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ABSTRACT

The Simplifying Conditions Method (SCM) is a set of guidelines for task analysis and sequencing of instructional content under the Elaboration Theory (ET). This article introduces the fundamentals of SCM and presents the findings from a formative research study on SCM. It was conducted in two distinct phases: design and instruction. In the first phase, the SCM process was used to design a course in order to determine the weaknesses of the SCM process. In the second phase, the course was taught using the SCM sequence in order to determine the weaknesses of SCM principles. Results suggest that the current SCM process is workable; however, three recommendations were offered: (1) the need to stress the holistic rather than the step-by-step approach; (2) the need to add more detailed prescriptions; and (3) the need for formative evaluation. Second, the study yielded no critical weaknesses that might lead to possible improvements in the SCM principles, since most of the learners were very satisfied with the sequence of the instruction. Three figures present results. (Contains 34 references.) (AEF)

Title:

Formative Research on the Simplifying Conditions Method (SCM) for Task Analysis and Sequencing

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The Simplifying Conditions Method (SCM) is a relatively new set of guidelines for task analysis and sequencing of instructional content under the Elaboration Theory (ET) (Reigeluth & Rogers, 1980; Reigeluth & Stein, 1983). During the last 20 years, even though ET has been one of the most well-received and extensively referred to method used by practitioners and researchers (Wilson & Cole, 1992), SCM has received relatively less attention compared to its potential strength as a tool for task analysis and sequencing.

Initially, SCM was developed for the procedural task (focusing on "how") by Reigeluth and Rogers (1980); it has been elaborated and proven that SCM also works well for the transfer task (focusing on "why") (Reigeluth & Kim, 1991). Since 1991, we have invested a lot of effort into improving and extending the scope of SCM while incorporating knowledge from the current advances of cognitive psychology and constructivism (Reigeluth, 1992; Wilson & Cole, 1992) and from the several empirical field applications and testings (Kim, 1994; Reigeluth & Kim, 1991, 1992, 1993). Since our findings provided meaningful information, giving us a relatively high level of confidence in SCM, we conducted formative research on SCM to finalize and synthesize our efforts.

This article introduces the fundamentals of SCM and shares the findings from our formative research on SCM.

Fundamentals of the Simplifying Conditions Method (SCM)

SCM was developed to add more detail to the Elaboration Theory, which resulted from Reigeluth's intensive work to integrate the knowledge base of instructional and learning theories into a set of prescriptions at the macro-level (Reigeluth & Stein, 1983). Consequently, the most important ideas of ET are based upon Gagné's (1977) hierarchical task analysis and sequence, Bruner's (1960) spiral curriculum, Ausubel's (1963) progressive differentiation, and Merrill's (1978) and Scandura's (1973, 1983) shortest-path sequence.

One of the most important theoretical elements of ET is a special kind of simple-to-complex sequence. The whole notion of elaborative sequence is based on a single type of content which is the most important type for achieving the general goals of the course. ET categorizes the content of the course with three types—concepts, procedures, or principles. When an elaborative sequence has been done to each of them, it is called a conceptual organization, a procedural organization, and a theoretical organization (Reigeluth & Stein, 1983).

SCM provides practical guidelines for making the elaborative sequence for procedural and theoretical (transfer) organization. The SCM process begins with finding conditions which make a task complex, non-representative, and difficult for learners. Then, it constructs an epitome which is simplified—an easy but still representative version of the task—by removing or dissolving the conditions of the complex task. The learners will start learning from the epitome so that they can work with the epitome without experiencing too much difficulty, but still be able to taste the representative flavor of the whole task. Subsequently, the conditions are gradually removed or dissolved according to a preassigned priority, and the more complex and difficult version of the task can be introduced. In this manner, the whole version of the task will be presented smoothly and meaningfully (Kim & Reigeluth, 1995a, 1995b).

SCM is composed of two major parts—an underlying theory, which functions as a framework, and a process, which is used as a guideline to embody the underlying theory.

SCM principles

The underlying principles of SCM fall into two categories: those that govern epitomizing and those that govern elaborating the version of the task. If epitomizing can be compared to sketching, then elaborating can be compared to adding detail to the sketch. So, with a good epitome and good elaborating, it is possible to make a sound sequence (Kim, 1994). Figure 1 illustrates these relationships.

Epitomizing principles. The principles of epitomizing are based upon the notion of holistic learning. Therefore, an epitome should begin with

- a whole task rather than a part of a task,
- a simple version of the task,
- a real-world version of the task if possible, and
- a representative version of the task.

Elaborating principles. After the epitome is identified, elaborating entails designing each subsequent module to teach another version of the whole task. Each elaboration should be slightly

- more complex,

• more divergent,
• more authentic, and
• less typical.

The SCM process

While the principles of SCM provide conceptual understanding about SCM for designers, the SCM process provides specific guidelines so the designers can apply their understanding.

We have worked with several versions of the SCM process since 1991. Since the version outlined in List 1 was the most recent version at the time, it was used for the study.

RESEARCH PROBLEMS

The purpose of this study was to improve the principles and process of the Simplifying Conditions Method for the procedural tasks by using formative research methodology with field testing. More specifically, this study investigated the following questions:

• What are the weaknesses of the principles of SCM?
• How can they be improved?
• What are the weaknesses of the SCM design process?
• How can they be improved?

FORMATIVE RESEARCH FOR INSTRUCTIONAL THEORY

The major research methodology for this study is the formative research methodology (Reigeluth, 1989) which is designed to improve the instructional theory and model. Using the formative research method to improve instructional design theory was a relatively new idea until Reigeluth (1989) suggested it as a means of improving prescriptive instructional theory. Since then, several studies have used this methodology for that purpose (Clonts, 1993; English, 1992; Farmer, 1989; Kim, 1994; Lim, 1994; Roma, 1990; and Simmons, 1991). These studies suggest that formative research methodology is an effective tool for improving instructional theories.

Reigeluth's (1989) formative research methodology is based on the principle that when instruction is developed under the strict guidance of a theory, without using any other guidelines or input—not even the designer's own intuition—the instruction (product) is an "instance" of that theory, and the results of the evaluation of the instruction will reflect the theory's weaknesses and strengths and will point to ways of improving the theory.

The process of formative research for instructional theories has similarities to and differences with formative evaluation for instructional products. Generally, formative evaluation begins when the designers and/or developers of the product have a basic but minimal level of confidence in the product and wish to determine early on any weaknesses of the product. This formative evaluation process can be repeated until the designer is satisfied with the revised product.
The process and purpose of formative research on an instructional theory or model are similar. An instructional theory or model requires a significant amount of trial and revision. Formative research should begin only when the creators of the instructional theory or model have a basic level of confidence and are ready to examine their product (the theory or model) for flaws. Formative research is complete only when the creators are satisfied with the modified version of the theory, which is based on the formative research results.

Also, there is a significant difference between formative evaluation of a product and formative research on an instructional theory. In the formative evaluation of an instructional product, a designer can collect data on the product from the learners directly (see Figure 2). The data-gathering process for formative research on an instructional theory is not as simple, however, since learners' data are gathered through the "instance" of the theory (see Figure 3). Consequently, the validity of the data from the formative research for the theory is much more important and critical than those of the formative evaluation for product. For the formative research, the "instance" must truly represent the theory. This distinction introduces following salient issues which should not be overlooked when considering the validity of a formative research study (Kim, 1994).

First, since the instructional designer develops the "instance" according to his or her understanding of the theory or model, the designer's ability to apply the theory is one of the critical factors in research validity. If the designer is an expert on the theory or model and has considerable experience developing "instances" of the theory, the validity of the study will generally be acceptable. However, if the designer lacks significant knowledge and/or experience regarding the theory, the validity of the study may be negated, since the "instance" may not accurately reflect the theory or model.

Second, even though an "instance" can be determined by a theory expert, it is recommended that another expert on the theory confirm this "instance" to lend further credence to its validity. Consequently, the first and second issues can be summarized into one question—"Is the product a true instance of the theory?" This raises the issue of construct validity. Third, when the product is "delivered" to the learners, the learning environment should be as natural as possible in order to increase the external validity (Reigeluth, 1989). It is also necessary to determine whether the characteristics of the task and the learners are realistic and representative the instructional settings to which one wishes to generalize.

Fourth, data gathering can be a critical issue in formative research on an instructional design theory or model. The following questions should be considered in the planning process: "What kind of data will be really useful for improving the theory?" and/or "How are useful data gathered?" (Reigeluth, 1983). The characteristics of the instructional design theory or model—sequencing, selection, instructional strategies, and/or task analysis—should be considered when answering these questions.

In previous formative research on instructional theories or models (Clonts, 1993; English, 1992; Farmer, 1989; Kim, 1994; Lim, 1994; Roma, 1990; and Simmons, 1991), data gathering relied heavily, but not exclusively, on the use of qualitative data.

DESIGN

This study was conducted in two distinct phases: design and instruction. In the first phase, we used the SCM process to design a course. This was done to determine the weaknesses of the SCM process. In the second phase, the course was taught using the SCM sequence. This was done to determine the weaknesses of SCM principles.

FIRST PHASE

Task

The task for this study was to use Authorware Professional to create a CAI program. It was selected based upon the following criteria:

1. The task should be procedural or theoretical, so that the procedural or theoretical SCM analysis and sequencing methodology can be used.
2. There should be a strong interrelationship among the topics in the task. (If the learning task were composed of unrelated topics, it would not be useful for this study.)
3. The context, task, and audience should resemble a normal instructional setting as much as possible in order to increase the external validity (Reigeluth, 1989). It is also necessary to determine whether the characteristics of the task and the learners are realistic and representative the instructional settings to which one wishes to generalize.
4. The task should require more than 10 hours to learn, including the time required for in-class activity as well as the time required to complete practice exercises and homework. If the task is short and requires less than 10 hours to master, learners can compensate for any weakness of the sequence and the sequence does not make any big difference on the effectiveness and efficiency of learning.
5. There should be a meaningful interval of time between one lesson and the next so the students can practice and review what they have learned.

Participants

An SCM design committee of six members was established to design the SCM sequence. Their specific roles were as follows:

1. The designer designed the sequence with the subject matter experts (SMEs) while using SCM.
2. The two SMEs designed the sequence with the designer and checked the content validity of the sequence of instruction.
3. The peer-debriefer gathered data while observing the design activity of the designer and the SMEs.
4. The task expert checked the content validity of the designed sequence of instruction to ensure it taught the task.
5. The SCM expert checked the construct validity of the designed sequence of instruction as an SCM sequence.

Data Gathering and Data Analysis

Data were collected by employing three different processes: (1) self-monitoring (Krieger, 1991) and self-reflection (Schön, 1987) by the designer; (2) the observations of the peer-debriefer (Lincoln & Guba, 1985); and (3) debriefing with the designer, peer-debriefer, and content SMEs who participated in the design process.

The gathered data were analyzed mainly by triangulation (Denzin, 1978; Miles & Huberman, 1984) among the gathered data from the three processes: designer's self-monitoring and self-reflection note, peer debriefer's observation note, and the

comments from the debriefing meetings. More specifically, the following questions were answered: What results are similar among the data? What is the difference among data? What causes the differences or similarities?

Procedure

To design the sequence of the task within the parameters of SCM, the designer, one SME, and the peer-debriefer met in a quiet place at the SME's company. While designing the sequence with the SME according to the SCM process, the designer tried to note in detail every problem or question that arose. The peer debriefer also tried to maintain a complete working log for each step of SCM. It took about 13 hours total over three days to complete the design sequence. After each day's work, the designer cross-checked the gathered data with the peer-debriefer and/or the SME.
After completing the sequence design, the content validity and the construct validity of the sequence were checked with the task (Authorware Professional) expert and SCM expert.

Results

The findings from the first phase, according to the identified weaknesses, could generally be placed into four categories: (1) need more prescriptions, (2) need to consider the holistic approach more, (3) need to teach SME, and (4) need to consider job aid/performance of designer/SME (see Table 1). Each weakness was also analyzed to determine whether it could be strengthened by modifying the step(s) or criteria or by adding new step(s) or criteria. In Table 1, for instance, "A:11" and "M:13" from the first column indicate that 11 more steps need to be added and 13 existing steps need to be modified with more detailed prescriptions.

Discussion

In general, the SCM process works fairly well and successfully reflects the principles of SCM. However, the results of this study clearly show why the

SCM process requires further improvement and what needs to be improved. First, issues related to improving the SCM process need to be considered—is it really possible to perform task analysis and sequencing with the SCM process? Second, issues related to specific aspects of the performance of SCM designers and SMEs also need to be considered—if a designer performs SCM for the first time, how well can he or she do task analysis and sequencing with SCM?

Since the second group of issues is more related to training or training materials development in ISD processes and more dependent on the performance of designer, the original focus of this study was on the first category--checking the soundness of the SCM process as a design process. For instance, some of the steps from the "need more prescriptions" category and all of the steps from the "need to consider holistic approach" category focus on the soundness of the process. If those steps were not added or modified, the vitality of the SCM process would be questioned as an instructional design theory. However, most of the steps of the other three categories—the rest of the steps from "need more prescriptions" and all of the steps from "need to teach SME" and "need to consider job aid/performance of designer/SCM" focus mainly on the performance of designers and SMEs. Therefore, those steps do not threaten the vitality of the SCM process. Without them, however, the efficiency and effectiveness of the SCM process would be endangered. Consequently, in order to improve any instructional design theory, both aspects must be considered and addressed.

Issues Concerning the Soundness of the SCM Process

The soundness of the SCM process depends on the consideration of two issues: (1) the holistic relationship between the principles and process and (2) formative evaluation of each level of sequencing.
Holistic relationship between the principles and process. The current SCM process may be misunderstood if treated as a step-by-step recipe-style procedure. Such problems can occur when the SME asks too many questions or demands too much deviation from the SCM process. Excessive deviation is risky because the SCM process requires a very dynamic/recursive type of iteration, a fine-tuning process, on the part of the design committee.

In fact many people have warned about the potential problem of the overproceduralization of complex ISD processes (Davies, 1983; Earle, 1985; McCombs, 1986; Shettle, 1983). The Elaboration Theory has also been criticized for the possibility of overproceduralization (Reigeluth, 1992; Wilson & Cole, 1992).

In order to forestall such problems, the SCM process must be expressed in a way that leaves its step-by-step prescriptions more holistically integrated with its principles. This can be done in two ways. First, one would display the relationship between the principles and the process more clearly within SCM process by, for instance, integrating a display of the related principles into the flowchart representation of the process. Second, one would emphasize more flexibility in the process within the scope of the principles, so that the design activity can be more systemic rather than systematic.
Formative evaluation of each level of sequencing. Formative evaluation is recommended for each level of sequencing. The

scope of formative evaluation can be very broad, encompassing one-on-one evaluation, small group evaluation, and field testing. Consequently, new prescriptions for the allowable scope, participants, and purpose of the formative evaluation should be developed, taking into consideration the rapid prototyping approach such as the following:

1. After making each unit of the sequence, there should be at least one one-on-one evaluation of the unit.
2. For the one-on-one evaluation activity, the learner should be realistic and representative of the targeted learners.
3. Evaluation criteria should include effectiveness, efficiency, and appeal of the instructional unit.

Issues concerning the Performance of Designers and SMEs

Although this study made separate efforts to find weaknesses in the principles and process of SCM, these two elements are holistically interrelated. Within this interrelationship, the success of SCM principles is relatively dependent on how well the designers understand SCM, while the success of the SCM process is relatively dependent on the performance of the designers and SMEs, which is based on this understanding and training. Consequently, the success of the principles (understanding) and the success of the process (performance) are, taken together, necessary and sufficient conditions for the success of SCM.

Viewed from this perspective, it appears that the current version of SCM might be improved by considering the performance and understanding of designers and SMEs on the following points:

- The SCM process needs to be described in plainer and more explicit terms.
- The available criteria are insufficient to evaluate the success of some steps.
- Easy concrete examples of the SCM approach would enhance the understanding and performance of the SMEs and the designers.

SECOND PHASE

In the second phase, using the product of the first phase's design activity, the designer taught the workshop for instructional designers at the Computer Education Research Center (CERC) of the Korean Education Development Institute (KEDI) in Seoul, Korea. The designer also gathered data from interactive interviews with participants of the workshop and observed the class. Likert-style data on their attitudes were gathered from the learners. All gathered data were checked and analyzed by triangulation with other learners.

Method

Participants

There were 10 participants for the second phase. Since the second phase was an unofficial internal workshop of a research/development institute which specializes in research and production of computer-based instruction, all of the participants were instructional designers employed by the institute. Each person had designed about five CAI programs every year and had worked at the institute for at least two years as an instructional designer. Some participants were fluent in using some authoring systems/languages, but none had had any prior experience with Authorware Professional.

Data Gathering

While conducting the workshop, the instructor gathered data through personal interviews with participants, assignments, observation, and the instructor's personal reflections. After completing the workshop, the instructor held three debriefing meetings with small groups of participants.

Procedure

The second phase included three stages—initiating, implementing, and debriefing.

Initiating stage. Before starting the workshop, the instructor interviewed every participant to assess the participant's previous experiences. During the interview, the instructor explained the purpose of this study and encouraged each participant to provide honest feedback on the sequence of the workshop.

Implementing stage. The instructor taught the nine-day workshop without any other instructors or assistants. Each day of the workshop included a lecture lasting about one hour and then individual practice for at least one hour. Two assignments were given during the nine days' training, and each took about one and a half hours to complete. During the workshop, the instructor interviewed each participant at least twice to obtain meaningful and relevant information about the sequence of the workshop. During the interim interviews, the learners were asked the following questions:

• What did you like or dislike about today's activity? Is your answer related to the sequence of instruction (or ordering and grouping of instruction)?
• What do you think would enhance your motivation in the course? Is it related to the sequence of instruction?
• What would help you understand the task better? Is your answer related to the sequence of instruction?
• If you encountered difficulties related to the sequence of instruction while learning the lesson, how could those difficulties be avoided in the future?
• Is the topic too difficult? Is this because of the sequencing?
• As a learner in this course, how do you think the sequence can be changed to make the course more attractive?

After the last day of the workshop, the learners were asked to respond to a final attitude survey to assess the appeal of the instruction and the their attitudes toward the sequence of instruction. The survey was composed of 13 Likert-style questions and five open-ended questions, which asked the learners if they liked the sequence of the daily lesson. Table 2 summarizes the survey results.

Debriefing stage. After the workshop, a debriefing meeting was attended by a debriefer for the first phase, two learners, and the instructor. In the meeting, the instructor shared the findings from his observations and personal interviews and then asked some questions which had been suggested by these personal interviews and observations.

Data Analysis.

Once data collection was complete, the information was organized so that comparing the difference and similarity among the data sets could be performed. The most important data were from the interviews with the learners and from the observation record. Like the data from the first phase, the interview results from the second phase were analyzed with an emphasis data on among the learners' and instructor's observations. Our data analysis involved data reduction, data display, and drawing conclusion (Miles & Huberman, 1984).

This analysis helped us identify the major strengths and weaknesses of the sequence so that the theory could be improved. The findings of the first and second phases were used to support and develop conclusions that might help determine the underlying principles of SCM and the weaknesses of the SCM process.

Results

Generally, the data clearly show the strength of the SCM sequence. The general results of the open-ended questions also agreed with those of the Likert-style questions, in supporting the strength of the SCM approach.

Table 2 displays a summary of the attitude survey, which is composed of three major groups: (1) general attitude toward the workshop, (2) feedback on the epitome, and (3) feedback on the sequence of the workshop.

General attitude toward the workshop: The results from questions 1 to 5 display the learners' general attitude toward the workshop. For the most part, the learners were very satisfied with the workshop. The mean of the answers to questions 1 to 4 was between 1 and 2, which stands for "strongly agree" and "agree." Also, the mean for question 5 was 4.5, indicating that all of the learners felt they had successfully understood the main characteristics of the task.

Feedback on the epitome: The feedback on question 6 shows that the first lesson (epitome) was highly helpful to the learners in understanding the course as a whole. The mean of question 6 was 1.9, indicating that the learners agreed that the first lesson was very helpful in understanding the content of the course as a whole.

Question 7 originated from a learner's suggestion in an interim interview during the workshop. That person had some understanding of the Elaboration Theory and liked the idea of "epitome." He felt that if the epitome could be reviewed during the course, it would help the learners understand the relationship between the epitome and each elaborated lesson, thus encouraging better-structured understanding while allowing them to verify their progress. The learner suggested this idea in the middle of the workshop. Even so, it is interesting that this person did not strongly disagree to question 7 when it was asked after the workshop. On his survey, he noted that "even if it is a good idea, it may not be practical, since it will take a lot of time."

Feedback on the sequence of the workshop. Results for questions 8 and 10 show consistently that the sequence of the course was not very difficult and that learning one lesson facilitated the mastery of the next. The results from questions 11, 12, and 13 clearly show that the sequence of the course was very good. The generally positive responses to Question 10 support this conclusion.

The results of the personal interviews support the findings from the attitude survey. The questions and the summary of answers are as follows:

• What did you like or dislike about the course? Is your answer related to the sequence of instruction (or ordering and grouping of instruction?): Almost all of the participants liked the first lesson and sequence. One person noted that repetition

of the content of the first lesson (epitome) during the first three lessons was a little boring; however, it proved very helpful for later learning for him.

• What do you think enhanced your motivation in the course? Is your answer related to the sequence of instruction?: "Since the first lesson was practical, it was not very difficult to maintain motivation. Each time we learned a limited amount of content, and there was always the potential for elaboration. Because of this potential, it was possible to peek at the content of upcoming lessons and this enhanced my motivation."

• What would help you to understand the task better? Is the answer related to the sequence of instruction?: "It might be helpful to check where the current lesson is on the big map of the whole task."

• If you encountered difficulties related to the sequence of instruction while learning the lesson, how could those difficulties be avoided in the future?: "Using window was one of the prerequisite skills for this workshop. Since I didn't know anything about the window, I had a lot of stress with window even though the class activity did not require using window a lot. It might be beneficial to have enough time to practice the prerequisite skills until I feel confident before starting any major lesson."

• As a learner for this course, how do you think the sequence can be changed to make the course more attractive?: "In general, the sequence of this course was OK for me. However, since my learning style is more inquiry-based, I would like to have a chance to explore more, rather than following the given instruction."

Discussion

In light of this study's goal—finding weaknesses so we could improve the underlying theory of SCM—the second phase was unproductive, since no significant weakness was found. This was expected, however, since the results of the pilot studies were very similar to those of the second phase. Consequently, rather than identifying weaknesses, the second phase provided some evidence of the strength of the underlying theory of SCM. Basically, it confirmed the validity of SCM's approach of providing a big picture of the task early in the instruction, thus enriching the epitome with additional elaboration efficiently and effectively, while maintaining the learners' motivation at a high level throughout the course.

Besides indicating these strengths, the results of the second phase also support the following two recommendations regarding possible improvements to the underlying principles of SCM and another one regarding the SCM process and SCM principles.

1. This study revealed a need to improve the descriptions of the principles identifying the SCM and the interrelationships among those principles by ensuring such descriptions are concrete, clear, and self-explanatory. As things now stand, designers must take a great deal of time (inventing many explanations and analogies on their own) to introduce the principles to the SME(s). If the principles are to be understood easily, workable explanations will have to be in place beforehand. One example would be calling the first day's instruction the "epitome."

2. The current way of describing the principles provides a kind of absolute set of criteria, such as "a whole task rather than a part of a task" (the first epitomizing principle). But in practice, the definition of a whole task can be varied according to the characteristics of the learners, the delivery constraints, etc. For instance, when the designer explained about the first epitomizing principle to the SME, the SME was asked about the scope of the course and other practical limits of the course. This dialog helped to identify the epitome version of the task.

Thus, it would be better to provide designers and SMEs with formulations of the principles that take these variable conditions into account. For instance, the first epitomizing principle (a whole task rather than a part of a task) could be described as "a whole task rather than a part of a task, within the limits imposed by the characteristics of the learners, their needs, the goal of the course, and the delivery constraints." In this manner, the relationship between the first epitomizing principle and the preparation stage of the SCM process can also be clarified.

3. The constructivist approach should be considered for the micro-level design. Most of the learners liked the SCM sequence; however, about 20% of learners wanted to have different ways of studying, such as explorative or constructive studying, made available to them. These results can easily mislead one into concluding that SCM limits the learners' learning style to expository only. However, SCM does not limit its application with any one way of learning such as expository or discovery. SCM can be used for discovery or in an explorative way also because SCM determines the learning sequence at the macro level and the decision of whatever to use an expository or explorative way of learning is made at the micro level. So these comments do not reflect on the SCM but rather on the decision of the designer at the micro level. For these studies of the SCM process, we implicitly used only the expository way of teaching.

These results raise an issue—prescriptions need to be added to micro-level design which can be designed for either expositive or explorative learning.

CONCLUSION

The results of this study suggest two conclusions. First, the current SCM process is workable; however, three recommendations were found for improvement.

- The need to stress the holistic rather than the step-by-step approach
- The need to add more detailed prescriptions.
- The need for formative evaluation.

Second, we were unable to find any critical weaknesses that might lead to possible improvements in the SCM principles, since most of the learners were very satisfied with the sequence of the instruction. The results of this study reveal that even though the principles of SCM are fundamentally sound, there is still room for improvement as indicated above. Therefore, future research can focuse more on the application of SCM and can confront such challenges as finding the best ways to train and guide the novice designer.

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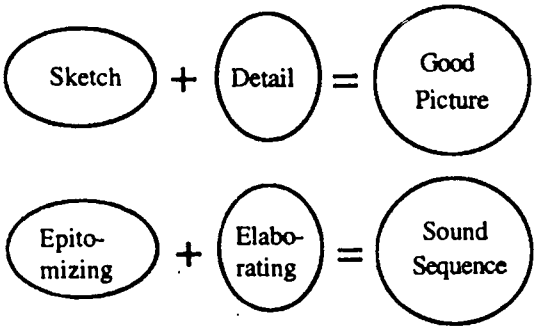
Figure 1: The underlying principles of SCM



List 1: Process for SCM procedural analysis and sequencing (1993 version).

The SCM Process for Procedural Analysis and Sequencing
(All steps are performed by a designer and a subject matter expert.)

Prepare
1) Establish rapport with subject matter expert (SME).
2) Identify the characteristics of the task in general.
3) Identify the characteristics of the learner in general.
4) Identify the delivery constraints of the task in general.
5) Introduce the SME to SCM.

Design the Epitome
1) Identify and order the simplifying conditions.
   1.1) Identify the full variety of versions of the task.
   1.2) Describe the conditions which differentiate each version.
   1.3) Rank order the conditions according to representativeness of the whole task.
2) Identify the epitome version of the task.
   2.1) Recall the simplest version that is representative.
   2.2) Describe the conditions for the epitome version.
3) Analyze the epitome version.
   3.1) Decide whether the task is procedural or theoretical. If it is procedural, continue.
   3.2) Identify all major steps for performing the epitome version under the conditions.
   3.3) Analyze each step down to the entry level of description (hierarchical analysis).
   3.4) Draw a flowchart for the epitome version.
4) Analyze supporting content for the epitome.
5) Check the size of the epitome.
   5.1) Analyze the delivery time constraints of the specific learning situation, if any.
   5.2) Compare the size of the epitome to the time constraints.
   5.3) If the epitome is longer than the time constraints, reduce its size by adding another simplifying condition.
   5.4) If the epitome is much shorter than the time constraints, increase its size by removing one of the simplifying conditions.
6) Design and develop instruction for the epitome.

Prepare for Elaboration

1) Refine the simplifying conditions.
   1.1) Identify additional simplifying conditions, if any, that may have been overlooked.
   1.2) Check for any conflict or overlap among the conditions and adjust them.
   1.3) Rank order the simplifying conditions.
2) Identify the relative amount of learning that would be required by removing each simplifying condition.
3) Identify those simplifying conditions whose removal will require learning skills similar to those for another simplifying condition.

Design the Elaborative Sequence

1) Identify the next simplest version (the next elaboration).
   1.1) According to the rank order, select the next simplifying condition to remove.
   1.2) If the removal requires additional conditions, identify them and add them to the rank order.
   1.3) Identify the version of the task that meets the new conditions.
2) Analyze the version.
   2.1) Identify all major steps for performing the simplest version under the conditions.
   2.2) Analyze each step down to the entry level of description, considering all previous instruction.
   2.3) Draw a flowchart for the lesson.
3) Analyze the supporting content for the version.
4) Check the size of the version.
   4.1) Compare the size of the lesson to the time constraints.
   4.2) If the lesson is longer than the time constraints, add in a secondary simplifying condition and return to step 4.1.
   4.3) If the lesson is much shorter than the time constraints, remove another simplifying condition according to the rank order and return to step 4.1.
5) Design and develop instruction for the lesson.
6) Repeat steps 1 through 5 for each remaining simplifying condition.

Figure 2: The Formative Evaluation Model for an instructional product.

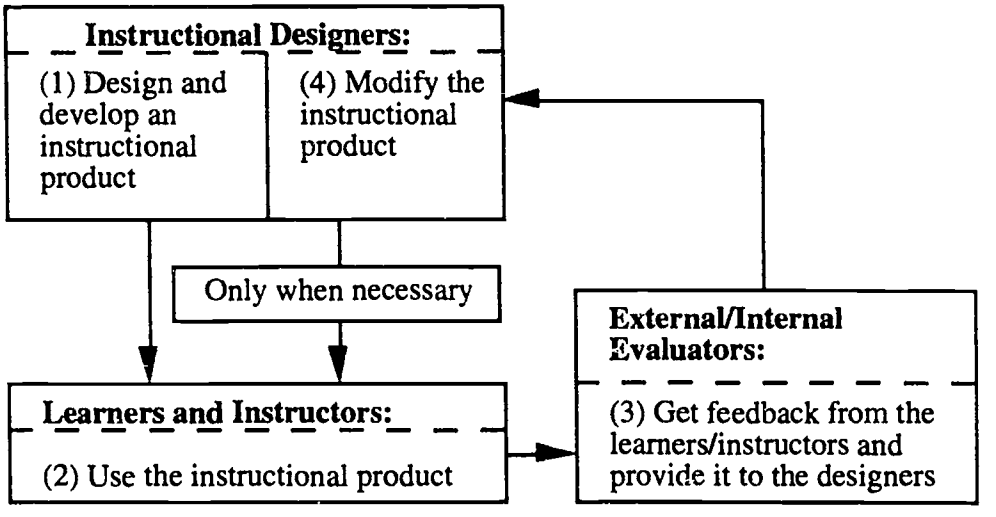


Figure 3: The Formative Research Model for an instructional theory.

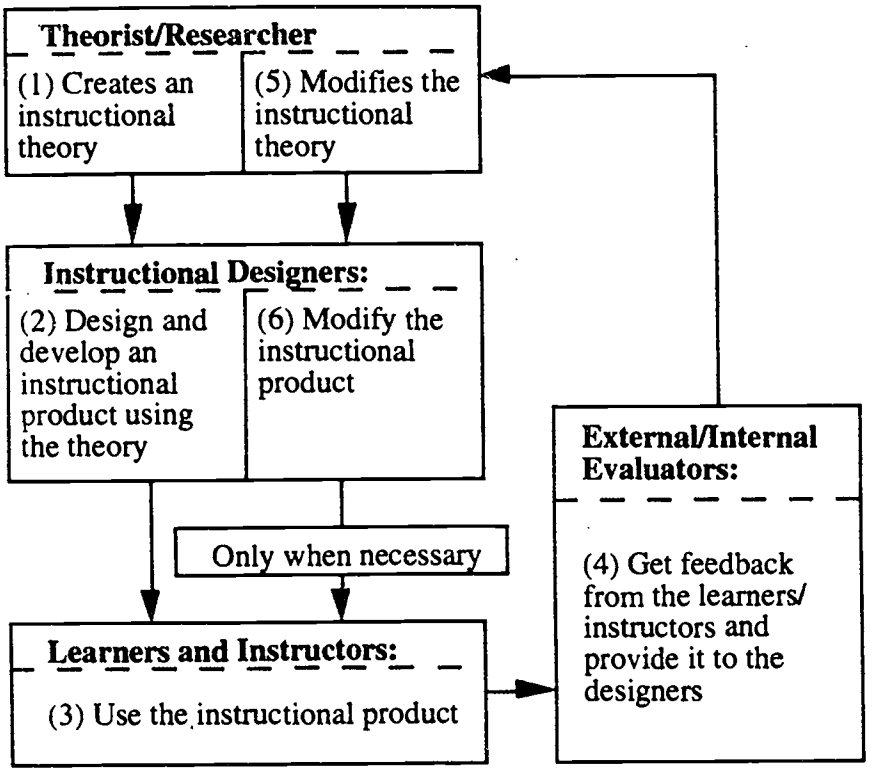


Table 1 Summary of the Results of the First Phase

Weakness	Need more prescrip-tions	Need to consider holistic approach	Need to teach SME	Need to consider job aid/performance of designer/SME
Frequency	A: 11 M: 13	A: 0 M: 5	A: 10 M: 1	A: 3 M: 1

M: Need to modify the step(s) or criteria
A: Need to add new step(s) or criteria

Table 2: Workshop Survey Results

	No.	Question	SA	A	U	D	SD
I	1	I learned a lot from this course.	9	1	0	0	0
	2	This course was very interesting.	8	2	0	0	0
	3	I really liked taking part in this course.	8	2	0	0	0
	4	I'm willing to participate again if a higher level of this course is offered someday.	4	6	0	0	0
	5	I still don't know what the main characteristics of the task presented in this course are.	0	0	0	5	5
II	6	The first lesson was very helpful in understanding the content of the course as a whole.	3	5	2	0	0
	7	It would be very good if the first lesson were reviewed during this course, in between the presentations of new material.	0	2	4	3	1
III	8	This course was too difficult for me.	0	0	0	4	6
	9	The amount of learning for each day was too much for me.	0	1	2	6	1
	10	It was not very difficult to understand the content of each new lesson, since each lesson was closely related to the previous one.	3	6	1	0	0
	11	The sequencing of topics from day to day was handled very well.	6	4	0	0	0
	12	The content was not presented in a logical sequence.	0	0	0	1	9
	13	It would have been better if the whole sequence of each lesson had been composed differently.	0	0	0	4	6

SA: Strongly Agree, A: Agree, U: Undecided, D: Disagree, SD: Strongly Disagree
I: General attitude on the workshop
II: Feedback on the epitome
III: Feedback on the sequence of the workshop