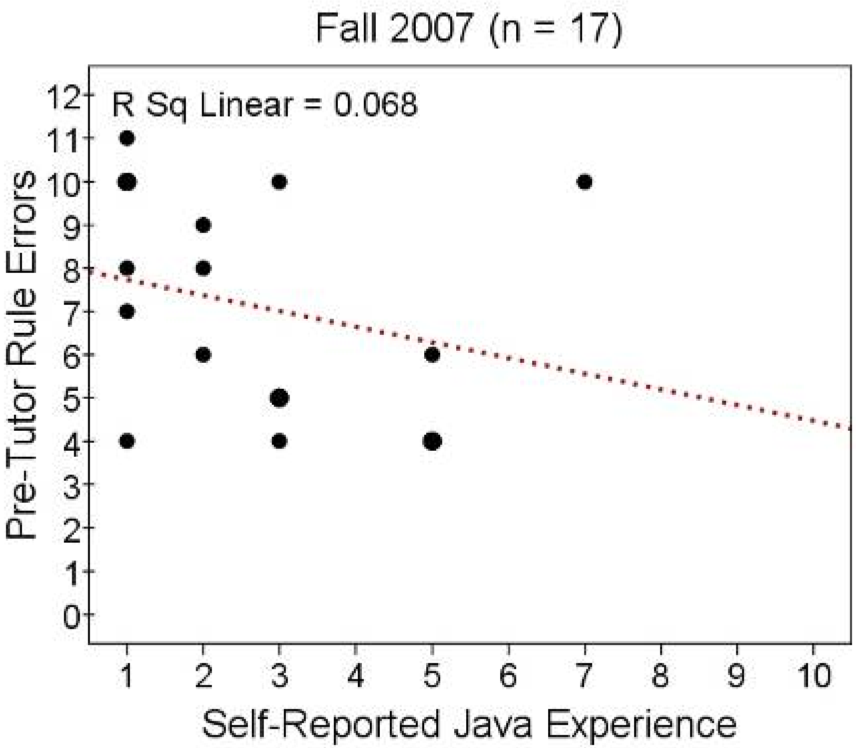


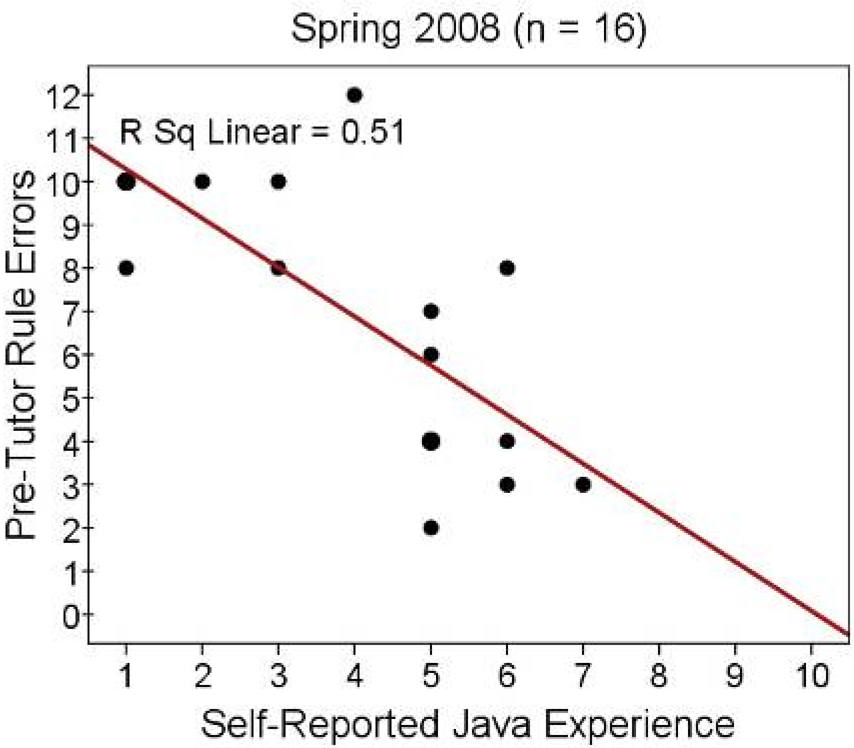
r = 0.98, n = 8, p = .000

r = 0.87, n = 9, p = .002

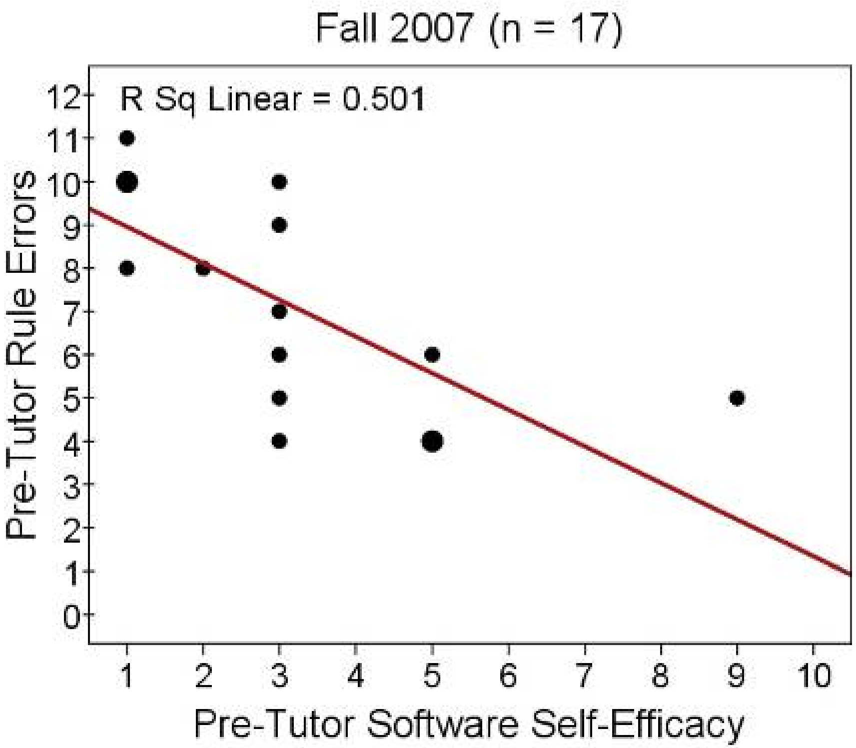
Pre-Tutor, Post-Tutor, Interteaching, Quiz

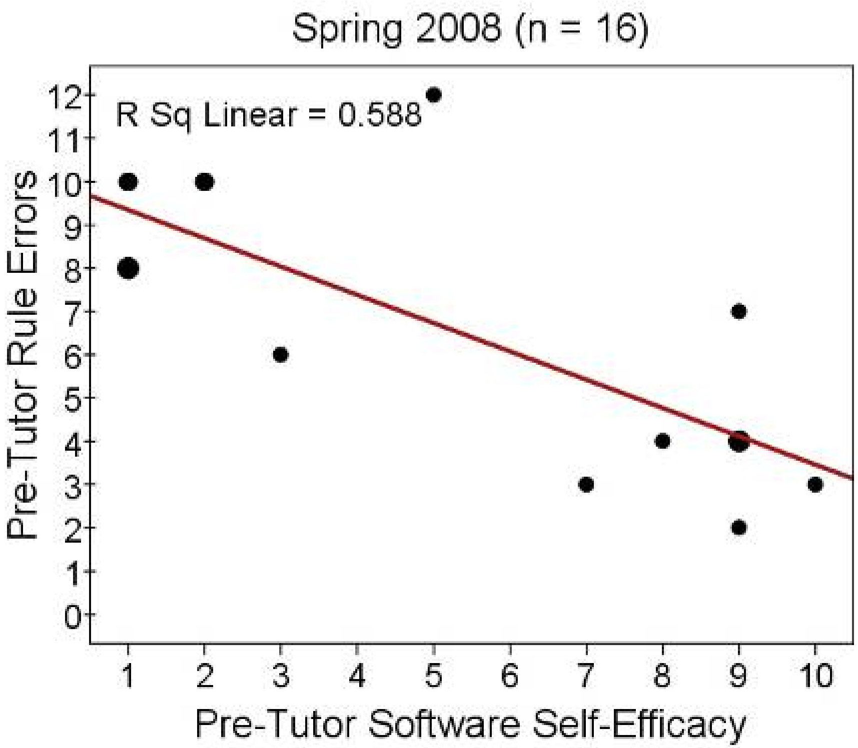
History Counts





History Counts





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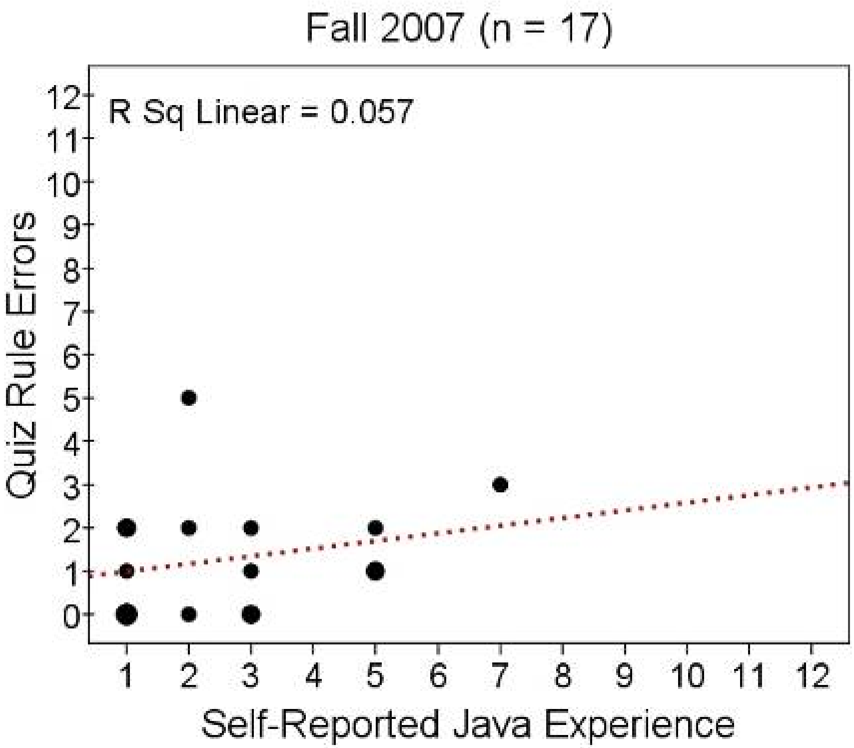

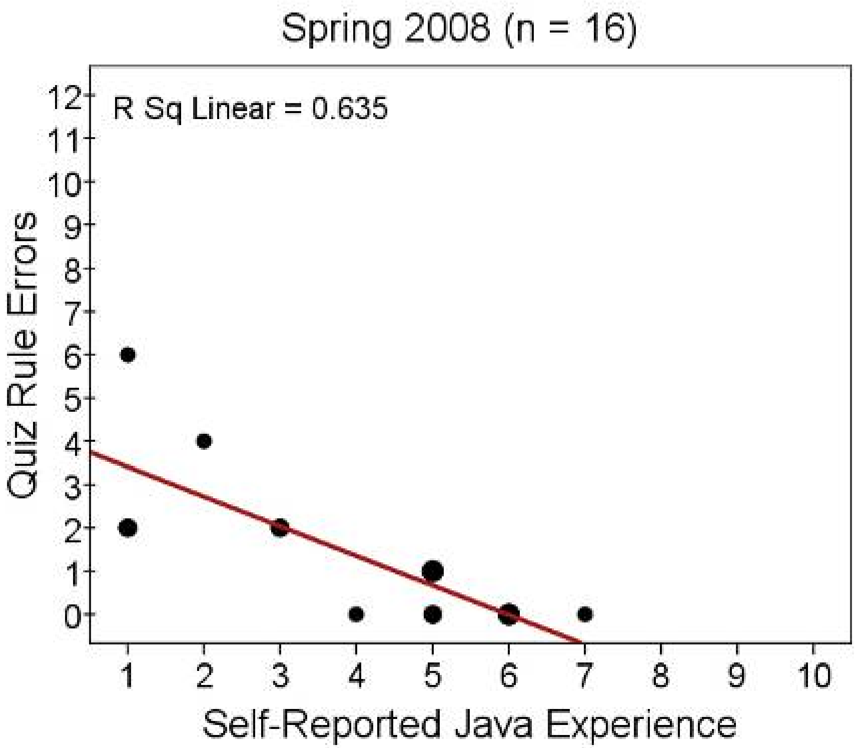

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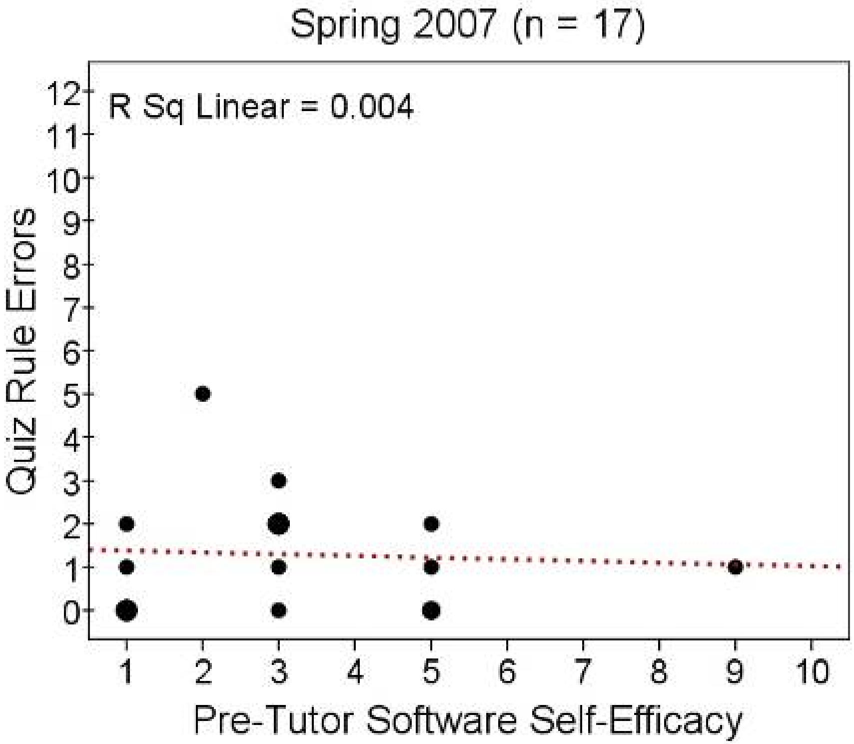

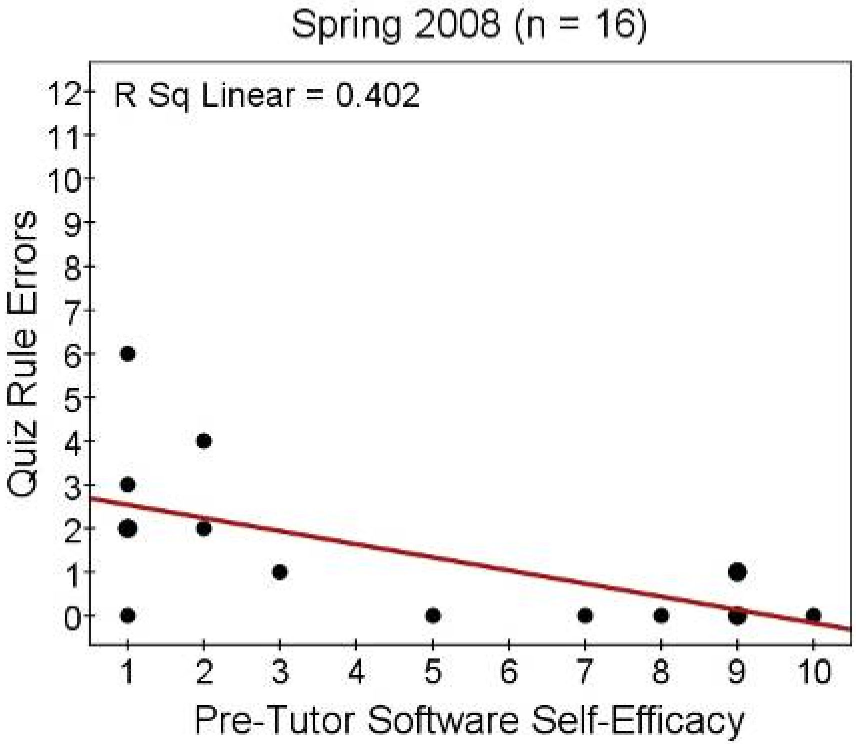

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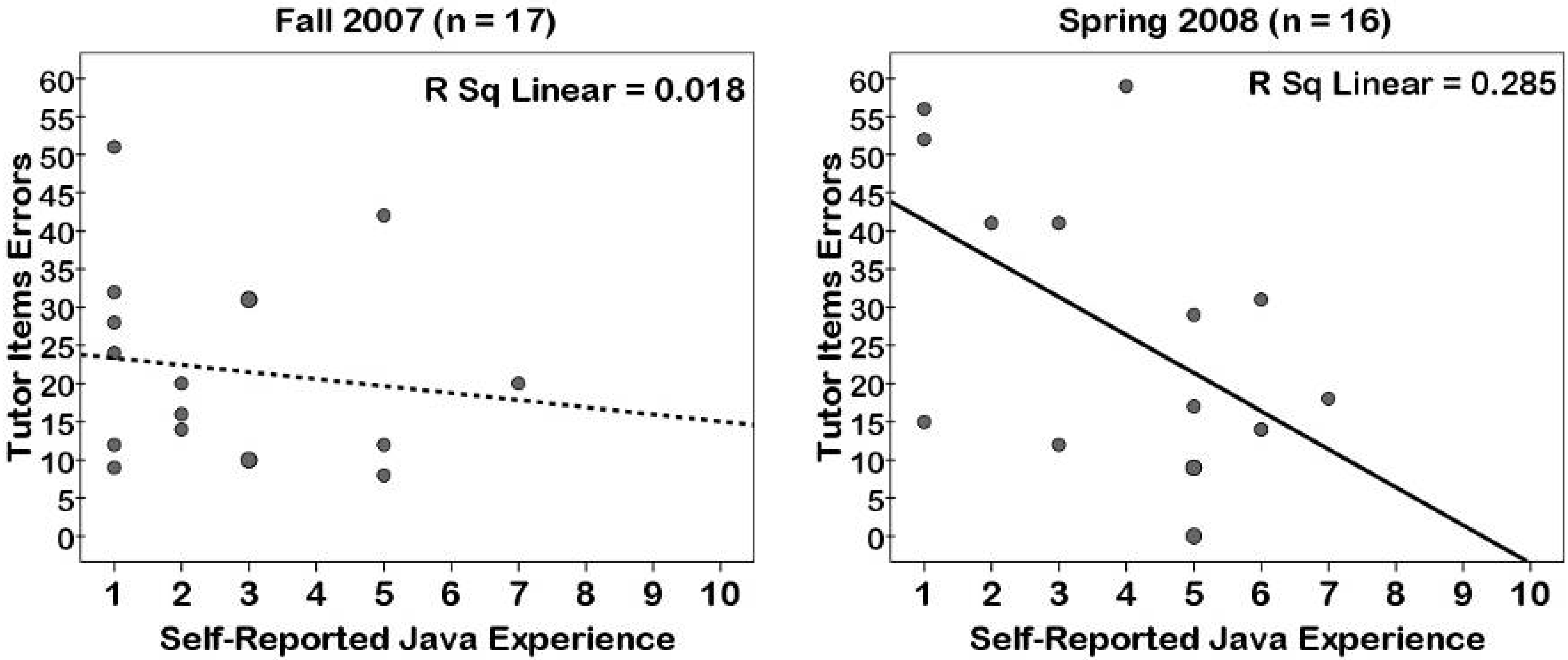

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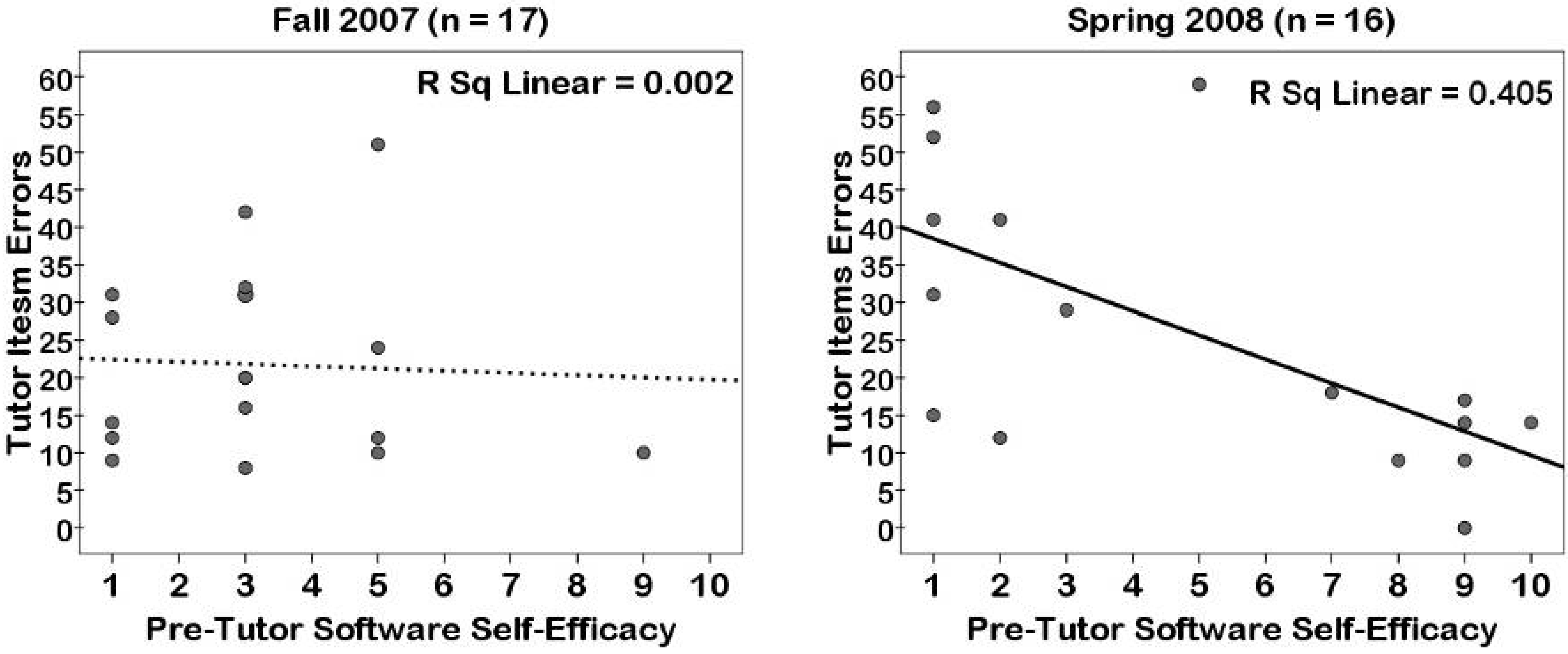

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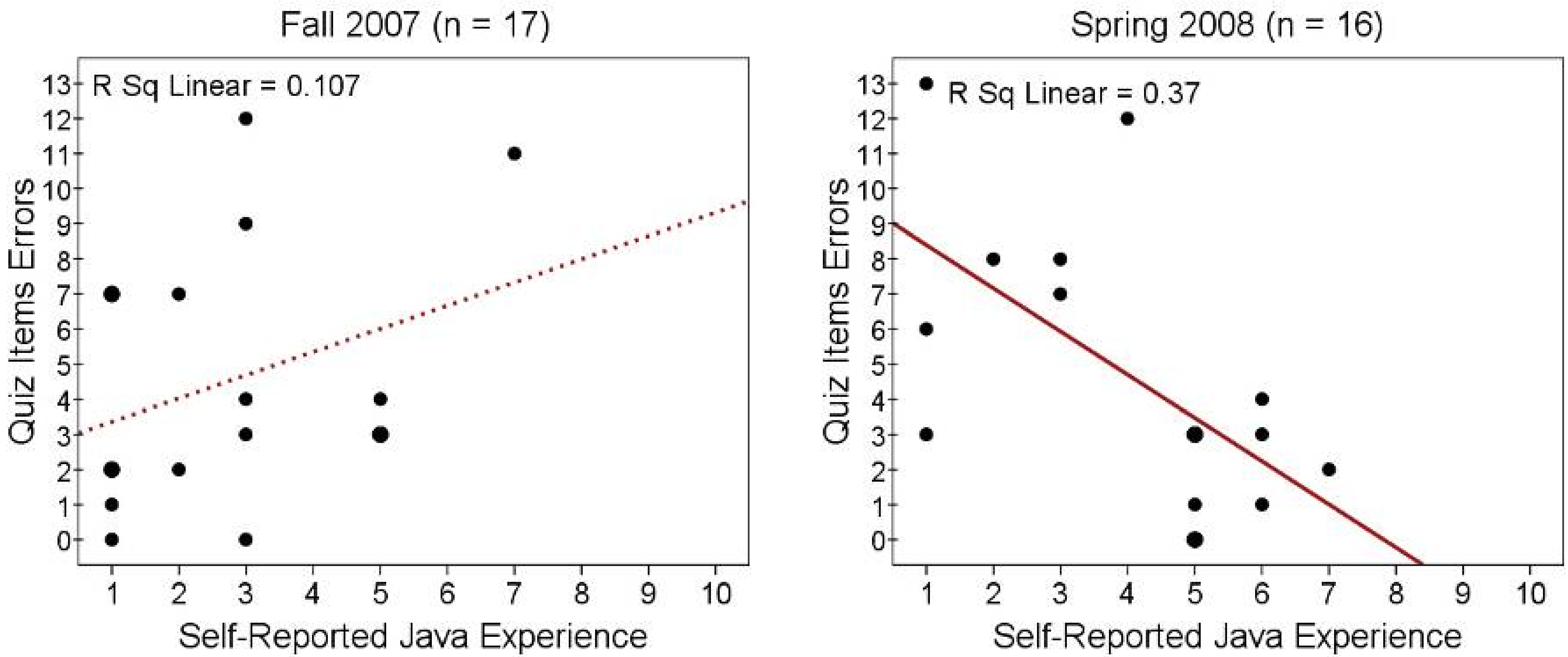

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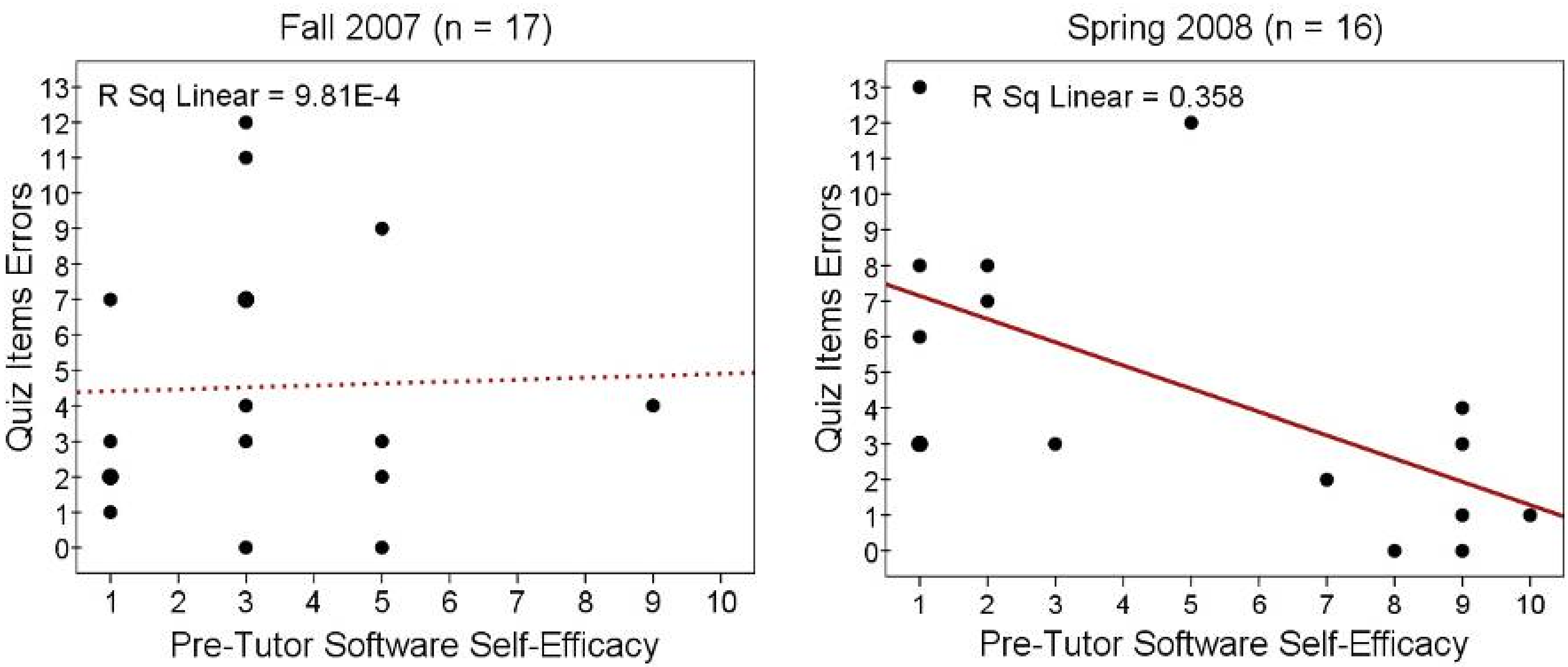


The below questions are based on the design of the Java programming language and associated conventions of the language. **Classification** refers to keyword, class, object, method, separator, and operator. Give the most informed rating that you can at this point in your understanding of Java.

1. How similar to each other are the following two items in terms of classification?

(1) import **(2)** new

Classification: Not Similar 1 2 3 4 5 6 7 8 9 10 Highly Similar
Enter a number here:

2. How similar to each other are the following two items in terms of classification?

(1) myLabel **(2)** JLabel

Classification: Not Similar 1 2 3 4 5 6 7 8 9 10 Highly Similar
Enter a number here:

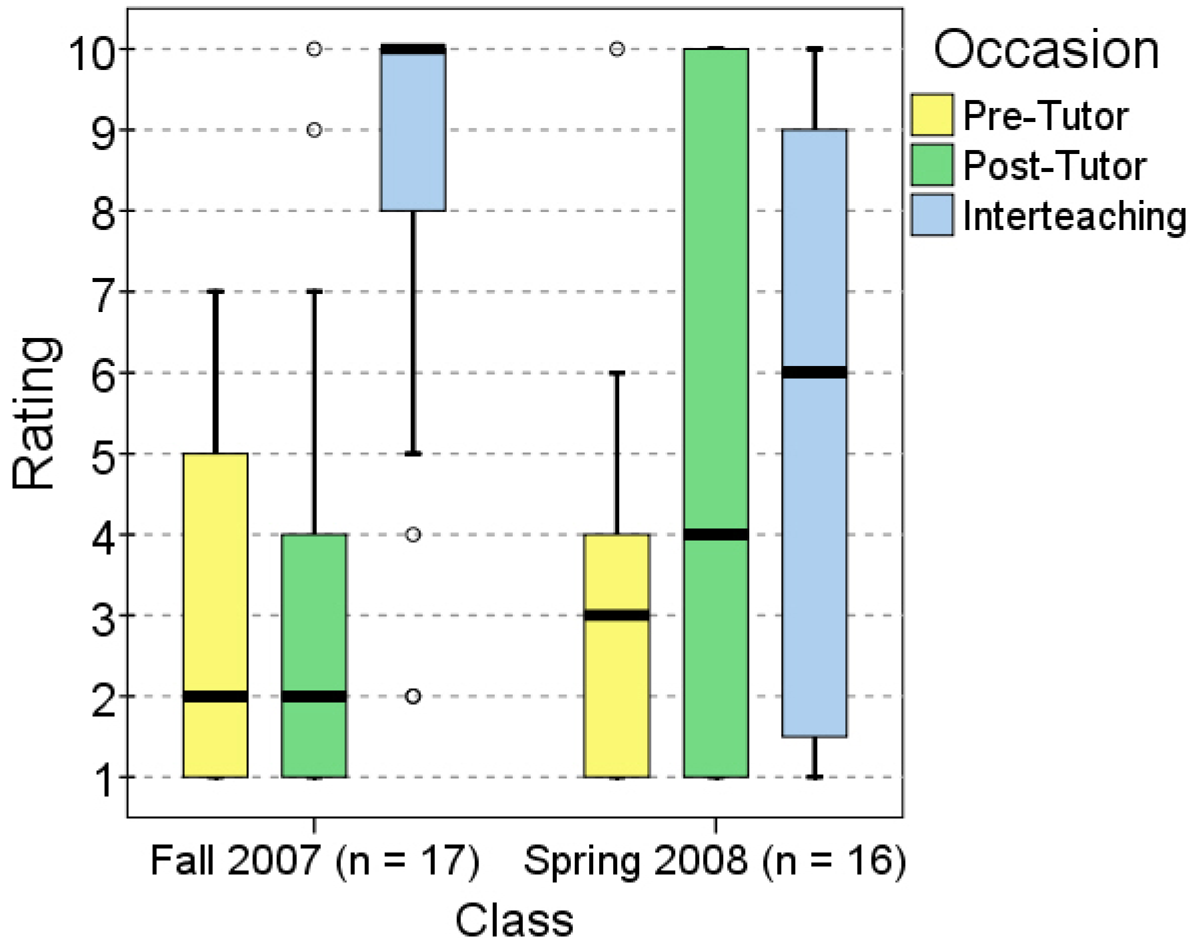
3. How similar to each other are the following two items in terms of classification?

(1) getContentPane() **(2)** init()

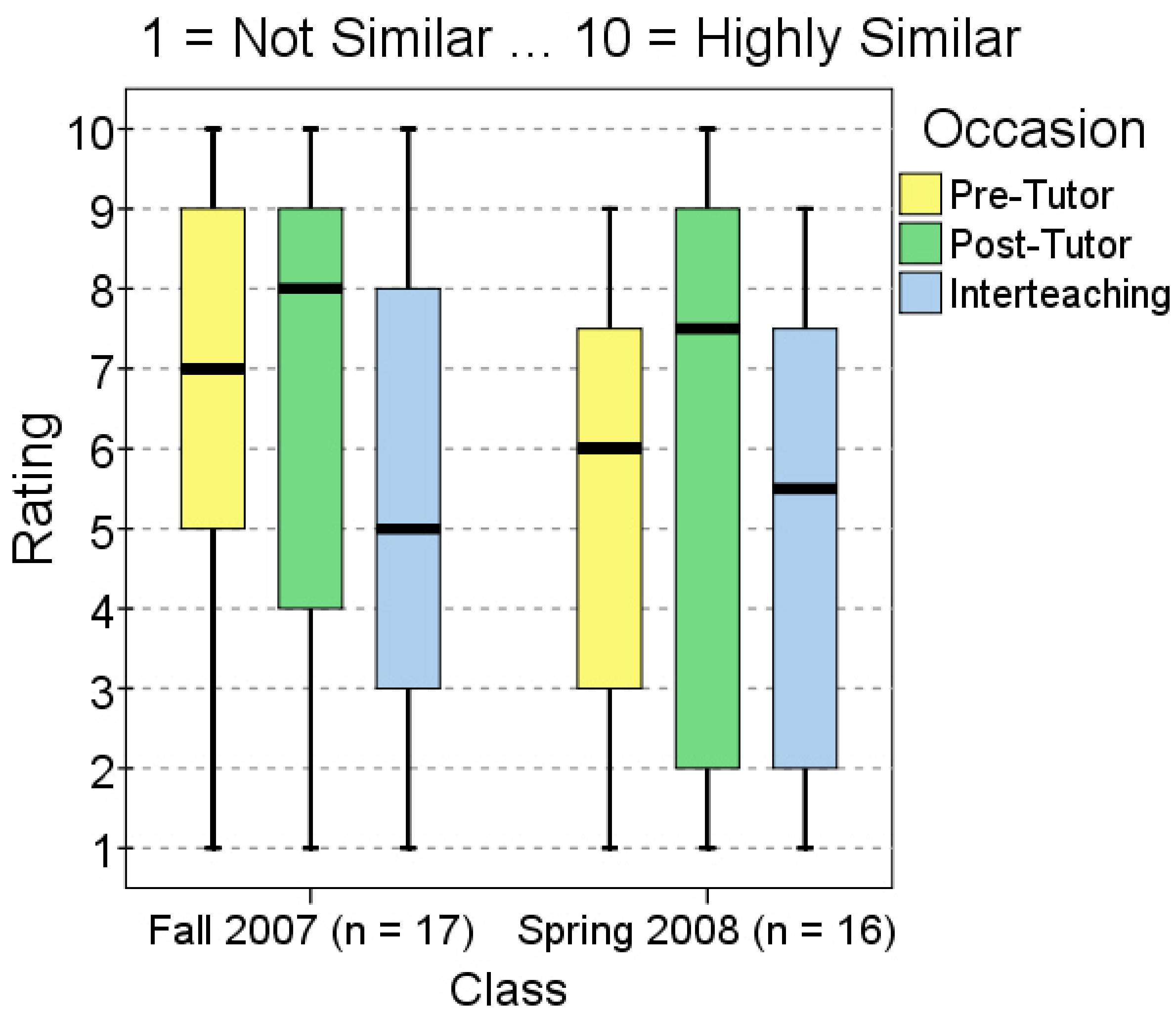
Classification: Not Similar 1 2 3 4 5 6 7 8 9 10 Highly Similar
Enter a number here:

Classify: (1) import (2) new

1 = Not Similar … 10 = Highly Similar

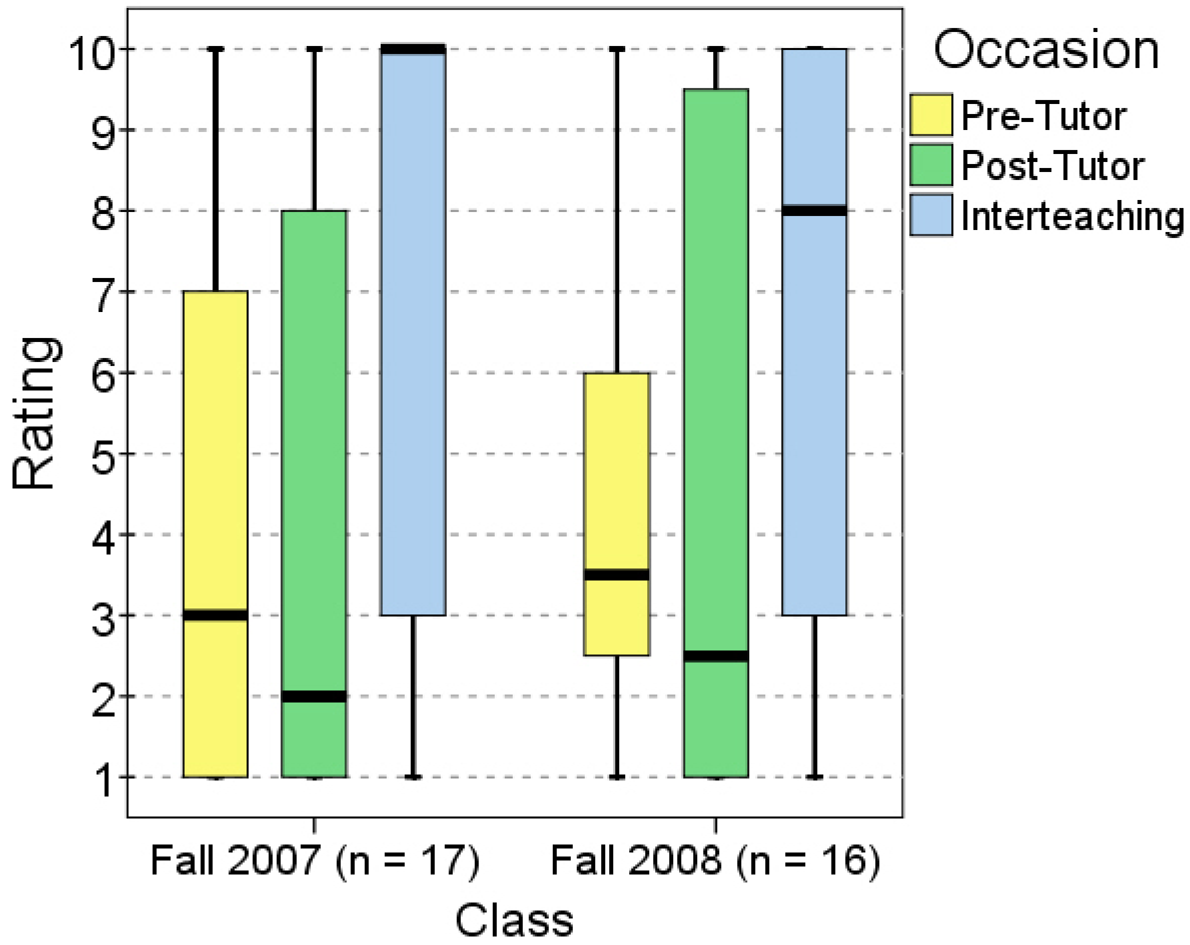


Classify: (1) myLabel (2) JLabel

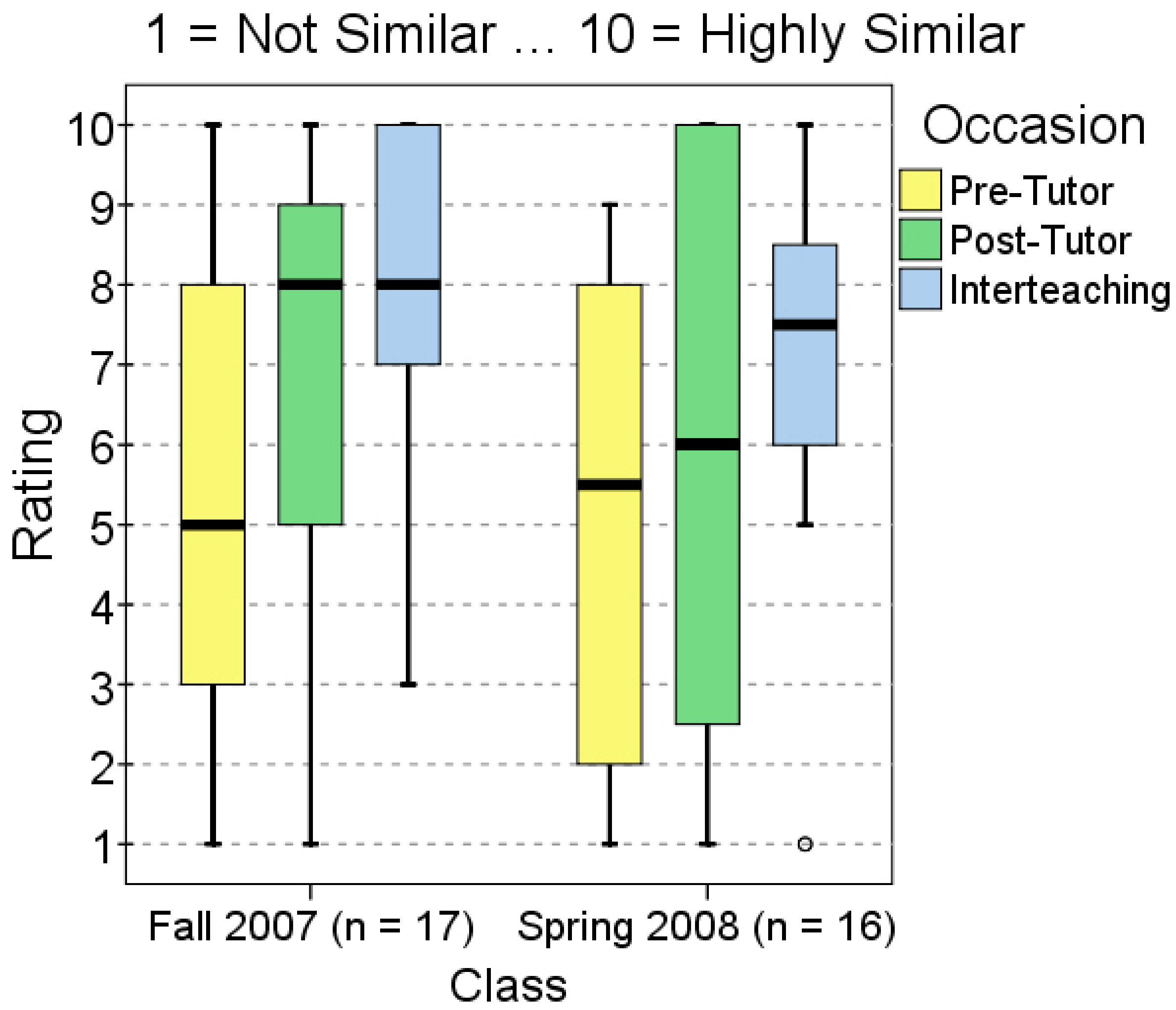


Classify: (1) getContentPane()   (2) init()

1 = Not Similar … 10 = Highly Similar



Classify: (1) MyProgram   (2) JApplet



Putting It All Together

- It is labor intensive to develop.
  - We have proposed to develop a generic shell.
- There are conceptual issues regarding the size of a learn unit.
  - The opportunity for repetition, until a multiple-choice item is answered correctly, can lead to careless reading.

- A rare student will show an aversion to collaborative learning.
- Pairs of students need different amounts of time.
- It is difficult to assess the “quality” of a collaboration objectively.
- “Understanding” is more than an intraverbal performance.

- I have to know what I’m talking about.

1. Programmed instruction is an effective tool in technology education.
   - It meets the needs of the individual learner.
   - The instructional design can promote meaningful learning and self-confidence.
   - The tutoring system is well-received by novitiate learners.
2. Interteaching may add value, but there are issues of retention and transfer.
3. The competency attained sets the occasion for advanced learning with enthusiasm.
4. Students like the tutor and the interteaching, and so do I.
5. I also like to use lectures with hands-on learning and classroom collaboration among students.

PRACTICE MAKES PERFECT!!

Questions?

The tutor, the source code, and all instructional material are freely available on the web.