Applying the Science of Learning

Richard E. Mayer

University of California, Santa Barbara
CONTENTS

Preface vii

INTRODUCTION 1

The Big Three: Learning, Instruction, and Assessment 2
Rationale for Applying the Science of Learning 4
What Is Applying the Science of Learning? 6
Historical Overview of the Relation between the Science of Learning and the Science of Instruction 8
Viewing the Relation between the Science of Learning and the Science of Instruction as Overlapping Goals 10
References and Suggested Readings 12

Section 1 HOW LEARNING WORKS 13

What Is Learning? 14
What Changes: Behavior or Knowledge? 16
What Is the Science of Learning? 18
A Look at Transfer 20
How Learning Works: Three Metaphors of Learning 22
   A Closer Look at Response Strengthening: Thorndike’s Law of Effect 24
   A Closer Look at Information Acquisition: Ebbinghaus’ Learning Curve 26
   A Closer Look at Knowledge Construction: Bartlett’s Assimilation to Schema 28
How Learning Works: Three Principles from the Learning Sciences 30
   A Closer Look at Dual Channels: Paivio’s Concreteness Effect 31
   A Closer Look at Limited Capacity: Miller’s Magic Number 7 32
   A Closer Look at Active Processing: Wittrock’s Generative Processes 33
How Learning Works: A Cognitive Model of Learning 34
   Three Memory Stores in Meaningful Learning 36
   Three Cognitive Processes in Meaningful Learning 37
The Mighty Ms: Motivation and Metacognition 38
   Motivation to Learn 39
   How Motivation Works 40
   Metacognition in Learning 42
Learning in Subject Areas 44
Eight Things We Know about Learning from Word Lists 46
References and Suggested Readings 48

Section 2 HOW INSTRUCTION WORKS 51

What Is Instruction? 52
What Is the Science of Instruction? 54
What Is an Instructional Objective? 56
   Three Levels of Instructional Objectives 58
   Five Kinds of Knowledge in Instructional Objectives 60
Section 3  HOW ASSESSMENT WORKS  91

What Is Assessment?  93
What Is the Science of Assessment?  94
Three Functions of Assessments  95
How to Construct a Useful Assessment Instrument  96
  What Works? Using Randomized Controlled Experiments  100
  When Does It Work? Using Factorial Experiments  102
  How Does It Work? Using Observational Analysis  103
A Closer Look at Experiments  104
  Using Effect Size to Assess Instructional Effects  104
  Six Reasons for No Difference between the Treatment and Control Groups  106
How to Assess Learning Outcomes  108
  Two Ways to Measure Learning Outcomes  108
  Three Kinds of Learning Outcomes  110
A Closer Look at Meaningful versus Rote Learning: Wertheimer’s Parallelogram Lesson  112
A Closer Look at Assessment of Learning Outcomes: How Much or What Kind?  114
Broadening the Domain of Assessment  116
A Closer Look at Broadening the Domain of Assessment: Attribute Treatment Interactions  118
Attribute Treatment Interactions Involving Prior Knowledge  120
What Can Go Wrong with Assessments?  122
References and Suggested Readings  124

EPILOGUE  127

Glossary and Subject Index  129
Author Index  134
This was the underlying theme when a select group of high-powered researchers and academics met at a conference on the Science of Learning (ASL) at the Kellogg West conference facility outside of Los Angeles earlier this Spring. Co-chairs Diane Halpern and Milton D. Hakel led the group through a series of discussions to examine gaps in research related to learning, barriers to change in educational institutions and practices, and strategies for implementing new approaches to education based on scientific evidence about the cognitive, individual, social and environmental factors that Learn online and earn valuable credentials from top universities like Yale, Michigan, Stanford, and leading companies like Google and IBM. ... Well, welcome everybody to The Science of Well-being: What psychological science says about the good life. I'm going to kind of give a quick introduction to the stuff about the course, and then we'll get to our particular topic of today. But, I kind of wanted to start because this is a bit of a strange adventure. I'm here sitting with about 25 of my students, most of these students are in Silliman College, one of the residential colleges here at Yale, but a couple of students who snuck in from other colleges. But we welcome you anyway. And I thought it's cool to welcome you