Educational Research (ISSN: 2141-5161) Vol. 2(8) pp. 1362-1372 August 2011
Available online@ http://www.interesjournals.org/ER

Full Length Research paper

How do instructional sequencing methods affect cognitive load, learning transfer, and learning time?

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Accepted 03 August, 2011

Recent instructional theories have focused on complex real-life tasks. Due to the complex nature of real-life authentic tasks, controlling cognitive load has become a key component for effective instructional design methods. Thus, on the purpose of investigating effective instructional design methods enabling to manage cognitive load effectively, this study examined the effects of three different sequencing methods on cognitive load management, learning transfer and learning time. Thirteen participants participated in this study and they were taught with three different types of materials organized according to the three different sequencing approaches. The result indicated that the whole-part sequencing with simple backward chaining was the most effective sequencing approach among the three sequencing approaches - whole-part sequencing with simple backward chaining, whole-part sequencing with backward chaining with snowballing, and part-task sequencing.

Keywords: Complex learning, cognitive load, holistic approach, sequencing methods, whole-part sequencing, backward, snowballing.

INTRODUCTION

Recent instructional researches have tended to concentrate on how to teach authentic tasks based on real life (Mayer, 2008; Merrill, 2002; Van Merriënboer et al., 2003). This real life, authentic learning task helps learners integrate knowledge and skills and ultimately transfer what they learned to their daily life (Van Merriënboer et al., 2003). However, due to the complex nature of authentic tasks, cognitive load imposed by such tasks is often inordinate for novice learners and may seriously hamper learning. From this line of thought, curbing cognitive load is a critical element for successful learning when leaners deal with authentic complex problems.

Cognitive load theory (CLT) tackles issues associated with learners' cognitive processes and instructional design (Sweller, 2008). According to Sweller (2008), there are three different kinds of cognitive load and the total cognitive load including intrinsic, extraneous, and germane load should not exceed our limited working memory capacity for learning to occur (Sweller, 2008). Intrinsic cognitive load is imposed by the nature of the material such as the number of elements of a task and its interactivity and able to be "managed by organizing learning tasks into easy-to-difficult task classes" (Van Merriënboer and Kirschner, 2007, p. 23). Extraneous cognitive load is imposed by poorly designed instructions such as disorganized instructions or extraneous materials (Paas et al., 2004) and "is managed by providing a large amount of support and guidance for the first learning task(s) in a task class" (Van Merriënboer and Kirschner, 2007, p23). Germane load is associated with processes that directly contribute to learning, for example, when learners engage in the cognitive process of organizing and integrating materials (Sweller, 2008). Germane cognitive load is considered positive as it is directly related to learning whereas the other two forms of cogni-

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tive load are likely to impede learning (Van Merriënboer and Kirschner, 2007).

Overview of different sequencing methods

As an instructional method to control cognitive load, sequencing approaches can be utilized. Rothwell and Kazanas (1992) argued that sequences indicate the order in which tasks are introduced to learners through instructional interventions. In the industrial-age paradigm, sequencing methods were to break contents or tasks down into small parts and teach them one at a time (Hannum and Hansen, 1989). The assumption of this part-task approach is that learners are introduced to each part of a lager objective and they should be able to perform the entire task by the end of instruction. However, unlike expected outcomes, the result often yields low transfer of learning (Van Merriënboer, 2007). That is, the part-task approach may be efficient to manage cognitive load as they are dealing with parts, not a whole task but it has a serious defect, known as transfer paradox, which defines "effective learning methods to achieve isolated learning objectives are not the methods that work best for reaching integrated objectives and increasing transfer of learning" (Van Merriënboer and Kirschner, 2007, p.9).

On the almost opposite to this piecemeal approach (Gagné, 1985), Van Merriënboer and Kirschner (2007) suggested the whole task sequencing approach based on holistic approach. The whole-task sequencing approach basically attempts to deal with complexity of a whole task from the outset without losing coordination between elements (Van Merriënboer and Kirschner, 2007; Mayer, 2008). This sequencing method first defines task classes based on task difficulty and each task class consists of whole tasks (Van Merriënboer and Kirschner, 2007).

To control cognitive load of whole tasks, sequencing tasks from easy to difficult can be utilized (Reigeluth, 1999, Van Merriënboer et al., 2003). However, if the easiest version of the whole task is still too demanding for learners to start learning with, Van Merriënboer, and Sweller (2005) argued that the part-task sequencing can be used to further decrease cognitive load to an acceptable level. That is, the whole-part sequencing approach might be a good strategy. In limited occasions when tasks are too complex, the still-difficult-first task of an easy-to-difficult sequence can be divided into meaningfully interrelated clusters or parts to further control cognitive load.

In addition, Van Merriënboer, and Kirschner (2007) suggested the backward chaining (C_{AB}-B_A-A) approach opposite to the sequence in which a task is usually performed. According to them, as the backward chaining confronts learners with useful examples and models of previous parts, learners are likely to relate parts to a whole task in the backward chaining. Also, they suggested the 'snowballing' approach. Van Merriënboer and Kirschner (2007) explained that in knowledge management, "simple backward chaining deals with the parts one-by-one (C_{AB}-B_A-A) (The subscript $_{AB}$ indicates that learners work with example A and B provided by an instructor as they have not studied skill clusters A and B yet) but "backward chaining with snowballing includes the previous part in each new part (C_{AB}-BC_A-ABC)" (p.72). Thus, they claimed that the sequencing with snowballing is considered more effective as it gives learners opportunities to practice the whole task (ABC).

In sum, Van Merriënboer and Kirschner (2007) argued that the whole-part sequencing with backward chaining with snowballing is most effective to control cognitive load without losing a sense of a whole task. However, when learners study B_A with an example A (indicated by the subscript B_A) in the second phase of the simple backward chaining, as learners have already studied part C previously, both B_A in the simple backward approach and BC_A in the snowballing approach may generate the same result in terms of learners' cognitive process. Also, in the simple backward chaining unlike in the part-task sequencing where learners need to wait to see the whole task until the last phase of the learning process, learners can have an impression of the whole task with examples A and B provided while dealing with C_{AB}. Thus, learners dealing with the simple backward chaining may be able to relate parts to a whole task as easily as the backward chaining with snowballing.

Furthermore, the snowballing approach does not seem effective in terms of cognitive load management. The reason why the whole-part sequencing is used instead of the whole-task sequencing is because the first task of the sequence from easy to difficult is too complex to start learning with. Then, providing parts together like a snowball that grows as it rolls down a mountain might overwhelm learners with difficulty and complexity of a learning task.

As successful learning or learning transfer is not likely to happen when learners are overwhelmed with complex learning materials, it is critical to understand the effects of different sequencing methods on cognitive load management. However, few researches were conducted on controlling cognitive load through sequencing methods (Ayres, 2006; Clarke et al., 2005; Pollock et al., 2002). More empirical studies are necessary to show effectiveness of the various sequencing approaches for successful learning. Thus, the research goal of this study is to empirically determine the effectiveness of three different sequencing approaches – part-task sequencing, whole-part sequencing with simple backward chaining, and whole-part sequencing with backward chaining with snowballing in terms of cognitive load management, learning transfer, and learning time when learners deal with authentic complex tasks.

Table 1: The learning task for the part-task sequencing group

Learning Task Write an around 10-sentence- or three-paragraph- formal business letter to request info	Skill Cluster A: plan before you write	· establish a clear objective for your letter (e.g. Requesting info.) · decide what to write a. brainstorm possible contents b. select and prioritize contents c. prepare an outline with main points and supporting details · consider your readers a. remain courteous and polite b. adapt styles, words and tones to your readers
	Skill cluster B: organize the information	·format with a professional layout (e.g. salutation, closure, etc.) · have a clear opening and conclusion ·link ideas together with appropriate connecting words (e.g. however) · plan a logical sequence · organize your ideas into paragraphs
	Skill cluster C: select the right language	· be concise · avoid jargons, abbreviations · start and finish with correct phrases (e.g. with reference to your letter) · pay attention to grammar, spelling and punctuation
	Skill cluster D: revise and edit	·take time to review contents, format, language style ·check grammar, punctuation and spelling again

Note. Adopted from New International Business English by Jones, L and Alexander, R ,2003, Communicating in Business English by Dignen, B, 2003, and Ready to Write More by Blanchard, K and Root, C, 1997

METHODOLOGY

Participants

Two doctoral and eleven master's students majoring in Educational Technology at a university located in Seoul participated in this study. They were the students who responded to email asking for their participations among the graduate students in the same department and expressed their willingness to participate in this experiment. They (eleven female and two male students) all speak Korean as their mother tongue and they learned English as a foreign language at school.

Learning materials

The learning task for this study was to write a 10 sentence- or three-paragraph formal business letter in English. Writing tasks require complex cognitive work (Brown, 2001) and this complexity might be escalated even more if learners use an unfamiliar foreign language which probably has different rhetorical traditions and conventions from their first language. Thus, as a complex learning task based on real-life tasks for this study, writing a formal business letter in English to request information was chosen.

The learning task was divided into two task classes and then four skill clusters to deal with the parts of the task were analyzed: plan before you write (skill cluster A), organize the information (skill cluster B), select the right language (skill cluster C), and revise and edit (skill cluster D). These skill clusters and their low-level skills were adopted from New International Business English (Jones and Alexander, 2003), Communicating in Business English (Dignen, 2003) and Ready to Write More (Blanchard and Root, 1997).

For the part-task sequencing group, there was one learning task and this task was broken down into parts from skill cluster A to skill cluster D and the low-level skills of each skill cluster were also analyzed (See Table 1). For the whole-part sequencing with simple backward

Table 2: The learning task for the whole-part sequencing with simple backward chaining group

Task class 1 Write a one-paragraph or three-to-five-sentence formal business letter to request info	Skill cluster D_{ABC}: revise and edit on the basis of given plans, language, organization of information
	Skill cluster C_{AB}: select the right language on the basis of the given plans and organization of information
	Skill cluster B_A: organize the information on the basis of given plans
	Skill cluster A: plan before you write
Task class 2 Write an around 10-sentence or three-paragraph formal business letter to request info	Skill cluster D_{ABC}: revise and edit on the basis of given plans, language, organization of information
	Skill cluster C_{AB}: select the right language on the basis of the given plans and organization of information
	Skill cluster B_A: organize the information on the basis of given plans
	Skill cluster A: plan before you write

chaining group, there were two tasks, Task class 1, the simplest one, and Task class 2, a little more difficult one. For each task class, the same four skill clusters were organized backward (See Table 2). For the whole-part sequencing with backward chaining with snowballing group, the same two task classes were introduced but low-level skills of each task class were organized backward with the snowballing approach (See Table 3).

Procedures

The participants were randomly assigned into three groups with five or four students- the part-task sequencing group, the whole-part sequencing with simple backward chaining group, and the whole-part sequencing with backward chaining with snowballing group. One instructor who was a former ESL teacher for adults in Canada and also has some experience with teaching English in Korea taught all the groups on a different day. At the beginning of the instruction, all the participants were asked to fill out the background questionnaire and write a one-or-two-paragraph letter to their friend in English to identify the level of their English writing skills.

Then, each group was given different materials. The materials contained basically the same contents but they were differently organized according to the sequencing methods. The part-task sequencing group has one learning task and they were taught from establishing a clear objective (the first task of the skill cluster A) to checking grammar, punctuation and spelling again (the last task of the skill Cluster D) in order (ABCD, see Table 1). The other two groups have two learning tasks. The whole-part sequencing with simple backward chaining group was taught first the easy task, Task class 1 from revising and editing an example given by the instructor to planning before you write. Then, the same teaching cycle happened again with the more difficult one, Task class 2 ($D_{ABC}C_{AB}B_AA$, $D_{ABC}C_{AB}B_AA$, see Table 2). Likewise, the whole part sequencing with backward chaining with snowballing group was taught from Task class 1 to Task 2. The parts previously taught were included into each new part ($D_{ABC}DC_{AB}DCB_ADCBA$, $D_{ABC}DC_{AB}DCB_ADCBA$, see Table 3). At the completion of the instruction, the participants in all the three groups took a transfer test of writing a business letter to an imaginary client in English to request information for one hour. The transfer test was provided with assessment criteria on its cover page.

Finally, the participants were asked to fill out the open-ended questionnaire regarding their learning experience during the sessions. It also included a subjective rating item of their mental effort expanded in order to evaluate

Table 3: The learning task for the whole-part sequencing with backward chaining with snowballing group

Task class 1 Write a one-paragraph or three-to-five –sentence formal business letter to request info	Skill cluster D_{ABC}: revise and edit on the basis of given plans, language, and organization of information
	Skill cluster DC_{AB} : revise and edit and select the right language on the basis of the given plans and organization of information
	Skill cluster DCB_{A}: revise and edit, select the right language and organize the information on the basis of given plans
	Skill cluster DCBA: revise and edit, select the right language, organize the information, and plan before you write
Task class 2 Write an around 10-sentence or three-paragraph formal business letter to request info	Skill cluster D_{ABC}: revise and edit on the basis of given plans, language, and organization of information.
	Skill cluster DC_{AB} : revise and edit and select the right language on the basis of the given plans and organization of information
	Skill cluster DCB_{A}: revise and edit, select the right language and organize the information on the basis of given plans
	Skill cluster DCBA: revise and edit, select the right language, organize the information, and plan before you write

cognitive load. Mental effort is “the aspect of cognitive load that refers to the cognitive capacity that is actually allocated to accommodate the demands imposed by the task” (Pass et al., 2003, p. 64). According to Pass and Van Merriënboer (1994), the intensity of mental effort learners experience is a reliable estimate of cognitive load. The subjective rating scale technique usually involving a questionnaire is used to measure this mental effort (Pass et al., 2003). Thus, a five-point scale was used with participants being asked to rate the amount of perceived mental efforts while they were working in class. The participants selected one of the five options (very low mental effort, low mental effort, average, high mental efforts, and very high mental effort). Follow-up interviews were conducted to clarify participants’ responses on the questionnaire, as necessary.

Table 4: The transfer test results of three groups according to the level of writing skills before the instruction in each group

group	The level of writing skills	M	SD	N
Whole-part sequencing with simple backward chaining	low	5.00	4.24	2
	average	8.00	.00	2
	good	10.00	.00	1
	total	7.20	3.03	5
Whole-part sequencing with backward chaining with snowballing	low	4.67	1.16	3
	average	8.00	.00	1
	total	5.50	1.92	4
part-task sequencing	low	5.33	2.31	3
	good	10.00	.00	1
	total	6.50	3.00	4
total	low	5.00	2.14	8
	average	8.00	.00	3
	good	10.00	.00	2
	total	6.46	2.60	13

RESULTS

The participants' level of writing skill and their experience with a formal business letter in English

The results of the writing test asking participants to write one or two paragraphs letter to their friend about what they did yesterday ranged from low, average to good; eight participants were allocated into the low level, four participants into the average level and one person into the good level. Two doctoral students were included in the average level group. Regarding their experience with a formal business letter in English, they all have not written a formal business letter before, but almost half of the participants indicated that they have sent email in English sometimes; one participant once a year, two participants several times a year, two participants more than six times a year and two at least once a month. However, the two most experienced participants, who checked "at least once a month", were included into the low and the average writing level respectively. It may be because email expressions are colloquial and writing email is not always required to follow formal conventions. Therefore, in terms of previous experience with writing a formal business letter in English, the participants seemed homogeneous.

Comparison of three different sequencing methods in terms of learning transfer

One participant from the whole-part sequencing with simple backward chaining group pointed out on the open-ended questionnaire that "*Working with examples was very helpful and I did not have to wait by the end of the learning processes to actually write a letter*." On the other hand, one participant from the whole-task sequencing with backward chaining with snowballing group commented that "*I could not understand it, and it was too complex, and unstructured. There were too many things to deal with*." The first remark indicated that the participant had an impression of what the whole task was while she was working on parts with examples. The fact that she had an image of the whole task in her mind can lead to high learning transfer and the highest learning transfer test result (M=7.20, see Table 4) supports this. The second remark seems to show that she was overwhelmed with the learning materials. As she failed to manage cognitive load, low learning transfer seemed to

Table 5: The summary of participants' perceived mental effort

	Perceived mental effort					χ^2	p
	Very low mental effort	Low mental effort	Average mental effort	High mental effort	Very high mental effort		
Part-task sequencing		1	3			6.82	.145
Whole-part sequencing with simple backward chaining			1	4			
Whole-part sequencing with backward chaining with snowballing			2	2			

N= 13. *p≤.05

occur and this assumption was supported with the lowest transfer test result as well (M=5.50, see Table 4).

In addition, three participants from the part-task sequencing group mentioned that "*I can remember details but still feel like I don't know where to start writing and how to start it*." Also, one mentioned that "*Parts are well understood, but the task itself seemed not to be focused on*" These results could be explained with the transfer paradox that effective learning methods to achieve isolated learning objectives are not the methods that work best for increasing transfer of learning (Van Merriënboer and Kirschner, 2007). This assumption was also backed up with their transfer test result (M= 6.50, see Table 4) lower than one of the whole-task sequencing with simple backward chaining group. These results imply that the part-task sequencing group seemed to understand each part well, but they seemed to have difficulty in integrating each part to successful accomplish the complex task.

Meanwhile, the part-task sequencing group has higher mean score in the transfer test than the whole-part sequencing with backward chaining with snowballing group. Besides, in the low writing skill groups of each sequencing group, the part-task sequencing group showed the highest mean score (M=5.33). These results seem to indicate that although the holistic approach is effective in terms of learning transfer, if controlling cognitive load fails, high learning transfer is not likely to happen.

Comparison of three different sequencing methods in terms of cognitive load management

The summary of thirteen students' responses to their perceived mental effort is shown in Table 5. There is no significant association among sequencing methods and patricians' perceived mental effort (χ^2= 6.82, p= .145). Nonetheless, considering that no one in the part-task sequencing group indicated that they exerted high mental effort, the part-task sequencing group is thought to be least overwhelmed during the instruction session.

One participant from the whole-part sequencing with backward chaining with snowballing group mentioned on the open-ended questionnaire that "*It was boring, felt like just repetition, and time was so short considering the amount of contents*" and another participant from the same group mentioned that "*The content was not well organized and I do not feel like it's logical*." Those remarks indicated that they felt overwhelmed by the materials. On the other hand, the participants from the whole-part sequencing with simple backward chaining group mentioned that "*It was good. In particular, the contents were presented from easy to difficult, which was good. It was easy to understand.*" Also, they said, "*Various examples were great and very helpful.*" These remarks seem to show that the whole-part sequencing with simple backward chaining approach was successful in terms of cognitive load management. Thus, from these findings, it is fair to say that the whole-part sequencing

Table 6: The summary of learning time

	Part-task sequencing	**Whole-part sequencing with simple backward chaining**	**Whole-part sequencing with backward chaining with snowballing**
Learning time	2hrs. 6 min	2hrs. 15 min	2hrs. 45 min

with simple backward chaining approach is more effective than the whole-part sequencing with backward chaining with snowballing approach in terms of cognitive management.

Comparison of three different sequencing methods in terms of learning time

The table 6 shows the summary of learning time of each sequencing group. As the atomistic approach splits a task into small pieces and chooses an optimal instructional method for each small one or learning objective, the part-task sequencing was thought to be most efficient and the findings support this. The whole-part sequencing with backward chaining with snowballing approach was expected to take the longest time considering the amount of contents that learners cope with and the finding showed the expected result. One participant from the whole-part sequencing with backward chaining with snowballing group mentioned that "*Many materials was repeated, it took too long."* This comment sustained the findings as well.

DISCUSSION

The purpose of this study is to investigate the effects of different sequencing methods on learning transfer, cognitive load management, and learning time. According to the findings, the whole-part sequencing with simple backward chaining was the most effective sequencing approach in terms of both learning transfer and cognitive load management. This result confirms Van Merriënboer and Kirschner's (2007) argument that the holistic approach is effective to facilitate high learning transfer. They argued that as learners are not able to integrate and coordinate the elements in a transfer situation, breaking a complex task into distinct elements does not often work. The results of this study show that the whole-task paradigm based on the holistic approach is a more effective approach than the part-task paradigm based on the atomist approach for learning transfer.

Also, Van Merriënboer and Kirschner (2007) insisted that as the backward chaining confronts learners with useful examples, it is easy for leaners to relate parts to a whole task. Considering the comments on effectiveness in working with examples from the simple backward group and the comments on the difficulty in integrating parts to do the transfer test from the part-task sequencing group, the backward approach seems an effective approach for learning transfer. Furthermore, the higher transfer test result of the whole-part sequencing with simple backward chaining group comparing to the part-task sequencing group backed up this assumption.

Regarding cognitive load management, the meaningfully divided whole-part approach seemed to decrease cognitive load further to a manageable level and as a result, high learning transfer seemed to occur. This finding is consistent with some earlier findings of Mayer and Moreno (2003), Clarke and co-workers (2005), Ayres (2006), Pollock and co-workers (2002). These researches attempted to lower intrinsic cognitive load through sequencing approach and showed that controlling cognitive load through sequencing methods is an effective technique for successful learning.

The snowballing approach does not seem an effective approach for successful learning as hypothesized. Van Merriënboer and Kirschner (2007) argued that the snowballing approach is considered effective because learners can have opportunities to practice a whole task. However, the finding showed that the learners in the part-task sequencing group did better on the transfer test than ones in the snowballing approach. This result with the participants' comments such as *'too complex, unstructured, too many things to deal with'* indicates that if learners are overwhelmed with the numbers of elements and high interactivity of a task, high learning transfer are not likely to happen. This finding is consistent with the claim of Pass et al (2003) that CLT is a major factor that determines the success of an instructional intervention, not a secondary element of the learning process. Without managing cognitive load, successful learning does not happen.

In a similar vein, it could be understood that the part-task sequencing group among the low writing skill groups was most successful. This finding might indicate the necessity of different sequencing approaches according to the expertise of the learner in that content area. The expertise reversal effect might provide explanation for this (Kalyuga et al., 2003). That is, intrinsic load is determined by the interaction between nature of the learning tasks and the expertise of the learner. As expertise develops in a domain, the intrinsic load caused

by a specific task decreases as a number of elements of a task and high interactivity of a task become learned and could be considered as a single element with well-developed schemas (Ayres, 2006; Clarke et al, 2005; Pass et al, 2003; Pollock et al, 2002). Clarke and the colleges' (2005) research showed that students who have experienced with spreadsheets would not need a sequenced approach. They were able to benefit from a more integrated approach, where new spreadsheets skills and mathematical concepts were learned together. Ayres's (2006) also showed high-expertise learners benefited from high-element interactivity materials used right from the start. Therefore, different sequencing approaches depending on learners' expertise should be considered in terms of cognitive load management and ultimately high learning transfer.

Learning time is also a critical component when it comes to instructional design. With rapid changes in working environments of modern society, both nature and skills necessary for currently available jobs quickly become obsolete. However, the available training time in which complex job skills have to be mastered is limited. Thus, how efficiently students or employees can be trained should be considered as a key component for instructional design. In this study, as expected, the part-task sequencing took least time, as this approach is designed to minimize costs with a cost of low learning transfer (Van Merriënboer, 2007). However, the learning time of the simple backward chaining approach was not much different from the part-task sequencing approach. Thus, considering learning time and leaning transfer as well as cognitive load management, the whole-task sequencing with simple backward chaining approach seems the most appropriate sequencing method among the three different sequencing methods.

CONCLUSIONS

The findings from this research indicate that the part-task sequencing was most effective and the whole-part sequencing with backward chaining with snowballing was least effective when it comes to cognitive load management. In terms of learning transfer, the whole-part sequencing with simple backward chaining was effective, but in the low writing skill groups, the part-task sequencing group showed the highest performance. This finding indicates that different sequencing approaches may need to be employed according to the expertise of participants in related content areas. In terms of learning time, the part-task sequencing was most efficient while the whole-part sequencing with backward chaining with snowballing was least efficient.

Although some critical implications were revealed from this study, there is a limitation. The sample size of this study is very small. A larger-scale empirical research is necessary to compare with or confirm its findings.

Particularly, a study regarding the effectiveness of different sequencing approaches according to participants' level of content-related knowledge deserves further investigation to ascertain the potential benefits of different sequencing techniques. Furthermore, one participant's remark that "*it's confusing, I prefer studying maybe a layout first*." seemed to infer that she preferred the forward approach dealing with parts in a natural order opposed to the backward approach. Empirical studies about comparison of the forward and backward approaches are necessary as well to draw a whole picture of the effectiveness of different sequencing methods.

In spite of the limitation, this is one of the few studies that actually provided empirical data on this research issue. The findings from this study could provide useful implications to instructional design professionals or educators who seek to find more effective instructional designs and help learners transfer complex cognitive skills to real-world contexts.

REFERENCES

Ayres P (2006). Impact of reducing intrinsic cognitive load on learning in a mathematical domain. *Appl. Cogn. Psycho. 20*:287-298.

Blanchard K and Root C (1997). *Ready to Write More*. NY: Addison Wesley Longman.

Brown HD (2001). *Teaching by principles: An interactive approach to language*. NY: Longman.

Clarke T, Ayres P, Sweller J (2005). The impact of sequencing and prior knowledge on learning mathematics though spreadsheet applications. *Educ. Technol. Res. Dev. 53*(3):15-24.

Dignen B (2003). *Communicating in Business English.* NY: Compass Publishing Inc.

Gagné RD (1985). *The conditions of learning* (4th Eds.). NY: Holt, Rinehart and Winston.

Hannum W, Hansen C (1989). *Instructional systems development in large organization*. Englewood Cliffs, NJ: ETP.

Jones L, Alexander R (2003). *New International Business English.* Cambridge UK : Cambridge University Press.

Kalyuga S, Ayres P, Chandler P, Sweller J (2003). The expertise reversal effect. *Educ. Psycho. 38*(1): 23-31.

Mayer RE (2008). *Learning and instruction* (2nd Ed.). Upper Saddle River, NJ: Pearson Education Inc.

Mayer RE, Moreno R (2003). Nine ways to reduce cognitive load in multimedia learning. *Educ. Psychol. 38*:43–52.

Merrill MD (2002). First principles of instruction. *Educ. Technol. Res. Dev. 50*: 43-59.

Paas F, Renkl A, Sweller J (2004). Cognitive Load Theory: instructional implications of the interaction between information structures and cognitive architecture. *Instructional Science, 32***,** 1–8,

Pass F, Touveine JE, Tabbers H, Van Gerver PWM (2003). Cognitive load measurement as a means to advance cognitive load theory. *Educ. psychol. 38*(1), 63-71.

Paas F, Van Merriënboer JJG (1994). Instructional control of cognitive load in the training of complex cognitive tasks. *Educ. Psychol. Review, 6*(4), 351-371.

Pollock E, Chandler P, Sweller J (2002). Assimilating complex information. *Learn. Instruct. 12*:61-86.

Reigeluth CM (1999). The elaboration theory: guidance for scope and sequence decisions. In C. M. Reigeluth (Eds.), *Instructional-design theories and models II: a new paradigm of instructional theory (pp. 425-453).* Mahwah, NJ: Lawrence Erlbaum Association, Inc.

Rothwell WJ, Kazanas HC (1992). *Mastering the instructional design process: a systemic approach*. San Francisco, CA: Jossey-Bass.

Sweller J (2008). Cognitive load theory and the use of educational technology. *Educ. Technol. 18*(1):32-35.

Van Merriënboer JJG (2007). Alternative models of instructional design: holistic design approaches and complex learning. In Reiser, R. A. and Dempsey, J. V. (Eds.), *Trends and issues in instructional design and technology* Columbus, OH: Pearson. pp. 72-81.

Van Merriënboer JJG, Kirschner PA (2007). *Ten Steps to complex Learning: a systematic approach to four-component instructional design.* N J: Lawrence Erlbaum Associates.

Van Merriënboer JJG, Kirschner PA, Kester L (2003). Taking the load of a learners' mind: instructional design for complex learning. *Educ. Psychol. 38*(1):5-13.

Van Merriënboer JJG, Sweller J (2005). Cognitive load theory and complex learning: recent developments and future directions. *Educ. Psychol. Rev. 17*(2):147-177.

Appendix

The open-ended questionnaire consists of total five questions including the question to measure cognitive load..

1. Please rate the amount of perceived mental effort while you were working in class.
___very low mental effort ___ low mental effort ___ average ___ high mental effort __very high mental effort

2. Would you rate your experience with this class as
2.1. Successful? _____
What aspects such as class materials, activities, instructional approaches etc. of the class contribute to your success?
2.2. Not successful? _____
What aspects such as class materials, activities, instructional approaches etc. of the class contribute to your unsuccess?

3. How difficult was the class?
_____very difficult, _____difficult, _____somewhat difficult
_____little difficult, _____not at all
3.1 Why do you think so? What aspects such as class materials, activities, instructional approaches etc. of the class contribute to your feeling?

4. How would you feel about the course materials?
4.1. Would you think the amount of course materials are proper?
_____strongly agree, _____ agree, _____ undecided,
_____disagree, _____ strongly disagree
And why do you think so?
4.2. Are the materials well organized and is it easy to follow the lesson with those materials?
_____ strongly agree, _____agree, _____undecided,
_____ disagree, _____ strongly disagree
And why do you think so?
4.3 Would you think the order of presenting the materials is logical?
_____ strongly agree, _____ agree, _____undecided,
_____ disagree, _____ strongly disagree
And why do you think so?

5. Is there any comment you would like to mention related to this class?