

Index

- accuracy, of judgment
 student judgment
 absolute accuracy, 624, 625–627
 relative accuracy, 624, 625, 626, 629–631
 absolute vs. relative accuracy, 624–625
 teacher judgment
 absolute accuracy, 679–680
 relative accuracy, 680
 absolute vs. relative accuracy, 680–681, 682
- accuracy, of self-monitoring. *see* calibration
 (accuracy of self-monitoring);
 metacomprehension:calibration (accuracy
 of self-monitoring)
- actions. *see* gestures; manipulation of objects
- activity theory, 267, 284
- Adaptive Control Hypothesis, 302
- AEIOU model, 701–702, 703, 706–709
- analogical reasoning, 186–187
- analogies and models
 computer simulation models, 78
 in science, 76–79
- anaphoric inferences, 240–241
- approximate number system (ANS), 101,
 151, 152
 vs. approximate magnitude system (AMS),
 153, 154
- area models, vs. number lines, 168–170
- artist recognition, and interleaved practice,
 414–416
- assessment instruments and methods
 behavioral inventory of life events, 60–61,
 62–63
 of conceptual knowledge, 130–131, 132
 of critical thinking, 59, 60–61
 formative assessments. *see* formative
 assessments
 of procedural knowledge, 131–132
 Programme for International Student
 Assessment (PISA), 149
 of reading skill, 256
 self-assessment. *see* metacognitive monitoring
 (self-monitoring)
 Stanford-Binet Intelligence Scales, 293
 tests. *see* tests
 Triple Task Procedure in Mathematics
 (TTPM), 653
 of vocabulary acquisition, 296–297
- attainment. *see also* test performance
 and class size, 43, 402
 cultural differences, 135, 149–150,
 214–215
 and diet, 38–39
 and English language proficiency, 306–310
 and math anxiety/worry, 113–114
 and socioeconomic status, 308–310
 and spatial skills, 108, 113–114
 and teacher judgment accuracy, 689–691
 mathematics literacy, 149–150
- attention
 and collaborative learning, 510, 520
 and interleaved vs. blocked practice, 425–426
 visual attention. *see* visual attention
- attention deficit hyperactive disorder (ADHD), 328
- augmented reality. *see* virtual and augmented reality
- authentic writing, vs. writing to learn, 283–284
- backward causal bridging inferences, 241
- Bandura, A., social-cognitive learning theory,
 187–188
- behavioral inventory of life events, 60–61, 62–63
- Bereiter, C., knowledge transforming model,
 268–269
- Betty's Brain, 592
- bilingualism, 292–312
 and adult second language learning, 300–303
 bidirectional language transfer in, 301
 dominant language regulation, 303, 304
 immersion, 303
 code switching in, 304–305
 cognitive advantages, 297
 and distributed (spaced) practice, 453–454,
 566–567
 early studies, 293–294
 English Language Learners, 306–312
 error correction and feedback in, 439, 447
 and executive functions, 297–300
 Adaptive Control Hypothesis, 302
 controlled and automatic processes, 299–300,
 301–302
 Inhibitory Control model, 298–299
 unity/diversity framework, 297–298

- in infancy and early childhood, 295–296, 300, 311
- and intelligence, 293–294
- learning strategies in, 707
- lexical-semantic mapping, 295
- and memory, 303–305
- neurological activity, 296, 300–301
- psycholinguistic models of, 294–295
- research gaps, 303–304, 305, 312
- and socioeconomic status, 293–294, 308–310
- translanguaging, 305
- and vocabulary acquisition, 296–297
- biology instruction, 78, 424, 661
 - and computer-assisted learning, 473, 590–592
 - and distributed (spaced) practice, 563–564, 568
 - error correction and feedback in, 443
 - and interleaved vs. blocked practice, 424
 - and learning journals, 276–277
 - use of analogies, 76
- blocked practice, 413, 427–428, *see also* sequence of study
 - benefits of, 417–420, 423, 425–426
 - concept sequencing in, 428
 - vs. interleaved practice. *see* interleaved practice:vs. blocked practice
 - with interleaved practice, 428
 - vs. spaced practice, 415–416
 - student preference for, 417, 419, 428
- calibration (accuracy of self-monitoring), 649–675
 - definition, 649
 - classroom vs. laboratory setting, 650–651
 - contributory factors
 - and performance postdictions, 651–654, 655–656, 660, 673–674
 - and performance predictions, 652, 654–657, 660
 - intervention studies, 657–674
 - across all social cognitive model phases, 674
 - concept mapping, 636–637
 - generative learning strategies, 633–634, 666, 668
 - generative learning strategies, delayed, 633–635
 - incentives and feedback, 661–665, 666–667, 671
 - inference test experiences, 639
 - key intervention components, 639–640, 675
 - in metacomprehension, 633–639
 - and performance improvements, 661–666
 - and performance postdictions, 657–660, 661–665, 666–668, 671
 - and performance predictions, 657–658, 659–660, 661, 664, 666–667, 671
 - re-reading, 635–636
 - rubric provision, 657–658, 661
 - scoring scheme manipulation, 658–659
 - self-explaining, 636
 - self-regulation instruction, 659–660, 661–665, 667–668
 - test expectancy, 638–639
 - and metacomprehension. *see under* metacomprehension
 - and retention, 665–666
 - and social cognitive model, 670–674
- category learning
 - and attention optimization, 425
 - and interleaved vs. blocked practice, 416, 418–419, 424
 - and sequence of study, 412–413
 - and Sequential Attention Theory (SAT), 421–423
- causal beliefs, revision of, 88, 89
- causal bridging inferences (backward), 241
- Chi, M.T.H., ICAP framework, 516–517
- class size, and student attainment, 43, 402
- code switching, in bilinguals, 304–305
- cognitive conflict, 73–74, 83–84
- cognitive load
 - and collaborative learning, 509, 513, 517
 - and multimedia learning, 463–465
 - and self-explaining, 538–539, 542, 543–544
- cognitive psychology, 18–19
 - definitions and scope, 18–19, 22–23
 - domain generality, 23
 - and collaborative learning, 503–505, 508, 515–517
 - and comprehension monitoring, 621
 - and distributed (spaced) practice, 550
 - history of, 18–19
 - vs. learning sciences, 21–28
 - and domain specificity, 23
 - and educational technologies, 21–22
 - and learning environments, 22–23, 24–26, 28–30
 - and levels of analysis, 23–25, 31
 - and research methodologies, 26–28
 - synergies, 28–30
 - research methodologies, 26–27, 31, 550
- cognitive science. *see also* learning sciences
 - definition, 19–20
 - and multimedia learning, 463–465
- cognitive strategy instruction, in reading comprehension, 383–385
- coherence
 - and cohesion, in reading comprehension, 362–363
 - and memory, in reading comprehension, 239, 240, 243–245
- coherence principle, in multimedia learning, 465–466
- coherence threshold, in reading comprehension, 249, 253–255
- collaborative learning, 500–520
 - definitions and scope, 502

- collaborative learning (cont.)
 benefits of, 508–511
 and cognitive load, 509, 513, 517
 cognitive mechanisms, 508–510, 513–514
 collaborative facilitation (synergy), 505
 collaborative inhibition, 505, 512
 computer-supported, 31, 267, 590
 co-operation and competition in, 501, 518–519
 costs of, 512–516
 error correction and feedback in, 449, 509–510, 512, 519
 goal-setting in, 519
 group dynamics, 501
 implementation strategies, 518–520
 perspectives
 cognitive and social psychology, 503–505, 508, 515–517
 educational psychology, 505–506, 508
 socio-cultural, 267, 502, 506–507
 psychological research in, historical context, 500–502
 in reading comprehension, 385, 401
 research design for, 503–507
 and task complexity, 513, 518
 theoretical frameworks, 515–517
 collaborative memory framework, 515–516
 Comenius, J.A., 461
 common ground, in collaborative learning, 510–511, 518, 520
 communities of practice, 20, 25
 complementary knowledge, in collaborative learning, 509
 comprehension. *see* reading comprehension
 computer games. *see* game-based learning environments (GBLE)
 computer simulation models, 78
 Computer-Assisted Learning Systems (CALS). *see also* multimedia learning; technologies, educational
 computer games. *see* game-based learning environments (GBLE)
 definitions and scope, 587, 588–590
 and emotions, 596–597
 future directions, 612–613
 hypermedia, 323, 588–589, 590–591
 intelligent tutoring systems (ITS), 442, 589, 590–591
 lesson segmenting in, 470
 personalized text in, 473
 research focus and methodologies, 588
 research gaps, 30, 613
 as research tools. *see* technologies, educational:as research tools
 and self-regulation, 587–613
 assessment of self-regulation, 604–612, *see also* technologies, educational:as research tools
 models of, 592–602
 self-regulation processes, 597–602
 teachable agents, 589–590, 592
 virtual and augmented reality, 589–590, 592
 computer-supported collaborative learning (CSCL), 31, 267, 590
 concept-mapping, 532, 636–637
 conceptual knowledge, 124–125
 definitions and scope, 125
 assessment methods, 130–131, 132
 intervention studies, 134, 135
 and procedural knowledge, 127–128
 and example-based learning, 190–191
 as “interwoven,” 249.90, 132–135
 ordering of instruction, 128–129, 136–140
 and transfer, 190–191
 conceptual thinking, instruction in, 72–74
 confidence bias
 of student judgment, 624, 627–628
 of teacher judgment, 679–680
 conflict regulation, 511, 515, 519
 confusion, 601, 607–608, 611
 Construction-Integration model, 245–246
 contextual interference, in interleaved practice, 414
 contextual variability theory, 553–554
 controlled and automatic processes, 299–300, 301–302
 control-of-variables strategy (CVS), 83–84
 co-ordination costs, in collaborative learning, 513, 518
 COPES model, 699, 703
 correction of errors. *see* error correction and feedback
 correlation-becoming-causation, 37–39, 40, 43, 54–56
 critical thinking (skills), 51–63
 definitions and scope, 53–54
 assessment of, 58–59
 changes during college, studies of, 57–58
 cross-domain transfer, 56
 as a disposition, 53–54
 historical models, 51–52
 importance of, 52–53
 as predictor of life events, 60–63
 instruction in, 54–58
 vs. intelligence, 62–63
 opposition to, 52
 and rote recall, 53
 and wisdom, 62–63
 cross-cueing, in collaborative learning, 509
 Crystal Island, 591–592, 606, 607–608
 cueing, in multimedia learning, 466–467
 cue-utilization framework, 622–623, 685
 cultural differences, 135, 149–150, 214–215
 data
 eye-tracking. *see* eye-tracking data

- facial expression, 604–605, 607
 log-file. *see* log-file data
 multimodal multichannel. *see* multimodal multichannel data
 physiological, 605–606, 607–608, 609, 610
 Dearborn, G.V.N., 696–697
 deep (interpretive) comprehension, 257, 367–369
 deictics (pointing gestures), 211, 213–214
 demonstrations. *see* example-based learning: modeling examples
 design-based research, 27–28, 31
 Deustch, M., 501
 diet, and attainment (lack of causal link), 38–39
 discourse synthesis, 275, 283
 discrepancy reduction (DR) model, 489, 490, 706–707
 Discrepancy-induced Source Comprehension (DISC), 365–367
 distributed (spaced) practice, 550–573
 definitions, 550
 in different populations, 556
 implementation strategies, 570–571
 vs. interleaved and blocked practice, 415–416
 and interstudy interval, 552–554, 566–567, 568
 in learning domains, 556–557
 intellectual, 57, 556, 563–564, 568–569, 570
 motor, 552, 556, 560–562, 567, 569–570
 social and emotional, 556, 565
 verbal, 453–454, 552, 556, 558–559
 vs. massed learning, 453–454, 552, 554–555, 557–567
 research design for, 550, 555
 and retention interval, 552, 554–555, 566–567, 568, 569
 theories of, 553–554
 distributed cognition theory, 267, 284
 Documents model framework, 363–367
 domain generality and specificity. *see* transfer drawing, as learning, 280
 dual coding (channel) theory, 384, 463
 Dynamics of Affective States Model, 596–597
 Ebbinghaus, H., 550, 552
 educational psychology
 and collaborative learning, 505–506, 508
 and comprehension monitoring, 621
 educational technologies. *see* technologies, educational
 electrodermal activity (EDA) data, 605–606, 607–608, 609, 610
 embodiment principle, in multimedia learning, 473–474
 emotions, and computer-assisted learning, 596–597, 604–605, 607–608
 engineering instruction, feedback timing in, 452
 English Language Learners. *see under* bilingualism
 epistemic regulation, in collaborative learning, 511
 erroneous examples, use of, 193–194, 539–540, 542
 error correction and feedback, 437–454
 definitions and scope, 438, 454
 accessing vs. skipping feedback, 448–449
 answer vs. explanation feedback, 442, 452–453
 in collaborative learning, 449, 509–510, 512, 519
 and conceptual change, 443
 and error resurgence, 450
 form of feedback, 442–443, 451–452
 and formative quizzes, 481
 and high-performing students, 447
 immediate vs. delayed feedback, 451–452, 454
 importance of, 437–438
 and misconceptions, 440–442, 450–451, 452–453, *see also* preconceptions and misconceptions
 right/wrong feedback, 439–440
 vs. error correction, 439
 in self- and peer-grading, 449
 student attention to feedback, 441–442, 447–449
 student preferences, 451–452
 student processing of feedback, 449
 surprising feedback, 441–442
 error interpretation, 87–88
 errorless learning, 437
 evaluation of sources, in reading comprehension, 369–371, 373–374
 evaluation, fear of, in collaborative learning, 515, 519
 evidence evaluation, in scientific thinking, 67–68, 85–89
 example-based learning, 183–199
 definitions and scope, 183
 effectiveness and efficiency, 184–190
 example-problem pairs and sequencing, 188–190
 “hybrid” worked-modeling examples, 184
 modeling examples, 184
 and attention, 187–188, 195
 in experimental design (instruction), 83–84
 in literacy, 197
 in mathematics, 196, 197
 model characteristics, 197
 in physics, 186, 197–198
 on video, 194–198
 viewing perspective, 197–198
 vs. practice problems, 186, 187, 188–189, 198, 538–539
 and productive failure, 198–199
 research gaps, 198
 and self-regulated learning, 198
 and transfer, 190–194

- example-based learning (cont.)
 worked examples, 184, 188–189
 and cognitive rehearsal, 194
 design of, 529–530
 erroneous examples, use of, 193–194,
 539–540, 542
 and explanations, 191–192
 in mathematics, 140, 529–530
 molar and modular examples, 192, 194
 in physics, 184, 188–189
 redundancy in, 194–195
 and self-explaining, 530, 532–533, 538–540,
 542
 split-attention, avoiding, 194–195
 student comparisons of, 192–194, 539–540,
 543–544
 subgoals, 194
- executive functions
 and bilingualism. *see* bilingualism:and execu-
 tive functions
 controlled and automatic processes, 299–300,
 301–302
 Inhibitory Control model, 298–299
 unity/diversity framework, 297–298
- exemplar inferences, in reading comprehension,
 241–242
- experimentation design skills, 79–83, 83–84
- explanations. *see also* self-explaining
 in collaborative learning, 510
 constructions, in science, 88–89, 275, 532, 537
 in example-based learning, 191–192
- eye movement modeling examples (EMME), 196
- eye-tracking data, 604, 606, 608
 suitability of, 609, 611
- facial expression data, 604–605, 607
- false memories, and collaborative learning, 512
- fantasy texts, and reading comprehension,
 252–253
- fear of evaluation, in collaborative learning, 515,
 519
- feedback. *see* error correction and feedback
- field independence and dependence, and
 note-taking, 325
- Flavell, J.H., 621, 622, 697
- flow state, 596, 597
- forethought, in social cognitive model, 648,
 670–672
- formative assessments, 686–689, 690–691,
see also tests
- frustration
 and computer-assisted learning, 601, 604–605,
 607–608, 610
 and confusion, 601, 607–608
 and Dynamics of Affective States Model,
 596–597
 measurement of, 604–605, 607–608, 610
- game-based learning environments (GBLE), 589
 for critical thinking skills, 57
 Crystal Island, 591–592, 606, 607–608
 design principles, 474–475, 538
- gaze cues, and modeling examples, 195–196
- geography instruction, 357–359
- Gesture-as-Simulated-Action (GSA) framework,
 211
- gestures, 209–229
 definitions, 210–211
 vs. actions, 209–210, 225–226, 227
 cultural differences, 214–215
 as embodied cognition, 211, 225–226
 and flexible learning, 224–225
 gesture-speech mismatch
 by students, 216–219
 by teachers, 220–221
 in literacy learning and education, 226
 in mathematics instruction. *see* mathematics
 instruction and math skills:gestures in
 in multimedia instruction, 473–474
 neurological activity, 225
 by students, 221–223
 doing vs. seeing, 227
 experimental studies, 216–219
 as explicitly taught strategies, 222–223, 228
 intervention studies, 222–223
 naturalistic observational studies, 213
 response to teacher gesture use, 222
 and transitional knowledge state, 216–219
 and synchrony with speech, 224–225
 by teachers, 213, 220–221, 228
 experimental studies, 220–221, 222, 224–225
 naturalistic observational studies, 212–215
 and student gesture use, 222
 videotaped vs. live instruction, 221
 and visual attention, 223–225
- Get the Gist graphic organizer, 399–400
- goal-setting, 268–269, 519
- Green, D.W., Adaptive Control Hypothesis, 302
- group dynamics, 501, *see also* collaborative
 learning
- Halpern Critical Thinking Assessment (HCTA),
 59, 60–61
- handouts, 335–336
- handwriting instruction, interleaved practice,
 413–414
- handwriting speed, and note-taking, 325–326
- Hiebert, J., 126, 128
- Hinsdale, B.A., 632
- history instruction
 and argument writing, 277–278
 and distributed (spaced) practice, 558–559,
 566
 and multiple texts, 277–278, 360, 361–362,
 364–365, 366, 372, 373

- hypercorrection effect, 441, *see also* error correction and feedback
- hypermedia learning environments, 323, 588–589, 590–591
- hypothesis forming and refinement, 74–79, 412–413
- hypothesis testing, 80–81, 608
- iconic gestures, 210–211, 214, 215
- If-Then learning tactic, 699
- imagistic gestures, 210–211, *see also* non-imagistic gestures
- Immediate Feedback Assessment Technique (IF-AT) system, 451–452
- immersion, and second language learning, 303
- inference. *see* reading comprehension:inference
- Information Processing Theory, 593–594
- informational writing, 241–243
- Inhibitory Control model, 298–299
- intelligence
 and bilingualism, 293–294
 vs. critical thinking, 62–63
 and socioeconomic status, 293–294
 vs. wisdom, 62–63
- intelligent tutoring systems (ITS), 442, 589, 590–591
- Interactive-Constructive-Active-Passive (ICAP) framework, 516–517
- interleaved practice, 413–417, *see also* sequence of study
 definition, 413
 vs. blocked practice, 413–426
 and attention, 425–426
 and concept types, 423
 and Sequential Attention Theory (SAT), 421–423
 and test types and performance, 424–425
 and working memory, 418, 426
 in artist recognition, 414–416
 in biology, 424
 in category learning and classification, 416, 418–419, 424
 in children vs. adults, 425
 in handwriting, 413–414
 in inference-making, 423–424
 in language learning, 419
 in mathematics, 414, 416–417, 418
 in medicine, 416
 in motor skills learning, 418
 in novices vs. experts, 425–426
 in psychology, 416, 419
 with blocked practice, 428
 and contextual interference, 414
 vs. spaced practice, 415–416
- interleaving, and bilingualism, 304–305
- iterative view, of conceptual and procedural knowledge, 127–128, 132–135, 137–139
- journals and reflective writing, 273–274, 276–277, 280–281
- Kahneman, D., 52
- Kintsch, W., Construction-Integration model, 245–246
- Kintsch, W., levels of representation, 238, 632
- knowledge transforming model, 268–269
- Koriat, A., cue-utilization framework, 622–623, 685
- language learning and mastery. *see also* bilingualism; verbal learning
 as a critical thinking skill, 55
 and distributed (spaced) practice, 558–559, 563–564
 and interleaved vs. blocked practice, 419
- Latent Semantic Analysis, 611
- learning disabilities, 328, 382, 386–387
- learning environments
 and cognitive psychology vs. learning sciences, 22–23, 24–26, 28–30
 design of, 25, 31
 as research focus, 30, 31
- learning sciences
 definitions and scope, 17, 20, 22, 23
 vs. cognitive psychology. *see* cognitive psychology:vs. learning sciences
 and educational technologies, 21–22
 history of, 21
 research methodologies, 26, 27–28
- learning strategies, 696, *see also* self-regulated learning
 AEIOU model, 701–702, 703, 706–709
 choice of strategy, 701–703
 how to study, 708–709
 and motivational factors, 701–702, 707–708
 and objective conditions, 701, 706–707
 and test expectancy, 702–703
 what to (re-)study, 491–492, 706–708
- COPES model, 699, 703
- discrepancy reduction (DR) model, 489, 490, 706–707
- early writings on, 696–698
- effectiveness, 704–706
- importance of, 698
- instruction in, 704–706, 708, 709
 and learning tactics, 698–700
- region of proximal learning model, 489
- research focus in, 697–698, 706–709
- research gaps, 708, 709–711
- SQ3 R method, 704
- “learning styles”, as unsupported by evidence, 10–11, 40–41
- lectures
 cues in, 334
 handouts, 335–336

- lectures (cont.)
 note-taking from. *see* note-taking:from
 lectures
 pace and density of delivery, 323–324, 334
 repetition of, 333–334
 letter-writing, 279
 Lewin, K., 501
 lexical-semantic mapping, in bilingualism, 295
 life events, and critical thinking skills, 60–63
 literacy learning and education. *see also* reading
 comprehension; verbal learning
 and distributed (spaced) practice, 569
 gestures, 226
 modeling examples, 197
 loafing, social, 514–515, 520
 log-file data, 605, 606, 608
 suitability of, 609, 611
 logical inferences, in reading comprehension, 242
 long-term memory
 and multimedia learning, 464
 and reading comprehension, 239–240,
 243–245, *see also* reading comprehen-
 sion:and memory
- macro and micro-level framework, 594–595
 manipulation of objects, 209
 vs. gestures, 209–210, 225–226, 227
 mathematics instruction and math skills
 algebra, 110, 111, 113, 214
 ANS. *see* approximate number system (ANS)
 approximate calculations, 107
 area and perimeter, 136
 arithmetic performance
 and mental rotation skill, 104, 105
 and number line estimations, 107
 and visuospatial working memory, 103, 113
 calculus, 111–113
 conceptual knowledge. *see* conceptual
 knowledge
 curriculum, secondary, 108–109, 140–141
 decimals, 137
 distributed (spaced) practice, 563–564, 568
 exact numeracy, 101–102, 103
 example-based learning, 140, 196, 197,
 529–530
 fractions, 148, 150, 153–174
 arithmetic operations, 163–164, 171–172
 and conceptual and procedural knowledge,
 133–134
 developmental precursors, 167
 fraction comparison strategies, 160–163,
 169, 170
 importance of, 150, 165–166
 intuitive understanding of, 148, 153–154
 and number lines, 161–162, 165, 168–170
 numerical density, 163
 as problematic, 150, 159–160
 symbolic notation, 159–163
 and whole number bias, 159–160, 162–163
 and whole number knowledge, 154–155,
 166–167, 170–171, 172
 geometry, 109–110, 111, 113
 and eye movement modeling examples, 196
 and linking (pointing) gestures, 214
 and self-explaining, 535
 gestures in, 212–229
 vs. actions, 225–226
 experimental studies, 220–225
 iconic gestures, 214, 215
 linking (pointing) gestures, 213–214
 and mathematical equivalence, 214, 220,
 221, 224–226
 metaphoric gestures, 214
 naturalistic observational studies, 212–215
 importance of, 148–149, 150, 165–166, 212
 interleaved vs. blocked practice in, 414,
 416–417, 418
 mathematical equivalence, 134, 137
 use of gestures, 214, 220, 221, 224–226
 mathematical thinking, developmental ori-
 gins, 101–102, 106, 151–156, 167
 mathematics literacy, 149–150
 and multimedia learning, 462–463
 number lines, 102, 106–107, 151–152,
 164–165
 vs. area models, 168–170
 and fractions, 161–162, 165, 168–170
 and mental rotation skill, 104, 106–107
 and proportional reasoning, 106
 and self-explaining, 539
 numerosity, 151–153
 ordering of conceptual and procedural knowl-
 edge instruction, 128–129, 136–140
 place-value, 212–213
 practice problems. *see* practice problems
 probability, 55, 532–534, 535
 procedural knowledge. *see* procedural
 knowledge
 proportional reasoning, 105–106, 107
 proportions and ratios (nonsymbolic),
 155–159, 166
 research gaps, 132, 136, 139–141, 172–174
 fractions, 173
 spatial skills, 109, 113, 114–115
 and self-explaining, 532–534, 535, 539
 and self-monitoring, 653, 655,
 664, 666–667
 and spatial skills. *see* spatial skills
 and mathematics
 symbolic approximation, 101
 symbolic notation, 159–163
 symmetry, 220
 teacher judgments
 accuracy, 678–682, 683–685
 diagnostic cues, 216–219, 685–687
 global test predictions, 679–681

- influence on instruction, 678, 679–680, 689–690
- item-level test predictions, 681–682
- research gaps, 678
- worked examples, 140, 529–530
- mechanisms
- in collaborative learning, 508–511, 513–515
 - mechanisms of change, in individual learning, 501–502
- medicine instruction, 416, 558–559, 560–562
- memory
- and bilingualism, 303–305
 - false (contagion), and collaborative learning, 512
 - long-term memory. *see* long-term memory
 - and mathematics. *see* visuospatial working memory (VSWM)
 - metamemory, 619–621, 629, 634–635, 637
 - and multimedia learning, 463–465
 - and reading comprehension. *see* reading comprehension:and memory
 - working memory. *see* working memory
- mental rotation, 103–105, 110–113
- metacognition, 621–622
- and choice of learning strategy. *see* learning strategies:choice of strategy
 - measurement of, in computer-assisted learning, 607, 608, 610, 611
 - self-monitoring. *see* metacognitive monitoring (self-monitoring)
 - self-regulation. *see* self-regulated learning
 - and testing, 489–492
 - and writing to learn, 282
- metacognitive monitoring (self-monitoring), 621–622, *see also* self-regulated learning
- accuracy of. *see* calibration (accuracy of self-monitoring)
 - cue-utilization framework, 622–623, 685
 - discrepancy reduction (DR) model, 489, 490, 706–707
 - educational vs. cognitive psychological perspective, 621
 - general heuristics in, 623
 - in mathematics, 653, 655, 664, 666–667
 - in physics, 653–654, 666
 - in psychology, 653–654, 655, 664–666
 - in reading comprehension. *see* metacomprehension
 - region of proximal learning model, 489
 - in research methods, 639, 651–653, 655–656
 - and social cognitive model, 649, 672
 - and testing, 489–491
- metacomprehension, 619–642, *see also* reading comprehension
- definitions, 619, 623–624, 628
 - calibration (accuracy of self-monitoring), 621, 667–668, *see also* calibration (accuracy of self-monitoring)
 - absolute accuracy, 624, 625–627
 - confidence bias, 624, 627–628
 - improving accuracy, intervention studies, 633–639
 - inter-person correlation, 628
 - and multimedia learning, 627
 - relative accuracy, 624, 625, 626, 629–631
 - relative vs. absolute accuracy, 624–625
 - and cues, 631–633, 635–636
 - cue selection, 638–639, 640
 - heuristic cues, 625–627, 631
 - data analysis methods, 629
 - and error detection, 619
 - instruction in, 398–399
 - and metamemory, 619–621, 634–635, 637
 - questioning, 398
 - and reading comprehension skill, 635–636
 - research design for, 619–620
 - research gaps, 640–642
 - situation-model approach, 631–633, 634
 - and working memory, 635–636
- metamemory, 619–621, 629, 634–635, 637
- metaphoric gestures, 210–211, 214, *see also* imagistic gestures
- MetaTutor, 590–591, 606, 607–608, 609
- misconceptions. *see* preconceptions and misconceptions
- Miyake, A., unity/diversity framework, 297–298
- modality principle, in multimedia learning, 472
- modeling examples. *see* example-based learning: modeling examples
- models. *see* analogies and models
- molar and modular examples, 192, 194
- Montessori approach, 209
- morphology, instruction in, 396–397
- motivation, in self-regulated learning, 648, 701–702
- motor skills learning, and distributed (spaced) practice, 552, 556, 560–562, 567, 569–570
- multimedia learning, 460–476, *see also* technologies, educational
- definitions and scope, 460, 461, 589
 - cognitive theory of, 463–465
 - vs. explanations alone, effectiveness of, 462–463
 - instructional design principles, 465–475
 - and metacomprehension, 627
 - research gaps, 475
- multimodal multichannel data, 604–612
- appropriate data channel selection, 609–610
 - data analysis methods, 611
 - electrodermal activity (EDA), 605–606, 607–608, 609, 610
 - eye-tracking data. *see* eye-tracking data
 - facial expression data, 604–605, 607
 - log-file data. *see* log-file data
 - physiological data, 605–606, 607–608, 609, 610

- multimodality, and writing to learn, 269–270, 285–286
- multiple choice tests
 advantages, 485–486, 492–494
 vs. free- or cued-recall tests, 481–487
 with multiple plausible alternatives, 493
 to reactivate knowledge, 450
 repeated testing, 484
- multiple text comprehension. *see* reading comprehension:of multiple texts
- “mush” model, of reading comprehension, 364–365
- music instruction, and distributed (spaced) practice, 560–562
- National Education Policy Center (NEPC), 42–43
- necessary inferences, in reading comprehension, 240–241
- neurological activity
 with bilingualism, 296, 300–301
 with gestures, 225
 with pattern completion in learning, 421
 with spatial skills and mathematical processing, 101, 102
- non-imagistic gestures, 211, *see also* imagistic gestures
- nonsymbolic approximate number system. *see* approximate number system (ANS)
- note-taking, 320–344
 definitions and scope, 320–321, 332–333
 and content familiarity, 323
 in court, 340–341
 development of, 342–343
 from lectures
 and cognitive skills, 325–326, 328–331, 332–333
 and disabilities, 328
 encoding and review, 321–324, 327–328, 330, 337–340
 and field independence/dependence, 325
 and gender, 325
 by hand vs. computer, 331–332
 and handwriting speed, 325–326
 information capture rate, 324
 lecture modifications to support note-taking, 333
 review methods instruction, 337–338
 self-testing from, 338–339, *see also* testing effect
 and test outcomes, 326–328, 333–336
 as ubiquitous, 321
 measurement of, 606, 611
 and multiple text comprehension, 368–369
 research gaps, 341–342, 344
- nStudy, 709–711
- number lines. *see* mathematics instruction and math skills:number lines
- number sense, 101
- numeracy, exact, 101–102, 103
- numerical density, understanding of, 163
- numerosity, 151–153
- observational learning, 183, *see also* example-based learning
- overconfidence. *see* calibration (accuracy of self-monitoring)
- paraphrasing, and reading comprehension, 399–400
- Peabody Picture Vocabulary Test (PPSVT), 296
- peer learning, 449, 486, *see also* collaborative learning
- Perfetti, C.A., Documents model framework, 363–367
- performance, in social cognitive model, 648–649, 672
- personalization principle, in multimedia learning, 473
- persuasion, 361
- pharmacy instruction, 653
- philosophy instruction, and learning journals, 277
- physics instruction, 73
 and distributed (spaced) practice, 563–564, 568–569
 error correction and feedback in, 445
 and modeling examples, 186, 197–198
 and multimedia learning, 462–463, 469–472
 and self-explaining, 530
 and self-monitoring, 653–654, 666
 and worked examples, 184, 188–189
- physiological data, 605–606, 607–608, 609, 610
- Piaget, J., 52, 79, 106, 209, 216, 501–502
- pointing gestures, 211, 213–214
- practice problems
 vs. example-based learning, 186, 187, 188–189, 198, 538–539
 example-problem pairs and sequencing, 188–190
 and productive failure, 198–199
 research gaps, 198–199
 and self-explaining, 538–539
 with teacher hints, 187
- preconceptions and misconceptions
 causal and non-causal beliefs, 88, 89
 error correction and feedback with, 440, 450–451, 452–453
 and scientific thinking and learning, 70–72, 73, 438, 444
 domain generality and specificity, 74
 gap-filling vs. conceptual changes, 71, 87
- predictive inferences, in reading comprehension, 242
- pretraining principle, 395, 470–472
- problems, practice. *see* practice problems
- procedural fluency, 129
- procedural knowledge

- definitions and scope, 126
 assessment methods, 131–132
 and conceptual knowledge. *see* conceptual knowledge:and procedural knowledge
 intervention studies, 134
 procedural thinking, instruction in, 74–79
 production blocking, in collaborative learning, 514
 Programme for International Student Assessment (PISA), 149
 proportional reasoning, 105–106, 107
 psychology instruction
 error correction and feedback in, 442–443
 and interleaved vs. blocked practice, 416, 419
 and self-monitoring, 653–654, 655, 664–666
 and testing, 487–488
 publication practices, 44

 “quackery”, 35–41
 definition, 35
 and correlation-becoming-causation, 37–39, 40, 43
 “Bunkum Awards”, 43
 in educational research, 37–41
 vs. evidence-based recommendations, 36–37
 quizzes. *see* tests

 Rajaram, S., collaborative memory framework, 515–516
 reading comprehension, 237–258, 356–375, 381–403
 coherence and cohesion, 362–363
 coherence threshold, 249, 253–255
 collaborative learning, 385, 401
 deep (interpretive) comprehension, 257, 367–369
 dual coding theory, 384
 fantasy texts, 252–253
 importance of, 381–382
 inference, 358–359
 and blocked practice, 423–424
 elaborative inferences, 241–243, 531
 instrumental inferences, 241–242
 necessary inferences, 240–241
 instruction in
 activating prior knowledge, 395
 building background knowledge, 394–395
 cognitive strategy instruction, 383–385
 duration of instruction, 390
 effectiveness, 387–394
 explicit mental modeling (think-aloud), 385
 group size, 402
 intensive intervention, 392–394, 401–402
 and legislation and policy, 386–387, 389–390
 previewing and visual prompts, 395
 questioning, 398, 400
 reciprocal teaching, 385
 Response to Intervention (RTI), 387
 self-monitoring strategies, 398–399
 self-regulation instruction, 402
 for struggling readers, 384–385, 387–389, 392–394, 396, 401–403, 637
 summarization and paraphrasing, 399–400
 text structure instruction, 705
 vocabulary instruction, 395–397
 and distributed (spaced) practice, 567
 and learning disabilities, 382, 386–387
 reading disability, 384–385
 legislation and policy in, 386–387, 389–390
 levels of representation, 238–239
 and memory, 239–245
 coherence and passive activation, 239, 240, 243–245
 Construction-Integration model, 245–246
 elaborative inferences, 241–243
 integration (linkage), 245, 247, 248
 linkage validation, 246–247, 248, 250–253
 metacomprehension, 635–636
 metamemory, 619–621, 634–635, 637
 multiple texts, 372
 necessary inferences, 240–241
 resonance, 239–240, 242–243, 244–245, 247
 RI-Val model, 247–250
 of multiple texts, 277–278, 356–375
 definitions, 356
 argument vs. summary tasks, 367–369
 comparisons, 358–359, 398
 Documents model framework, 363–367
 in geography (case study), 357–359
 in history, 277–278, 360, 361–362, 364–365, 366, 372, 373
 “mush” model, 364–365
 note-taking, 368–369
 and reader beliefs, 371–372
 in science, 369–370
 self-explaining, 369
 in social sciences, 374
 source evaluation, 369–371, 373–374
 source-content encoding, 364–366
 sourcing heuristic, 361–362
 summarization, 282, 367–369
 taught strategies for, 372–374
 and text discrepancies, 365–367
 word recognition skills, 372
 and working memory, 372
 and persuasion, 361
 problems, 382–383
 processing time course, 249–250
 questioning, 398, 400
 reader-response theory, 385
 and reading style and speed, 255–256
 research focus in, 237–238, 250, 360–361
 and multimodal multichannel data, 606
 research gaps, 371–372, 375, 403
 schema theory, 384, 394
 science writing, 396–397

- reading comprehension (cont.)
 self-monitoring in. *see* metacomprehension
 self-regulation in, 386, 402
 and semantic anomalies (illusions), 250–252
 Simple View of Reading, 384–385
 and struggling readers, 256, 384–385,
 387–389, 392–394, 396, 401–403, 637
 summarization, 275, 280, 282, 383–384,
 399–400
 as task-influenced, 367–369, 372
 and text discrepancies, 365–367
 and vocabulary acquisition, 395–397
 reading disability, 384–385
 reading styles, and comprehension, 255–256
 recall
 retrieval practice. *see* retrieval practice
 rote recall, and critical thinking, 53
 reciprocal teaching. *see* collaborative learning;
 peer learning; reading comprehension:
 instruction in (reciprocal teaching)
 redundancy principle, in multimedia learning, 469
 re-exposure, in collaborative learning, 509
 reflective writing and journals, 273–274, 276–277,
 280–281
 reform-oriented instruction, 136
 rehearsal, cognitive, and worked examples, 194
 relational reasoning, 154, 173
 relational regulation, in collaborative learning,
 511, 515
 relative accuracy, of student and teacher
 judgment. *see under* accuracy, of
 judgment
 representational thinking, 68–70
 research integrity, 41–43
 research methods instruction, 493, 494, 639,
 651–653, 655–656
 resonance model, of reading comprehension,
 239–240, 242–243, 244–245, 247
 Response to Intervention (RTI), 387
 retrieval practice. *see also* testing effect
 in collaborative learning, 509, 514
 free- or cued-recall vs. recognition, 481–487
 vs. re-studying, 19, 338–339
 rhetorical goals, 268–269
 RI-Val model, 247–250
- schema theory, and reading comprehension, 384,
 394
- science instruction. *see also* scientific thinking:
 instruction in
 example-based learning, 184, 197–198
 practice guidance, 90
 and preconceptions/misconceptions. *see*
 preconceptions and misconceptions:and
 scientific thinking and learning
 Science Writing Heuristic, 278–279, 283
 scientific concepts, 444–445
 scientific disciplines
 biology. *see* biology instruction
 ecology, 590–592
 evolution, 73, 78
 geology, 77–78
 medicine, 416, 558–559, 560–562
 pharmacy, 653
 physics. *see* physics instruction
 psychology. *see* psychology instruction
 Science Writing Heuristic (SWH), 283
 science, “belief” in, 51
 scientific thinking, 67–91
 analogic writing, 275
 conceptual knowledge. *see* conceptual
 knowledge
 curiosity and questioning, 75–76
 data analysis and interpretation, 87–88
 definitions and taxonomy, 67, 69
 developmental origins, 68–71, 85–86
 error interpretation, 87–88
 evidence evaluation, 85–89
 explanation construction, 88–89, 275, 532,
 537
 instruction in, 71–89, *see also* science
 instruction
 conceptual thinking and change, 72–74
 experimentation skills, 79–84
 procedural thinking, 74–79
 self-explaining, 537
 use of analogies and models, 76–79
 and preconceptions/misconceptions. *see*
 preconceptions and misconceptions:and
 scientific thinking and learning
 procedural knowledge. *see* procedural
 knowledge
 representational thinking. *see* representational
 thinking
 SDDS (Scientific Discovery as Dual Search)
 framework, 67–68, 74–75, 79
 seductive detail, in multimedia learning, 465–466
 segmenting principle, in multimedia learning, 470
 self-assessment. *see* metacognitive monitoring
 (self-monitoring)
 self-attention, in collaborative learning, 515
 self-control, 648–649, 672
 self-efficacy, and problem-solving, 189
 self-esteem, and academic achievement (lack of
 causal link), 38
 self-explaining, 528–544
 definitions and scope, 528–529, 531
 and cognitive load, 538–539, 542, 543–544
 diminishing returns in, 540, 542
 explanation skills transfer, 537–538
 instruction in, 536–538, 541
 and metacomprehension accuracy, 636
 and practice problems, 538–539
 practice recommendations, 542–543
 principle-based, 531–534
 prompts for, 529–530, 535–536, 541

- and reading comprehension, 369
 research gaps, 541
 teacher assessment of, 542–543, 544
 and worked examples, 530, 532–533, 538–540, 542
- self-grading, and error correction, 449
- self-monitoring. *see* metacognitive monitoring (self-monitoring)
- self-motivated learning, 648, 701–702
- self-regulated learning, 647–675, *see also* learning strategies
 definition, 700
 and computer-assisted learning. *see* Computer-Assisted Learning Systems (CALIS):and self-regulation
 Dynamics of Affective States Model, 596–597
 and example-based learning, 198
 importance of, 647
 Information Processing Theory, 593–594
 instruction in, 402, 659–660, 661–664, 667–668, 704–706
 using virtual reality, 612
 macro and micro-level framework, 594–595
 and metacognitive judgment, 682–683, 690
 and process granularity, 600–601
 and process quality vs. quantity, 597–600
 measurement of, 611
 and process time vs. event-based thresholds, 601
 and reading comprehension, 386, 402
 research gaps, 650
 self-monitoring. *see* metacognitive monitoring (self-monitoring)
 and sequence of study (blocked practice), 419, 428–429
 social cognitive model, 647–649
 forethought phase, 648, 670–672
 performance phase, 648–649, 672
 self-reflection phase, 649, 673–674
 and writing to learn, 269, 282, 284, 285
 self-regulation theory, of writing to learn, 269, 282, 284, 285
- semantic anomalies (illusions), and reading comprehension, 250–252
- semantic maps, 339
- sequence of study, 411–413
 blocked practice. *see* blocked practice
 and category learning, 412–413
 interleaved practice. *see* interleaved practice
 research gaps, 427, 428–429
 Sequential Attention Theory (SAT), 421–423
- signaling principle, in multimedia learning, 466–467
- Simple View of Reading, 384–385
- simulation models, 78
- situation model, 238–239, 326, 631–632, 634
- skin conductance response (SCR), 605–606,
see also electrodermal activity (EDA) data
- slideshows, 465–467, 469, 472, 473–474
- social cognitive model. *see* self-regulated learning:social cognitive model
- social loafing, in collaborative learning, 514–515, 520
- social mechanisms in collaborative learning, 510–511, 514–515
- social science instruction, and multiple text comprehension, 78
- socio-cognitive learning theory, 187–188
- socio-cultural perspective, and collaborative learning, 267, 502, 506–507
- socioeconomic status
 and attainment, 308–310
 and bilingualism, 293–294, 308–310
 and intelligence, 293–294
- source evaluation, and reading comprehension, 369–371, 373–374
- sourcing heuristic, in reading comprehension, 361–362
- spaced practice. *see* distributed (spaced) practice
- spatial contiguity principle, in multimedia learning, 467–468
- spatial skills, and mathematics, 100–115, *see also* visuospatial working memory (VSWM)
 and attainment, 108, 113–114
 mental rotation, 103–105, 110, 111–113
 neurological activity, 100, 101, 102
 number lines. *see under* mathematics
 instruction and math skills
 proportional reasoning, 105–106, 107
 research gaps, 109, 113, 114–115
 spatial scaling, 105–106
- spatial strategies, for problem-solving, 107–108
- special education services, and English Language Learners, 311–312
- speed of reading, and comprehension, 255–256
- split-attention, avoiding, in worked examples, 194–195
- Stanford-Binet Intelligence Scales, 293
- study-phase retrieval theory, 553, 554
- subgoals, in worked examples, 194
- summarization
 effectiveness, 275, 282, 704–705
 of multiple texts, 282, 367–369
 and reading comprehension, 275, 280, 282, 383–384, 399–400
- symbolic approximation, 101
- symbolic notation, in mathematics, 159–163
- Synchronous Massive Online Courses (SMOCs), 39–40
- task analysis, in self-regulated learning, 648, 670–671
- teachable agents, 589–590, 592
- teacher demonstrations. *see* example-based learning:modeling examples
- teacher judgments
 accuracy

- teacher judgments (cont.)
 absolute accuracy, 679–680
 relative accuracy, 680
 absolute vs. relative accuracy, 680–681, 682
 and formative assessments, 687–689
 and student attainment, 689–691
- in mathematics. *see* mathematics instruction and math skills:teacher judgments
- of self-explanation skills. *see* self-explaining: teacher assessment of
- technological artifacts, in learning sciences, 20, 24, 29–30, 31
- technologies, educational
 computer games. *see* game-based learning environments (GBLE)
 computer simulation models, 78
 computer-assisted learning. *see* Computer-Assisted Learning Systems (CALS)
 and distributed (spaced) practice, 570–571
 hand-held response systems (clickers), 485–486
 instructional design principles, 465–475
 learner-centered approach, importance of, 461–462
 and learning sciences, 21–22
 research gaps, 30, 613
 as research tools, 30–31, 590, 591–592, 602–612, *see also* multimodal multi-channel data
 data channel selection, 606–611
 nStudy, 709–711
 process data types, 604–606
 research design, 602–604, 609–610
 slideshows, 465–467, 469, 472, 473–474
 Synchronous Massive Online Courses, 39–40
 videotaped instruction, 184, 194–198, 221
- temporal contiguity principle, in multimedia learning, 468–469
- test expectancy
 and choice of learning strategy, 702–703
 and metacomprehension, 638–639
- test performance
 and distributed (spaced) practice. *see* distributed (spaced) practice:and interstudy interval; distributed (spaced) practice:and retention interval; distributed (spaced) practice:vs. massed learning
 and feedback in formative quizzes, 481–486
 and interleaved vs. blocked practice, 424–425
 and note-taking, 326–328, 333–336, *see also* note-taking
 past performance, as diagnostic cue, 686
- testing effect, 480, *see also* retrieval practice
 classroom research on, 480, 483–486
 laboratory studies, 481–483
 and long-term retention, 338–339, 343–344
 and recall of related information, 493–494
 and summative exam format, 484–485
- tests, 480–495, *see also* formative assessments
 direct benefits.*see* testing effect
 as distributed practice, 570
 indirect benefits, 487–492, 495
 and metacognitive control, restudying, 491–492
 and metacognitive monitoring, 489–491
 multiple choice. *see* multiple choice tests
 performance in. *see* test performance
 pretesting, 494
 repeated testing, 484
- textbase, and testing, 326–327
- think-aloud (explicit mental modeling), 385
- thinking
 conceptual, instruction in, 72–74
 critical. *see* critical thinking (skills)
 dual-process models, 52
 dual-space framework, 67–68, 74–75
 procedural, instruction in, 74–79
 proportional reasoning, 105–106, 107
 relational reasoning, 154, 173
 representational, 68–70
 scientific. *see* scientific thinking
- transfer
 cross-domain, and critical thinking, 56
 in mathematical learning, 154–155, 190–194
 near and far transfer, 190–191
 of self-explanation skills, 537–538
- transitional knowledge state, and gesture-speech mismatch, 216–219
- translanguaging, 305
- Triple Task Procedure in Mathematics (TTPM), 653
- underconfidence. *see* calibration (accuracy of self-monitoring)
- unity/diversity framework, of executive functions, 297–298
- verbal learning. *see also* literacy learning and education; reading comprehension
 and distributed (spaced) practice, 453–454, 552, 556, 557–567, 558–559
 languages. *see* language learning and mastery
- videotaped instruction, 184, 194–198, 221
- virtual and augmented reality, 590, 595, 612
- visual attention, 187–188, 195, 223–225
 and eye-tracking data. *see* eye-tracking data
- visuospatial working memory (VSWM), 103, 107, 109–110, 113, 114–115
- vocabulary acquisition, 296–297, 395–397
- vocational training, and distributed (spaced) practice, 560–562

- voice, importance of, in multimedia learning, 473
 Vygotsky, L.S., 502
- What Works Clearinghouse (WWC), 42
- Whipple, G.M., 696, 697
- whole number bias, in fraction reasoning,
 159–160, 162–163
- whole number reasoning, 151–153
- wisdom, 61, 62–63
- worked examples. *see* example-based learning:
 worked examples
- working memory
 and interleaved vs. blocked practice, 418, 426
 and mathematics, 103, 107, 109–110, 113,
 114–115
 and multimedia learning, 464
 and note-taking, 325, 326,
 328–331, 332–333
 and reading comprehension. *see* reading
 comprehension:and memory
 and self-explaining, 538–539
- writing to learn, 266–286
 vs. authentic writing, 283–284
 drawing, 280
 in elementary (primary) education, 273–276,
 285
- graphs and formulas, 279
- implementation strategies, 284–285
- informational writing, 274–275
 analogies, 275, 281
 arguments, 274–275, 277–278, 367–369
 brief tasks, 281, 283
 explanations, 275
 summaries. *see* summarization
- letters, 279
- and multimodality, 269–270, 285–286
- number of writing assignments, 279
- in post-secondary education, 280–281, 285
- reflective writing and journals, 273–274,
 276–277, 280–281
- research design for, 270–273
- research focus in, 266–267
- research gaps, 276, 283, 285–286
- and rhetorical goals, 268–269
- Science Writing Heuristic, 278–279, 283
- in secondary education, 276–280, 285
- text genres in, 270
- theories of, 267, 268–270, 284, 285
- Zimmerman, C., social cognitive model, 697
- zone of proximal facilitation, 517