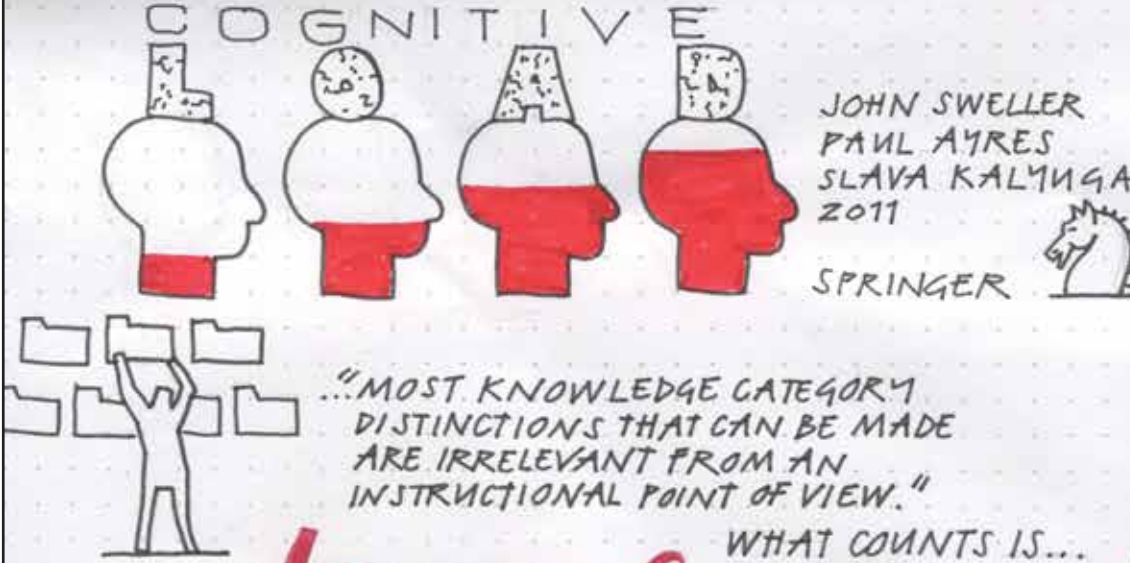


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COGNITIVE

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PAUL AYRES
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CHAPTER
1

CATEGORIES OF KNOWLEDGE:
An Evolutionary Approach

"MOST KNOWLEDGE CATEGORY DISTINCTIONS THAT CAN BE MADE ARE IRRELEVANT FROM AN INSTRUCTIONAL POINT OF VIEW."

WHAT COUNTS IS...

Biological PRIMARY & SECONDARY KNOWLEDGE

"WE HAVE EVOLVED TO ASSIMILATE BIOLOGICALLY PRIMARY KNOWLEDGE"

- RECOGNISING FACES & SPEECH
- GENERAL PROBLEM SOLVING
- BASIC SOCIAL RELATIONS

"WE LEARN THESE SKILLS BUT THERE IS LITTLE EVIDENCE THAT THEY CAN BE TAUGHT."

"PRIMARY KNOWLEDGE ACQUISITION DOES NOT REQUIRE INSTITUTIONAL SUPPORT."

"WE HAVE NOT EVOLVED TO LEARN TO WRITE... ACCORDINGLY, THE INSTRUCTIONAL PROCESS REQUIRED TO LEARN TO WRITE ARE VASTLY DIFFERENT FROM THOSE REQUIRED TO LEARN TO SPEAK."

"WHILE WE LEARN TO SPEAK JUST BY IMMERSION IN A SPEAKING SOCIETY, WE ARE UNLIKELY TO LEARN TO WRITE JUST BY IMMERSION IN A WRITING SOCIETY."

"SECONDARY KNOWLEDGE NEEDS TO BE EXPLICITLY TAUGHT AND IS USUALLY CONSCIOUSLY LEARNED, UNLIKE PRIMARY KNOWLEDGE."

"FOR SURVIVAL, WE HAVE EVOLVED TO CONSTRUCT KNOWLEDGE AND SO KNOWLEDGE CONSTRUCTION IS A PRIMARY SKILL."

"OUR ABILITY TO CONSTRUCT SECONDARY KNOWLEDGE IS BASED ON PRIMARY KNOWLEDGE AND SO WE DO NOT NEED TO BE TAUGHT HOW TO CONSTRUCT SECONDARY KNOWLEDGE."

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CHAPTER

2

AMASSING INFORMATION:
The Information Store Principle

experts & MEMORY



PLANTS, AND ANIMALS HAVE NATURAL INFORMATION SYSTEMS TO HELP THEM DEAL WITH COMPLEXITY AND VARIABILITY OF THE ENVIRONMENT

"THE ROLE OF LONG-TERM MEMORY IN COGNITION PROVIDES AN ANALOGICAL EQUIVALENT TO A GENOME IN EVOLUTIONARY BIOLOGY."



"IN INFORMATION PROCESSING TERMS, MANY 'SIMPLE' ACTIVITIES ARE ANYTHING BUT SIMPLE."

PICKING A FLOWER MAY SEEM SIMPLE, BUT IT IS BEYOND COMPUTERS' CAPABILITIES.



De GROOT
1965
THOUGHT & CHOICE
IN CHESS
MONTON:
THE HAGUE
FIRST PUBLISHED
1946



CHASE & SIMON
1973
PERCEPTION
IN CHESS.
COGNITIVE
PSYCHOLOGY
4, 55-81

WHAT MAKES GRANDMASTERS SO DOMINANT?

GMS & PLAYERS OF ALL ABILITIES WERE SHOWN CHESS BOARD CONFIGURATIONS FOR JUST 5 SECONDS - AND ASKED TO RECALL THEM. GMS WERE SIGNIFICANTLY SUPERIOR TO ALL OTHER PLAYERS.

THE BASIS FOR THEIR SUPERIORITY IN CHESS WAS NOT IN THEIR GAME STRATEGY BUT IN THEIR MEMORY.

C&S REPLICATED De GROOT'S RESULTS - AS WELL AS LEARNING SOMETHING NEW AND REVEALING.

FACED WITH RANDOM CONFIGURATIONS, THE GMS WERE NO BETTER AT RECALL THAN THE OTHER PLAYERS.

SIMILAR FINDINGS OCCURRED WHEN LOOKING AT

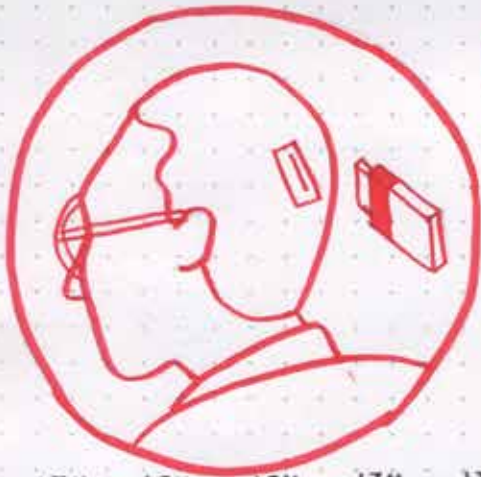
- UNDERSTANDING & REMEMBERING TEXT
- ELECTRONIC ENGINEERING
- PROGRAMMING
- ALGEBRA

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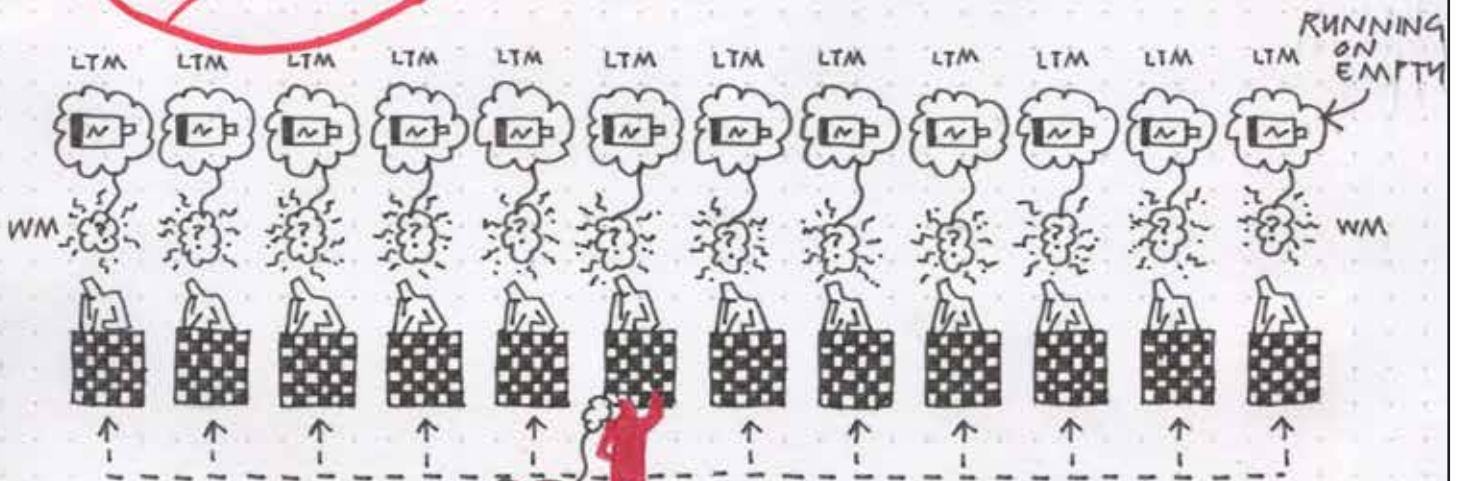
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2011, SPRINGER

2

CHAPTER

part 2

THE EDUCATIONAL
IMPLICATIONS OF
De GROOT'S STUDY
OF CHESS GRANDMASTERS



GRANDMASTERS
PLAYED A DOZEN
CLUB PLAYERS
SIMULTANEOUSLY
AND WON THEM
ALL EASILY.



WM THE CLUB PLAYERS SPENT THEIR
TIME ON STRATEGY - THINKING
DEEPLY ABOUT FUTURE MOVES
AND THEIR POTENTIAL OUTCOMES -
EVERYTHING, IN FACT, THAT MAKE
UP CLASSIC MEANS-END PROBLEM
SOLVING.

THEY RAPIDLY MOVED FROM TABLE TO
TABLE, AND EQUALLY RAPIDLY
RECOGNISED THE PATTERN OF PLAY
SUCH THAT THEY COULD MAKE AN
AUTOMATIC MOVE. THIS WAS DUE
TO THEIR VERY LARGE KNOWLEDGE
STORED IN LONG-TERM MEMORY AS
A NETWORK OF SCHEMA.

THIS INTENSE COGNITIVE ACTIVITY TOOK
PLACE IN THEIR OVER-FULL WORKING
MEMORIES. WHAT WASN'T VERY ACTIVE
WAS THEIR LONG-TERM MEMORIES
AS THEY CONTAINED REMARKABLY
SMALLER AMOUNTS OF KNOWLEDGE
ABOUT POSSIBLE CONFIGURATIONS.

THE GRANDMASTERS DID NOT THEN
DO ANY 'DEEP THINKING' ABOUT
STRATEGY. THEY SIMPLY KNEW
WHAT TO DO BECAUSE OF THEIR
DOMAIN-SPECIFIC KNOWLEDGE.

**"NOVICES NEED TO USE THINKING
SKILLS. EXPERTS USE KNOWLEDGE."**

**"LONG-TERM MEMORY IS NOT ONLY
CENTRAL TO HUMAN COGNITION
BUT CENTRAL TO THOSE ASPECTS OF
COGNITION THAT ARE SEEN AS
REPRESENTING THE APEX OF THE
HUMAN MIND."**

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BUFFERING



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CHAPTER 3

ACQUIRING
INFORMATION:
the Borrowing and
Reorganising Principle
and the Randomness
as Genesis Principle

"Devising instruction, according to CLT, means devising instructional procedures that facilitate the borrowing of information."

Borrowed Info.

- "ALMOST ALL OF THE SECONDARY KNOWLEDGE STORED IN LONG-TERM MEMORY IS BORROWED FROM OTHER PEOPLE."
- "BORROWED INFORMATION HAS ALREADY BEEN ORGANISED."
- "THE EVIDENCE IS STRONG THAT BORROWED INFORMATION IS REORGANISED."



↓
BARTLETT, F. C., 1932
REMEMBERING: A STUDY IN EXPERIMENTAL
AND SOCIAL PSYCHOLOGY. MACMILLAN, OXFORD



WE 'FLATTEN'
THOSE PARTS
THAT HAVE
LITTLE RELATION
TO WHAT'S IN
OUR LONG-TERM
MEMORY

WE 'RAISE'
THOSE PARTS
THAT CORRESPOND
WITH WHAT'S IN
OUR LONG-TERM
MEMORY

- "WE SHOULD PROVIDE LEARNERS WITH AS MUCH RELEVANT INFORMATION AS WE ARE ABLE."

CREATIVITY

- "A RANDOM GENERATE AND TEST PROCEDURE IS THE ULTIMATE SOURCE OF ALL NOVELTY IN NATURAL SYSTEMS."
- "RANDOM GENERATE AND TEST DURING PROBLEM-SOLVING MAY PLAY THE SAME ROLE IN HUMAN COGNITION AS RANDOM MUTATION PLAYS IN EVOLUTION BY NATURAL SELECTION."

THE DIFFERENCE IN PEOPLE'S CREATIVITY HAS A BASIS IN THEIR KNOWLEDGE STORE.

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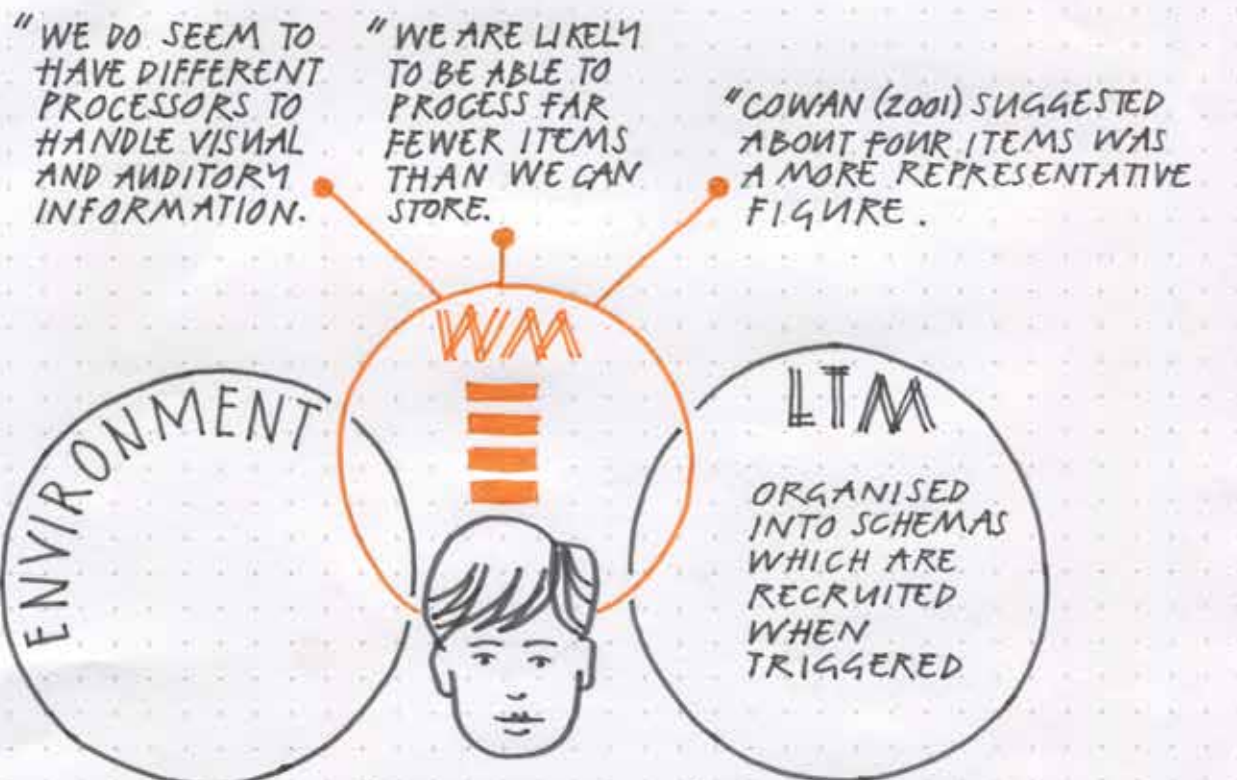
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CHAPTER 4

INTERACTING WITH THE
EXTERNAL ENVIRONMENT:
The Narrow Limits of
Change Principle and the
Environmental Organising
and Linking Principle

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"THE ENVIRONMENT INFORMS US WHICH OF THE MULTITUDE OF SCHEMAS HELD IN LONG TERM MEMORY ARE APPROPRIATE.

"A MAJOR PURPOSE OF EDUCATION IS TO PERMIT US TO PERFORM APPROPRIATELY IN OUR ENVIRONMENT, REQUIRING US TO SELECTIVELY ACCESS INFORMATION FROM LONG-TERM MEMORY.

"IN GENERAL TERMS, MOST STUDENTS ARE NOVICES AND SO MOST OF THE INFORMATION PROVIDED TO THEM IS NOVEL AND MUST BE PROCESSED BY A LIMITED CAPACITY, LIMITED DURATION WORKING MEMORY.

"THE AMOUNT OF ORGANISED INFORMATION FROM LONG-TERM MEMORY THAT CAN BE DEALT WITH BY WORKING MEMORY HAS NO KNOWN LIMITS.

"INFORMATION IN LONG TERM MEMORY DOES NOT BECOME ACTIVE UNTIL IT HAS BEEN TRIGGERED BY CUES FROM THE ENVIRONMENT THAT INDUCE WORKING MEMORY TO CHOOSE ONE SET OF SCHEMA OVER ANOTHER.

"THE SQUIGGLES [ie TEXT] ARE USED AS A TRIGGER BY WORKING MEMORY TO TRANSFER SCHEMAS FROM LONG-TERM MEMORY — TO BE USED TO DERIVE MEANING.

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CHAPTER
5

INTRINSIC &
EXTRANEONS
COGNITIVE LOAD

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ADDITIVE

INTRINSIC & EXTRANEONS

"IMPOSED BY THE BASIC
STRUCTURE OF THE
INFORMATION"
BEING TAUGHT



"IMPOSED... BY THE
MANNER IN WHICH THE
INFORMATION IS
PRESENTED OR THE
ACTIVITIES IN WHICH
LEARNERS MUST
ENGAGE."

"ONE AIM OF INSTRUCTIONAL DESIGN IS TO REDUCE
EXTRANEONS COGNITIVE LOAD SO THAT A GREATER
PERCENTAGE OF THE POOL OF WORKING MEMORY
RESOURCES CAN BE DEVOTED TO ISSUES GERMANE
TO LEARNING RATHER THAN TO ISSUES
EXTRANEONS TO LEARNING."

"LEVELS OF BOTH INTRINSIC AND EXTRANEONS
COGNITIVE LOAD ARE DETERMINED BY ELEMENT
INTERACTIVITY. INTERACTING ELEMENTS ARE
DEFINED AS ELEMENTS THAT MUST BE PROCESSED
SIMULTANEOUSLY IN WORKING MEMORY
BECAUSE THEY ARE LOGICALLY RELATED."

LOW LEVEL
INTERACTIVITY



HIGH LEVEL
INTERACTIVITY



SCHEMA
FORMATION



"WHEN DEALING WITH LOW
ELEMENT INTERACTIVITY
INFORMATION, WE ASSUME,
CORRECTLY, THAT LEARNING
BY ROTE IS UNAVOIDABLE
BECAUSE NO OTHER FORM
OF LEARNING IS AVAILABLE."

"ELEMENT INTERACTIVITY
CAN BE USED TO DEFINE
UNDERSTANDING
INFORMATION IS FULLY
UNDERSTOOD WHEN ALL OF
ITS INTERACTING ELEMENTS
CAN BE PROCESSED IN W.M."

"ONCE A SCHEMA HAS
BEEN CONSTRUCTED,
IT BECOMES ANOTHER,
SINGLE, ELEMENT
THAT DOES NOT IMPOSE
A HEAVY W.M. LOAD."

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6

MEASURING COGNITIVE LOAD

MEASUREMENT

- "IN THE EARLY DAYS OF CLT, COGNITIVE LOAD WAS NOT MEASURED."
- "THESE INDIRECT MEASURES, USED IN CONJUNCTION WITH PERFORMANCE TEST SCORES, STRENGTHENED THE THEORY."
- "SUBJECTIVE MEASURES HAVE PROVIDED COLLABORATING EVIDENCE IN SUPPORT OF C.L.T."



SECONDARY TASK

- "THE TRADITIONAL METHODS OF ASSESSING WORKING MEMORY LOAD IS TO USE A SECONDARY TASK IN COMBINATION WITH A PRIMARY TASK."
- "IF THE PRIMARY TASK IMPOSES A HEAVY COGNITIVE LOAD, PERFORMANCE ON THE SECONDARY TASK DETERIORATES."
- "THE MORE COMPLEX THE PROBLEM, THE LESS MIGHT BE LEARNED."

MENTAL EFFORT

- "LEARNERS ARE ABLE TO INTROSPECT THE AMOUNT OF MENTAL EFFORT INVESTED DURING LEARNING AND TESTING, AND THIS 'INTENSITY OF EFFORT' MAY BE CONSIDERED TO BE AN 'INDEX' OF COGNITIVE LOAD."
- "PAAS (1992) FOUND A MATCH BETWEEN SELF-RATED MENTAL EFFORT AND TEST PERFORMANCE."
↳ USING A 9-POINT SCALE OF MENTAL EFFORT

DIFFICULTY

- "SUBJECTIVE MEASURES OF DIFFICULTY VARIED SIGNIFICANTLY ACCORDING TO THE LEVEL OF ELEMENT INTERACTIVITY OF A TASK."
↳ SEE CHAPTER 5 SUMMARY
- "ALTHOUGH THE TWO MEASURES ARE OFTEN CORRELATED, DIFFICULTY DOES NOT ALWAYS MATCH EFFORT."
↳ SOME TASKS ARE SO DIFFICULT FOR SOME LEARNERS THEY CAN'T MAKE ANY REALISTIC EFFORT."

EFFICIENCY

- "HIGH INSTRUCTIONAL EFFICIENCY RESULTS FROM HIGH TASK PERFORMANCE AND LOW MENTAL EFFORT."
- "LEARNING EFFICIENCY MAY BE A GOOD INDICATOR OF SCHEMA ACQUISITION AND AUTOMATION."
- "EFFICIENCY MEASURES CAN ONLY BE BASED ON GROUP DATA."

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7

THE GOAL-FREE EFFECT

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"WHEN NOVICES SOLVE A CONVENTIONAL PROBLEM, THEY WILL FREQUENTLY WORK BACKWARDS FROM THE GOAL TO THE GIVENS USING A MEANS-ENDS STRATEGY."

but

"WORKING MEMORY MAY BE OVERWHELMED BY A MEANS-ENDS STRATEGY, REDUCING OR EVEN PREVENTING LEARNING."

"OVER A SET OF PROBLEMS, THE GOAL-FREE GROUP GAINED MORE KNOWLEDGE ABOUT THE STRUCTURE OF THE PROBLEMS THAN THE GOAL-SPECIFIC GROUP"

"MEANS-END ANALYSIS DID NOT PROMOTE RULE INDUCTION OR ACQUISITION OF SPECIFIC PROCEDURAL SCHEMAS."

"ACQUIRING LOCAL STRUCTURAL KNOWLEDGE IS VERY SIMILAR TO THE PROCESS OF SCHEMA ACQUISITION"

"CONVENTIONAL PROBLEM SOLVING, PARTICULARLY FOR NOVICES IN A DOMAIN, SHOULD BE AVOIDED BECAUSE OF THE EXTRANEOUS COGNITIVE LOAD CREATED BY SEARCH STRATEGIES SUCH AS MEANS-ENDS ANALYSIS."

"ASKING STUDENTS TO LEARN THROUGH PROBLEM SOLVING INVOLVED TWO PROCESSES: SOLVING THE PROBLEM AND LEARNING FROM THE EXPERIENCE."

"ON THE STRUCTURAL KNOWLEDGE INDICATOR, THE GOAL-FREE GROUP MADE MORE LOCAL LINKS AND LESS [sic] GOAL LINKS THAN THE GOAL GROUP."

"LEARNERS ARE MORE LIKELY TO ACQUIRE SCHEMAS UNDER GOAL-FREE THAN CONVENTIONAL GOAL CONDITIONS."

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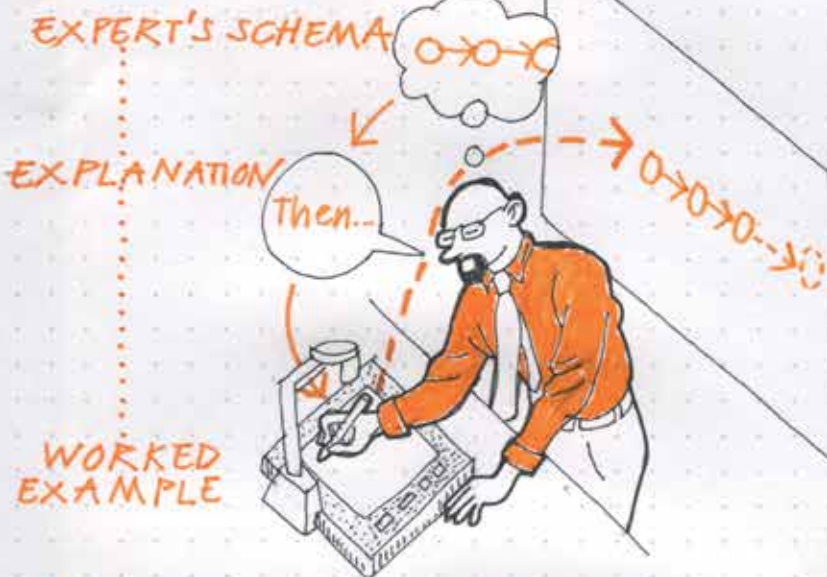
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COGNITIVE LOAD THEORY

CHAPTER 8

THE WORKED EXAMPLE AND PROBLEM COMPLETION EFFECTS

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by @olivercaviglioli



"WORKED EXAMPLES CAN EFFECTIVELY PROVIDE US WITH PROBLEM-SOLVING SCHEMAS THAT NEED TO BE STORED IN LONG-TERM MEMORY USING THE INFORMATION STORE PRINCIPLE."

"WORKED EXAMPLES IMPOSE A RELATIVELY LOW WORKING MEMORY LOAD... COMPARED TO SOLVING PROBLEMS USING MEANS-END SEARCH."

"STUDYING WORKED EXAMPLES PROVIDES ONE OF THE BEST, POSSIBLY THE BEST, MEANS OF LEARNING HOW TO SOLVE PROBLEMS IN A NOVEL DOMAIN."

"THE MOST EFFICIENT METHOD OF STUDYING EXAMPLES AND SOLVING PROBLEMS WAS TO PRESENT A WORKED EXAMPLE AND THEN IMMEDIATELY FOLLOW THIS EXAMPLE BY ASKING THE LEARNER TO SOLVE A SIMILAR PROBLEM."
= THE ALTERNATION STRATEGY

"ONE EARLY CONCERN ABOUT THE USE OF WORKED EXAMPLES WAS THAT THEY LED TO PASSIVE RATHER THAN MORE ACTIVE LEARNING."

"TO ENSURE LEARNERS PAID SUFFICIENT ATTENTION TO THE WORKED EXAMPLES WAS TO PROVIDE LEARNERS WITH COMPLETION PROBLEMS."

"A COMPLETION PROBLEM IS A PARTIAL WORKED EXAMPLE."

"WE MUST ACQUIRE SCHEMATICALLY BASED KNOWLEDGE THAT ALLOWS US TO RECOGNISE PROBLEM TYPES AND THE CATEGORIES OF SOLUTION MOVES TO SOLVE PARTICULAR CATEGORIES OF PROBLEMS IRRESPECTIVE OF WHETHER THE PROBLEMS ARE WELL STRUCTURED OR ILL STRUCTURED."

"COMPLETION PROBLEMS ARE A HYBRID, INCLUDING ELEMENTS OF BOTH A WORKED EXAMPLE AND A PROBLEM TO BE SOLVED."

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CHAPTER 9

THE SPLIT-ATTENTION EFFECT

"SPLIT-ATTENTION OCCURS WHEN LEARNERS ARE REQUIRED TO SPLIT THEIR ATTENTION BETWEEN AT LEAST TWO SOURCES OF INFORMATION THAT HAVE BEEN SEPARATED EITHER SPATIALLY OR TEMPORALLY."



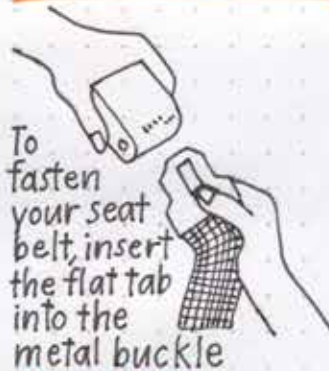
"THE SPLIT-ATTENTION EFFECT OCCURS WHEN AN INSTRUCTIONAL STRATEGY BASED ON INTEGRATED MATERIALS LEADS TO BETTER LEARNING OUTCOMES THAN ONE BASED ON SPLIT SOURCE MATERIALS."

"THE RESULT WAS ATTRIBUTED TO A REDUCTION IN EXTRANEOUS COGNITIVE LOAD DUE TO A REDUCED NEED TO SEARCH FOR CORRESPONDENCES AND REFERENTS."

"THE SPLIT-ATTENTION EFFECT CLOSELY ACCORDS WITH HUMAN COGNITIVE ARCHITECTURE."

WORKED EXAMPLES

"WORKED EXAMPLES HAD NO ADVANTAGE OVER CONVENTIONAL PROBLEM SOLVING WHEN THEY WERE CONSTRUCTED IN A SPLIT-SOURCE PRESENTATION FORMAT, BUT HAD A SIGNIFICANT ADVANTAGE IF THEY WERE STRUCTURED ACCORDING TO AN INTEGRATED APPROACH."



TAKEN FROM
CLARK et al's 2006
EFFICIENCY IN
LEARNING

"IF LEARNERS ARE USING WORKING MEMORY RESOURCES TO INTEGRATE DISPARATE SOURCES OF INFORMATION, THEY MAY HAVE FEW RESOURCES AVAILABLE TO CONSIDER THE SOLUTION."

SEGMENT & SIGNAL

"PRESENTATIONS COULD BECOME VERY CLUTTERED IF LARGE AMOUNTS OF TEXT ARE INSERTED INTO A PICTURE." } SO

"A COLOUR CODING SYSTEM WAS USED TO CONNECT THE TEXT DIRECTLY WITH THE RELEVANT PARTS OF THE DIAGRAM."

"REDUCING VISUAL SEARCH BY CHANGING WAS ALSO FOUND TO BE AN EFFECTIVE STRATEGY."

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COGNITIVE LOAD THEORY

10

THE MODALITY EFFECT

JOHN SWELLER
PAUL AYRES
SLAVA KALYUGA

SPRINGER, 2011

SUMMARISED BY
@olivercaviglioli
of
teachinghow2s.com

SOUND AND VISION



"THE AMOUNT OF INFORMATION THAT CAN BE PROCESSED USING BOTH AUDITORY AND VISUAL CHANNELS SHOULD EXCEED THE PROCESSING CAPACITY OF A SINGLE CHANNEL!"

"THE MODALITY EFFECT IS USUALLY STRONGER FOR MEASURES OF TRANSFER RATHER THAN RETENTION."

"LEARNER CONTROL OF THE PACING MAY HAVE REDUCED THE COGNITIVE LOAD ASSOCIATED WITH SPLIT-ATTENTION IN THE CASE OF THE VISUAL-ONLY REPRESENTATIONS."

"THERE IS EVIDENCE THAT THE EFFECT MAY BE ELIMINATED OR REVERSED WITH RELATIVELY MORE EXPERIENCED LEARNERS."

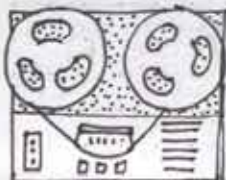
VISUO-
SPATIAL
SKETCHPAD



CENTRAL
EXECUTIVE



AUDITORY
LOOP



CONDITIONS TO OBTAIN MODALITY EFFECT

- 1 AS FOR SPLIT-ATTENTION, DIAGRAMMATIC AND TEXTUAL INFO MUST REFER TO EACH OTHER AND BE UNINTELLIGIBLE UNLESS THEY ARE PROCESSED TOGETHER
- 2 ELEMENT INTERACTIVITY MUST BE HIGH
- 3 AUDITORY TEXT MUST BE LIMITED. LENGTHY, COMPLEX TEXT SHOULD BE PRESENTED IN WRITTEN, NOT SPOKEN FORM — AS IT CAN'T BE HELD AND PROCESSED IN WORKING MEMORY.
- 4 IF DIAGRAMS ARE VERY COMPLEX, CUEING OR SIGNALLING MAY BE REQUIRED SO THAT LEARNERS CAN FOCUS ON THOSE PARTS OF THE VISUAL DISPLAY BEING REFERRED TO BY THE AUDITORY INFORMATION.

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COGNITIVE LOAD THEORY

CHAPTER 11

THE REDUNDANCY EFFECT

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"THE REDUNDANCY EFFECT OCCURS WHEN INFORMATION THAT INCLUDES REDUNDANT MATERIAL RESULTS IN LESS LEARNING THAN THE SAME INFORMATION MINUS THE REDUNDANT MATERIAL."

"THE REDUNDANCY EFFECT MAY OCCUR WHEN THE MULTIPLE SOURCES OF INFORMATION CAN BE UNDERSTOOD SEPARATELY WITHOUT THE NEED FOR MENTAL INTEGRATION."

"WRITTEN OR SPOKEN TEXT THAT SIMPLY RE-DESCRIBES A DIAGRAM THAT CAN BE FULLY UNDERSTOOD WITHOUT THE TEXT PROVIDES AN EXAMPLE."

"ACCORDINGLY, REDUNDANT INFORMATION SHOULD BE OMITTED TO PRECLUDE AN INCREASE IN EXTRANEOUS COGNITIVE LOAD CAUSED WHEN LEARNERS INEVITABLY FOCUS ATTENTION ON UNNECESSARY INFORMATION AND PHYSICALLY INTEGRATE IT WITH ESSENTIAL INFORMATION."

THE NOTION OF REDUNDANCY MAY BE DEPENDENT ON LEVELS OF LEARNER EXPERTISE.

"THE REDUNDANCY EFFECT IS PERVASIVE. IT CAN BE FOUND IN A WIDE VARIETY OF INSTRUCTIONAL CONTEXTS UNRELATED TO DIAGRAMS AND TEXTS."

"IN SEVERAL EXPERIMENTS WITH ELECTRICAL ENGINEERING MATERIALS, LEARNERS WHO WERE NOT EXPLICITLY REQUESTED TO INTEGRATE TEXT AND DIAGRAMS NEEDED LESS TIME TO LEARN BUT PERFORMED BETTER THAN LEARNERS WHO WERE EXPLICITLY INSTRUCTED TO INTEGRATE TEXT AND DIAGRAMS."

"THE PRESENCE OF A CONCURRENT SPOKEN PRESENTATION RENDERED READING COMPREHENSION LESS EFFECTIVE COMPARED WITH WRITTEN ONLY INSTRUCTIONS."

"COGNITIVE LOAD THEORY SUGGESTS THAT WHEN TEACHING NOVICE SECOND/FOREIGN LANGUAGE LEARNERS TO READ OR TO LISTEN, THE COMMON PROCEDURE OF PRESENTING BOTH WRITTEN AND SPOKEN TEXT SIMULTANEOUSLY MAY NOT BE APPROPRIATE."

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CHAPTER 12

THE EXPERTISE REVERSAL EFFECT

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SUMMARY
BY
@olivercavigliol



"DETAILED TEXTUAL EXPLANATIONS, ESPECIALLY IF THEY ARE EMBEDDED INTO DIAGRAMS THUS REDUCING THE POSSIBILITY OF IGNORING THEM, MAY BE ESSENTIAL FOR NOVICES BUT REDUNDANT FOR EXPERTS."

"THE ADVANTAGES OF WORKED EXAMPLES ON HOW TO PROGRAM INDUSTRIAL EQUIPMENT OVER LEARNING BY PROBLEM SOLVING DISAPPEARED AS TRAINEES ACQUIRED MORE KNOWLEDGE IN THE TASK DOMAIN."

"THE INFORMATION OR ACTIVITIES THAT PREVIOUSLY WERE ESSENTIAL MAY BECOME REDUNDANT CAUSING INCREASED LEVELS OF EXTRANE-
OUS COGNITIVE LOAD."

"WITHIN THE COGNITIVE LOAD FRAMEWORK, THE EXPERTISE REVERSAL EFFECT IS EXPLAINED BY THE NEED TO PROVIDE NOVICES WITH INFORMATION THAT IS ESSENTIAL FOR THEIR UNDERSTANDING AND IN THE CASE OF EXPERTS, TO UNNECESSARILY PROCESS

THAT SAME INFORMATION THAT IS REDUNDANT FOR MORE KNOWLEDGEABLE LEARNERS."

"THE NEED FOR EXPERTS TO ESTABLISH CONNECTIONS BETWEEN ELEMENTS OF PRESENTED INFORMATION AND THEIR EXISTING KNOWLEDGE BASE CAN INTERFERE WITH LEARNING."

"IN ORDER TO MINIMISE EXTRANE-
OUS COGNITIVE LOAD IN LEARNING

- DETAILED, DIRECT INSTRUCTIONAL SUPPORT SHOULD BE PROVIDED TO **NOVICE** LEARNERS, PREFERABLY, IN INTEGRATED OR DUAL-MODALITY FORMATS.
- AT **INTERMEDIATE** LEVELS OF EXPERTISE, A MIX OF DIRECT INSTRUCTION AND PROBLEM-SOLVING PRACTICE WITH REDUCED SUPPORT MAY BE OPTIMAL FOR LEARNING.
- FOR **ADVANCED** LEARNERS AT HIGHER LEVELS OF EXPERTISE, MINIMALLY GUIDED PROBLEM-SOLVING TASKS SHOULD PROVIDE COGNITIVELY OPTIMAL INSTRUCTIONAL METHODS."

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CHAPTER 13

THE GUIDANCE FADING EFFECT

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"INSTRUCTIONAL METHODS INCLUDING THE AMOUNT OF INSTRUCTIONAL GUIDANCE PROVIDED TO LEARNERS SHOULD BE DYNAMICALLY TAILORED TO CHANGING LEVELS OF LEARNER EXPERTISE IN A PARTICULAR AREA."

ONE POSSIBLE MEANS OF A SMOOTH TRANSITION FROM WORKED EXAMPLES TO PROBLEM SOLVING PRACTICE IS THE USE OF COMPLETION TASKS.

"THE GRADUAL REDUCTION OF INSTRUCTIONAL GUIDANCE AS LEVELS OF LEARNER EXPERTISE INCREASE HAS PROVED TO BE A MORE EFFECTIVE INSTRUCTIONAL PROCEDURE THAN ABRUPT SWITCHES FROM WORKED EXAMPLES TO PROBLEMS."

"ACCORDING TO THE EXPERTISE REVERSAL EFFECT, APPROPRIATE INSTRUCTIONAL GUIDANCE NEEDS TO BE PRESENTED AT THE RIGHT TIME, AND REMOVED IN A TIMELY FASHION AS LEARNERS GRADUALLY GAIN EXPERTISE."

"THE MOST OBVIOUS INSTRUCTIONAL STRATEGY THAT FLOWS FROM THE EXPERTISE REVERSAL EFFECT IS THE USE OF FADED WORKED EXAMPLES."

"FOR MORE EXPERIENCED LEARNERS, PRACTICE AT PROBLEM SOLVING WITHOUT THE ASSISTANCE OF WORKED EXAMPLES IS LIKELY TO BE SUPERIOR DURING LATER PHASES OF SKILL ACQUISITION."

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CHAPTER 14

FACILITATING EFFECTIVE MENTAL PROCESSES: THE IMAGINATION AND SELF-EXPLANATION EFFECTS

SWELLER, AYRES & KALYUGA, 2011, SPRINGER



PREVIOUS RESEARCH ON
IMAGINATION WAS
VARIOUSLY KNOWN AS

- SYMBOLIC REHEARSAL
- IMAGINARY PRACTICE
- MENTAL PRACTICE
- INTROSPECTIVE REHEARSAL
- COVERT REHEARSAL
- MENTAL REHEARSAL

AND IS MOSTLY CONDUCTED
IN LEARNING MOTOR
SKILLS AND SPORTS
PERFORMANCE.

"IMAGINING OR SELF-EXPLAINING A PROCEDURE
CAN BE REGARDED AS A FORM OF DELIBERATE
PRACTICE THAT REQUIRES INTENTIONAL PROCESSING
OF INFORMATION IN WORKING MEMORY
TO STRENGTHEN SCHEMAS HELD IN
LONG-TERM MEMORY."

"THE SELF-EXPLA-
NATION EFFECT
CAN BE RELATED
TO THE IMAGINATION
EFFECT BECAUSE
SELF-EXPLANATIONS
USUALLY INVOLVE
IMAGINING A
PROCEDURE OR
PROCESS WHILE
TRYING TO RELATE
THE PROCEDURE
OR PROCESS TO
KNOWN PRINCIPLES
OF THE DOMAIN."

"THE IMAGINING
TECHNIQUE WAS
BENEFICIAL ONLY FOR
MORE KNOWLEDGEABLE
LEARNERS. THE RESULTS
INDICATED THAT THE
IMAGINING TECHNIQUE
WAS NOT USEFUL FOR
LOW-KNOWLEDGE
STUDENTS BECAUSE
OF THE HEAVY WORKING
MEMORY LOAD IT
GENERATED FOR
THESE LEARNERS."

"SWITCHING FROM STUDYING
WORKED EXAMPLES TO
IMAGINING PROBLEM
SOLUTIONS MAY BE AS
EFFECTIVE OR EVEN MORE
EFFECTIVE AS EXPERTISE
INCREASES THAN SWITCHING
FROM STUDYING WORKED
EXAMPLES TO SOLVING
PROBLEMS VIA FADED
WORKED EXAMPLES

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CHAPTER

15

THE ELEMENT INTERACTIVITY EFFECT

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"THE FACT THAT COGNITIVE LOAD EFFECTS TEND TO BE OBTAINABLE ONLY IF INTRINSIC COGNITIVE LOAD IS HIGH IS REFERRED TO AS THE ELEMENT INTERACTIVITY EFFECT."

High levels of element interactivity are a major impediment to learning

"IMAGINING HIGH ELEMENT INTERACTIVITY MATERIALS ALLOWED LEARNERS TO COMBINE THE MULTIPLE INTERACTING ELEMENTS OF INFORMATION INTO A SINGLE SCHEMA THAT COULD BE MORE READILY PROCESSED IN WORKING MEMORY."

"THE EXTENT TO WHICH WE UNDERSTAND INSTRUCTIONS DEPENDS ON LEVELS OF ELEMENT INTERACTIVITY. INCREASES IN LEVELS OF ELEMENT INTERACTIVITY INCREASE THE DIFFICULTY OF UNDERSTANDING AS MORE ELEMENTS MUST BE PROCESSED SIMULTANEOUSLY IN WORKING MEMORY."

"INTRINSIC COGNITIVE LOAD IS DETERMINED BY THE LEVEL OF INTERACTIVITY BETWEEN ESSENTIAL ELEMENTS OF INFORMATION."

"THE EXPERTISE REVERSAL EFFECT WAS OBTAINED ONLY FOR RELATIVELY COMPLEX TASKS WITH HIGH LEVELS OF ELEMENT INTERACTIVITY."

"BOTH THE IMAGINATION AND THE WORKED EXAMPLE EFFECTS WERE LARGER FOR MATERIALS WITH HIGHER LEVELS OF ELEMENT INTERACTIVITY THAN FOR MATERIALS WITH LOWER LEVELS OF ELEMENT INTERACTIVITY."

"ELEMENT INTERACTIVITY DUE TO INTRINSIC COGNITIVE LOAD CAN BE MANIPULATED BY CHANGING THE NATURE OF A TASK."

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ALTERING ELEMENT INTERACTIVITY AND INTRINSIC COGNITIVE LOAD

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"BY BREAKING DOWN THE FORMULA INTO CONSTITUENT PARTS CORRESPONDING ELEMENTS ARE ISOLATED."

"THE MODULAR APPROACH REDUCES ELEMENT INTERACTIVITY AND INTRINSIC COGNITIVE LOAD."

"A learner is more likely to integrate new knowledge with old if tasks are completed in small sections."

"INTRINSIC COGNITIVE LOAD CAN ONLY BE ALTERED BY CHANGING THE NATURE OF THE TASK AND THE NATURE OF WHAT WE EXPECT STUDENTS TO LEARN (LEARNING GOALS)."

"DECLARATIVE KNOWLEDGE HAS A HIGHER DEGREE OF ELEMENT INTERACTIVITY THAN PROCEDURAL INFORMATION AND THEREFORE SHOULD NOT BE PRESENTED DURING PRACTICE."

"COMPLEXITY CAN BE LOWERED BY A NUMBER OF STRATEGIES SUCH AS USING ISOLATED ELEMENTS. LEARNING OF COMPLEX MATERIALS CAN BE ACHIEVED BY REDUCING ELEMENT INTERACTIVITY INITIALLY AND THEN CAREFULLY PROGRESSING TO FULL ELEMENT INTERACTIVITY IN A SIMPLE-TO-COMPLEX SEQUENCE."

"SIMILARLY, OPTIMAL LEVELS OF ELEMENT INTERACTIVITY MAY BE ACHIEVED BY INCREASING VARIABILITY OF EXAMPLES."

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CHAPTER 17A

EMERGING THEMES IN C.L.T. THE TRANSIENT INFORMATION EFFECT



"WHENEVER A TEACHER ORALLY EXPLAINS SOMETHING TO A CLASS OR A PUPIL ... THE INFORMATION PRESENTED IS TRANSIENT."

"UNLESS IT IS RECORDED, ANY SPOKEN INFORMATION DISAPPEARS."

"IF IT IS IMPORTANT INFORMATION FOR THE LEARNER, THEN THE LEARNER MUST TRY TO REMEMBER IT."

"ALL SPOKEN INFORMATION HAS THE POTENTIAL TO INTERFERE WITH LEARNING UNLESS IT IS ... SUPPORTED BY EXTERNAL OFFLOADS SUCH AS WRITTEN NOTES."

"FURTHERMORE, IF SPOKEN INFORMATION REQUIRES COMPLEX PROCESSING, THEN THE DEMANDS ON WORKING MEMORY BECOME EVEN MORE INTRUSIVE."

We define the Transient Information Effect as a loss of learning due to information disappearing before the learner has time to adequately process it.

"WHETHER VIEWED ON A COMPUTER OR A TELEVISION SCREEN, AS FRAMES ROLL FROM ONE TO ANOTHER, VISUAL INFORMATION DISAPPEARS FROM SIGHT."

"MUCH OF THIS RESEARCH HAS BEEN CONDUCTED ON THE EFFECTIVENESS OF INSTRUCTIONAL ANIMATIONS WITH STATIC GRAPHICS. THE RESULTS HAVE NOT BEEN ENCOURAGING."

"THE TRANSIENCE OF ANIMATED INFORMATION MAY BE A KEY FACTOR IN EXPLAINING WHY INSTRUCTIONAL ANIMATIONS HAVE NOT PRODUCED THE CONSISTENTLY POSITIVE EFFECTS THAT HAVE BEEN ANTICIPATED."

"STATIC DIAGRAMS COULD LEAD TO MORE ACTIVE LEARNING. IN A SEQUENCE OF STATIC DIAGRAMS, LEARNERS ARE REQUIRED TO MENTALLY INTEGRATE THE STATIC DIAGRAMS."

"TRANSIENCE IS A PARTICULAR CHARACTERISTIC OF DYNAMIC REPRESENTATIONS THAT HAVE RAMIFICATIONS FOR WORKING MEMORY!"



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CHAPTER

17
B

EMERGING THEMES IN C.L.T. COLLECTIVE WORKING MEMORY EFFECT



"THE COLLECTIVE WORKING MEMORY EFFECT IS A NEW COGNITIVE LOAD THEORY EFFECT THAT OCCURS WHEN INDIVIDUALS OBTAIN HIGHER LEARNING OUTCOMES THROUGH COLLABORATIVE WORK THAN WHEN LEARNING ALONE."

Such sharing will not be beneficial if the transaction costs exceed the advantages gained by off-loading some of the elements to other people.

"ON TESTS OF RETENTION, INDIVIDUALS WERE MORE EFFICIENT LEARNERS, BUT ON TESTS OF TRANSFER, GROUP MEMBERS LEARNED MORE EFFICIENTLY, WHERE EFFICIENCY WAS CALCULATED BY COMBINING PERFORMANCE WITH MENTAL EFFORT MEASURES."

"RESEARCH INTO COLLABORATION SUGGESTS THAT GROUP LEARNING IS SUPERIOR ON COMPLEX PROBLEM-SOLVING TASKS, BUT INDIVIDUAL LEARNING IS SUPERIOR ON LESS COMPLEX TASKS."

"EVEN WHEN TRANSACTION COSTS ARE ADDED, GROUP WORK MEMBERS MAY EXPERIENCE A LOWER COGNITIVE LOAD THAN INDIVIDUAL LEARNERS."

"AN IMPORTANT ASPECT OF COLLABORATIVE LEARNING IS SHARING AND COORDINATING INFORMATION, WHICH KIRSCHNER et al (2009) REFER TO AS TRANSACTION COSTS."

"COMPLETING SUCH TRANSACTIONS REQUIRES WORKING MEMORY RESOURCES, WHICH HAVE THE POTENTIAL TO NULLIFY THE ADVANTAGE OF SHARING WORKING MEMORY RESOURCES IF THEY ARE TOO HIGH."

"COLLABORATION CAN BE USED TO SHARE THE WORKING MEMORY LOAD ON COMPLEX LEARNING TASKS."

"UNDER APPROPRIATE CONDITIONS, COLLABORATION CAN ENHANCE LEARNING."

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COGNITIVE LOAD THEORY IN PERSPECTIVE

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THE DIVISION
OF KNOWLEDGE
INTO BIOLOGICALLY
PRIMARY AND
BIOLOGICALLY
SECONDARY
KNOWLEDGE

AN EMPHASIS
ON HUMAN
COGNITIVE
ARCHITECTURE

THE DIVISION
OF COGNITIVE
LOAD INTO
CATEGORIES

ASSUMPTION
OF THE PRIMACY
OF DOMAIN-
SPECIFIC RATHER
THAN DOMAIN-
GENERAL
COGNITIVE
STRATEGIES

EMPHASIS ON
COLLECTING DATA
THROUGH THE
USE OF
RANDOMISED
CONTROLLED
EXPERIMENTS



"COGNITIVE LOAD THEORY, WITH ITS EMPHASIS ON HUMAN COGNITIVE ARCHITECTURE, DOMAIN-SPECIFIC KNOWLEDGE AND INSTRUCTIONAL EFFECTS BASED ON RANDOMISED CONTROLLED EXPERIMENTS HAS GENERATED A CONSIDERABLE RANGE OF INSTRUCTIONAL PROCEDURES. THE INTEGRATION OF THESE FACETS INTO A UNIFIED WHOLE HAS BEEN PRODUCTIVE. COGNITIVE LOAD THEORY IS THAT UNIFIED THEORY."

"MODERN INSTRUCTIONAL THEORIES TEND TO PLACE A HEAVY EMPHASIS ON WHAT CAN BEST BE DESCRIBED AS GENERAL COGNITIVE STRATEGIES."

"COGNITIVE LOAD THEORY ASSUMES SUCH STRATEGIES EXIST BUT MOST, EVEN IF NOT ALL, ARE BIOLOGICALLY PRIMARY AND SO ACQUIRED EASILY, AUTOMATICALLY AND UNCONSCIOUSLY AT A YOUNG AGE. THEY USUALLY CANNOT BE READILY TAUGHT."

"THE THEORY CONSIDERS OUR KNOWLEDGE OF HUMAN COGNITIVE ARCHITECTURE TO BE CRITICAL TO INSTRUCTIONAL DESIGN. HUMAN COGNITIVE ARCHITECTURE, BASED ON THE DISTINCTION BETWEEN WORKING AND LONG-TERM MEMORY, IS NOT MERELY RELEVANT TO COGNITIVE LOAD THEORY, IT IS INTEGRAL."

"THE MAJOR POINT IS THAT COGNITIVE LOAD THEORY DOES TEST HYPOTHESES. MANY INSTRUCTIONAL THEORIES DO NOT."