

The Acquisition of Procedural Skills: An Analysis of the Worked Example Effect Using Animated Demonstrations

Dissertation defense

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Purpose

1. Palmiter's retention deficit
2. consider the worked example and variability effects using animated demonstrations

Cognitive load theory



John Sweller

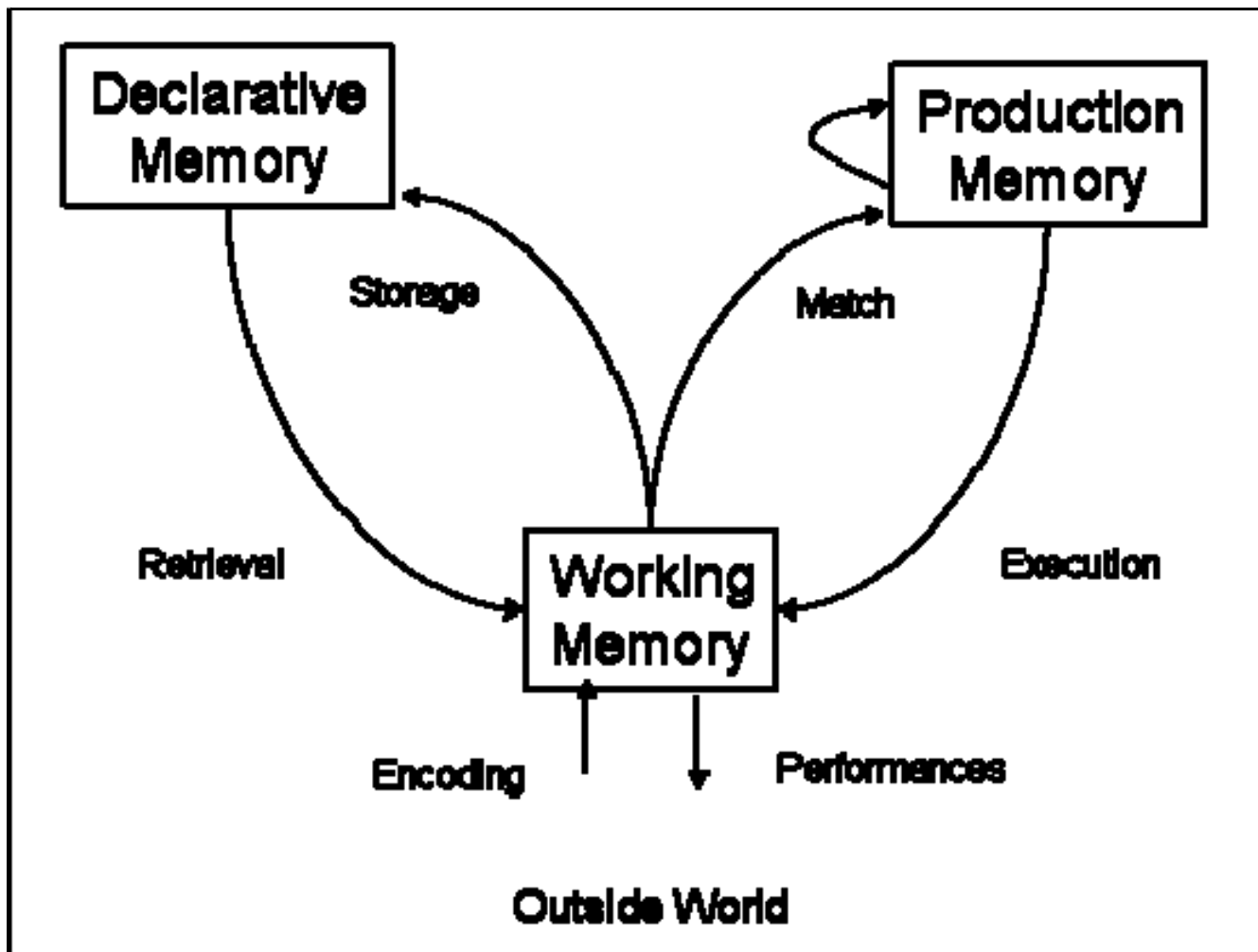
- **Worked example effect**
(Sweller, 1988; Sweller & Cooper, 1985; Tuovinen & Sweller, 1999).
- **Rationale: problem-solving search, is a non-schema forming activity.**
(Sweller, 1988)

ACT-R

(Anderson, 1976)



John Anderson



Expository vs. discovery learning



Jerome Bruner

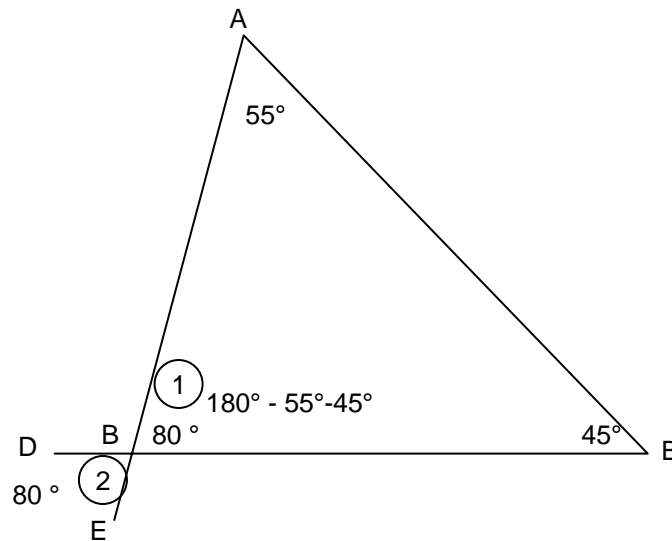
- Expository – Teacher guided
- Discovery learning – Student/self guided

Cognitive load theory and discovery learning

Cognitive load theorists

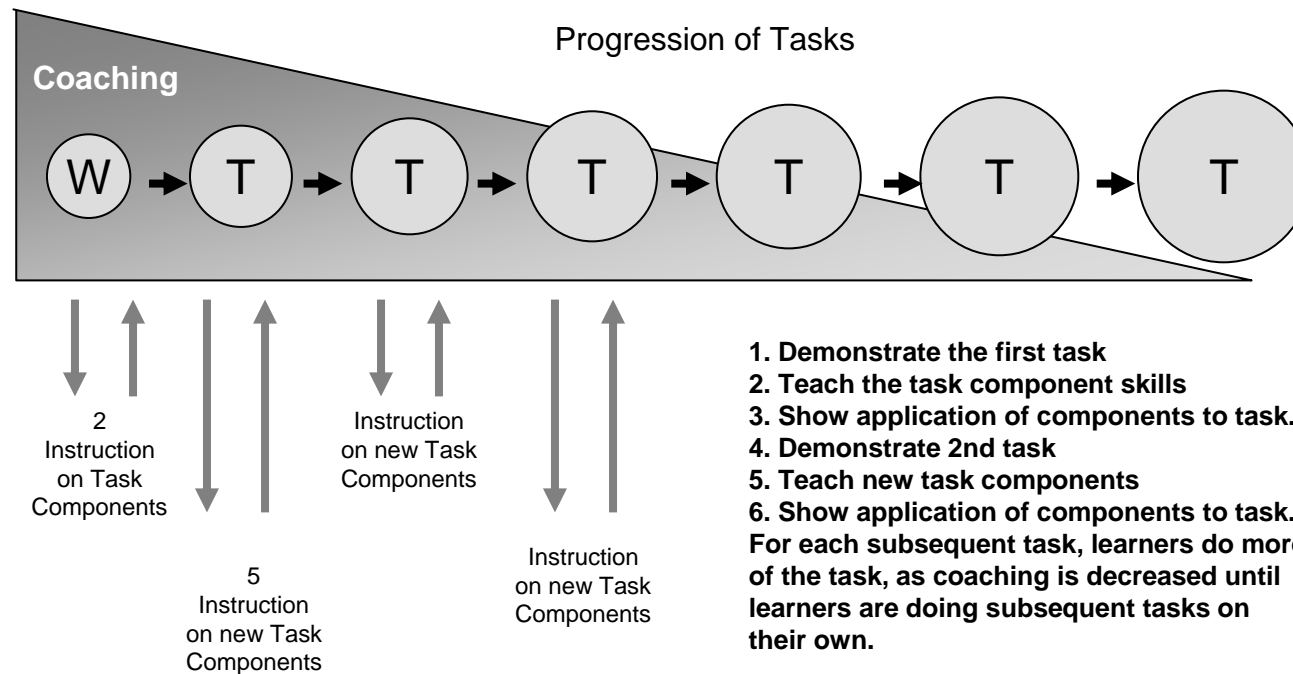
- Interested in how one introduces novices to problems and problem solving
- Reduce cognitive load by providing worked examples

Worked example



Angle $DBE = \text{Angle } ABC$ (vertically opposite angles are equal)
 $= 80^\circ$

TASK-CENTERED INSTRUCTIONAL STRATEGY



Animated demonstration

The screenshot shows the Bank of America website interface. At the top left is the Bank of America logo. To the right are links for 'Locations', 'Contact Us', 'Help', 'Sign In', and 'En Español'. Below these is a search bar. A red navigation bar contains 'PERSONAL', 'SMALL BUSINESS', 'CORPORATE & INSTITUTIONAL', and 'ABOUT BANK OF AMERICA'. The main content area is split into two columns. The left column is a blue sidebar for 'Online Banking' with an 'Enroll' link, a 'View demo' link (highlighted with a green box), an 'Enter Online ID' field, a 'Save this Online ID' checkbox, a 'Sign In' button, and links for 'Forgot or need help with your ID?', 'Reset Passcode', and 'Sign in for location other than FL'. Below this is a 'Your Privacy & Security' section. The right column features a 'Museums on Us' promotion with the text 'Get free admission to over 70 museums nationwide.' and a 'Learn More' button. Below the promotion are three columns of 'Products & Services', 'Manage Your Accounts', and 'Achieve Your Goals'.

Bank of America Locations · Contact Us · Help · Sign In · En Español

PERSONAL ▾ SMALL BUSINESS ▾ CORPORATE & INSTITUTIONAL ▾ ABOUT BANK OF AMERICA ▾

Online Banking Enroll [View demo](#) | [Learn more](#)

Enter Online ID:

Save this Online ID

[Where do I enter my Passcode?](#)

Sign In

[Forgot or need help with your ID?](#)

[Reset Passcode](#)

[Sign in for location other than FL](#)

Your Privacy & Security
Our security commitment
Norton Internet Security 2008 - Free Trial
Monitor & manage your credit
[Report suspicious email](#)

Museums on Us[®]
Get free admission to over 70 museums nationwide.

Learn More

Products & Services **Manage Your Accounts** **Achieve Your Goals**

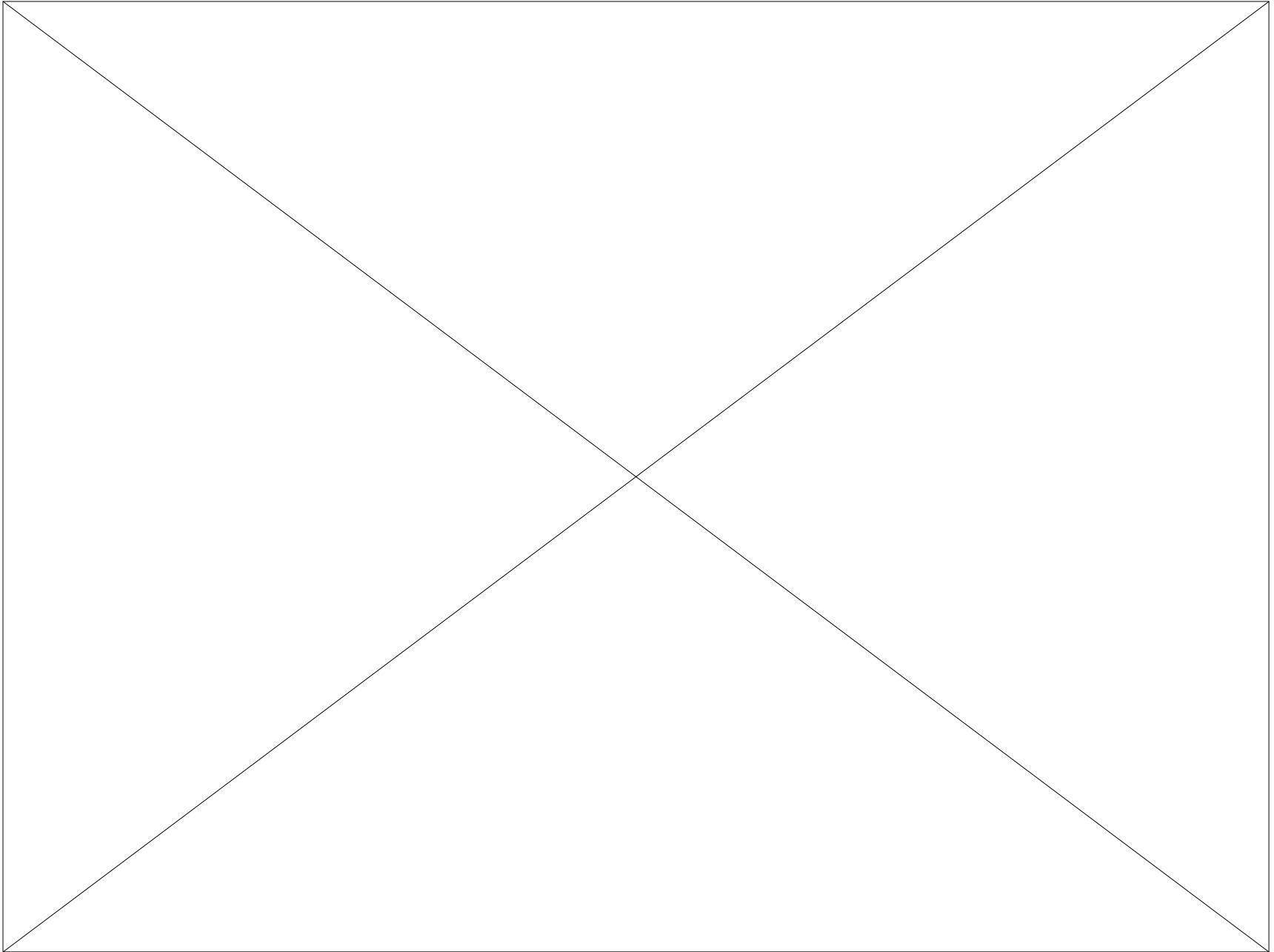
Checking
Savings & CDs
Credit cards
Mortgages
Home equity
Personal loans
IRAs
Investment Services

Fees and processes
Order Check Card
Online Investing

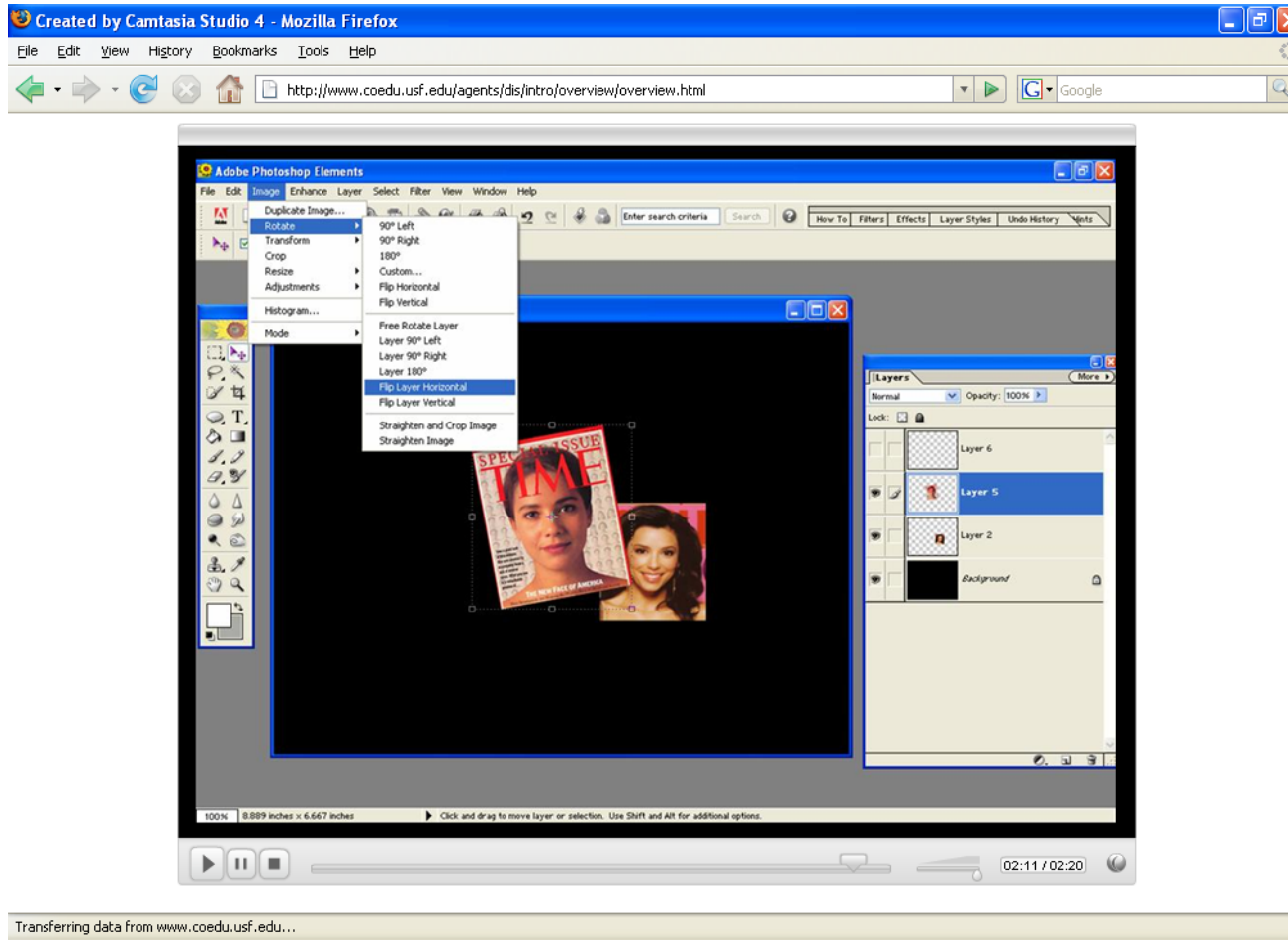
Online Banking >
Viewing your accounts
Accessing credit cards
Paying bills online

Keep the Change[®]
Buying a home
Searching for a home
Retirement Center
Planning for college
Student loans
Purchasing a car
Consolidating debt

Animated demonstration


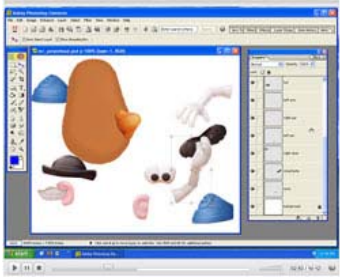
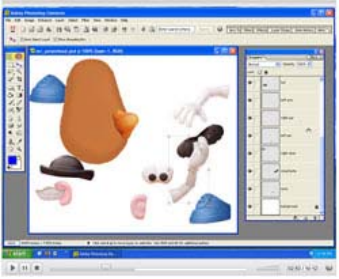
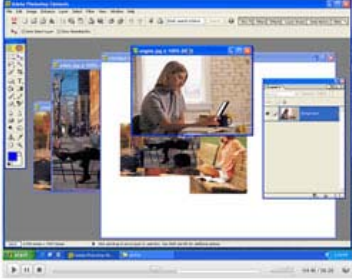





Overview



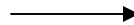
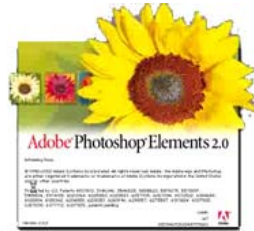
Transferring data from www.coedu.usf.edu...

Acquisition Phase (1st week)

<p>overview</p> 			
demo	demo+practice	demo2+practice	practice
			<p>No demonstration</p>
<p>No practice</p>			

Problem Scenario (1st week)

Disassembled Mr. Potatohead

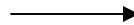
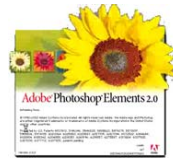


Reassembled Mr. Potatohead



3 of the 4 groups

Performance Phase (1 week after initial instruction)



All 4 groups

Performance time

The screenshot displays the Morae Manager software interface. The main window shows a 3D scene titled "Recording - 76" depicting a beach with a picnic table, a striped umbrella, and two figures. The interface includes a menu bar (File, Segment, Marker, Search, View, Player, Help), a toolbar, and a sidebar with "Analyzer" and "Presenter" tabs. The "Analyzer - Project" pane shows a tree view with "76" containing "Markers" (start, end) and "Segments". The "Details" pane lists recording information for "Student Interaction 76". The "Events" pane shows a table of recorded events.

Details

Name: Student Interaction
Recording: 76
In Point: 0:11:22.90
Out Point: 0:21:20.50
Duration: 0:09:57.61
Creation Time: February 22, 2007
Start Frame: 6829
End Frame: 12805
Audio Note: No
Text Notes: <None>

Events

Elapsed ...	Event	Title	Description	Application	Time/Date
0:00:04.40	Mouse	FolderView	L Button Down	Windows Ex...	17:46:05 / D...
0:00:13.20	Browser	bump page	http://www....	Internet Exp...	17:46:13 / D...
0:00:13.40	Mouse	bump page <...	L Button Down	Internet Exp...	17:46:14 / D...
0:00:18.60	Browser	Survey	http://www....	Internet Exp...	17:46:19 / D...
0:00:30.40	Mouse	Survey - Mic...	L Button Down	Internet Exp...	17:46:31 / D...
0:00:31.80	Mouse	Survey - Mic...	L Button Down	Internet Exp...	17:46:32 / D...
0:00:33.80	Mouse	Survey - Mic...	L Button Down	Internet Exp...	17:46:34 / D...
0:00:35.60	Mouse	Survey - Mic...	L Button Down	Internet Exp...	17:46:36 / D...
0:00:38.00	Mouse	Survey - Mic...	L Button Down	Internet Exp...	17:46:38 / D...
0:00:40.40	Mouse	Survey - Mic...	L Button Down	Internet Exp...	17:46:41 / D...

Accuracy

	A	B	C	D	E
1	flip	layer	rotate	move	item
2	1	***	1	1	umbrella
3	x	***	1	1	tshirt
4	***	***	x	x	head
5	***	***	***	x	right leg
6	***	***	1	x	head 2
7	***	***	1	1	purple shirt
8	***	x	1	1	hat
9	***	***	***	1	s left leg
10	***	***	***	1	bent right leg
11	***	***	***	x	left leg
12	***	1	1	1	green shorts
13	***	***	***	x	arm 2
14	***	x	1	1	pink shorts
15	***	***	***	x	left arm
16	***	***	x	x	body
17	***	***	1	1	picnic basket
18	***	***	***	x	arm
19	***	***	x	x	right arm
20	***	***	1	1	torso
21	***	***	1	1	table
22	***	***	1	1	bird3
23	***	***	***	1	bird2
24	***	***	1	1	bird1
25	1	1	12	14	30

The screenshot displays a software interface for recording student interactions. The main window, titled 'Recording - 76', shows a 3D scene with a picnic table, a striped umbrella, and two figures (one in a red shirt, one in a purple shirt) on a yellow ground. The interface includes a 'Student Interaction' log on the left and a detailed event log at the bottom. The event log shows a list of events with columns for Elapsed Time, Event, Title, Description, Application, and Time/Date. The total number of events is 543, and 0 are selected.

Elapsed ...	Event	Title	Description	Application	Time/Date
0:00:04.40	Mouse	FolderView	L Button Down	Windows Ex...	17:46:05 / D...
0:00:13.20	Browser	bump page	http://www....	Internet Exp...	17:46:13 / D...
0:00:13.40	Mouse	bump page ...	L Button Down	Internet Exp...	17:46:14 / D...
0:00:18.60	Browser	Survey	http://www....	Internet Exp...	17:46:19 / D...
0:00:30.40	Mouse	Survey - Mc...	L Button Down	Internet Exp...	17:46:31 / D...
0:00:31.00	Mouse	Survey - Mc...	L Button Down	Internet Exp...	17:46:32 / D...
0:00:33.80	Mouse	Survey - Mc...	L Button Down	Internet Exp...	17:46:34 / D...
0:00:35.60	Mouse	Survey - Mc...	L Button Down	Internet Exp...	17:46:36 / D...
0:00:38.00	Mouse	Survey - Mc...	L Button Down	Internet Exp...	17:46:38 / D...
0:00:40.40	Mouse	Survey - Mc...	L Button Down	Internet Exp...	17:46:41 / D...

Post performance survey

Survey 2

Earlier today you participated in an instructional activity...

1. How would you describe this activity... I invested:

- very, very low mental effort
- very low mental effort
- low mental effort
- rather low mental effort
- neither low nor high mental effort
- rather high mental effort
- high mental effort
- very high mental effort
- very, very high mental effort

Relative Condition Efficiency

$$\text{RCE} = \frac{Z_{AC2} - Z_{RME}}{\sqrt{2}}$$

Condition 1	Test score	Z-Score	Mental effort	Z-Score
Student A	70	0.36	2.3	-1.25
Student B	80	1.30	3.4	-0.22
Student C	75	0.81	2.9	-0.68
Average Z-score		0.82		-0.72
Plot Values: Performance =0.82 and Mental Effort =-0.72				
Condition 2				
Student D	64	-0.18	4.3	0.63
Student E	52	-1.26	3.6	-0.02
Student F	55	-0.99	5.3	1.5
Average Z-score		-0.81		0.70
Plot Values: Performance =-0.81 and Mental Effort =0.70				
Grand Mean	66		3.63	
Std dev	11.08		1.06	

Condition 1

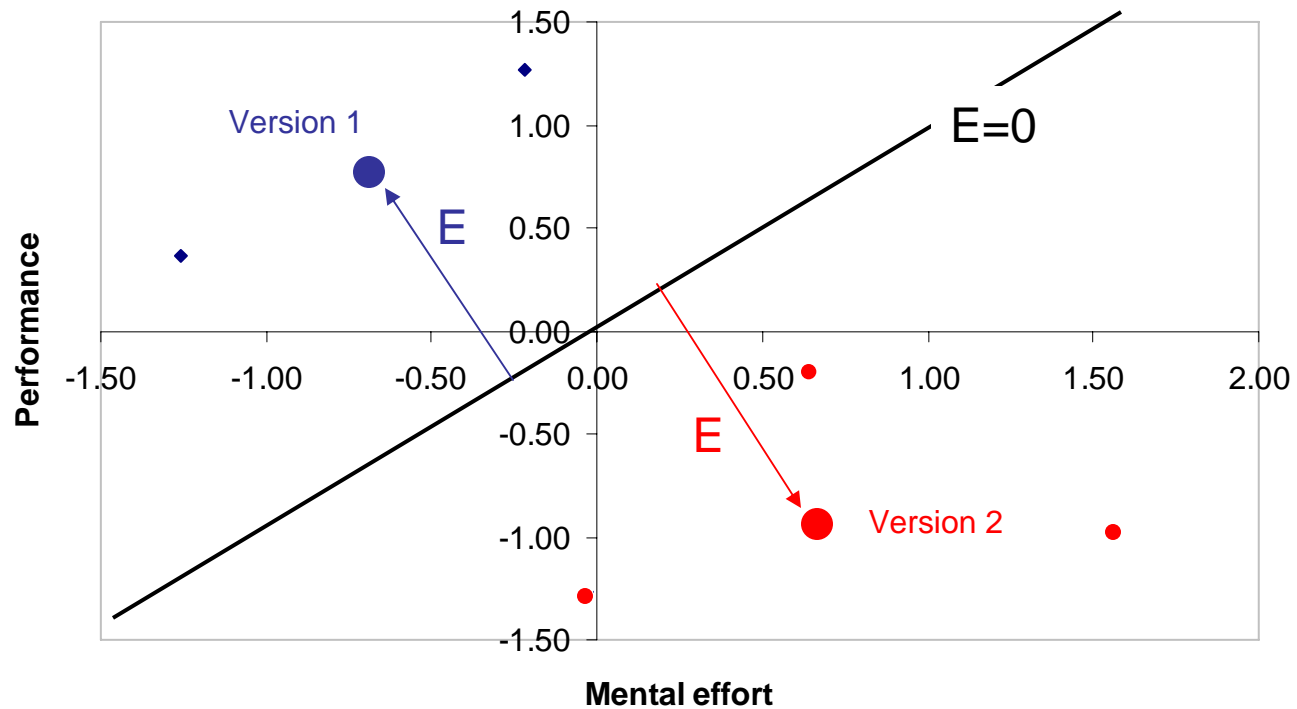
$$E = \frac{0.82 - -0.72}{\sqrt{2}} = 1.09$$

Condition 2

$$E = \frac{-0.81 - 0.70}{\sqrt{2}} = -1.07$$

Note: Adapted from Clark, R.C., Nguyen, F., and Sweller, J. (2006a). *Efficiency in learning: evidence-based guidelines to manage cognitive load*. San Francisco: Pfeiffer. p 335

Relative Condition Efficiency



$$E = \frac{Z_{AC2} - Z_{RME}}{\sqrt{2}}$$

Relative Condition Efficiency (RCE)

$$RCE = \frac{Z_{AC} - Z_{RMPE}}{\sqrt{2}}$$

Research questions



Question 1: Is there a significant difference among the instructional conditions, relative to **performance time**?

Question 2: Is there a significant difference among the instructional conditions, relative to **accuracy**?



Question 3: Is there a significant difference among the instructional conditions, relative to **“relative condition efficiency”**?

Question 4: Is there a significant difference among the instructional conditions, relative to **“performance efficiency”**?





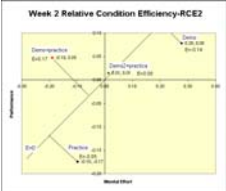

Questions over two phases

Phase	Q1 PerfTime	Q2 Acc	Q3 RCE	Q4 PE
Acquisition 				
Retention 				


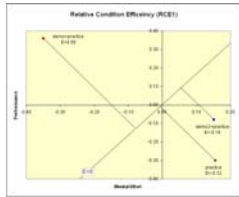




MANOVAs

Phase	Q1 PerfTime	Q2 Acc	Q3 RCE	Q4 PE
Acquisition 	MANOVA			
Retention 	MANOVA			

RCE & PE

Phase	Q1 PerfTime	Q2 Acc	Q3 RCE	Q4 PE
Acquisition 	MANOVA			
Retention 	MANOVA			

Results at a glance

Phase	Q1 PerfTime	Q2 Acc	Q3 RCE	Q4 PE
Acquisition 	MANOVA ***		* 	*** 
Retention 	MANOVA (NS)		NS 	NS 

* = a p value of <0.05

*** = p value of <0.001

Acquisition Phase MANOVA

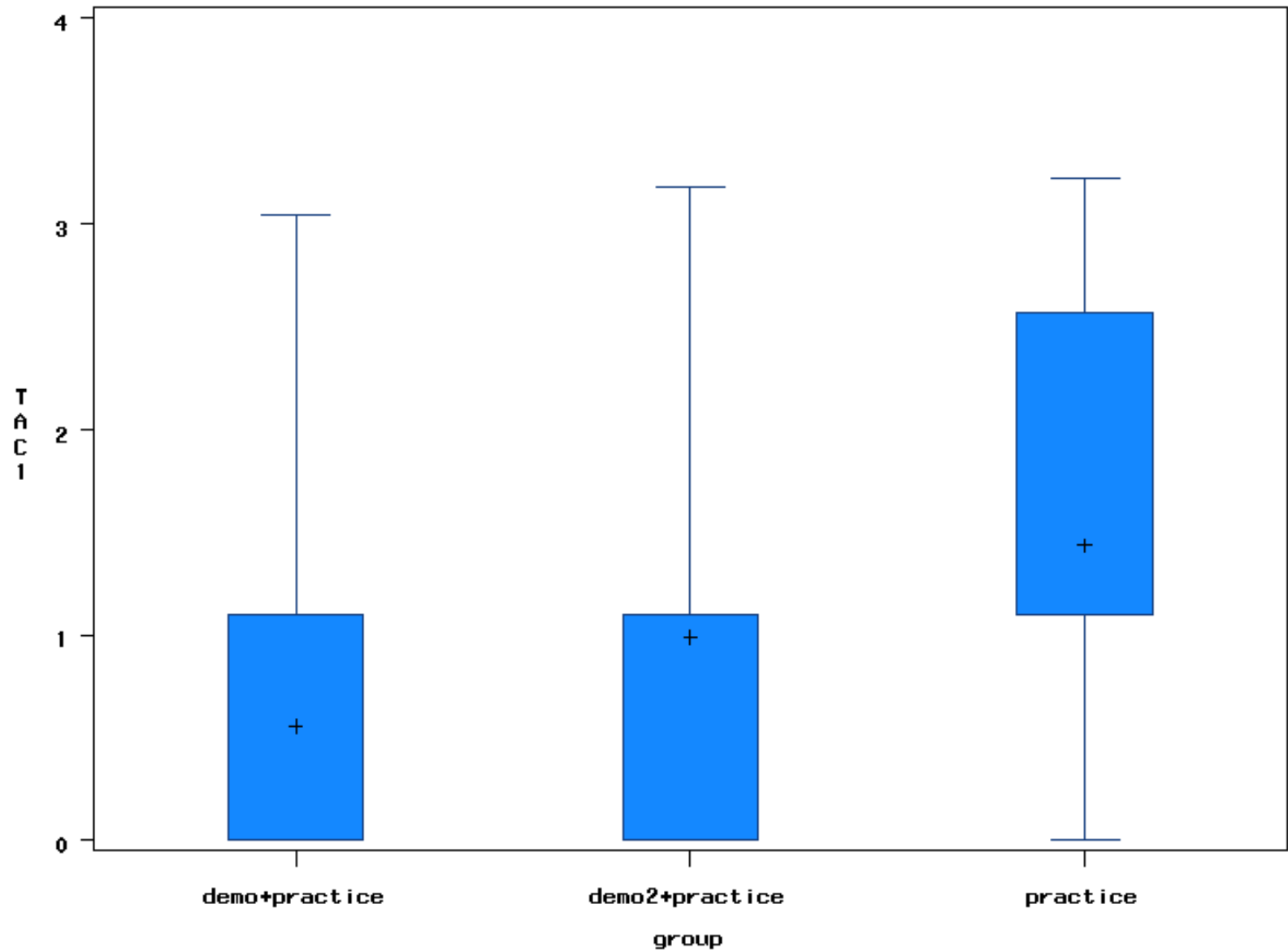
Wilks' $\Lambda=0.68$, $F(2, 68) = 6.83$,
 $p < 0.0001$, $\eta^2 = 0.32$

- Post hoc comparisons w/ Scheffé's test ($p < 0.025$)
- demonstration learners assembled the problem, in significantly less time

Acquisition Phase MANOVA

- $F(2, 68) = 3.19, p=0.0478$ for accuracy (AC1)
- $F(2, 68) = 7.84, p=0.0009$ for performance time (PT1)

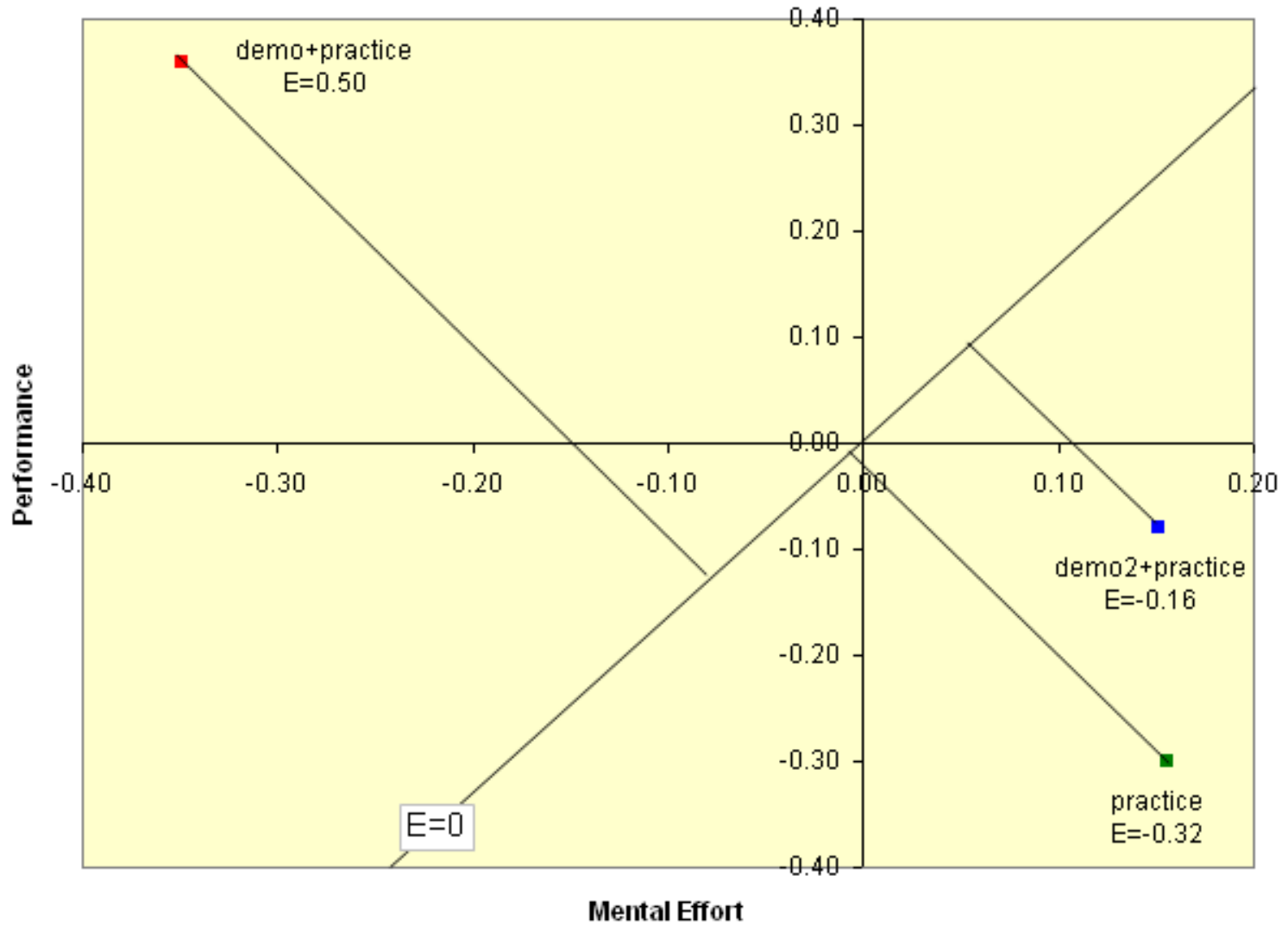
Transformed accuracy (retaining outliers)(week 1)



Relative Condition Efficiency (RCE1)

- $F(2, 68) = 3.69, p=0.03$

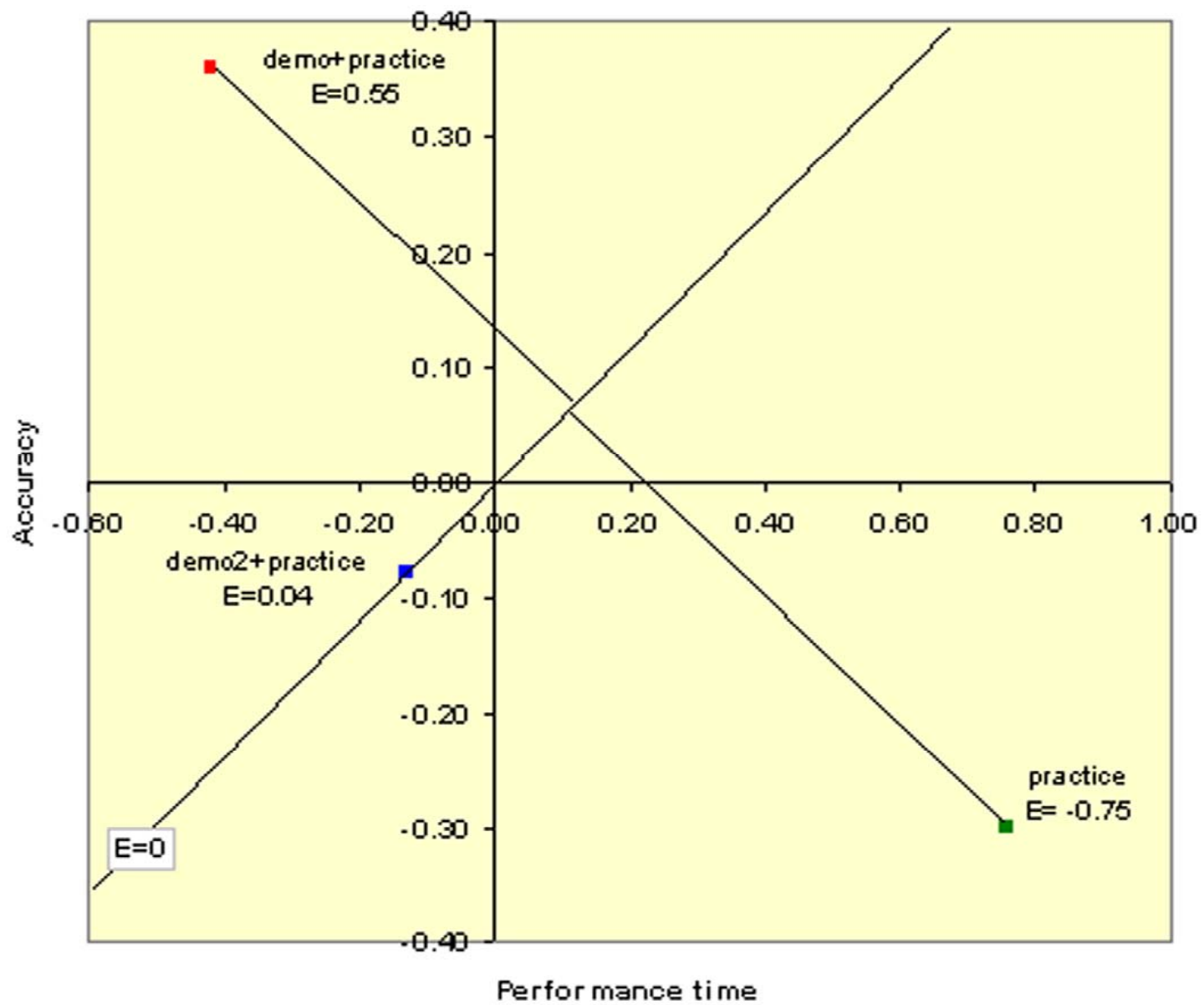
Relative Condition Efficiency (RCE1)



Performance Efficiency (PE1)

- $F(2, 68) = 12.95, p < 0.0001$
- post hoc comparisons with Scheffé's test ($p < 0.05$)
- demonstration learners were significantly more efficient

Performance Efficiency (PE1)



Retention Phase

- No significant differences between groups
 - Week two MANOVA
 - RCE2
 - PE2

Conclusion

- positive evidence of both the worked example and variability effects given animated demonstrations;
- demonstrated the durability of worked example based instruction;
- “performance efficiency” used to objectively compare several instructional conditions, to analyzed the relative efficiency of learner performance;
- further evidence that Palmiter’s animation deficit is not a concern given *narrated* animated demonstrations.