

HOW DOES COURSEWARE'S DESIGN AFFECT LEARNERS' COGNITIVE-STRATEGY?

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Abstract

The emergence of the computer as an aid to education, with its unlimited range of instructional control options available to designer and user supports the vast development of coursewares. Hundreds of coursewares, aim to increase learners' learning outcomes were developed. However, to have a courseware fits with learners' characteristics many issues need to be explored. Referring to Resnick's (1989) definition of learning as *knowledge construction*, it is critical for coursewares to support learners in the process of acquiring, retaining, and retrieving different kinds of knowledge and performance. In acquiring, retaining, and retrieving information learners use procedures known as *cognitive strategies*. It is assumed that cognitive strategies are integral to the process of learning, but initiation of their use may come from the learner's self-instruction, or, from an instructional unit or system. This study intends to show how courseware design affects the use of cognitive strategies, especially from the high-school learners in Indonesia. A close examination on the psychological processes in learning was made to address questions: (a) how does screen density affect the use of cognitive strategies? (b) Does material presented in a linear format differs with material presented in non-linear (hypertext-based) in producing learner's learning outcomes? The results show that learners employed better cognitive strategies when presented with 25% text density material compare to 60%. Hypertext-based courseware was also found to have an effect on how learner processed the information.

Keywords: courseware, cognitive-strategy, computer-assisted instruction (CAI), knowledge construction

1. Introduction

The use of computers in education has been widely accepted today. Computer software that is designed to create some sort of instructional environment for the purpose of facilitating learning is known as courseware. Courseware is computer software that has an instructional purpose. Courseware is a relatively recent appellation for computer-assisted instruction (CAI), which refers to the use of computers for the delivery of instruction in an interactive mode.

Hundreds of coursewares were developed aimed at increasing learner's knowledge and skills. On the other hand, several investigators have sought to see the effectiveness of CAI unfortunately the results from those studies were inconclusive. In his literature review on learning from media, Clark (1983) proposed that in order to reach an educational goal the kind of media (technology) used to deliver educational material is not that important compare to the instructional design (or, courseware design). Technologies do not mediate learning rather knowledge is mediated by the thought processes engendered by technologies. So, we must

look for the instructional design that result in the most productive thought processes which in return results in the greatest learning. Learning then, is more directly affected (mediated) by the instructional design (soft technologies) than it is by the microcomputer (hard technologies) (Jonassen, 1988a & 1988b).

Instructional design is a professional activity. It is the "process of deciding which methods of instruction are best of bringing about the desired changes in learner knowledge and skills for a specific learner population" (Reigeluth, 1983).

Based on principles of cognitive psychology, we now make an entirely different set of assumptions about how learner process information than when behaviorism dominated learning theory. Rather than passively responding to instructional controls imposed by the author/designer/teacher while integrating stimuli of any sort, learners actually need to attend to stimuli, access existing knowledge to relate to it, realign the structure of that knowledge in order to accommodate that new information, which then, becomes accessible in order to explain and interpret new information.

Jacoby & Craik (1979) proposed that what gets encoded into memory depends on the level or depth of processing of the presented information as it is encoded into memory. Processing deepens on a continuum as one progresses from sensory to semantic processing. Assigning meaning to materials naturally entails semantic processing. Only deeper, semantic processing of information requires the learner to access prior knowledge in order to interpret new material. As the level of processing deepens, then, more information will be recalled because more meaning will be assigned to it. This further means that activities embedded in courseware should reflect deeper level of processing, where meaning for material presented by the computers is generated by activating and altering existing knowledge structures in order to interpret what is presented.

To foster the unique interpretation and encoding of information into memory, learners employed *cognitive strategies*. Cognitive strategies are mental "operations or procedures that learner may use to acquire, retain, and retrieve different kinds of knowledge and performance" (Rigney, 1978). Suradijono (1997a & 1997b) in her study with junior-high and senior-high school students in Jakarta has identified 16 types of learning strategy employed during text processing, as shown in Table 1.

Table 1. Types of Learning Strategy

Type of strategy
1. Problem-awareness
2. Reread
3. Repetition
4. Problem-What
5. Text Evaluation
6. Paraphrase
7. Ask-for-Information
8. Problem-Gap
9. Problem-Hypothesis
10. New-Knowledge
11. Verification
12. Knowledge evaluation
13. Meaning
14. Elaboration
15. Inference
16. Anticipation

Using Perfetti's (1989) differentiation of comprehension --- (1) *achieving a meaning* for a text, and (2) *achieving an interpretation* for a text --- Suradijono (2000) grouped the 10 of the 16 types of cognitive strategies as follow:

1. Achieving a meaning for a text:
Problem-awareness, Reread, Repetition, Problem-What, Text Evaluation, Paraphrase, & Ask-for-Information
2. Achieving an interpretation for a text:
Elaboration, Inference, & Anticipation

Whereas the other 6 types: *Problem-Gap, Problem-Hypothesis, New-knowledge, Verification, Knowledge evaluation, and Meaning*, are considered as "transitional strategies" because they cannot be mapped to any of the above two groups directly.

In a text-based courseware, where reading is the main activity, the type of cognitive strategy used by learner plays an important role. As proposed by Harris & Sipay (1985) "reading is the meaningful interpretation of printed and written verbal symbols." They also stated "reading is the act of interpreting, by the reader, what was written by the author."

2. Research Questions

Duchastel (in Jonassen 1991) further stated: "learner may be deficient in their use of text processing strategies, (however) the text itself should encourage the use of the appropriate strategies --- largely through the design features of the text itself, i.e., through display techniques." However, to make the design features match with learner's characteristics, several questions should be answered such as: (a) how does screen-density affect the use of cognitive strategies? (b) Does material presented in a linear format differ with material presented in non-linear format (hypertext) in producing learner's learning outcomes? By conducting a close examination on the psychological processes in learning, this study intends to address those questions.

3. Method

3.1 Subjects

- *Study on screen density*: 36 High School Students in Jakarta, Indonesia, age 15 to 16 years.
- *Study on hypertext-based courseware*: 51 High School Students in Jakarta, Indonesia, age 15 to 16 years.

3.2 Instruments

- *Study on screen density*:
 - a). Linear-based courseware on AIDS (learners were asked to read starting from page one, then, page two, three, etc.). One group of learners (18 learners) obtained the texts displayed in 25% screen density (around 644 characters), and the other group (18 learners)

obtained texts displayed in 60% screen density (around 1200 characters).

- b). Prior knowledge tests
- c). General ability tests: Raven's Progressive Matrices

- *Study on hypertext-based courseware:*

- a). Hypertext-based (non-linear) courseware on AIDS and a linear-based courseware on AIDS. A group of 24 learners obtained hypertext-based courseware, and another group of 37 learners obtained a linear-based courseware.
- b). Prior knowledge tests
- c). General abilities test: Raven's Progressive Matrices

3.3 Data collection

To obtain answers to these questions, a close examination on the *process* and *strategies* involved in the learning task offered by the courseware from each learner were made. This study employed two different data collection methods. First, there was a *group method*. The Raven's Progressive Matrices test was given to groups of 15 to 16 years old children. Second, there was an *individual method*, in which the researcher met individually with each of the children to administer the prior-knowledge Test, and the lesson. Prior to the lesson, learners were trained in the think-aloud technique.

- *Study on screen density:* The expository texts were given individually. Each learner was asked to say what is in his or her mind (*think-aloud*) while reading. Learner's think-aloud was audio taped, and the researcher also made some observation notes.
- *Study on hypertext-based courseware:* The group of learners that obtained the hypertext-based courseware was allowed to precede reading the text in any order of "pages" they wanted. They could go forward, backward, and skip pages (the *forward/backward* option). Learners were also allowed to choose a topic from five different topics offered (the *select-topic* option), and to pursue further information on concepts they wanted to know more about (the *more-information* option). They could also go back to the previous text (the *review* option) in order to answer the embedded questions presented at the end of each topic. A *help* option was offered so learners could at anytime ask for assistance.
- The group of learners that were presented with a linear-based courseware was asked to read through each page linearly, starting from page one, then page two, three, etc. They were not given the "skip-page" option, but were given the "help" option.

Both groups were asked to think-aloud during reading the text, after they were trained for it. The full session was audio taped. At the end of each session, therefore, the researcher had accumulated qualitative data in the form of think-aloud protocols, interview responses, and observation notes.

During the sessions the researcher sat beside the child. The researcher provided encouragement and asked questions when the child fell silent (e.g., "tell me what you are thinking"), or prompted for further information. The researcher attended also to children's nonverbal cues or facial expression, such as frowning or slowing down the reading rate, and used them as points for discussion.

Data collected were first analysed to look at the type of cognitive strategies they used. Analyses were done toward the think-aloud that each learner produced during reading different texts: 1) with different density, 2) hypertext vs. non-hypertext based. Then, the identified cognitive strategies were linked with learners' prior knowledge and general ability.

4. Results

4.1 The screen-density study

- Perfetti (1989, in Resnick, 1998) made a distinction between reading processes only at the level of *achieving meaning*, and reading processes at the level of *text interpretation*. Text meaning is more restricted, stays close to the text itself, is symbol driven, and involves little inference beyond information directly provided by the text. Text interpretation is less restricted, less text based, less symbol driven, and more inferential. The critical issue that divides meaning from interpretation is the richness of inference. There is a continuum of inferential processing on the process level. So, with enough inference comprehension moves from meaning to interpretation.

From the analyses of the 36 think-aloud protocols it was found that in the move from comprehension at the "meaning" level to the "interpretation" level, learners in this study employed four types of cognitive strategies --- *problem-hypothesis*, *verification*, *elaboration*, and *inference*.

a. *Problem-hypothesis*

The learner identified a problem and was able to form a hypothesis about an answer or answers, in need of verification.

Example (in Bahasa Indonesia):

TEKS: AIDS adalah singkatan dari Acquired Immuno Deficiency Syndrome, artinya sekumpulan gejala penyakit yang muncul bersamaan sebagai akibat menurunnya kekebalan tubuh.

THINK-ALOUD: “*eee saya berfikir koq... kenapa sekumpulan gejala penyakit, bukan langsung gejala penyakit... ini yang dikatakan.... yang muncul bersamaan..... mungkin karena eee dari tanda-tandanya.... dan ini eee kalau orang yang kena AIDS kan eee apa namanya.... selang waktunya lama, mungkin baru ketahuan kalau dia itu kena AIDS..... begitu aja*”

b. Verification

The learner verified (or validated) the information with his or her pre-existing knowledge.

Example (in Bahasa Indonesia):

TEKS: Virus herpes juga dapat menyerang otak sehingga menyebabkan gangguan pada fungsi ingatan, juga dapat menyebabkan kelumpuhan.

THINK-ALOUD: “*yaa... karena kita bernafas... tiap hari bernafas... apalagi di Jakarta... kotor, hanya orang yang kuat saja yang dapat menahan bakteri ini... bagaimana dengan penderita AIDS... dia kan bernafas juga.... sedangkan tubuhnya nggak kuat... jadi mudah sekali terkena...*”

c. Elaboration

The learner used his or her prior-knowledge to elaborate upon the given information.

Example: (in Bahasa Indonesia)

TEKS: *Pneumocystis Carinii Pneumonia*, adalah radang paru-paru yang disebabkan oleh sejenis protozoa yang banyak terdapat di udara.

THINK-ALOUD: “*eee disini saya mikirin... memang benar ya... kalau otak itu... maksudnya... sangat berfungsi disegalanya.... maksudnya... tubuh itu berfungsi karena adanya otak... dan eee saraf-saraf otak ini saling ya... misalnya kalau kena.... walaupun terkena eeee apa sekecil apapun dapat berakibat fatal, dan ini eee apa namanya.... orang lumpuh memang sering gara-gara sel rusak... mungkin kayak orang stroke gitu tahu-tahu bisa lumpuh....*”

d. Inference

The learner stated a conclusion based on the information written in the text.

Example (in Bahasa Indonesia):

TEKS: Komite Nasional Taksonomi Virus kemudian menyeragamkan kedua istilah virus tersebut dan sepakat diberi nama Human Immuno Deficiency Virus (HIV)

THINK-ALOUD: “*Berarti disini... eee HIV ini baru di.... eee... apa maksudnya... dirumuskan setelah kedua orang ini menemukan virus-virus didalam penderita penyakit AIDS, kemudian eee dalam komite ini apa namanya.... dia itu... menyepakati bahwa kedua virus itu digabung aja namanya jadi virus HIV*”.

Within the four cognitive strategies --- problem hypothesis, verification, elaboration, and inference --- inference was the frequently used strategy (Mean = 12.1), followed by verification (Mean = 3.9), elaboration (Mean = 3.2), and problem hypothesis (Mean = 1.6). Thus, this study revealed that the students processed the text to achieve not just a *meaning* of a text, but beyond it, which is an *interpretation* of text. The two cognitive strategies: elaboration and inference will process the new information in a semantic level where learner will access prior knowledge to interpret new material and encode it into memory deeper than when it goes through sensory processing.

When prior-knowledge and general ability were crossed with the kinds of cognitive strategies employed in the two groups (25% & 60% screen-density), this study revealed that prior-knowledge and general ability did not affect learners from the group with 25% screen-density, in the types of cognitive strategy employed. T-test scores from the two groups --- 25% & 60% screen-density --- crossed with kinds of cognitive strategies used were 1.05, 0.85, -0.51, 1, and 1.27, all of them not significant for $\alpha = 0.05$. Nevertheless, in the group with 60% screen-density, learners with high prior-knowledge and above average in their general ability tend to perform deeper processing (used more verification and inference strategy) than the learners with below average prior-knowledge and average general ability.

4.2 The hypertext-based courseware study

- Analyses of 51 the think-aloud protocols revealed that both groups (the group with linear-based courseware and the group with hypertext-based courseware) employed four types of cognitive strategy that resulted with deep processing of information. The four types of cognitive strategy are: *elaboration, verification, inference* and *anticipation*.
- Post-test scores obtained from the group of learners given the linear-based courseware tended to be *higher* than the group of learners with the hypertext-based courseware.

- Nevertheless, further analyses on the group of learners with the hypertext-based courseware revealed that in searching for information they used different learning paths. More than half (73%) of the learners were found to be reading the text in an orderly, forward sequence and used the more-information option (during reading the text) to assist them in comprehending the text. Around 27% of the learners either read the text in an orderly, forward sequence but *did not* asked for more information, or, read the text *not* in an orderly, forward sequence, or, stopped and changed topic every time after reading the first one-two pages. This later group of learners (27%) was found to gain less in their posttest score, compare to the previous group (73%). Learners from the later group tend to show some difficulty in self-regulating their learning process.
- Compare to the elementary school learners (age 11 to 12 years), the learning skills from these high school learners (age 15 to 16 years) in learning through a hypertext-based courseware, can be stated to be not much different. Suradijono (1993) in her study with the elementary school learners (given a hypertext-based courseware) found that more than half of the learners (60%) were not able to use the rich environment offered to them. They seemed to have problems in focusing to the material presented, and their self-regulated learning skills were also poor.
- When general ability, prior-knowledge, and the four types of cognitive strategy --- *elaboration, verification, inference, and anticipation* --- were crossed with the level of reading comprehension learner attained, it was found that the four types of cognitive strategy have the most impact, followed by the level of learner's prior-knowledge.

5. Discussion

Text written with 25% screen-density will help learner to reach a high level of comprehension, no matter of its level of prior-knowledge and general ability. In other words, if we want to present a text to learners that we know might have low prior-knowledge and/or low general ability it is better to offer the information using the 25% screen-density. Text written with 60% screen-density tends to be more difficult to be processed except if the learner uses the verification and the inference cognitive strategies.

Interesting to see that the hypertext-based information in this study did not resulted with a higher increase of knowledge (post-test score) compare to the linear-based. Though, it was assumed that the features offered in the hypertext-based environment would heighten learner's

search for more information. Learner's self-regulated learning skills may be one of the critical factors that determined how the rich hypertext-based environment would be explored. Learner that is poor in navigating his/her learning process can easily be lost in this hyperspace. Learner with low self-regulated learning skills tend to read the information in a linear sequence, thus was not able to take the benefit of the hypertext-based environment.

This means, many of the high school students, as shown in this study, have low self-regulated learning skills. Or, expect to be "spoon-fed" by the teacher, as the elementary school students (Suradijono, 1989).

Types of cognitive strategies employed were revealed to have the most significant impact in reaching a high level of comprehension (the text-interpretation level) compare to how the information was offered (dense vs. not-dense and hypertext-based vs. linear-based). However, from the four types of cognitive strategies found in this study, the inference and anticipation cognitive-strategies resulted with a deep processing of information.

Thus, it can be concluded that this study supported Duchastel's (in Jonassen, 1991) statement: "*Learners may be deficient in their use of text processing strategies, (however) the text itself should encourage the use of the appropriate strategies --- largely through the design features of the text itself, i.e., through display techniques.*"

References

- Clark, R. E. 1983. "Reconsidering Research on Learning from Media" in *Review of Educational Research*. 53:4, pages: 445-459.
- Haris, A.J. and E.R. Sipay. 1985. *How to Increase Reading Ability*. New York: Longman.
- Jacoby, L.L. and F.I.M. Craik. 1979. "Effects of Elaboration of Processing at Encoding and Retrieval: Trace Distinctiveness and Recovery of Initial Context" in *Levels of Processing in Human Memory*. L.S.Cermak & F.I.M.Craik (Ed.), Hillsdale, NJ.: Lawrence Erlbaum Associates.
- Jonassen, David H. 1988a. *Computers in the Classroom: Mindtools for Critical Thinking*. New Jersey: Prentice Hall.
- Jonassen, David. H. 1988b. "Integrating Learning Strategies into Courseware to Facilitate Deeper Processing" in D. H. Jonassen (Ed.), *Instructional Designs for Microcomputer Courseware*. Hillsdale, NJ.: Lawrence Erlbaum Associates. pages 151-182.

Jonassen, H. 1991. *The Technology of Text: Principles of Structuring, Designing and Displaying Text*. New Jersey: Englewood Cliff.

Perfetti, C.A. 1998. "There are Generalized Abilities and one of them is Reading" in *Knowing, Learning and Instruction*. L.B. Resnick (Ed.). Hillsdale: N.J.: Lawrence Erlbaum Associates.

Reigeluth, C.M. 1983. "Instructional Design: What Is It and Why Is It?" in *Instructional-Design Theories and Models: An Overview of their Current Status*. C.M. Reigeluth (Ed.). Hillsdale, N.J.: Lawrence Erlbaum Associates.

Rigney, J.W. 1978. "Learning Strategies: A Theoretical Perspective" in *Learning Strategies*. H. F. O'Neil Jr. (Ed.). New York: Academic Press.

Suradijono, Sri Hartati. 1989. "The Relation of Self-reported Knowledge Lacks to Understanding" Master's Thesis, Ontario, Canada: University of Toronto.

Suradijono, Sri Hartati. 1993. "Perception of Own Learning Process Using Learner Controlled Instruction". Doctoral Thesis, Canada: University of Toronto.

Suradijono, Sri Hartati. 1997a. "Penelitian Strategi Belajar Siswa SMU dengan Jenis Teks Linier dan Non-linier". Research Report. Depok: Faculty of Computer Science, University of Indonesia.

Suradijono, Sri Hartati and Budhitama Subagdja. 1997b. *Lingkungan Belajar Kolaboratif Cerdas untuk meningkatkan Kemampuan Belajar Mandiri Siswa Sekolah Tingkat Menengah di Indonesia*. Unpublished Paper. Depok: Faculty of Computer Science, University of Indonesia.

Suradijono, Sri Hartati. 2000. *Analisis Penggunaan Lingkungan Belajar Kolaboratif MELATI pada Siswa Sekolah Tingkat Menengah di Indonesia*. Research Report. Depok: Faculty of Computer Science, University of Indonesia.