
# PROCEEDING

## INTERNATIONAL CONFERENCE ON LESSON STUDY

## LESSON STUDY: A CHALLENGE FOR QUALITY IMPROVEMENT IN EDUCATION

Thursday, 31 July 2008 – Saturday, 2 August 2008

**UNIVERSITAS PENDIDIKAN BANDUNG**
**INDONESIA**


ICLS
2008
International Conference
on Lesson Study
Lesson Study: A Challenge for Quality Improvement in Education

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# PROGRAM SCHEDULE OF INTERNATIONAL CONFERENCE ON LESSON STUDY 2008

## Conference Day 1
## Thursday, 31 July 2008

| | |
|---|---|
| 07:30 – 08:30 | *Registration* |
| 08:30 – 09:30 | *Opening Ceremony*<br>• OC Report<br>• Opening Speech of Rector of UPI<br>• Launching of ICLS |
| 09:30 – 10:00 | *Coffee Break* |
| 10:00 – 12:30 | *Plenary Session 1*<br>Chairperson: Prof. Yaya Surya Kusumah, M.Sc., Ph.D.<br>1. Thailand's Experience in Lesson Study for Enhancing Quality in Education. ***Maitree Inprasitha, Ph.D.*** (Center for Research in Mathematics Education, Khon Kaen University, Thailand)<br>2. Lesson Study as an Instrument for School Reform: A Case of Japanese Practices. ***Eisuke Saito, Ph.D.*** (International Development Center of Japan) |
| 12:30 – 13:30 | *Lunch Break* |
| 13:30 – 16:00 | *Parallel Session 1*<br>at Room S-301, S-302, S-303, S-304, S-305, S-306 |


## Conference Day 2
## Friday, 1 August 2008

| | |
|---|---|
| 08:00 – 09:30 | *Plenary Session 2*<br>Chairperson: Dr. Anna Permanasari, M.Si.<br>1. Lesson Study in the Context of Educational Reforms in Singapore: Potential, Practices and Pitfalls.<br>***Christine Kim-Eng Lee and Fang Yanping***. (National Institute of Education Nanyang Technological University, Singapore)<br>2. Lesson Study in Indonesia: Practice and Challenges for Teacher Professional Development.<br>***Sumar Hendayana, Ph.D.*** (Indonesia University of Education) |
| 09:30 – 10:00 | *Coffee Break* |
| 10:00 – 11:00 | *Plenary Session 2 (Continued)* |
| 11:00 – 13:30 | *Lunch Break* |
| 13:30 – 16:00 | *Parallel Session 2*<br>at Room S-301, S-302, S-303, S-304, S-305, S-306 |
| 16:00 – 17:00 | *Closing Ceremony* |

## Workshop
## Saturday, 2 August 2008

| | |
|---|---|
| 06:30 – 07:00 | *Preparation* |
| 07:00 – 09:00 | *Trip to Sumedang* |
| 09:00 – 12:00 | *Open Lesson* |
| 11:00 – 13:00 | *Lunch Break* |
| 13:00 – 15:00 | *Discussion* |
| 15:00 – 17:00 | *Trip to Bandung* |



| Parallel Session 1 | | | | | |
|---|---|---|---|---|---|
| **S.301** Moderator: Elah Nurlaelah, M.Si. | **S.301** Moderator: Heni Rusnayati, M.Si. | **S.303** Moderator: Diana Rochintaniawati, M.Ed. | **S.304** Moderator: Ali Kusrijadi, M.Si. | **S.305** Moderator: Amprasto, M.Si. | **S.306** Moderator: Fitri Khoerunisa, M.Si. |
| A.1 | B.1 | C.1 | D.1 | E.1 | F.1 |
| A.2 | B.2 | C.2 | D.2 | E.2 | F.2 |
| A.3 | B.3 | C.3 | D.3 | E.3 | F.3 |
| A.4 | B.4 | C.4 | D.4 | E.4 | F.4 |
| A.5 | B.5 | | D.5 | E.5 | F.5 |

| Parallel Session 2 | | | | | |
|---|---|---|---|---|---|
| **S.301** Moderator: Elah Nurlaelah, M.Si. | **S.301** Moderator: Heni Rusnayati, M.Si. | **S.303** Moderator: Diana Rochintaniawati, M.Ed. | **S.304** Moderator: Ali Kusrijadi, M.Si. | **S.305** Moderator: Amprasto, M.Si. | **S.306** Moderator: Fitri Khoerunisa, M.Si. |
| A.6 | B.6 | C.5 | D.6 | E.6 | F.6 |
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| A.8 | B.8 | C.7 | D.8 | E.8 | F.8 |
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| A.10 | B.10 | | | | |


# MAKING LESSON STUDY MORE EFFECTIVE: A COGNITIVE LOAD APPROACH

Endah Retnowati, M.Ed.
Department of Mathematics Education
Faculty of Mathematics and Natural Sciences
Yogyakarta State University

Abstract

Cognitive Load Theory provides principles of learning based on human cognitive architecture. Our knowledge of human cognitive architecture has illuminated our understanding of how knowledge is acquired and automated. It is particularly concerned with the fact that working memory is severely limited and that these limits may be circumvented by retrieving prior knowledge stored in unlimited long term memory. The theory suggests that when to be learned material have a high intrinsic cognitive load, for example novel material or problem solving, instructional learning that require a low extraneous cognitive load on working memory would likely be effective. The effectiveness of instructional designs based on cognitive load theory has been shown by numerous controlled experiments across domain specific knowledge.

This paper is intended to find out the implementation of the principles of cognitive load theory within lesson studies and so improving the effectiveness of lesson studies. Concerning the ground theory is how information is naturally processed by our cognitive architecture; cognitive load theory should have provided us how to conduct lesson studies that is in accord with natural information processing. Understanding how students construct and automate knowledge would also improve lesson studies.

Keywords: lesson study, knowledge construction, cognitive load

## A. Introduction

Lesson study is basically a collaborative research toward classroom activities among teachers or in service teachers. Specifically, it is mainly concerned with how students learn of the subject matter. The lesson study could involve some aspects regarding students learning activities, which are instructional learning, learning settings, classroom facilities and syllabus. Nevertheless, these aspects should be integrated in order to facilitate students with learning. Students' performances after learning might be the major outcome expected from classroom activities, and indeed the lesson study is proposed to figure out successful classroom activities in bridging students with effective learning.

Learning occurs if students construct or automate schemas. Schema construction and automation is naturally processed by our human cognitive architecture. The term "cognitive architecture" refers to how our cognitive is structured including how learning and understanding is organised. It should have been understood that without our understanding of how students' cognitive architecture works, teachers would be challenged with unanswered questions such as why some material are easy for some students but for the others, why some students cannot learn effectively, why problem solving is difficult or why some attractive presentations do not facilitate learning.

The following discussion provides description of cognitive load theory that underlies on human cognitive architecture and sources of cognitive load. Further, this paper presents to what extent the theory benefits lesson study programs.

## B. Cognitive Load Theory

Cognitive load theory is based on human cognitive architecture. Cognitive architecture has been deeply discussed since the early of 1930s by various researchers and is still intensively studied today. A basic information processing model of human cognitive architecture, the modal model, was proposed by Shiffrin and Atkinson (1969) and is presented in Figure 1.

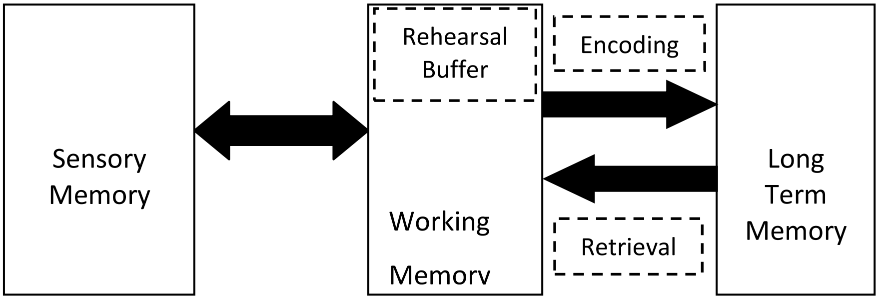


Figure *1 . The Modal Model (adapted from Shiffrin & Atkinson, 1969, p. 180)*

This model has been further developed to give detailed descriptions of the structure of memory (See Baddeley, 1992; Ericsson & Kintsch, 1995) and cognitive processes including learning, understanding and its evolution (See Bruning, Scraw, Norby, & Ronning, 2004; Sweller, 2004, 2006, 2007). The model described in Figure 1 involves some aspects of the information processing system used in human cognition: sensory memory, working memory and long term memory. How these parts work is described as follows.

**Sensory Memory**

Sensory memory is assumed as a bridge between information from the outside world and the information processor in the human brain. We have five senses: sights, sounds, smells, tastes and touches, which enable us to recognise environment. So far, it is known that sensory memory comprises of a visual sensory register and an auditory sensory register, which store information from the sense of sight and sound respectively (Bruning et al., 2004). However, information attends this memory for just a few seconds or perhaps a fraction of seconds. Information flows quickly through this memory, unless the information is passed over into working memory to be recognised, identified and assigned meaning to. Therefore, some information are forgotten quickly and replaced by new coming information. This replacement is necessary because the continuous changes of information from our environment. Sensory memory is not responsible for processing the meaning or the information. It merely identifies inputs and sends them to short term memory (working memory) as the thinking processor. The result, which is the meaning attached to the information, will be either stored in long term memory or passed on to sensory memory to act behaviour.

**Long Term Memory**

Long term memory provides permanent storage in human cognitive architecture. The natural information processing in human includes the information stored in this memory. It has an unlimited capacity to store organised information or knowledge structures that determines how we deal with information in working memory. Level of expertise in a specific domain is also determined by the information stored in long-term memory.

Knowledge structures are mental constructs called schemas. Schemas provide a mechanism to recognise patterns or configurations or elements of information as a single element categorised according to the manner in which it will be used (Sweller, 1999; Sweller & Cooper, 1985; Sweller, van Merrienboer, & Paas, 1998). A variety of interacting elements may be categorised within a single schema. The number of interacting elements that can be categorised (chunked) as a single element depends on retrieved schemas. For example, mathematical equations vary in terms of symbols, connections or functions. A quadratic equation schema permits us to identify a quadratic form as a single category, eliminating the variation of its symbols. If such a schema is not stored in long term memory, the equations may be treated as several simple patterns of symbols associated without any mathematical meaning.

The schematic structure in long term memory determines levels of expertise in a particular area (Sweller et al., 1998). De Groot (1978) investigated why chess grand masters perform better than less able players, by examining both more and less able players who were required to reproduce chess configurations taken from real games. The result demonstrated that more able players performed this task more accurately and more quickly than less able players. Chase and Simon (1973) revealed that both master and amateur players are equally able to reproduce random chess configurations. Simon and Gilmartin (1973) suggested that master players had stored hundreds of thousands of chess configurations. The investigations concluded that expert players spend many years learning about chess. The more they learn, the more schematic networks are structured. Thus, they become familiar with a large number of chess configurations. Consequently, they can easily and accurately reproduce the configuration taken from real games which they are familiar with, but they cannot reproduce any random configuration because they are not familiar with these. In other words, master players almost certainly win games because they draw on their huge number of chess configurations stored in long term memory to recognise a configuration and the best move associated with it. They do not rely on sophisticated problem solving strategies.

Moreover, experts appear able to quickly recognise patterns of information and so eliminate procedures in solving problems because their well organised schemas enable them to mentally integrate some procedures and directly go forward to the task goal (De Groot, 1978). More knowledgeable learners are also likely to have an effective way of encoding schemas to long term memory and retrieving prior schemas because they engage a large number of relevant schemas in their domain. Consequently, they solve problems faster. Nevertheless, in some cases, experts might solve problems more slowly than novices because they might think about the problem in more detail and more carefully before deriving decisions. Experts attempt to understand problems rather than jump immediately to solution strategies. This was indicated by the study of Chi, Feltovich and Glaser (1981) who found that experts' solutions are derived on the basis of the principles that can be applied to solve the problems but novices' solutions are derived on the basis of the problems' surface attributes.

The schema structures of experts and novices may be represented in Figure 2.

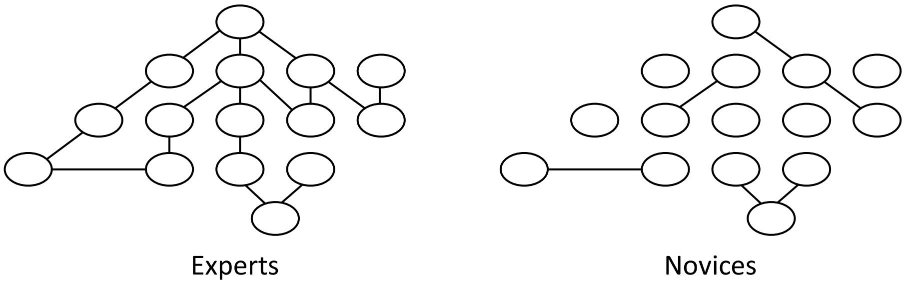


Figure 2. *Experts and Novices Schema Structures*

Having a well organised schematic structure certainly would support learning and solving problems. Erricson (2003) argued that only by deliberate practice, which means an intensive, extended, meaningful learning, will a well organised schematic structure be developed. Even if learners are talented in a specific area or have high intelligence, deliberate practice is required to built hierarchically ordered schemas (Cooper, 1998; Ericsson, 2003; Ericsson & Kintsch, 1995; Sweller, 1999). Without extensive practice, people will not develop a large knowledge base.

Schema automation considerably contributes to enhancing information processing (Kalyuga, Ayres, Chandler, & Sweller, 2003; Pass, Renkl, & Sweller, 2004; Sweller, 1999). Schema automation occurs when schemas from long term memory are processed unconsciously in working memory. Schema automation results from frequent practice. To illustrate, the first time we learn how to read a word, we must pay attention to each letter, but with practice we need less effort to read; thus we can process other information by reading thousands of words. Schemas incorporating letters, words, meanings of words and sentences are automatically recognised during reading allowing us to unconsciously decode written information.

**Working Memory**

Working memory is part of the brain system that initially receives and holds information from sensory memory (Bruning et al., 2004). What we are currently thinking is information that is actually in our working memory. Therefore, we also call working memory as thinking processor. Working memory manipulates, encodes and structures information in the form of schemas, by retrieving prior schemas from long term memory to recognise current information, to create connection and to maintain them step by step by simultaneously contrasting, comparing and combining in a someway in order to give meaning and understand the information.

Under most circumstance, human working memory capacity is limited, able to store no more than 7±2 chunks of information simultaneously (Miller, 1956). Peterson and Peterson (1959) indicated that the number of those elements that can still be processed simultaneously considerably decreases within a few seconds because of interference, decay and replacement by new information. Simultaneous information processing in the verbal and visual components may exceed a working memory capacity. As a consequence of a limited working memory, process of transferring new information to long term memory is slow and incremental.

Working memory can be considered to consist of four subcomponents: a central executive as the attention controller and to organise the other slave components: a phonological or articulator loop to maintain speech based information; a visual-spatial sketchpad for dealing with visual images; and an episodic buffer to (1) integrate information from phonological and visual-spatial components and (2) link new and prior information from long term memory (Baddeley, 2000; 2002). Prior knowledge, either stored in long term memory or borrowed from other people by written or oral communication, can act as the central executive. The central executive functions to direct our attention, hold and organise new information.

As indicated above, prior schemas from our long term memory act as an executive in working memory and so determine how to deal with new information. If there is a lack of relevant schemas from long term memory, random generation followed by tests of effectiveness is an unavoidable process, unless relevant information can be borrowed from other resources, for instances from worked examples or others' long term memory.  Accordingly, if schemas concerning potential moves to solve a problem is unavailable in our or others' long term memory, working memory will randomly generate a move using a general problem solving strategy and test the effectiveness of this move. Ineffective or non-beneficial moves are rejected while effective ones are stored as new schemas in long term memory.

It has been discussed that well organised schemas in long term memory distinguish experts from novices in a domain (Kalyuga et al., 2003; Kalyuga, Chandler, & Sweller, 1998; Sweller, 1999). Well defined schemas enable experts in a domain to solve problems working forward to the goal, because they can recognise what is known and have the procedural actions leading to solution. In contrast, novices tend to solve problems using a searching based strategy by creating sub-goals from the problem goal, rather than from the given information and then randomly match them with possible moves. When errors occur, problem solvers establish another sub-goal and try to find operators to reach it. Such a process of problem solving search is called means-ends-analysis and imposes a heavy working memory load (Ayres & Sweller, 1990; Sweller & Chandler, 1994). This indicates why direct instruction is important when acquiring secondary knowledge.

If long term memory has unlimited amounts of information consisting of organised schemas that can be transferred to working memory, working memory load can be extended (Sweller, 2007). Consequently, the freeing of working memory capacity can be employed to assimilate, accommodate and construct new higher level schemas. Thus, learning is enhanced into an expert level.

**Sources of Cognitive Load**

Sweller (2006) and Cooper (1998) define cognitive load as the total amount of mental activity imposed on working memory. Cognitive load can be divided into three categories: intrinsic, extraneous and germane cognitive load. Cognitive overload occurs if the total cognitive load exceeds working memory capacity. Accordingly, learning process will be compromised because too much burden in working memory reduces probability of changes to long term memory (Sweller, 2006).

Some materials have natural difficulty because they consist of a set of concepts that must be processed simultaneously in working memory to be understood. Cognitive load caused by these materials is categorised intrinsic cognitive load (Cooper, 1998, Sweller 1999, 2006). For example, the mental calculation of 5+4 has lower intrinsic cognitive load than the derivative of $d(2x–1)^2/dx$. Material that is low in element interactivity does not contain interacting elements and thus each element can be learnt individually. The intrinsic cognitive load is low. Conversely, some material is high in element interactivity where the elements are associated with each other and so have to be processed by working memory simultaneously. The intrinsic cognitive load is high.

Intrinsic cognitive load cannot be modified by instructional learning. In other words, material which is high in element interactivity, if presented by any instructions will remain high element interactivity (Cooper, 1998). Sweller (2006) suggests that material which has high intrinsic load should be initially thought in isolated elements and learned the relevant interaction afterwards. Although understanding is not obtained at the first stage, by this way learning can be advanced because learners already acquire the conditional knowledge of the interacted elements.

Extraneous cognitive load relates with instructional learning used to present to-be-learned information (Cooper, 1998, Sweller, 1999, 2006). If instructions ignore the natural principles of information processing on human cognitive architecture, they might cause heavy extraneous cognitive load. In order to reduce extraneous cognitive load, instructional learning should be designed according to learners' prior knowledge level and the novelty of the material.

An approach that has been well established by various research in many domain specific, worked example, shows that novice learners learn better using this approach compared with using a problem solving approach. They would be benefited using worked examples because they do not have sufficient prior knowledge to solve problems and thus need more guidance in learning. In this case, worked example approach is lower extraneous cognitive load. However, for more knowledgeable learners, worked examples would not be advantageous. It could higher extraneous cognitive load because of redundancy effect. More knowledgeable learners might already have prior knowledge to solve problems and thus the worked example is redundant. Less guidance instructions is better for more knowledgeable learners because they already posses higher level of expertise.

Material presented with diagram can also cause heavy extraneous cognitive load, when split attention occurs. It is frequently found description for the diagram is separated from the correspondence diagram. This demands high extraneous cognitive load in working memory because this presentation requires us to integrate some information in the diagram and the text. Such presentation might also cause redundancy if the diagram is self explained. It means that the instruction to learn the description of the text imposes higher extraneous cognitive load.

Another way to prevent heavy extraneous cognitive load is the uses of goal free problem. Using goal free problems is better because it prevents means-ends-analysis that do not guide us to construct schemas into a well define building in long term memory (Sweller, 1999, 2004). Students who use means-ends-analysis require a heavy extraneous cognitive load because they do not have sufficient schemas to solve problems. The use of goal free problems would direct students to identify given information and run required possible process, instead of jumping to the goal of problems without necessarily construct schema for solving problems in forward direction.

Germane cognitive load concerns with the degree of effort involved in the productive learning (Sweller, 2006). Activities associating with schema acquisition and automation would increase germane cognitive load. This load would be available if the working memory capacity is not exceeded by intrinsic and extraneous cognitive load. It is ultimate to manage extraneous cognitive load when to be learned material imposes high intrinsic cognitive load and hence free working memory load could be directed for germane activities.


## C. Making Lesson Study More Effective

The above discussion provides us some advance insight of how students' construct knowledge. Moreover, the above description presents us how expertise is developed. It is widely known that classroom activities is centred to students, which means that any activities in the classroom conducted by teachers is merely for learning done by the students. Students who are responsible for their knowledge construction, however, teachers are more responsible for facilitating students for effective learning. On the other hand, lesson study is conducted to find out the effective way to facilitate effective learning. Accordingly, our knowledge of how students' cognitively process knowledge is ultimate. Thus, approaches developed by cognitive load theory should have assisted us toward the more effective lesson study.

Cognitive load theory provides general principles of natural information processing. These principles are generated as the consequences of cognitive processes in human cognitive architecture. Consequently, these principles must be considered in order to conduct learning activities that is in accord with students' cognitive processes. These principles are as follows.

(1) There is unlimited schema can be stored in long term memory. This schema might be retrieved either consciously or automatically by working memory and permits us to recognise and organise information in working memory.

(2) Working memory is severely limited when dealing with novel information. Its capacity is critical to learning. Learning, which means schema construction, schema reorganisation or schema changes in long term memory, merely occurs when working memory is not over loaded.

(3) Schema automation and acquisition allow us to circumvent our limited working memory when dealing with novel information. Schema acquisition and automation are essential to enhance learning and therefore instructions should be directed to these activities.

(4) Acquiring knowledge specific in domain, for instance problem solving strategy, requires explicit instructions, in particular for novice learners.

Cognitive Load Theory focuses on the critical feature of working memory capacity. Ultimately, our understanding of classroom activities that facilitate students' working memory in a manageable level would provide us a deeper insight of their learning activities.

As aforementioned, there are three sources of cognitive load. It is important for researchers who are involved in lesson study to comprehend the management of this cognitive load, in order to analyse effectiveness of the classroom design. Following are three questions concerning cognitive load should be addressed that might be advantageous for discussion in lesson study:

(1) The intrinsic cognitive load: what is the degree of element interactivity in the study material aligned to the nature of the material and expertise level of learners? Have teacher organised the material according to students' prior knowledge level?

(2) The extraneous cognitive load: How teacher present to be learned material? how much mental effort do learners need to cognitively process the presented information?

(3) The germane cognitive load: Are there any cognitive resources left after the intrinsic and extraneous cognitive load for schema acquisition or automation? Does teacher direct students to germane activity?

Such questions are essential for effective and efficient learning activity. Moreover, cognitive load theorist has been developed some methods to manage cognitive load in working memory during learning (for instances: Atkinson, Derry, Renkl, & Worthan, 2000; Ayres, 2006; Chandler & Sweller, 1991; Kirschner, 2002; Mayer &

Moreno, 2003; Morrison & Anglin, 2005; Paas & Van Gog, 2006; Sweller, 1999). Referring to these research results would definitely benefit for lesson studies.

To summarise, human cognitive architecture describes how students think or learn. It is an essential knowledge in order to conduct effective cognitive processes in classrooms. Cognitive load theory provides principles for instructional learning designs that is in accord with human cognitive architecture. As lesson study is aimed to collaboratively learn how students learn and think, using cognitive load approach would make lesson study more effective.

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