Psychology of gifted learning

Session 5 Information processing models of learning applied to gifted learning

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Objectives of the session. At the end of this session you should be able to
- describe the information processing approach to learning ,
- discuss its implications for teaching and education of gifted children,
- discuss the concepts of attention and memory processes in learning.
- discuss the concepts of short term and long term memory and their implications for teaching.

Content

Models of information processing to explain learning Learners learn by processing information. Key questions include:
- what types of information can individuals process ? What determines this ?
- where does the processing (that is, the ideas-re organizing) take place ?
- how much information can a learner process at once ?
- what initiates the processing at any time ?

Learners as information processors Learners' existing knowledge ('long term memory') provides the 'information processing units' and the ways of linking ideas. Learners can handle several types of information at once. Different types of existing knowledge involves units of meaning organised or linked in different ways:
- conceptual
- episodic
- motoric
- knowledge of one's self as a learner

The information is processed in site for learning or thinking space; short term working memory . At any time this is limited; learners process a restricted amount of information at once. Two metaphors are used to explain thinking and learning in terms of information processing:
- a structures metaphor, proposing several separate structures for doing the processing and
- a processes metaphor, proposing that the information is processed in several different ways.

The structures metaphor assume that we have several types of mental structures;
- a sensory level store in which incoming information is retained until it is processed
- a thinking space or 'working memory' in which ideas are manipulated during processing
- a long term store in which knowledge is retained long term (your knowledge of the world),
- a central processor that manages thinking space activity and
- a response system for displaying thinking space activity (how you show what you know).

Learning goes on in our thinking spaces : the site for learning is our *thinking space*.

<table>
<tr><td>feedback</td><td>visual scratch pad retains visuo-spatial images both by receiving visual perceptual information and by generating visual images retain for 1-2 seconds.</td><td rowspan="2">Thinking / learning space managed by control mechanism; existing knowledge is re-arranged
• retain for 1-2 minutes
• limited capacity; 7 ± 2 items</td><td rowspan="2">Ways in which learner shows what is known; managed by thinking space:
• talk
• write
• act, do
• draw</td></tr>
<tr><td>culturally determined information</td><td>phonological loop retains speech-based information and information from scratch pad that has been sub vocally rehearsed; uses articulatory naming process</td></tr>
</table>

<table>
<tr><td colspan="5">Long term memory storage - existing knowledge; unlimited duration and unlimited capacity</td></tr>
<tr><td>conceptual</td><td>episodic</td><td>motoric</td><td>affective</td><td>knowledge of how one learns</td></tr>
</table>

Short term memory

Short term memory is where the action occurs during learning; where learners bring together the information and what they already know. Terms such as immediate memory, (short term), working memory, working space, information processing and attention are used. Investigators differ in how they operationalize it precisely.

Input information involves several levels of memory processing. These include

- retaining visual information, for example, real world visual information and visually-presented symbolic information such as print in a temporary visual information store.
- retaining words read and their meaning, grammatical properties, the names of every-day items and events seen.
- retaining in an on-going way a representation of text read .
- retaining auditorally represented information (information heard).
- retaining kinaesthetic and tactile information.
- encoding semantic aspects of the information that has already been processed.

The distinction between short and long term memory is in many ways arbitrary. Knowledge stored in long term memory is used during short term memory activity. Word meanings, grammar and knowledge of text used while comprehending a text you are reading come from your long term memory. If your knowledge of a set of ideas during reading changes, you may decide to retain this change permanently by recoding it in long term memory.

Baddeley's model of short durational retention Baddeley (1990) proposed that short-term working memory consists of three sub-systems; a central executive (thinking space) and two buffer stores, an auditory short-term memory (the articulatory loop) and a visual short-term memory (the visuo-spatial scratch pad). It operates as follows,

- when an item is presented visually, it is initially stored in the visual scratch pad. This store retains visuo-spatial images. It receives information either through visual perceptual processes or by generating visual images.

- a phonological input store that retains speech-based information for a brief period and information that was visually presented and recoded or named by a subvocal rehearsal operation. Memory traces last for 1.5 to 2 seconds before fading if they are not rehearsed sub vocally. The store can hold a limited amount of information.

- the central executive in working memory processes information and retains the outcomes; ideas currently being manipulated, the inferences drawn and the up-dated idea links. It integrates data from the buffers and from long duration storage. It can select the most beneficial strategies for dealing with particular information.

  It has greater capacity and longer duration than the stores and is a flexible work-place that does not use codes of a particular modality. It may have two or more processors, each representing and manipulating different types of information, for example, one for processing written information and one for spatial information (Cantor et al., 1991; Daneman, 1987).

- aspects of the representation may be retained in a more permanent form by adding to or modifying the learner's conceptual and linguistic knowledge in long-term memory.

In summary, learners code information in short term memory as follows:

- they have different ways of coding ideas.
- they can recode the input to other formats; they can switch between codes for an idea.
- they have a management / control mechanism that allows them to select ways of learning and to monitor how well the learning is proceeding.
- different ways of knowing demand different levels of attention.
- each code involves a particular way of thinking or relating ideas.

The processes metaphors focus on how we act on or process the information and link it with other ideas. Remembering visual aspects is the 'shallowest' level of processing, followed by sound processing. Semantic processing leads to the deepest encoding and best performance.

Using attention Attention is a form of energy we invest in ideas we are thinking about at any time. To process information we need to invest attention. It is used in the thinking space by the central processor when we handle ideas, retrieve them and activate the response system to show what we know. Attention isn't usually used to retain ideas in long term stores or to receive the information in the first place (although faulty receptor systems or impure input messages can use it).

Storing information in short term memory To retain information in STWM longer you act on it in some way., Memory strategies to assist retrieval include

- ***rehearsing the information,*** recycle the knowledge, say it over and over, phonemically rehearse it.
- ***elaborating it,*** by adding to the items to be recalled, for example, linking them in a sentence or image, link bits in a larger picture; convert to images in space and time.
- ***organizing it in some way*** 'acting on' the knowledge in particular ways, eg, break the idea into 2 or 3 parts and say each over to yourself. semantically organize the information, represent it as an action sequence

Types of long term memory; this is what we use to we process information:

- ***Recognition memory*****;** learners recognize a piece of information they have experienced earlier, for example, seen or heard. They use this to decide whether pieces of information 'fit together' although they can't explain why or how. This develops early in a child's life.
- ***Episodic memory;*** learners recall how to act, what to say, etc, based on their memory of earlier specific real-life experiences, storing ideas in nonverbal ways; storing ideas in distinctive episodes in which the ideas were experienced, for example, when they decide how to act in a particular context, storing ideas in terms of action sequences. Ideas are linked in real-life contexts with co-occurring ideas.
- ***Semantic or conceptual network memory,*** storing ideas in terms of their meaningful relationships to other ideas, recalling conceptually-linked ideas or abstract ideas, for example, the meanings of words, the ideas necessary for producing an explanation, sets of linked abstract ideas, ; verbal semantic memory
- ***Ways of thinking and solving problems***.
- ***Beliefs, attitudes about the specific topic,*** emotions and feelings linked with ideas.

Some knowledge is automatized (handled automatically) while other aspects are attention-demanding. Skills are procedures that can be applied automatically.

Storing information in long term memory Remembering ideas long-term involves;

- storing the information in memory by linking it to knowledge already there, eg, draw concept maps and draw in the new ideas, discuss links between known and new and
- retrieving it by gradually reconstructing the information. They reconstruct it initially, perhaps using external cues and prompts to assist and gradually recall it more automatically.

Uses of recognition memory in teaching Not used to the extent that it could be in teaching.

- Ensure that students can recognize an idea before they are asked to retrieve it.
- If students can't recall a set of ideas, see whether they can recognize parts of them, how they are fitting together.

Implications of information processing theory for gifted learning

Use of organisational strategies for retaining information in short term memory Gifted children

- show a higher level of recall and use higher level organizational strategies than average children on multi trial free-recall tasks, employing different sets of items on each trial (Coyle, Read, & Gaultney, 1998; Gaultney, Bjorklund & Goldstein, 1996). They were presented with different sets of categorizable words on each trial and remembered them for later recall. Four strategies were coded on each trial: whether the learners used sorting at study, rehearsal, category naming and clustering at recall. Gifted learners

- showed greater use of active strategies than did non gifted children for recall of nonsense words as stimuli.
- showed more strategy use and higher levels of recall than non-gifted children.
- showed higher level of stability in strategy use with relatively high levels of recall at the second, third, and fourth grades (Coyle, Read, Gaultney & Bjorklund, 1998); cognitive stability is a prominent characteristic of gifted cognition. Strategic variability was assessed in terms of fluctuation in the use of single strategies over trials, use of different combinations of multiple strategies over trials, and trial-by-trial switches in strategy use.

- show linked creativity and imagery processes (Shaw & de Mers, 1986-1987). Three commonly used creativity tests and 3 measures of imagery (i.e., self-reported vividness of imagery, self-reported control of imagery, visual memory) administered to 54 high-IQ 5th and 6th graders (to maximize the independence of creative thinking from IQ) showed that these were not unitary constructs, but rather that some types and aspects of each are related.

- show short term memory performance that matches their area of giftedness (Hermelin & O'Connor, 1986). Mathematically gifted learners do better on verbally presented spatial tasks that require a verbally formulated answer while artistically gifted learners were more adept on visually presented tasks that involved a choice of 1 of several visually presented alternatives; they did better using constructive imagination on the basis of minimal perceptual cues. Both mathematically and artistically gifted learners were equally good and were superior to IQ-matched controls in visual short-term memory tasks involving nonverbalizable shapes and with the capacity to name objects or animals on the basis of minimal visual cues. The results suggest that level of performance on some of these tasks is to some extent IQ-independent but related to specific artistic or mathematical talent.

- who show primarily verbal precocity show enhanced working-memory capacity for words, while those who show primarily mathematical precocity show enhanced capacity for digit and location stimuli Dark & Benbow, 1991) . In working-memory manipulation, the mathematically gifted 13- and 14-yr-olds outperformed the verbally gifted in working memory manipulation of digits and letters. The verbally precocious showed enhanced speed in encoding into working memory. Different types of intellectual talent appear to be associated with different working-memory.

- show a relationship between type of stimulus (numeric and verbal) and type of precocity (mathematical and verbal)for working memory tasks that involve encoding, capacity and information manipulation for gifted youth (aged 11-24 yrs) (Dark & Benbow, 1994) . Scholastic Aptitude Test (SAT-M) correlated positively with numeric categorization latency, recall in a continuous paired-associate task with words and digits, and recall of digit lists. SAT-V scores correlated only with word recall in a continuous paired-associate task and recall of word lists. Mathematical precocity is more strongly related to performance than is verbal precocity, especially with numeric stimuli.

- are less able to self-generate imagery that they are to use experimenter provided visuals to facilitate recall and recognition on a memory task (Carrier, et al 1983) . Gifted 4th-6th graders were compared on the effects of rote repetition, self-generated visualization and supplied visuals on the memorization of concrete noun word pairs. The supplied visual condition produced best results, suggesting that the use of appropriate techniques helps gifted children learn certain memory tasks.

- show mnemonic strategy transfer; while gifted and non gifted 4th and 5th graders (mean Stanford Achievement Test percentiles 95.64 and 67.63, respectively) were assisted by mnemonic strategy instruction for learning Italian vocabulary or information about North American minerals, only the gifted students transferred successfully the strategy spontaneously to a new content area (Scruggs, Mastropieri, Jorgensen, & Monson, 1986).

- at the grade 3 (Full Scale IQs of >=120) often do not differ from average learners in their attention span, memory, sequential reasoning, visual-spatial perception, or visual-motor coordination on the Wechsler Intelligence Scale for Children--Revised (WISC--R), while they excel in complex reasoning (Wilkinson, 1993).

- who have learning disabilities frequently have memory difficulties. Of 68 gifted children (aged 9-14 yrs), those who were also learning disabled, 50% scored in the impaired range on the Tactual Performance Test Memory and Localization subtests of the Halstead-Reitan Neuropsychological Test Battery for Children (HRNB--C) (McIntosh, Dunham, Dean & Kundert, 1995).

Metamemory ; an awareness of the memory demands of reading, of one's memory ability, how to use memory processes in terms of goals for reading (Feldt & Witte, 1988). Gifted students

- at the 5th and 6th grade levels showed metamemory awareness that was related to IQ, achievement and divergent thinking (Carr, & Borkowski, 1987).

- and average learners (mean age of 13.3 yrs) did not differ on metamemory interview and recall tasks (Kontos, Swanson & Frazer, 1984). Metamemory correlated with memory.

- and average 5th and 7th grade matched learners differ in metamemory and sort recall (Kurtz & Weinert, 1989) . They also differed in attributional beliefs; gifted learners were more likely to attribute their academic successes to high ability than were average learners who showed a stronger belief in the importance of effort in determining task outcomes. Metacognitive knowledge predicted performance on the memory task, especially for average learners.

Information processing; gifted children

- process lower-order information for elementary cognitive tasks (ECTs more rapidly and efficiently than academically average age peers (Kranzler, Whang & Jensen, 1994). Tasks used were Raven's Advanced Progressive Matrices and the ECTs: simple reaction time (RT), choice RT, and the Odd-man paradigm, which is a measure of the speed and efficiency of spatial discrimination. After eliminating the effect of differences in knowledge base, differences between gifted and non gifted children on ECTs are related to the required processing complexity. Gifted children differ not only in the effectiveness of higher-order processes but also in speed and efficiency. Differences in movement time were found.

- display a high level of cognitive efficiency in elementary information processes (e.g., memory span and processing speed) (e.g., Geary & Brown, 1991; Saccuzzo, Johnson, & Guertin, 1994). These f elementary cognitive processes have a significant role in determining more complex cognitive processes; that is, differences in how efficiently information is stored in memory or how efficiently stored information is retrieved would influence higher level performance in many domains (e.g., Jackson & Butterfield, 1986). For example, a poor reader may have to devote most of his or her limited attentional capacity to such low-level aspects of the reading process as identifying individual letters or words, leaving little attention free for the higher order synthesis and comprehension of text (Perfetti & Lesgold, 1981). These studies suggest that intellectually and academically gifted children show highly efficient memory processes (Hong, 1999).

- process information at a global level in a qualitatively different manner from average children was shown using the Wechsler Intelligence Scale for Children--Revised (WISC--R) (Brown & Yakimowski, 1987). Factor analysis of WISC--R scores of gifted children identified 4 main factors in how these students process information : Perceptual Organization, Verbal Comprehension, Acquisition of Knowledge and Spatial Memory. This accounted for about 65% of the variance. Children with average and above average IQs revealed 2- and 3 main factor solutions.

- benefit from instruction that models, teaches, and shows strategies for problem solving (Rawl & O"Tuel, 1983). Useful techniques for such instruction include heuristic strategies such as means end analysis, analogies, chunking, brainstorming, reduction of a task into smaller steps, and reevaluation of givens. Teachers need to know how to adjust the type of problem and its presentation to permit encoding and memory retrieval, and to help students focus on strategies that lead to success.

- who are exceptionally gifted (aged 4-22 yrs) (IQ scores > 170) differ from their more moderately gifted peers (IQ scores > 140) quantitatively and qualitatively in cognitive information processing, including ability for abstract reasoning, empathy, exceptional memory, precision, easy grasp of the essential element of an issue, and inclination toward immersion (Lovecky, D. V., 1994) .

- process information faster; measures of speed of processing correlate with IQ for gifted and non gifted 2nd--6th grade children (Saccuzzo, Johnson & Guertin, 1994). Four information-processing tasks: inspection time (backward masking paradigm), reaction time (RT), coincidence timing, and mental counters (working memory) were used. Coincidence timing and IQ were related.

- initiate alpha-power more efficiently in task-relevant brain areas. While the EEG patterns of gifted and average adult learners did not differ in resting conditions, they did differ while solving tasks that involved processing speed, working memory, arithmetic operations, proportional, deductive and inductive reasoning (Jausovec, 1998). Gifted learners during problem solving showed higher alpha-power (less mental activity) than average peers. The differences were most pronounced over the frontal brain areas for the tasks involving working memory and arithmetic operations.

- display evidence of superior non strategic memories. A comparison of differences in strategy use and text recall between 4th and 5th graders trained to use elaborative interrogation (a reading-comprehension strategy) showed that gifted learners had greater recall than did average learners prior to and 1 wk after training, despite equivalent levels of strategy use. Average learners benefited from using the strategy, while gifted learners didn't. Gifted children, because they seem to have superior non strategic memories, may require more difficult tasks than average children to acquire and use memory strategies. An optimal level of strategy use may differ as a function of one's cognitive abilities.

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