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EFFECTS OF TASK-CENTERED vs. TOPIC-CENTERED INSTRUCTIONAL STRATEGY APPROACHES ON PROBLEM SOLVING – LEARNING TO PROGRAM IN FLASH

BY

RINAT B. ROSENBERG-KIMA

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Rinat B. Rosenberg-Kima defended this dissertation on November 15, 2011.

The members of the supervisory committee were:

Tristan E. Johnson
Professor Directing

E. Ashby Plant
University Representative

Allan Jeong
Committee Member

Gershon Tenenbaum
Committee Member

M. David Merrill
Committee Member

The Graduate School has verified and approved the above named committee members, and certified that the dissertation has been approved in accordance with university requirements.

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ABSTRACT

The task-centered instructional strategy (Merrill, 2009) was designed specifically for the purpose of teaching complex problem-solving skills and emphasizes teaching in the context of a concrete real world task. Nevertheless, unlike other problem-centered instructional methods (e.g., constructivism) the task-centered instructional strategy is a type of direct instruction that is in the context of authentic, real-world tasks. Unlike traditional part-task instructional strategies (e.g., Gagné, 1968), which assume that any task can be broken down into a collection of instructional objectives that need to be mastered, the task-centered instructional strategy is content-centered meaning the content-to-be-learned and not the objectives are specified first. Specifically, a progression of complete tasks with increasing complexity is specified and serves as the backbone of instruction.

The purposes of the current study were to (a) investigate whether and why a task-centered approach might be superior to a topic-centered approach for problem solving, (b) attempt to reveal emotional and cognitive processes behind complex learning in the domain of technological skills, and (c) provide recommendations for effective training methods while considering individual differences. Rooted in Bandura's (1986) Social Cognitive Theory in which the effects of the environment on human behavior are assumed to be mediated by cognitions with a continuous reciprocal interaction, in the current model two reciprocal interactions are assumed to be in the heart of task-centered instructions. These interactions that can be viewed as two positive feedback loops include performance-motivation loop and performance-cognition loop. In the performance-motivation loop, the progression of tasks from easy to difficult increases the likelihood of successful completion leading to an increase in self-efficacy, which in turn should influence performance further (e.g., Bouffard-Bouchard, 1990). In the performance-cognitive loop, authentic-tasks, which characterize task-centered instructions, can help the learner construct schemata, which may reduce working memory and lead to better performance, which in turn may further increase schemata construction. Thus, it was expected that task-centered instruction would result in better performance as a result of motivational and cognitive considerations.

To achieve the study purposes, two computer-based instructional strategies for teaching Flash were employed. In the **task-centered** condition, the learners were first presented with three tasks with increased level of difficulty. Each of the three tasks included

all the elements of the whole-task, thus, in step one, for example, the learners learned the basics of timeline, texts, and buttons. In the **topic-centered** condition, on the other hand, no task was presented to the learners up front. Instead, objectives were presented to the learners at the beginning of each topic section. Thus, in the topic-centered condition, each of the three steps referred to only one of the topics. Overall, sixty five students from a large southeastern university in the United States were randomly assigned to one of the two conditions.

The results revealed that participants in the task-centered condition performed significantly better on part 3 of the module, on the skill-development test, and on the near and far process development tests than participants in the topic-centered condition. In addition, participants in the task centered condition reported significantly higher cognitive load on parts 1 and 2 of the module and significantly lower cognitive load on part 3 of the module than participants in the topic-centered condition with matching differences in completion time. Regarding attitudes, consistent with the hypothesis, participants in the task-centered condition reported significantly lower computer anxiety after the module than participants in the topic-centered condition. In contrary to the hypothesis, there was no significant difference in computer self-efficacy between the conditions. Nevertheless, participants in the task-centered condition reported significantly higher confidence on part 3 of the module than participants in the topic-centered condition. In addition, as expected, participants in the task-centered condition indicated significantly higher level of relevance, and significantly higher level of confidence. Last, self-efficacy was found to be a significant partial mediator of the effect of instructional strategy on skill-development performance, and near and far transfer process-development performance.

Overall, findings of this study suggest using the task-centered instructional strategy (Merrill, 2007b) for the purpose of teaching complex problem-solving skills with far-transfer needs and support the proposed theoretical model. Task-centered instructional strategy resulted in better performance while completing the module, which led to an increase in self-efficacy, which then led to better performance on the post-test. The superior performance on the post-test was also likely a result of cognitive considerations including advanced schemata construction in the task-centered condition. This theoretical model can be used to further investigate the cognitive and motivational factors that are in the heart of complex learning.

CHAPTER I: INTRODUCTION

Context of Problem

One of the characteristics of the information age is the incredible speed in which new technologies replace older ones, requiring individuals to transfer their skills to new settings and learn new technologies on a regular basis. Even individuals who were not trained in a technological profession such as computer sciences and engineering are expected to acquire complex technological skills. This reality raises the need for an effective training method that addresses not only the specific complex skill on hand but also promotes transfer of the skill to newer technologies. Unfortunately, when it comes to technology, many people hold low self-efficacy beliefs and suffer from computer anxiety; these are a major reason for technology avoidance and low performance (e.g., Brosnan, 1998; Connolly, Murphy, & Moore, 2009; Meier, 1985; Wilfong, 2004).

Effective technology and computer skills training should therefore meet the demands of teaching transferable complex problem-solving skills while taking into consideration that the target population may have low self-efficacy beliefs and high computer anxiety. What should characterize high quality instruction in such settings? According to Mayer (1998) effective instructions for problem solving should address three components. These components according to Mayer are skill, metaskill, and will.

First, derived from research on problem solving, expertise (Chi, Glaser, & Farr, 1988; Ericsson & Smith, 1991) is the crucial role of domain-specific knowledge, or in other words the problem solvers' *skill*. An instructional implication of the skill-based view according to Mayer (1998, p. 50) is that “students should learn basic problem-solving skills in isolation”. Nevertheless, in order to promote non-routine problem solving, it may not be enough to master each component skill separately. As stated by Mayer (Mayer, 1998, p. 50): “Students need to know not only what to do, but also when to do it”. Therefore, a second component is the ability to control and monitor cognitive processes, or the problem solver's metaskill. The instructional implication of the metaskill approach according to Mayer (1998) is that students need practice in solving problems in context, using realistic problem-solving settings.

Furthermore, according to Mayer (1998, p. 50), “A focus solely on teaching problem solving skill and metaskill is incomplete, because it ignores the problem solver’s feelings and interest in the problem.” Therefore, a third prerequisite for successful problem solving is the problem solver’s *will*, which includes motivation based on interest, self-efficacy, and attributions. In summary, according to Mayer problem solving skill and metaskill are best learned within personally meaningful contexts where the problem solvers’ motivational needs are addressed and emotional support is provided.

The importance of using real-world authentic tasks, especially in the context of complex cognitive learning, is emphasized in recent instructional strategies (Jonassen, 1999; Merrill, 2002a; van Merrienboer, 1997). First, the use of authentic and relevant problems is very likely to provide for an interesting learning environment and increase motivation. In addition, authentic tasks, which integrate different knowledge, skills, and attitudes, can facilitate the process of not only learning various skills but also integrating and coordinating the different component for effective task performance. Specifically, authentic tasks can help the learner to construct a schemata (van Merrienboer & Sweller, 2005). A schemata or schema is “a data structure for representing the generic concepts stored in memory” (Rumelhart, 1980, p. 34).

A dominant educational approach that advocates the use of authentic tasks is constructivism. Constructivist educational approaches that focus on authentic tasks include the case-based method (e.g., Williams, 1992), problem-based learning (Hmelo-Silver, 2004), open-ended learning environment (OELE) (Hannafin, Hall, Land, & Hill, 1994), goal-based scenario (GBS) (Schank, Berman, & MacPerson, 1999), cognitive apprenticeship learning (A. Collins, Brown, & Newman, 1989) and collaborative problem solving (Nelson, 1999). Jonassen (1999) presented a generic model for designing constructivist learning environments (CLE), with the following essential components: 1) Problem/project, 2) Related cases, 3) Information, 4) Cognitive tools, 5) Conversation/Collaborative tools, and 6) Social/Contextual support.

The main risk of such approaches is that the learner may be faced with extremely high levels of cognitive load when trying to solve an authentic real-world complex problem. According to Cognitive Load Theory (CLT) working memory is limited and can store about 7 elements (±2) yet can operate on just two to four elements. *Intrinsic* cognitive load refers to the working memory load caused by the intrinsic nature of the tasks whereas *extraneous* cognitive load refers to the working memory load caused by the way in which the tasks are presented (van Merrienboer & Sweller, 2005). A further distinction can be made between extraneous cognitive load and *germane* cognitive load. While extraneous cognitive load is a result of poorly designed instruction and is not desired, germane cognitive load reflects the mental effort invested directly in learning (Sweller, van Merrienboer, & Paas, 1998).

Based on the assumption that extraneous cognitive load is not necessary for learning, various strategies for reducing cognitive load have focused on different ways to reduce the extraneous cognitive load of instruction. These strategies include, for example, the completion problem effect, the modality effect, the worked example effect, the redundancy effect , and the split attention effect (Mayer & Moreno, 2003). Nevertheless, such methods to decrease extraneous cognitive load may not be sufficient in the case of real-world complex problem where the intrinsic cognitive load may be too high for novice learners. It was found that using highly complex learning tasks from the beginning has negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). On the other hand, an authentic task can help the learner construct schemata not only of all the components of the tasks but also of the way the different components relate to each other. From CLT perspective, in addition to helping organize and store knowledge, schemata are an effective mechanism for reducing working memory load as one schema will be considered as only one element in working memory regardless of its complexity (van Merrienboer & Sweller, 2005).

The high intrinsic cognitive load that is associated with real-world tasks led to the development of other instructional approaches that aim to reduce the intrinsic cognitive load of the task. Instructional theories developed in the 1960s and 1970s typically advocate the use of part-task approaches to prevent overloading the learners with complex problems at an early stage (Reigeluth, 1983; van Merrienboer, Kirschner, & Kester, 2003). Thus, intrinsic cognitive load of the materials should be reduced by eliminating the interactions between the information elements until the learners master all the separate elements. *Part-task* approaches separate the different components of the complex task and teach them separately usually by topics. A recurring theme of these instructional approaches is the notion that any task can be broken down into a collection of “instructional objectives”. By mastering each objective the student should be able to complete the larger task.

Likewise, according to Gagne’s (1968) *learning hierarchy* a set of component skills must be learned before the complex skill that includes these set of component skills can be learned. Although sometimes the learners are given the opportunity to put together several of the steps during the course of the program, only when the learners reach the end of the instructional unit, do they get the opportunity to practice the whole task. Even though this strategy can be beneficial (Pollock, Chandler, & Sweller, 2002) it was found that part-task approaches do not work well for complex performances that requires integration of skills, knowledge, and attitudes (Goettl & Shute, 1996; Peck & Detweiler, 2000; van Merrienboer, 1997; van Merrienboer, Kirschner, & Kester, 2003).

Whole-task approaches, on the other hand, attend to the coordination and integration of constituent skills from the very beginning. The learner develops first a holistic vision of the task (the global skills) and only afterwards the local skills (van Merrienboer, Kirschner, & Kester, 2003). Both the part-task and the whole-task approaches aim to reduce intrinsic cognitive load by manipulating the level of interactions among the elements. However, while the part-task approach achieves this by first eliminating the interactions and then presenting them at the end, the whole-task approach progresses from a simplified version of the interactions (i.e. simplified version of the whole-task) to a more complex version of the task that includes the more complex interactions.

In accordance with the whole-task approach, in his work to identify the first principles of instruction, Merrill (2002a) stressed the importance of instruction to be in the context of authentic, real-world problems or tasks. In particular, Merrill made the distinction between a *task-centered* and *topic-centered* instructional strategy. While topic-centered instructional strategies usually teach the content in a hierarchical fashion (i.e. only one topic is taught at a time, until all the component skills have been taught), in task-centered instructional strategies a simplified version of the whole task is demonstrated right up front and the instructions that follow provide the necessary information to complete this task. According to Merrill, a truly effective task-strategy involves a progression of task complexity and a corresponding decreasing amount of learner guidance. Merrill’s (2007b) Task-Centered Instructional Strategy brings together several components, including the Pebble-in-the-Pond model (Merrill, 2002c), to create a multi-strand strategy specifically intended for teaching how to solve real-world problems or for how to complete real-worlds tasks. The task-centered instructional strategy differs from constructivist methods such as the problem-centered instruction in that it is a form of direct instruction but in the context of authentic, real-world problems or tasks (Merrill, 2009).

CHAPTER I: INTRODUCTION

Similar to Merrill’s (2007b) Task-Centered instructional strategy approach, the four-component instructional design model (the 4C/ID model) (van Merrienboer, 1997) stresses the use of authentic whole-tasks for the acquisition of complex learning skills. Like Merrill’s approach, the 4C/ID model is content-centered (as opposed to topic-centered) modification of traditional instructional design. Thus, in the 4C/ID model the contents-to-be-learned and not the abstract learning objectives are specified first and instructions are presented directly, yet in the context of authentic, real-world problems or tasks. According to the 4C/ID model, complex learning deals with coordinating and integrating the separate skills that comprise real-world tasks and has little to do with learning separate skills in isolation (van Merrienboer, Clark, & de Croock, 2002).

In terms of motivational considerations, inherent to both the 4C/ID and the task-centered instructional strategy models is management of student’s self-efficacy. According to Bandura (1986), actual experiences is the most important source of self-efficacy (Stipek, 2002). Being task-centered, both of the models provide extensive actual experiences. However, unlike constructivism in which highly complex tasks may be presented from the beginning, these models avoid using highly complex learning tasks from the start given the potentially negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). Instead, they propose progression of tasks from simple to complex, thus assuring that the actual experience is truly a positive experience, and that the psychological state of the students is kept positive. In addition, both Merrill (2007b) and van Merrienboer (1997) attribute high intrinsic motivational value to the inherent task-centered characteristic of the modules. According to Merrill (2007b), traditional instruction is often not clear with regard to how the knowledge and skill components will eventually be applied (“you won’t understand it now but later it will be really important to you…”), causing the instruction to lack the necessary relevance for the learner. Likewise, van Merrienboer (1997, p. 32) noted that “For whole-task practice, intrinsic motivation (natural satisfaction with task accomplishment) will usually be relatively high, because there is a clear resemblance between practice and post-instructional performance”.

Purpose of the Study

The purposes of the current study were to (a) investigate whether and why a task-centered approach might be superior to a topic-centered approach for problem solving, (b) attempt to reveal emotional and cognitive processes behind complex learning in the domain of technological skills, and (c) provide recommendations for effective training methods while considering individual differences. In particular, it was of interest to investigate the reciprocal effects of instructional strategy, performance (skill and transfer) and affective measures, including computer-self efficacy, computer anxiety, cognitive load and attitudes.

To achieve the study purpose, two computer-based instructional strategies were employed. In the **task-centered** condition, the learners were first presented with three tasks with increased level of difficulty. Each of the three tasks included all the elements of the whole-task, thus, in step one, for example, the learners learned the basics of timeline, texts, and buttons. In the **topic-centered** condition, on the other hand, no task was presented to the learners up front. Instead, objectives were presented to the learners at the beginning of each topic section (timeline, dynamic texts, and buttons). Thus, in the topic-centered condition, each of the three steps referred to only one of the topics.

Research Questions

The following research questions were examined in this study:

Research question 1

What are the effects of instructional strategy (task-centered vs. topic-centered) on: (1) performance (skill-development performance, process-development performance (near and far transfer)), (2) cognitive load, (3) time on task, and (4) Attitudes (computer self-efficacy, computer anxiety, and motivation)?

Research question 2

What are the relationships between computer anxiety, computer self-efficacy and: (1) performance (skill-development performance, process-development performance (near and far transfer)), (2) cognitive load, (3) time on task, and (4) attitudes toward training?

Research question 3

Does self-efficacy mediate the effects of instructional strategy on: (1) skill-development performance, (2) near transfer process-development performance, and (5) far transfer process-development performance?

Research question 4

Is there an interaction between learner’s level of expertise and treatment condition with regard to: (1) computer self-efficacy, (2) computer anxiety (3) learners satisfaction (4) cognitive load (5) skill-development performance, (6) process-development performance (near and far transfer), and (7) time on task?

Significance of the Study

Previous studies relating to van Merrienboer’s (1997) 4C/ID-model, have focused mainly on investigating specific aspects of the 4C/ID-model, including problems sequencing (e.g., Paas & van Merrienboer, 1994), information presentation timing (e.g., Kester, Kirschner, van Merriënboer, & Baumer, 2001), and learning tasks optimal step sizes (e.g., Nadolski, Kirschner, & van Merrienboer, 2005; Nadolski, Kirschner, van Merrienboer, & Hummel, 2001). However, the effects of the 4C/ID-model in comparison to topic-centered instruction have not been investigated in much depth.

The only study that compared the two approaches was conducted by Lim et al. (2009) who investigated the effects of the two instructional approaches (part-task: traditional instructions, and whole-task: 4CID model) and learner prior knowledge on learner acquisition and transfer of a complex cognitive skill (preparing a grade book using Microsoft Excel) (see also Lim, 2006). They found that the whole-task condition resulted in significantly better performance than the part-task condition on a skill acquisition test and a transfer test. While Lim et al. found the 4C/ID-model to be superior, they were not able to determine which element of the 4C/ID-model was responsible of its superiority, as indicated by Lim et al. (2009, p. 74), “future researchers may want to examine which particular aspects of the 4C/ID approach facilitate student learning and transfer. Because the study examined, from a holistic perspective, the effects of an instructional program based on the 4C/ID instructional approach, it is uncertain what specific aspects of that approach promoted student learning and transfer.” In addition, Lim et al. did not include in their study a measure of self-efficacy, thus, it is not possible to determine whether performance is mediated and can be explained by increase in self-efficacy.

The proposed study is significant in that it provides a clean comparison between topic-centered and task-centered instructional strategies. In contrary to other studies (e.g., Lim, Reiser, & Olina, 2009), in this study, the conditions are designed in a way that the *only* difference between them is whether the materials are presented around tasks or topics. Thus, each unit within this overall structure is presented exactly the same way. This unique design enabled not only to determine which instructional strategy is superior, but also to determine the exact reason for the difference. In other words, in previous studies comparisons were made between strategies that differed in more than one dimension; consequently, this kind of conclusion was not possible.

In addition, the proposed study is unique in that it aims to provide theoretical explanation as to *why* differences exist between the efficiency of the conditions. As mentioned before, according to Mayer (1998), successful problem solving depends on three components: skill, metaskill, and motivation. According to Social Cognitive Theory (Bandura, 1986), the effects of the environment on human behavior are mediated by cognitions with a continuous reciprocal interaction between personal factors, the environment in which an individual operates, and behavior. Thus, it is assumed that both motivational factors and cognitive factors have an important role in the learning process. By assessing cognitive load, performance, as well as motivational measures including self-efficacy, computer anxiety, and attitudes it was hoped to reveal the nature of those reciprocal relationships.

CHAPTER II: LITERATURE REVIEW

In the following chapter the theory upon which the proposed research model is designed will be reviewed. The review will start with Jonassen's (2000b) definition of problem solving and problem classifications. Subsequently, an overview of two key factors in problem solving: cognitive factors and motivational factors will be provided. In particular, Cognitive Load Theory (CLT) (Sweller, 1988), Social Cognitive Theory (Bandura, 1977a, 1986), Self Determination Theory (Deci & Ryan, 1985), and Interest Theory will be reviewed. For both the cognitive and the motivational factors implications for instruction will be discussed.

Next, the extent to which CLT and motivational considerations described above are taken into account by prominent instructional theories with respect to problem solving learning were examined. Three distinct instructional design approaches are presented: traditional instructivist instructional design theories with a focus on Gagné's theory of instruction (Gagné, 1985), continue to constructivist instructional approach with a focus on Jonassen's constructivist learning environment (Jonassen, 1999), and finish with recent models with a focus on Merrill's task-centered instructional strategy (Merrill, 2007b) and van Merrienboer's 4C/ID model (van Merrienboer, 1997). These models combine characteristics of traditional instructional theories (i.e., direct learning) with characteristics of constructivism (i.e., whole-task approach). Then the extent to which each instructional approach takes into consideration CLT and motivational considerations and thus its appropriateness for problem solving learning was examined.

Next, literature that is specific to computer programming, which is the specific domain that the proposed study examined, is reviewed. This review includes literature regarding motivational constructs such as computer self-efficacy and computer anxiety as well as the efficiency of instructional strategies in this domain. Last, the research model for this study, grounded in the motivational and cognitive theory described above, is described.

Defining Problem Solving

Even though problem solving is considered to be an important cognitive activity in everyday and professional context, according to Jonassen (2000b, p. 63) "instructional design research and theory has devoted too little attention to the study of problem-solving processes or methods and models for supporting problem-solving learning". Problem solving is "any goal directed sequence of cognitive operations" (Anderson, 1980, p. 257). Those operations include a mental representation of the situation (aka mental model), also known as problem space. In addition, problem solving requires activity-based manipulation (i.e., thinking) of the problem space (Jonassen, 2000a; Newell & Simon, 1972), with a continuous reciprocal feedback between activity and knowledge (Fishbein, Eckart, Lauver, Van Leeuwen, & Langmeyer, 1990; Jonassen, 2000b).

Information processing models of problem solving usually assume general problem solving strategies. A number of informational processing models of problem solving have attempted to explain the problem solving process. The IDEAL problem solver (Bransford & Stein, 1983) describes problem solving as the general process of "*Identifying* potential problems, *Defining* and representing the problem, *Exploring* possible strategies, *Acting* on those strategies, and *Looking* back and evaluating the effect of those activities" (Jonassen, 2000b, p. 65). Even though the IDEAL model acknowledged the fact that different types of problems demand different strategies, it did not suggest how to select an appropriate strategy for each problem type (Bransford & Stein, 1983; Jonassen, 2000b). The classic General Problem Solver (Newell & Simon, 1972) describes problem solving as two sets of thinking processes, understanding processes and search processes. Gick (1986) presented a simplified synthesized model of the problem-solving process. The model includes processes of constructing a problem representation, searching for solutions, and implementing and monitoring solutions. Thus, in an attempt to generalize problem solving procedure, information processing models tend to treat all problems the same (Jonassen, 2000b).

Nevertheless, problems are not alike, either in content, form, or process. Schema theory models argue that each type of problem requires its own schema. Thus, experts are better problem solvers because they are able to recognize the most appropriate schema for a given problem, whereas novices, who are not able to recognize appropriate schema, must rely on general problem solving strategies, such as the information processing approaches described above, which provide weak strategies for problem solutions (Jonassen, 2000b; Mayer, 1992). According to Jonassen (2000b) “the ability to solve problems is a function of the nature of the problem, the way that problem is represented to the solver, and a host of individual differences that mediate the process” (see figure 2.1). To provide meaningful guidance for instructions, and better understanding of the problem solving process, it is necessary to acknowledge variations with respect to each of those elements. The next section provides a description of those problem elements variations as described by Jonassen (2000b).

Problem Variations→	**Representation →**	**Individual differences =**	**Problem Solving Skill**
- Ill-structuredness - Complexity - Abstractness/Situatedness	- Context - Cues/Clues - Modality	- Knowledge - Cognitive styles - General problem-solving strategies - Self-confidence - Motivation/perseverance	

Figure 2.1 Problem-Solving Skills (Jonassen, 2000b)

Problem Variations

According to Jonassen (2000b), problems vary in terms of their structuredness, complexity, and abstraction (domain specificity).

Structuredness

Jonassen (1997) distinguished *well-structured* from *ill-structured* problems. Well-structured problems (e.g., algorithms, story problems) “present all elements of the problem to the learners, require the application of a limited number of regular and well-structured rules and principles that are organized in a predictive and prescriptive ways, and have knowable, comprehensible solutions where the relationship between decision choices and all problem states is known or probabilistic” (Jonassen, 2000b, p. 67). Ill-structured problems (e.g., systems analysis, design) on the other hand “possess problem elements that are unknown or not known with any degree of confidence, possess multiple solutions, solutions paths, or no solutions at all, possess multiple criteria for evaluation solutions, and often require learners to make judgments and express personal opinions or beliefs about the problem” (Jonassen, 2000b, p. 67).

Instructional design for well-structured problems is rooted in information-processing theories, which conceive of learning outcomes as generalizable skills that can be applied across content domains. In contrary, instructional design for ill-structured problems shares assumptions with constructivism and situated cognition, which argue that any performance is domain specific and therefore recommend presenting instruction in some authentic context. Jonassen (1997) recommended different design models for well and ill-structured problems (see figure 2.2), arguing that each kind of problem calls on different skills.

	Well-structured problem-solving instructions:	**Ill-structured problem-solving instructions:**
Step 1	Review prerequisite component, concepts, rules, and principles.	Articulate problem context.
Step 2	Present conceptual or causal model of problem domain.	Introduce problem constraints.
Step 3	Model problem solving performance in worked examples.	Locate, select, and develop cases for learners.
Step 4	Present practice problems.	Support knowledge base construction
Step 5	Support the search for solutions (scaffolding).	Support argument construction.
Step 6	Reflect on problem state and problem solution.	

Figure 2.2 Recommendations for Developing Well-Structured and Ill-Structured Problem Solving Instruction

Complexity

According to Jonassen (2000b, pp. 67-68) “Problem complexity is defined by the number of issues, functions, or variables involved in the problem, the degree of connectivity among those properties; the type of functional relationships among those properties; and the stability among the properties of the problem over time (Funke, 1991)”. Complex problems are more difficult to solve because they involve more cognitive operations than simpler ones, thus placing heavy burden on working memory. Ill-structured problems are usually more complex, nevertheless, well-structured problems can be extremely difficult while ill-structured problems can be fairly simple. For example, playing chess is a very complex well-structured problem, while selecting a shirt for different occasions is a simple ill-structured problem (at least for some).

Domain Specificity (Abstract-Situated)

According to current research and theory in problem solving, problem solving skills are domain and context specific. This is because solving problems within a domain relies on cognitive capabilities that are specific to the domain. (Jonassen, 2000b; Mayer, 1992). Methods of solving a problem within a domain are regarded as strong methods, as opposed to domain-general strategies, which are regarded as weak methods. While in general ill-structured problems tend to be more situated than well-structured problems, this is not always the case.

Problem Representations

The second factor that effect problem solving skills according to Jonassen (2000b) is the way problems are represented and perceived by the problem solver. Problems can be represented in their most authentic form; nonetheless the problem space can be manipulated by providing and withholding contextual cues, prompts, or other clues. In addition, the conditions for solving the problem can be similar to or easier than the source problem in terms of time constraints, social pressures, level of cooperation and competition and so on. This manipulation of the problem representation will directly shape the problem difficulty and complexity. A key question in designing for problem solving is to what extent the problem should be represented in its natural complexity.

Individual Differences

The last factor to influence problem solving skills according to Jonassen (2000b) is individual differences. Unlike problem variation and problem representation, which are considered to be external factors in problem solving (M. U. Smith, 1991), individual differences, or variations in the problem solvers, are regarded as internal factors in problem solving. Individual differences can be generally categorized into three categories, which include aspects that relate to experience with similar problems, cognitive and metacognitive skills, and attitudes.

One of the strongest predictors of problem-solving ability is the solver’s familiarity with the problem type (Jonassen, 2000b), which is a result of better developed problem schemas. Nevertheless, that skill is not transferable to other type of problems, or even the same problem in a different representation (e.g., analogous problem in different domain) (Gick & Holyoak, 1983). Another predictor of problem solving skills is the solver’s level of domain and structural knowledge. To be able to use domain knowledge for problem-solving, the solver must understand how concepts within a domain are interrelated, or in other words possess structural knowledge of the domain.

Another variation in problem solvers is their cognitive styles and controls (i.e., patterns of thinking that control processing and reasoning of information). For example higher cognitive flexibility and cognitive complexity should result in better problem solving because more alternatives are considered (Jonassen, 2000b; Stewin & Anderson, 1974). At a higher level, variation in metacognition also account for differences in problem solving ability. Metacognition is the awareness of how one learns, the ability to judge the task difficulty, monitor understanding, and assess learning progress. All those skills are important to the problem solving process (Flavell, 1979). In addition, epistemological beliefs regarding the nature of problem solving also may affect the way a solver approaches a problem. For example, a common belief is that there is a right or wrong way to do things, whereas in order to solve ill-structured problems the solver needs to acknowledge the existence of various ideas and to consider multiple perspectives.

According to Jonassen and Tessmer (1996), all the cognitive processes described above are indeed necessary yet insufficient requirements for solving problems, in particular complex and ill-structured ones. Another prerequisite for successful problem solving involves affective and conative (motivational and volitional) elements. Affective elements, such as attitudes and beliefs about the problem, problem domain, and self-efficacy significantly affect a problem solver’s performance. Related to affective elements, conative elements, such as engagement, persistence, and motivation affect the effort made in trying to solve a problem and therefore the likelihood of success (Mayer, 1998; Renninger, Hidi, & Krapp, 1992). For example, while given a computer programming problem, some students would immediately give up, believing it was too complex while others would keep trying (Perkins, Hancock, Hobbs, Martin, & Simmons, 1986).

In summary, developing instruction for problem-solving is a challenging task. To develop instructional guidance for problem solving it is first necessary to acknowledge the complexity and variation within problem-solving activities. Nevertheless, for the most part, instructional design textbooks do not provide adequate guidelines for teaching problem-solving, and when they do, the prescription involves a general problem-solving strategy (e.g., P. L. Smith & Ragan, 1999). Gagné, Briggs and Wager (1992) regarded complex problems as higher order rules and did not provide guidance different from teaching rule-learning outcomes, e.g., “A higher-order rule is still a rule and differs only in complexity from the simpler rules that compose it “ (Gagné & Driscoll, 1988, p. 52).

Considerations for Developing Problem-solving Instruction

Cognitive Load

Integration of concepts from information-processing theory and schema theory form the base of Cognitive Load Theory (CLT) (Driscoll, 2005; Paas, Renkl, & Sweller, 2003; Sweller, van Merrienboer, & Paas, 1998). Cognitive load refers to the tension that is put on limited working memory by the processes involved in learning a new task. Schemas are stored in long term memory, which unlike working memory has no size limitations. Schemas, in addition to providing a mechanism for knowledge organization and storage, help to reduce working memory load. Thus, an important consideration of instruction is the construction and automation of relevant schemas (Sweller, van Merrienboer, & Paas, 1998), while controlling for working memory load.

Working memory load may be affected either by *intrinsic* cognitive load, which is the intrinsic nature of the learning tasks or by *extraneous* cognitive load, which is the manner in which the tasks are presented (van Merrienboer & Sweller, 2005). A further distinction can be made between extraneous cognitive load and *germane* cognitive load. While extraneous cognitive load is a result of poorly designed instructions and is not desired, germane cognitive load reflects the mental effort invested directly in learning (Sweller, van Merrienboer, & Paas, 1998). Increasing germane cognitive load is desired when both intrinsic and extrinsic cognitive load are low, leaving unused working memory that could have been used to enhance schema construction.

Working Memory

Rooted in cognitive information processing theory, working memory, also referred to as short-term memory, acts as a mediator between sensory memory and long-term memory. Within working memory further processing is conducted to make information ready for long-term storage or response (Driscoll, 2005). According to Sweller, van Merrienboer and Pass (1998), working memory can be equated with consciousness: “Humans are conscious of and can monitor only the contents of working memory. All other cognitive functioning is hidden from view unless and until it can be brought into working memory” (Sweller, van Merrienboer, & Paas, 1998, p. 252).

Working memory is limited in that it can only hold limited amount of information for a limited amount of time. Miller (1956) demonstrated that only about 7 (±2) elements of information can be hold in working memory at a time. Nevertheless, the size of those elements can vary widely in size (Driscoll, 2005), thus, working memory capacity may be increased through creating larger bits of information, known as the process of *chunking*. Moreover, while working memory can store about 7 elements, it can only deal with two or three elements simultaneously when the task is to process rather then merely hold information (Sweller, van Merrienboer, & Paas, 1998).

Schema Construction

According to schema theory, schemas are used to store knowledge in long-term memory. Unlike the limited capacity of short-term memory, long-term memory can store unlimited amount of information. A schema is "a data structure for representing the generic concepts stored in memory" (Rumelhart, 1980, p. 34). Schemas, which form domain specific knowledge, is a major factor distinguishing experts from novices in problem solving skills (Sweller, 1988). For example, de Groot (1966) found that expert chess players remember chess positions as single elements and encode them as a single chunk. Moreover, Chase and Simon (1973) demonstrated that this difference was not due to superiority in terms of their working memory; expert chess players were not better in remembering the board configuration when it was random, but only when it was taken from real games. Hence, expert chess players do not need to search for good moves using limited working memory. Rather, they use their knowledge of as many as 100,000 board configurations (Chase & Simon, 1973) and their knowledge of the appropriate move for each configuration. Other studies have demonstrated that the major distinction between novice and expert problem solvers is knowledge of an enormous number of problem states and their associate moves (see Sweller, van Merrienboer, & Paas, 1998). Thus, intellectual ability relies on schemas stored in long-term memory, rather then an ability to engage in long, complex chains of reasoning in working memory.

In addition to providing a mechanism for knowledge organization and storage, schemas also help reduce working memory load. As mentioned before, working memory can only hold about seven elements at a time; however the size of each element can vary. Once a schema has been constructed, the interacting elements are incorporated and the schema can act as a single element in working memory and therefore will require minimal working memory demands, especially if it is automated (Sweller, van Merrienboer, & Paas, 1998). Even a high complex schema can be dealt with as only one element in working memory (van Merrienboer & Sweller, 2005).

Reducing Extraneous Cognitive Load

Extraneous cognitive load refers to the cognitive load caused by the way in which the materials are presented. Based on the assumption that extraneous cognitive load is not necessary for learning, traditional approaches for reducing cognitive load focused on different ways to reduce the extraneous cognitive load of instructions. Sweller et al. (1998) summarized the main effects that can be used to reduce extraneous cognitive load, which include the following: (1) worked example effect - use worked example rather than conventional problems, (2) the completion problem effect - provide a partial solution that must be completed by the learners, (3) the split attention effect - a single integrated source of information is better than multiple sources of information, (4) the modality effect - a multimodal source of information like spoken text and a visual source are better than a unimodal source of information like written text and visual source, and (5) the redundancy effect - one source of information is better than multiple self-contained sources (Mayer & Moreno, 2003). Nevertheless, those methods to decrease extraneous cognitive load may not be sufficient in the case of real-world complex problems where the intrinsic cognitive load may be too high for novice learners; not leaving them enough resources for schema construction. Thus, it is also necessary to find methods to decrease intrinsic cognitive load.

Reducing Intrinsic Cognitive Load

Intrinsic cognitive load refers to the load caused by the intrinsic nature of materials. The degree of intrinsic cognitive load is a function of the “number of elements that must be processed simultaneously in working memory, which depends on the extent of element interactivity” (Sweller, van Merrienboer, & Paas, 1998, p. 259). It should be noted that a large number of interacting elements that might overload working memory for one person might be a single element for more experienced person. Thus, intrinsic cognitive load may be very high for problem solving; especially when the learner does not poses relevant schemas. In the early stages of CLT, it was believed that intrinsic cognitive load is a characteristic of the task to be learned and cannot be changed by instruction: “Intrinsic cognitive load cannot be altered by instructional interventions because it is intrinsic to the material being dealt with" (Sweller, van Merrienboer, & Paas, 1998, p. 259). Nevertheless, development in CLT led to new instructional approaches that aim to reduce the intrinsic cognitive load of the task.

Authentic tasks, which are often characterized by high element interactivity, can help the learner construct schemata not only of all the components of the tasks but also of the way the different components interact with and relate to each other. Authentic tasks are viewed by many instructional theories as the basis for complex learning (A. Collins, Brown, & Newman, 1989; Jonassen, 1999; Merrill, 2002b; Sweller, van Merrienboer, & Paas, 1998). The main risk of those approaches is that the learner may be exposed to extremely high levels of cognitive load when trying to solve an authentic real-world problem. As mentioned previously, using highly complex learning tasks from the start has negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998).

Instructional theories developed in the 1960s and 1970s typically advocate the use of part-task approaches to prevent overloading the learners with complex problems at an early stage (Reigeluth, 1983; van Merrienboer, Kirschner, & Kester, 2003). *Part-task* approaches separate the different components of the complex task and teach them separately. Although sometimes the learners are given the opportunity to put together several of the steps during the course of the program, only when the learners reach the end of the instructional unit do they get the opportunity to practice the whole task. Even though this strategy can be beneficial (Pollock, Chandler, & Sweller, 2002) it was found that part-task approaches do not work well for complex performances that requires integration of skills, knowledge, and attitudes (Goettl & Shute, 1996; Peck & Detweiler, 2000; van Merrienboer, 1997; van Merrienboer, Kirschner, & Kester, 2003). Based on the part-task approach the intrinsic cognitive load of the materials should be reduced by eliminating the interactions among the information elements until the learners master all of the separate elements.

Whole-task approaches, on the other hand, attend to the coordination and integration of constituent skills from the very beginning. The learner develops first a holistic vision of the task (the global skills) and only afterwards the local skills (van Merrienboer, Kirschner, & Kester, 2003). Both the part-task and the whole-task approaches aim to reduce intrinsic cognitive load by manipulating the level of interactions among the elements. However, while the part-task approach is doing that by first eliminating the interactions and then presenting them at the end, the whole-task approach progresses from a simplified version of the interactions (i.e. simplified version of the whole-task) to a more complex version of the task that includes more complex interactions.

Cognitive Load and the Expertise Reversal Effect

In general, according to CLT, effective instruction should aim to reduce the cognitive load experienced by learners, thus preventing cognitive overload. However, a line of research within CLT has found that the positive effect of reducing cognitive load on learning is only true for learners with very low level of knowledge or skills (i.e., novices) (Kalyuga, 2007). It was found that when learners' level of expertise increases, this effect disappears and eventually reversed. This phenomena is referred to as the *expertise reversal effect* (Kalyuga, Ayres, Chandler, & Sweller, 2003). While for novices external cognitive load may be caused by insufficient guidance that forces them to search for answers using cognitively inefficient procedures, for experts, external support may overlap with already existing knowledge base forcing them to waist limited resources on redundant information. Thus, whether cognitive load is extraneous or intrinsic may depend on the learner's level of expertise: some strategies that may reduce intrinsic cognitive load for novices may be irrelevant and therefore increase extraneous cognitive load for more experienced learners (Kalyuga, 2007).

All types of cognitive load, including extraneous, internal, and germane, were found to contribute to the expertise reversal effect. For example, it was found that the split-attention and the redundancy effects, both used as guidelines for reducing extraneous cognitive load, reversed as learner gain more expertise. In accordance to the split-attention effect, novices learned best from textual explanation that were embedded into the electrical writing diagrams. Nevertheless, this effect decreased while the effectiveness of the diagram alone condition increased as learners gained more expertise (Kalyuga, Chandler, & Sweller, 1998). With respect to the worked examples effect (Sweller, 1988), Kalyuga et al. (2001) found that the superiority of worked examples over problem-solving practice disappeared as trainees acquired more experience. Likewise, Cooper et al. (2001) found that more knowledgeable students who held prerequisite schemas benefited more from imagining procedures and relations, whereas less knowledgeable students benefited more from worked examples.

Implications for Complex Problems Instruction

In summary, teaching complex problem solving can be challenging since the nature of such tasks usually involve high levels of element interactivity which may overload working memory. The challenge increases further when novice learners do not have any established schemas to rely upon. Taking CLT into consideration, the goal of instructional design should be construction and automation of schemas while taking into consideration working memory constraints and individual differences.

Motivational Considerations

According to Mayer (1998) effective instructions for problem solving should address three components: skill, metaskill, and will. This approach suggests that a focus solely on teaching problem solving skills and metaskills is incomplete, because it ignores the problem solver's attitudes and interest in the problem. Thus, addressing motivational aspects of cognition, or the problem solver's will, is necessary for successful problem solving (see alsoRenninger, Hidi, & Krapp, 1992).

Social Cognitive Theory

Grounded in reinforcement theory, behavioral models of motivation assume that behavior is caused by environmental events external to the person and is determined by its consequences (Stipek, 2002). Likewise, models that focus on individual reactions to computing technology such as Diffusion of Innovation (DOI) and the Technology Acceptance Model (TAM) focus on the perceived outcome of using the technology (e.g., perceived usefulness and perceived ease of use) as the main source of motivation (Compeau, Higgins, & Huff, 1999; Davis, Bagozzi, & Warshaw, 1989; Venkatesh & Davis, 1996). Nevertheless, others' expectations of positive outcomes of a behavior may be meaningless if they doubt their potential to successfully perform the behavior in the first place (Compeau, Higgins, & Huff, 1999). In other words, a behavior might be expected to result in positive outcomes, yet not be undertaken due to a doubt in the ability to successfully execute the behavior.

Taking that into consideration, Social Cognitive Theory (Bandura, 1977a, 1986) is based on the premise that people are not entirely regulated by external forces. Instead, the effects of the environment on human behavior are assumed to be mediated by cognitions with a continuous reciprocal interaction between the environment in which an individual operates, personal factors, and behavior (Bandura, 1986). Bandura referred to this relationship as "triadic reciprocality" (see figure 2.3), for example, behavior is influenced by cognitive and personal factors, but also affects those same factors. Bandura addresses two groups of expectations as the major cognitive forces influencing behavior. The first group of expectations refers to outcomes. People are more likely to undertake behaviors they believe will result in positive outcomes as opposed to negative outcomes. The second group of expectations refers to beliefs regarding one's ability to successfully execute a particular behavior, or what Bandura refers to as *self-efficacy*. According to Bandura (1986), self-efficacy influences choices regarding which behavior to undertake, the effort put in completing the task on hand, and ultimately the mastery of the behavior (Compeau & Higgins, 1995b).

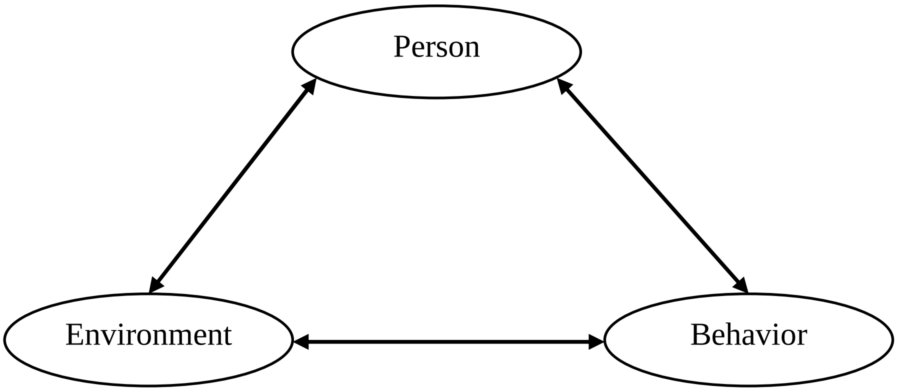


Figure 2.3 Bandura's Triadic Reciprocality

Self-Efficacy

Self-efficacy refers to the belief that one is capable to execute situational demands (e.g., Bandura, 1977a, 1986; Wood & Bandura, 1989). Bandura (1986, p. 391) defines self-efficacy as "People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not only with the skills one has but with judgments of what one can do with whatever skills one possesses". In addition "competent functioning requires both skills and self-beliefs of efficacy to use them effectively" (Bandura, 1986, p. 391). Self-efficacy is domain specific, thus, a person can have high self-efficacy in one domain and low self-efficacy in another domain (Bandura, Barbaranelli, Caprara, & Pastorelli, 1996).

In learning situations, high self-efficacy is associated with high goal setting (Zimmerman & Bandura, 1994), choice of more difficult tasks (Sexton & Tuckman, 1991), longer persistent at tasks (Bouffard-Bouchard, 1990), use of constructive strategies for learning (Pintrich & De Groot, 1990), positive emotions and reduced fear and anxiety (Zimmerman, 1995), all of which affect achievement outcomes. Moreover, self-efficacy was found to be more predictive than actual skills on achievement behavior (J. Collins, 1982).

According to Bandura (1986), judgments of self-efficacy are based on four principal sources of information. First, *actual experience* is according to Bandura the most important source. Nevertheless, the relationship between objective experience and self-efficacy is not simple. For example, previous success may not attribute to efficacy if the student attributes success to external factors such as luck. Second, *vicarious experiences* of observing the performance of others affect self-perceptions of efficacy. Vicarious experiences are in particular influential in situations in which people have little personal experience with the task. Third, *verbal persuasion* such as encouragement and types of social influence also influence self-efficacy judgments. Finally, one's *psychological state* can also affect judgment of self-efficacy. For example, a high state of anxiety may reduce a student's confidence and perception of efficacy, especially if the student has previous experience where anxiety affected performance. Lower perception of efficacy can, in turn, increase anxiety even higher (Stipek, 2002).

Self-Determination Theory

Related to self-efficacy, the importance of competence is emphasized by intrinsic motivation theory. This theory presumes human beings have an intrinsic need to feel competent, are naturally inclined to practice newly developing competencies, and that practicing those new skills is inherently satisfying (Piaget, 1926; Stipek, 2002; R. W. White, 1959). According to self-determination theory (SDT), human beings can be proactive and engaged, or alternatively, passive and alienated, depending on the social conditions in which they develop and function (Ryan & Deci, 2000).

Cognitive evaluation theory (CET), a sub theory within SDT, specifies factors that influence intrinsic motivation. CET proposes that events and conditions that enhance a person's sense of *autonomy* and *competence* support intrinsic motivation, whereas events and conditions that reduce perceived autonomy or competence weaken intrinsic motivation

(Deci & Ryan, 1985). *Autonomy* concerns a sense of volition or willingness when doing a task. Giving the learner choice have been shown to enhance autonomy and, in turn, intrinsic motivation (e.g., Lahey, Hurlock, & McCann, 1973). *Competence* concerns the need for challenge and feeling of efficacy. Thus, factors that increase the experience of competence (e.g., opportunities to successfully execute a behavior) enhance perceived competence, and, in turn, intrinsic motivation.

Interest Theory

Related to intrinsic motivation is the concept of interest. According to interest theory, "students think harder and process the material more deeply when they are interested rather than uninterested" (Mayer, 1998, p. 57). In contrast to an effort-based approach, an interest-based approach assumes that when a student "goes at a matter unwillingly [rather] than when he goes out of the fullness of his heart" the result is "dull, mechanical, unalert, because the vital juice of spontaneous interest has been squeezed out" (Dewey, 1913, p. 3). According to Dewey, the educators justify an effort-based approach, using methods such as drill-and-practice because "life is full of things not interesting that have to be faced" (Dewey, 1913, p. 3).

Research shows that there is a persistent correlation between interest in a school subject and achievement in that subject (Shiefele, Krapp, & Winteler, 1992). Students' engagement in tasks can be increased by giving them interesting materials. Nevertheless, according to interest theory simply adding interesting materials that are not directly relevant to the information to be taught may increase interest but not learning, and as Dewey put it "when things have to be made interesting, it is because interest itself is wanting" (Dewey, 1913, pp. 11-12). Adding seductive details (e.g., irrelevant images or text) may not improve learning although the details themselves were well remembered (Wade, 1992). For example, Harp and Mayer (1998) found that any type of seductive information (textual, visual, or both) led to significantly worse recall and problem-solving performance results compared to the base text condition. While seductive details such as personal anecdotes may increase interest, they also increase required attention and working memory, which could otherwise be devoted to essential information (Wade, 1992).

According to Mayer (1998), effort theory and interest theory have very different educational implications. While effort theory is most consistent with the practice of teaching skills separately, interest theory is consistent with teaching skills in context, which can be implemented by using real world tasks.

Implications for the instruction of complex problems

In summary, many studies have demonstrated how motivational factors such as self-efficacy, competence, and interest can influence how students learn to solve problems in an academic setting (Mayer, 1998). Addressing the motivational aspects is important for developing instruction in general, and for that purpose Keller (1983) has developed a model for motivational design, known as the ARCS model. Keller proposed four conditions for motivation that must be met: A-attention, R-relevance, C-confidence, and S-satisfaction. Nevertheless, implementing those recommendations in the context of complex problem solving can be challenging. On the one hand, interest theory is consistent with teaching skills in context, for example by using authentic tasks. On the other hand, exposing the students to problems that are too complex can be detrimental to their sense of self-efficacy. Thus, instructions should have personally meaningful contexts, while keeping in mind the students' perceived sense of self-efficacy and confidence.

Instructional Approaches for Problem Solving: Overview

The purpose of this section is to examine the extent to which prominent instructional theories take into consideration the CLT and motivational factors described above are and consequently their appropriateness for problem solving learning.

Reigeluth (1983, p. 352) defined instructional theory as “identifying methods that will best provide the conditions under which learning goals will most likely be attained”. The goal of instructional theory according to Reigeluth (1999, p. 11) is “to attain the highest possible probability of the desired results”. According to Driscoll (2005), while learning theory specifies the link between what is learned and the certain conditions that accompany the learning, instructional theory adds the component of instructional method to the existing equation (see Figure 2.4).

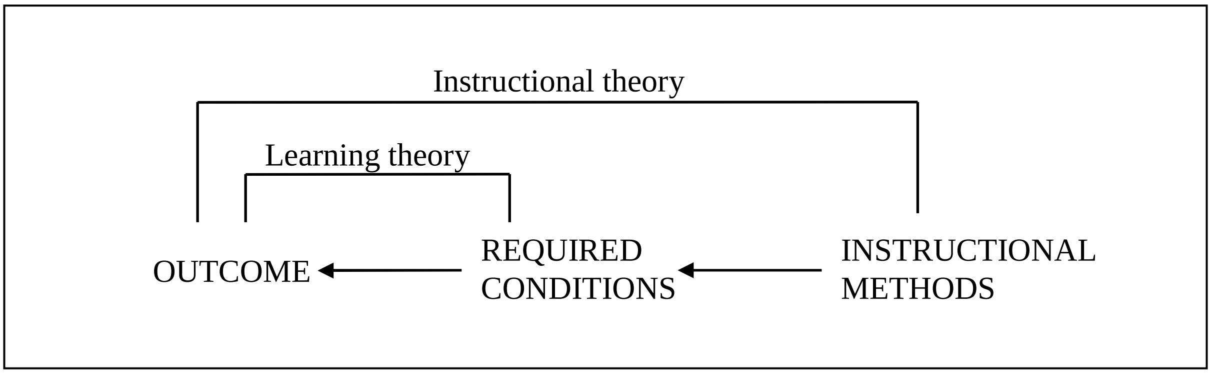


Figure 2.4 The Relationship between Instructional Theory and Learning Theory (Driscoll, 2005)

Next, three distinct instructional design approaches are presented starting with traditional instructivist instructional design theories with a focus on Gagné’s theory of instruction (Gagné, 1985), continuing to describe the constructivist instructional approach with a focus on Jonassen’s constructivist learning environment (Jonassen, 1999), and finishing with recent models that combine direct learning (a main characteristic of traditional instructional theories) with a whole-task approach (a main characteristic of constructivism), focusing upon Merrill’s task-centered instructional strategy (Merrill, 2007b) and van Merrienboer’s 4C/ID model (van Merrienboer, 1997). For each instructional theory its assumptions regarding learning outcomes, the required conditions for learning, and finally its suggested instructional methods are presented. Then, the extent to which each instructional approach considers CLT and motivational factors and consequently is appropriate for problem solving learning is examined.

Traditional Instructivist Instructional Theories

As mentioned previously, instructional theories developed in the 1960s and 1970s typically advocate the use of part-task approaches to prevent overloading the learners with complex problems at an early stage (Reigeluth, 1983; van Merrienboer, Kirschner, & Kester, 2003). A recurring theme of such instructional approaches is to break the task down into a collection of “instructional objectives”. By mastering each objective the student should be able to complete the larger task. In 1934, Ralph Tyler wrote that objectives must be defined in terms that specify the behaviors to be taught in a course (Reiser & Dempsey, 2002). The programmed instruction movement also identified objectives for learners to attain via instructional materials. Guidelines for such materials include presenting instructions in small steps, including learners’ response followed by feedback, and allowing for learner self-pacing (Skinner, 1954, 1958). Following this trend, Bloom et al. (1956) also developed a taxonomy of learning objectives.

A prominent model following this approach is Gagné’s theory of instruction (Gagné, 1985). One of the fundamental assumptions of Gagné’s approach to instructional design is that different learning outcomes necessitate different conditions of learning (Gagné, 1985). Based on this assumption, Gagné developed an instructional theory that combines three major elements: a taxonomy of learning outcomes, specific learning conditions required for the attainment of each outcome, and nine events of instruction (Driscoll, 2005).

First, Gagné presented a taxonomy of learning outcomes that include verbal information, intellectual skill, cognitive strategies, attitudes, and motor skills (see Table 2.1). Building on his work with learning hierarchies (Gagné, 1968), Gagné subdivided intellectual skills into five subcategories hierarchically ordered: discrimination, concrete concepts, defined concepts, rules, and higher order rules. A *learning hierarchy* refers to a set of skills that must be learned before it is possible to learn the complex skill of which they are a part (Gagné, 1985). In the context of problem-solving, a learning hierarchy is a task analysis that results in a hierarchy of subtasks involved in any problem-solving task (Mayer, 1998). Thus, an intellectual skill should be taught by identifying all of its underlying components and supporting the student in mastering each one of them. It is assumed that a student who masters a higher-level task can master all prerequisite tasks in the hierarchy (R. T. White, 1974).

Table 2.1 Gagné's Taxonomy of Learning Outcomes (Driscoll, 2005)

Learning outcome	Definition
1) Verbal Information	Stating previously learned materials such as facts, concepts, principles and procedures.
2) Intellectual skills	
Discrimination	Distinguishing objects, features, or symbols
Concrete concepts	Identifying classes of concrete objects, features, or events e.g., colors, shapes
Defined concepts	Classifying new examples of events or ideas by their definition must be identified by means of definition
Rules	Applying a single relationship to solve a class of problems e.g., constructing grammatical sentences
Higher order rules	Applying a new combination of rules to solve a complex problem
3) Cognitive strategies	Employing personal ways to guide learning, thinking, acting, and feeling
4) Attitudes	Choosing personal actions (toward things, persons, or events) based on internal states of understanding and feeling
5) Motor skills	Executing performances involving the use of muscles

Once instructional goals have been identified in terms of learning outcomes, Gagné identified the conditions required for each skill, knowledge, or attitude (see Table 2.2). It is important to note that the conditions listed below represent the external conditions essential for learning. In other words, from the CLT perspective, those conditions correspond with strategies to reduce extraneous cognitive load. Nevertheless, Gagné also acknowledges the existence of internal conditions of learning that correspond with intrinsic cognitive load. For example, limitations of short-term memory and learners' prior knowledge are considered to be internal conditions.

Table 2.2 A Summary of Gagné Conditions of Learning (Gagné & Driscoll, 1988)

Type of learning outcome	Critical learning condition
Verbal information	1. Draw attention to distinctive features by variations in print or speech 2. Present information so that it can be made into chunks 3. Provide a meaningful context for effective encoding of information 4. Provide cues for effective recall and generalization of information
Intellectual skills	1. Call attention to distinctive features 2. Stay within the limits of working memory 3. Stimulate the recall of previously learned component skills 4. Present verbal cues to the ordering or combination of component skills 5. Schedule occasions for practice and spaced review 6. Use a variety of context to promote transfer
Cognitive strategy	1. Describe or demonstrate the strategy 2. Provide a variety of occasions for practice using the strategy 3. Provide information feedback as to creativity or originality of the strategy or outcome
Attitudes	1. Establish an expectancy of success associated with the desired attitude 2. Assure student identification with an admired human model 3. Arrange for communication or demonstration of choice personal action (i.e., provide vicarious experience). 4. Give feedback for successful performance, or allow observation of feedback in the human model
Motor skills	1. Present verbal or other guidance to cue the executive subroutine 2. Arrange repeated practice 3. Furnish immediate feedback as to the accuracy of performance 4. Encourage the use of mental practice

Finally, Gagné (1985) proposed the nine events of instructions as a mean to activate processes that are relevant for learning (see Table 2.3). Those processes include attention, pattern recognition, retrieval, rehearsal, and retention as well as executive control processes such as modifying the information flow and setting priorities for the processes (Driscoll, 2005).

Table 2.3 Gagné’s Nine Events of Instruction Associated with the Internal Learning Process they Support (Gagné & Medsker, 1996)

Internal process	Instructional event	Action
Reception	1. Gaining attention	Use abrupt stimulus change
Expectancy	2. Informing learners of the objective	Tell learners what they will be able to do after learning
Retrieval to working memory	3. Stimulating recall of prior learning	Ask for recall of previously learned knowledge or skills
Selective perception	4. Presenting the content	Display the content with distinctive features
Semantic encoding	5. Providing “learning guidance”	Suggest a meaningful organization
Responding	6. Eliciting performance	Ask learner to perform
Reinforcement	7. Providing feedback	Give informative feedback
Retrieval and reinforcement	8. Assessing performance	Require additional learner performance with feedback
Retrieval and generalization	9. Enhancing retention and transfer	Provide varied practice and spaced reviews

Cognitive Load Considerations

Even though Gagné presented his instructional theory prior to Sweller’s conceptualization of CLT, Gagné used methods to reduce both external and internal cognitive load. Regarding external cognitive load, in accordance with schema theory and CLT (Sweller, 1988), Gagné proposed that learners organize their knowledge in themes or schemata which then provide the necessary foundation for acquiring related information as well as solving problems (Driscoll, 2005). Accordingly, his conditions of learning include techniques that aim to reduce the load of working memory (e.g., “Present information so that it can be made into chunks”, “Stay within the limits of working memory”, “Stimulate the recall of previously learned component skills.”, and so on).

Regarding intrinsic cognitive load, Gagné’s theory as well as other theories that advocate instructional objectives (e.g., Bloom, Englehart, Furst, Hill, & Krathwohl, 1956; Skinner, 1958), use a part-task approach to reduce intrinsic cognitive load. In part-task approaches complex tasks are broken into smaller parts that are trained separately assuming that by the end of instructions the learners should be able to perform the whole-task. While this strategy can be beneficial (Pollock, Chandler, & Sweller, 2002), it was found that part-task approaches may not work well for complex performances that requires integration of skills, knowledge, and attitudes (Goettl & Shute, 1996; Peck & Detweiler, 2000; van Merrienboer, 1997; van Merrienboer, Kirschner, & Kester, 2003). Furthermore, while the main assumption of a learning hierarchy is that a student who masters a higher-level task has mastered all prerequisite tasks in the hierarchy, the direction of this assumption only holds for one way. Thus, students often are able to master all prerequisite tasks but still fail to master the corresponding higher-level task (Mayer, 1998).

Motivational Considerations

With respect to motivational considerations, Gagné's taxonomy of learning outcomes includes "attitude" as an outcome by itself. Returning to Bandura's social cognitive theory (Bandura, 1977a, 1986), Bandura addressed two groups of expectations one referring to outcomes and the other referring to beliefs regarding one's ability to successfully execute a task, or in other words self-efficacy. Self-efficacy is based on four principal sources of information: actual experience, vicarious experiences, verbal persuasion, and psychological state.

In accordance with social cognitive theory, Gagné's conditions of learning for attitudes include improving outcome expectations (e.g., "Establish an expectancy of success associated with the desired attitude"), improve self-efficacy though vicarious experiences (e.g., "assure student identification with an admired human model" and "arrange for communication or demonstration of choice personal action"), and verbal persuasion (e.g., "give feedback for successful performance, or allow observation of feedback in the human model"). Nevertheless, Gagné did not specifically address the learner's experience and psychological state such as anxiety as means to increase self-efficacy within the conditions for learning. Yet, Gagné includes actual experiences in the nine events of instructions ("6. Eliciting performance"). Moreover, attitude is regarded as a separate learning outcome (e.g., choosing personal actions), and it is not explicit that the learner's attitude may play an important role in learning higher order rules and therefore should be considered as part of the conditions of higher order rules.

With respect to interest theory, according to Mayer (1998), teaching skills in isolation is more consistent with effort theory whereas teaching skills in context is more consistent with interest theory. Therefore, implementing a part-task approach such as Gagné's might be less interesting then using real world tasks. Such alternative instructional approaches are discussed next.

Appropriateness for Problem Solving

Even though part-task approaches are effective for reducing cognitive load, Naylor and Briggs (1963) indicated in the 1960s that they are not very suitable for teaching complex problem solving. It appears that part task approaches work well for skills that can be mastered in less than 20-40 hours, or for skills that are not characterized by integrated sets of constituent skills (van Merrienboer, 1997; Wightman & Lintern, 1985). Moreover, as noted by Mayer (1998), mastering each component skill is not enough to promote non-routine problem solving. Additional two prerequisites for problem solving include the ability to control and monitor cognitive processes, or metaskills, and the problem solver's will (Mayer, 1998). While those additional prerequisites appear in Gagné conditions for learning as cognitive strategies and attitudes, it is not clear that they are an integral part of problem solving, or in Gagné's terminology, higher order rules. Finally, as noted by Jonassen (2000b), even though Gagné acknowledged problem-solving as a difficult task, it is not considered as an outcome by itself on Gagné taxonomy; "a higher order rule is still a rule and differs only in complexity from the simpler rules that compose it" (Gagné & Driscoll, 1988, p. 52).

Constructivism

According to van Merrienboer (1997) there has been a shift in the field of instructional design from instructivist approaches towards constructivist approaches. Instructivist approaches correspond to the epistemological beliefs of objectivism, assuming that the role of knowledge is to represent the real world, and that reality is objective. Thus, meaning is determined by the real world and is external to the learner. It is also assumed that knowledge can be transferred or transmitted from teachers or other technologies to the learners. Gagné's instructional theory as well as other instructional theories described in the previous section (e.g., programmed instruction) represent instructivist approaches.

Constructivist approaches on the other hand are based upon the epistemological foundation of interpretivism, assuming that the role of knowledge is to reflect our personal understanding and beliefs about the real world, and that reality is constructed, multiple, and holistic (Driscoll, 2005). According to constructivism, the construction of cognitive schemata results from both interaction with the world and past experiences and beliefs (van Merrienboer, 1997). Thus, knowledge is subjective and the knowledge of different learners may represent a different reality. Importantly, it is also assumed that knowledge cannot be transmitted; therefore, instruction should include experiences that facilitate knowledge construction.

Considering learning goals, unlike the objectivist approach that focuses on analyzing and defining the objectives that the learner must know, the constructivist approach emphasizes learning in context. As stated by Jonassen (199), "The fundamental difference between constructivist learning environments and objectivist instruction is that the problem drives the learning, rather than acting as an example of the concepts and principles previously taught. Students learn domain content in order to solve the problem, rather than solving the problem as an application of learning" (Jonassen, 1999, p. 218). Moreover, unlike objectivists, constructivists also believe learners should identify and pursue their own learning goal. Consequently, constructivist conditions for learning emphasize the use of rich, realistic, authentic learning environment that consist of social negotiation and encourage ownership in learning (see Table 2.4).

Table 2.4 Constructivist Conditions for Learning (Driscoll, 2005)

	Conditions for learning
1.	Embed learning in complex, realistic, and relevant environments
2.	Provide for social negotiation as an integral part of learning
3.	Support multiple perspectives and the use of multiple modes of representation.
4.	Encourage ownership in learning.
5.	Nurture self-awareness of the knowledge construction process.

Practical constructivist educational approaches that focus on authentic tasks include the case-based method (e.g., Williams, 1992), problem-based learning (Hmelo-Silver, 2004), open-ended learning environment (OELE) (Hannafin, Hall, Land, & Hill, 1994), goal-based scenario (GBS) (Schank, Berman, & MacPerson, 1999), cognitive apprenticeship learning

(A. Collins, Brown, & Newman, 1989) and collaborative problem solving (Nelson, 1999). Jonassen (1999) presented a generic model for designing constructivist learning environment (CLE), which describes the essential components that should be included in such an environment (see Figure 2.5).

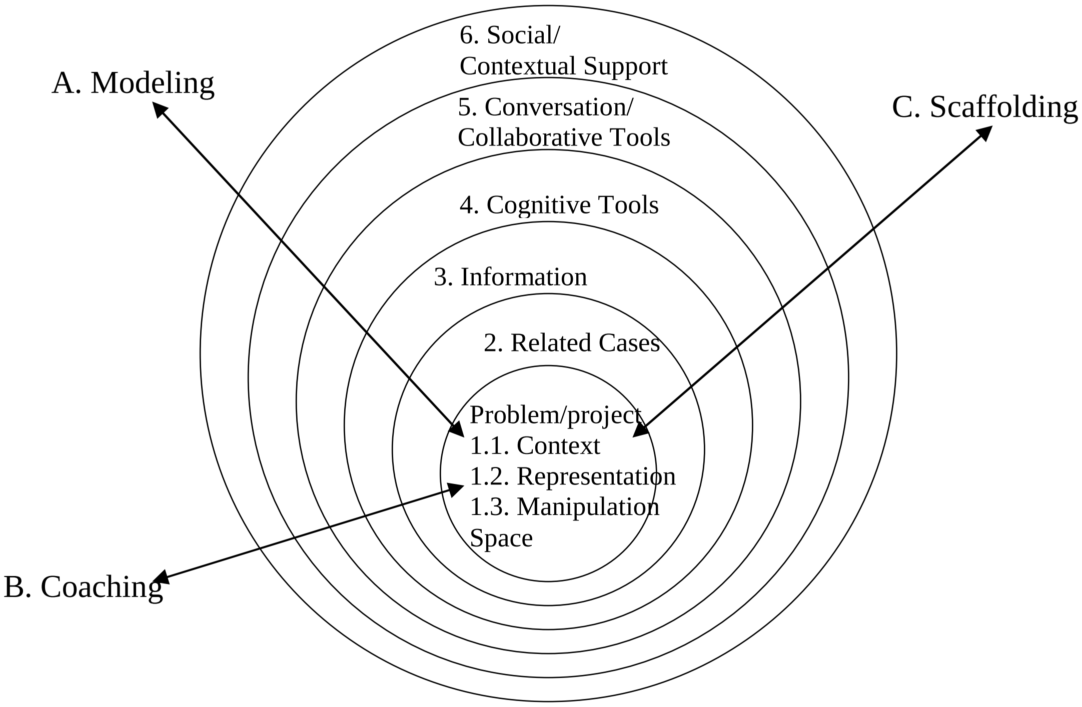


Figure 2.5 Jonassen's Model for Designing Constructivist Learning Environments (CLE) (Jonassen, 1999)

According to Jonassen (1999, p. 218) "the focus of any CLE is the question or issue, the case, the problem, or the project that learners attempt to solve or resolve". Thus, the model starts with a problem as the focus of the environment, with support systems surrounding it. Those systems include related cases and information resources to support understanding, cognitive tools (e.g., visualization tools) to help learners interpret and manipulate aspects of the problem, conversation/collaborative tools (e.g., discussion boards) to enable communities of learners negotiate and construct meaning, and social/contextual support systems (e.g., workshops for teachers) to help users implement the CLE. In addition, learners should be provided with instructional support through modeling, coaching, and scaffolding.

Cognitive Load Considerations

With respect to cognitive load considerations, constructivist learning environments call for complex, realistic, and relevant environments. Even though Jonassen (1999) included recommendations for task difficulty adjustment in the form of scaffolding, he also indicated that "most educators believe that 'authentic' means that learners should engage in activities which present the same type of cognitive challenges as those in the real world" (Jonassen, 1999, p. 221). Moreover, according to many constructivists simplifying tasks for learners will disable them to learn how to solve the complex problems they will face in real life (Driscoll, 2005).

On the one hand, authentic tasks, which integrate different knowledge, skills, and attitudes, can help the learner to construct a schemata, which in turn can reduce working memory load (van Merrienboer & Sweller, 2005). On the other hand, in a real-world complex problem the intrinsic cognitive load may be too high for novice learners and not leave them with enough resources for schema construction. It was found that using highly complex learning tasks from the start have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). This concern was also raised by Dick, "Why are constructivists not concerned that the gap will be too great between the schema of some students and the tools and information that they are provided?" (Dick, 1991, p. 43).

Motivational Considerations

Jonassen's CLE puts a lot of emphasis on motivational issues. In particular, it uses emotional support system in the form of modeling, coaching, and scaffolding (that also provide cognitive support). Returning again to Bandura's social cognitive theory (Bandura, 1977a, 1986), self-efficacy, which is an important factor of motivation, is based on four principal sources of information: actual experience, vicarious experiences, verbal persuasion, and psychological state.

Consistent with the idea of vicarious experiences, modeling provides learners with an example of the desired performance: "carefully demonstrate each of the activities involved in a performance by a skilled (but not an expert) performer" (Jonassen, 1999, p. 231). Another means to support learners is providing them coaching. The motivational role of coaching is consistent with Bandura's idea of verbal persuasion. Using motivational prompts, the coach should boost the learner's confidence levels, especially during the early stages of the problem. Another motivational function of the coach relates to Bandura's idea of outcomes expectancy: "A good coach relates the importance of the learning task to the learner. In case the learners are not immediately engaged by the problem, the CLE coach needs to provide learners a good reason for becoming engaged" (Jonassen, 1999, p. 233). Related to Bandura's idea of actual experience, a third emotional support system suggested by Jonassen is scaffolding, designed to provide temporary frameworks to support learning and student performance beyond the learners' capacity by adjusting task sequencing and difficulty. The system can perform part of the task for the student, change the nature of the task, or impose the use of cognitive tools.

With regard to interest as source of motivation, the use of authentic and relevant problems is very likely to contribute to an interesting learning experience. Furthermore, Jonassen emphasizes the importance of learners' ownership of the problem: "problem should not be overly circumscribed. Rather, it should be ill defined or ill-structured, so that some aspects of the problem are emergent and definable by the learners. Why? Without ownership of the problem, learners are less motivated to solve or resolve it" (Jonassen, 1999, p. 219).

Appropriateness for Problem Solving

In summary, authentic tasks, which are the heart of the constructivist approach, can help the learner to construct a schemata, which can reduce working memory load (van Merrienboer & Sweller, 2005). Moreover, authentic tasks provide an interesting and motivating environment. Even though Jonassen (1999) suggested a cognitive and emotional support system, he also suggested that learners should engage in activities which present the same type of cognitive challenges as those in the real world. Nevertheless, real-world complex problem intrinsic cognitive load may be too high for novice learners and not leaving them enough resources for schema construction.

Acknowledging the assumption of instructional design that different learning outcomes necessitate different conditions of learning, Jonassen (2000b) himself criticized constructivist learning theories stating that "they recommend instructional strategies, such as authentic cases, simulations, modeling, coaching, and scaffolding to support their implicit problem-solving outcomes, but they inadequately analyze or explicate the nature of the problems to be solved." Jonassen also noted that CLEs are not appropriate for all learning outcomes. Furthermore, Jonassen (1997) even recommended an instructivist approach for teaching well-structured problems (see Figure 2.2), noting that while instructional design for well-structured problems is rooted in information-processing theory, instructional design for ill-structured problems shares assumptions with constructivism and situated cognition. Jonassen also noted that “while objectivism and constructivism are usually conveyed as incompatible and mutually exclusive…I prefer to think of them as complementary design tools (some of the best environments use combinations of methods) to be applied in different contexts” (Jonassen, 1999, p. 217). Thus, given that “problem-solving” is not a single outcome but rather there are various types of problems, it is not quite clear what type of instructional strategy should be used for a given problem.

In the next section a new line of instructional strategies that, like constructivism, have authentic problems as the starting point of instruction, yet are closer to the epistemology foundations of instructivism in their preference for direct instruction are presented.

Task-Centered Instructional Approaches for Problem Solving

In this section, two task-centered instructional models, Merrill’s task-centered instructional strategy (Merrill, 2007b) and the four-component instructional design (4C/ID) model (van Merrienboer, 1997; van Merrienboer & Kirschner, 2007) are presented. Those two models share several unique elements that distinguish them from traditional instructional strategies as well as from constructivist instructional strategies. Specifically, both of the models: (a) are specifically designed for the purpose of teaching complex problem-solving skills (b) are a content-centered modification of traditional instructional design in which the contents-to-be-learned are specified first (c) emphasize teaching in the context of concrete real world tasks (d) recommend direct instruction in the context of authentic, real-world problems or tasks.

Merrill’s Task-Centered Instructional Strategy

Merrill’s (2007b) Task-Centered Instructional Strategy brings together several theoretical frameworks to create a multi-strand strategy intended for teaching how to solve real-world problems or for how to complete real-worlds tasks. The frameworks include the first principles of instructions (Merrill, 2002a), the pebble-in-the-pond approach to instructional design (Merrill, 2002c), taxonomy of learning outcomes (Merrill, 1997), and Component Display Theory (Merrill, 1983, 1994). The task-centered instructional strategy as suggested by its name emphasizes teaching in the context of a concrete real world task. At the same time, it is different than the problem-centered instructional methods described in the previous section. “A task-centered instructional strategy is not the same as problem-based learning. A task-centered instructional strategy is a form of direct instruction but in the context of authentic, real-world problems or tasks” (Merrill, 2009, p. 13).

In terms of learning outcomes, Merrill (e.g., 1997) identified five kinds of learning outcomes, each consisting of knowledge and skill components (see Table 2.5). The five learning outcomes include information-about, parts-of, kinds-of (concept), how-to (procedure), and what-happens (process). While instruction can result in each of the five learning outcomes, Merrill noted the only learning outcomes that can be considered as generalizable skills (i.e., skills that can be applied to two or more different specific situations) are concept classification (or kinds-of), executing a procedure (or how-to), and predicting consequences or finding faulted conditions in the executions of a process (or what-happens) (Merrill, 2009).

Table 2.5 Knowledge and Skill Components for Different Learning Outcomes (Merrill, 2007b)

Learning Outcome	**Remember Information (knowledge)**	**Apply Information to Portrayal (skill)**
Info-about	Remember the description of an entity	Given a description recognize a given instance of an entity
Parts-of	Remember the names and description of the parts of an entity	For a given entity, locate the parts in the context of the whole
Kinds-of	Remember the definition – the property values that define a class of entity	Classify examples-identify entity portrayals that belong to a specific class of entity
How-to	Remember the steps- a sequence of action names or descriptions	Do the task- execute the actions in sequence
What-happens	Remember the name, description, conditions and consequence for the process	Given the conditions predict a consequence or given a consequence find missing or faulted conditions

In his Component Display Theory (Merrill, 1983, 1994), Merrill identified four primary instructional strategy forms: presentation (tell), demonstration (show), recall (ask), and apply (do) (see Table 2.6). Those forms can be represented by either information or portrayal (i.e., actual application\example of the information). While information is general, inclusive, and applicable to many specific situations, portrayal is specific, limited, and applicable to one case or a single situation (Merrill, 2007b). Thus, information can be presented (tell) and recalled (ask), and a portrayal can be demonstrated (show) and submitted to application (do).

Acknowledging that "different kinds of knowledge and skill each require different conditions (strategies) for learning" (Merrill, 1997, p. 1), Merrill indicates consistent information and portrayal for each instructional outcome. Effective instructions for each learning outcome should include all the components described in the table. Merrill further defined a *knowledge object*, which is "a framework consisting of containers for different kinds of general information and specific portrayals (the knowledge components) that are required for instruction" (Merrill, 2007b, p. 10). The same knowledge object can then be used for a wide variety of different topics within a subject matter (Merrill, 1998, 2001).

Table 2.6 Component Display Theory: Instructional Strategies for each Instructional Outcome (Merrill, 2007b, 2009)

	INFORMATION		**PORTRAYAL**	
	PRESENT (TELL)	**RECALL (ASK)**	**DEMONSTRATE (SHOW)**	**APPLY (DO)**
Info-about	Tell information	Recall information	-	-
Parts-of	Tell location	Recall location	-	-
Kinds-of	Tell the definition	Recall the definition	Show several specific examples	Classify new examples
How-to	Tell the steps and their sequence	Recall the steps and their sequence	Show the procedure in several different situations	Carry out the procedure in new situations
What-happens	Tell the conditions and consequence involved in the process	Recall the conditions and consequence involved in the process	Show the process in several different situations	Predict a consequence or find faulted conditions in new situations

The first principles of instructions (Merrill, 2002a, 2007a, 2009) emerged as a result of an effort to identify prescriptive instructional design principles that are common to the various instructional design theories regardless of their philosophical orientation. Noting that "instruction in the context of complex, authentic, real-world tasks was critical part of an engaging instructional strategy" (Merrill, 2007b, p. 6), the first principles of instruction describe a cycle of instructional phases consisting of activation, demonstration, application, and integration all within the context of real world problems or tasks (see Figure 2.6). Specifically, the first principles of instructions indicate that: “(1) Learning is promoted when learners are engaged in solving real-world problems, (2) Learning is promoted when existing knowledge is activated as a foundation for new knowledge, (3) Learning is promoted when new knowledge is demonstrated to the learner, (4) Learning is promoted when new knowledge is applied by the learner, and (5) Learning is promoted when new knowledge is integrated into the learner’s world” (Merrill, 2002a, pp. 44-45).

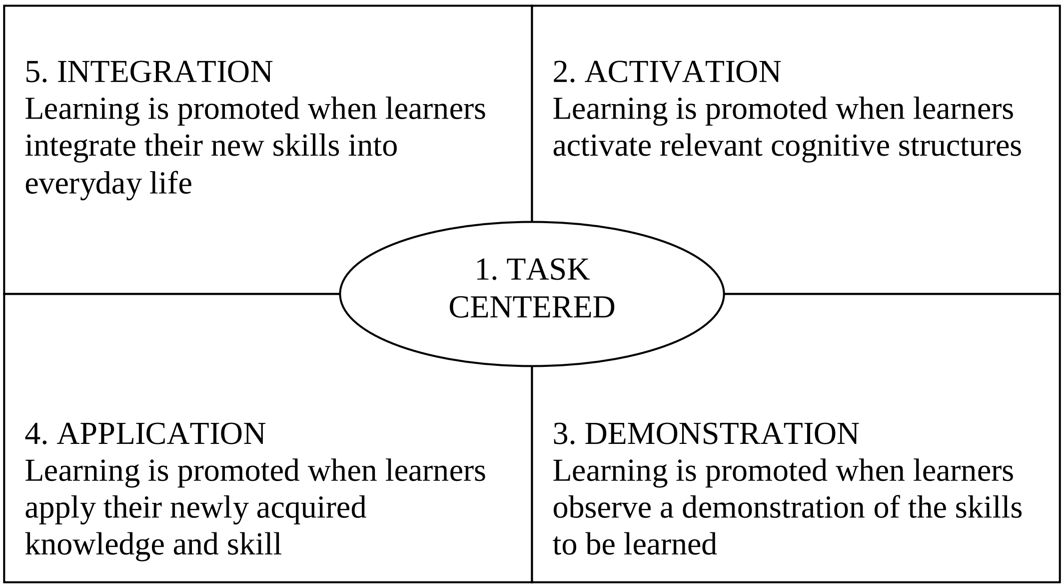


Figure 2.6 Merrill’s First Principles of Instruction (Merrill, 2002a)

The main purpose of component display theory (Merrill, 1983, 1994, 1997) previously described is to provide instructional strategies that are consistent and most effective for the different types of learning outcomes. Component display theory can be implemented successfully within task-centered instructions; nevertheless, since its focus is on teaching individual skills, it is also possible that implementation of its guidelines will eventually result in topic-centered instructions. First principles of instructions (Merrill, 2002a), on the other hand, provide prescriptive instructional design principles with a focus on task-centered strategy; nevertheless, this theory does not provide instructional strategy guidelines with respect to specific learning outcomes. In addition, it is also not obvious how it can be implemented within the framework of more traditional instructional system development (ISD) models. To bridge this gap, the Pebble-in-the-Pond instructional design model (Merrill, 2002c) is a modification of more traditional ISD with a purpose to facilitate integration of the first principles of instructions and component display theory into a task-centered instructional design model. Traditional ISD models start with specifying the objectives during the early analysis phase, while specifying the actual content to be taught occurs only later in the development phase. In contrast, the Pebble-in-the-Pond model specifies the content to be taught in the first step through identifying a collection of real world tasks that will later form the actual content of the instruction (see Figure 2.7).

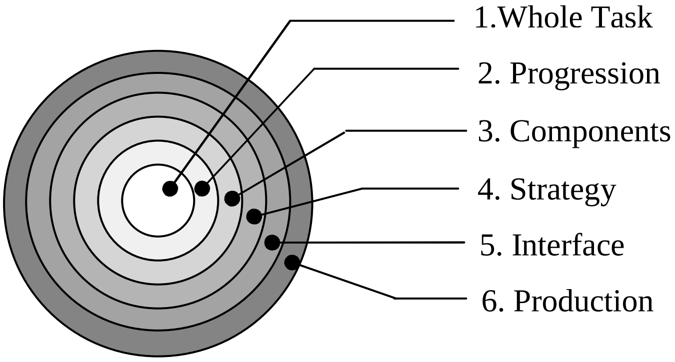


Figure 2.7 Merrill's Pebble-in the-Pond Approach to Instructional Design (Merrill, 2007b)

In the second phase a progression of complete tasks with increasing complexity is specified. In the third phase, using the previously described learning outcomes taxonomy (see Table 2.5), the components knowledge and skills of these tasks are specified. In the fourth phase, component display theory (see Table 2.6) is used to specify the instructional strategy. Figure 2.8 illustrates the traditional topic-centered approach to presenting these components, whereas Figure 2.9 illustrates how the same components can be sequenced around tasks in the task-centered instructional strategy. Thus, in Figure 2.8, the sequence is topic 1 (presentation, presentation, practice, presentation, practice), topic 2 (presentation, practice, presentation, presentation, practice), and so on where in the end there is a final practice that incorporates elements of all the topics. In Figure 2.9 the sequence is task A (presentation of the task, 4 presentations that refer to all the topics, followed by task A that consists of 4 practice elements), task B (presentation of the task, 2 presentations that refer to topic 1 and topic 3 followed by task B that consists of 4 practice elements), and so on.

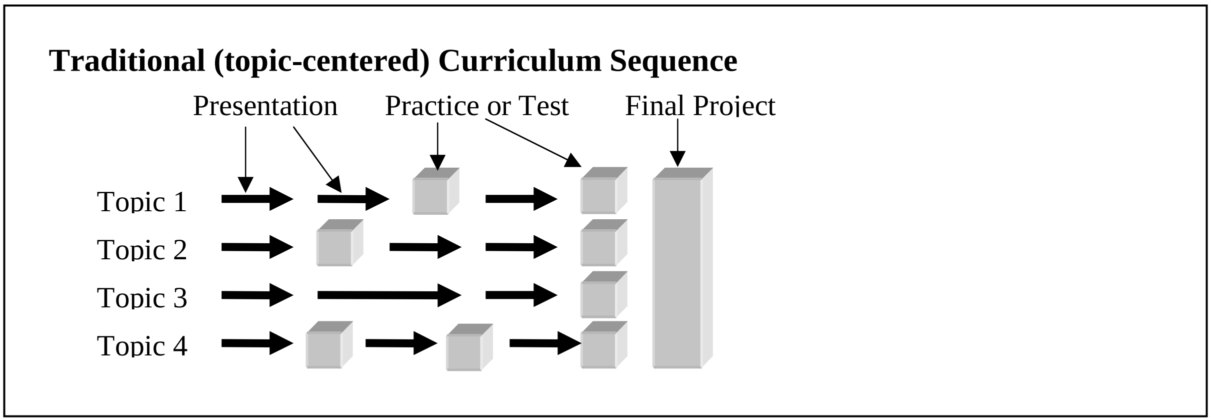
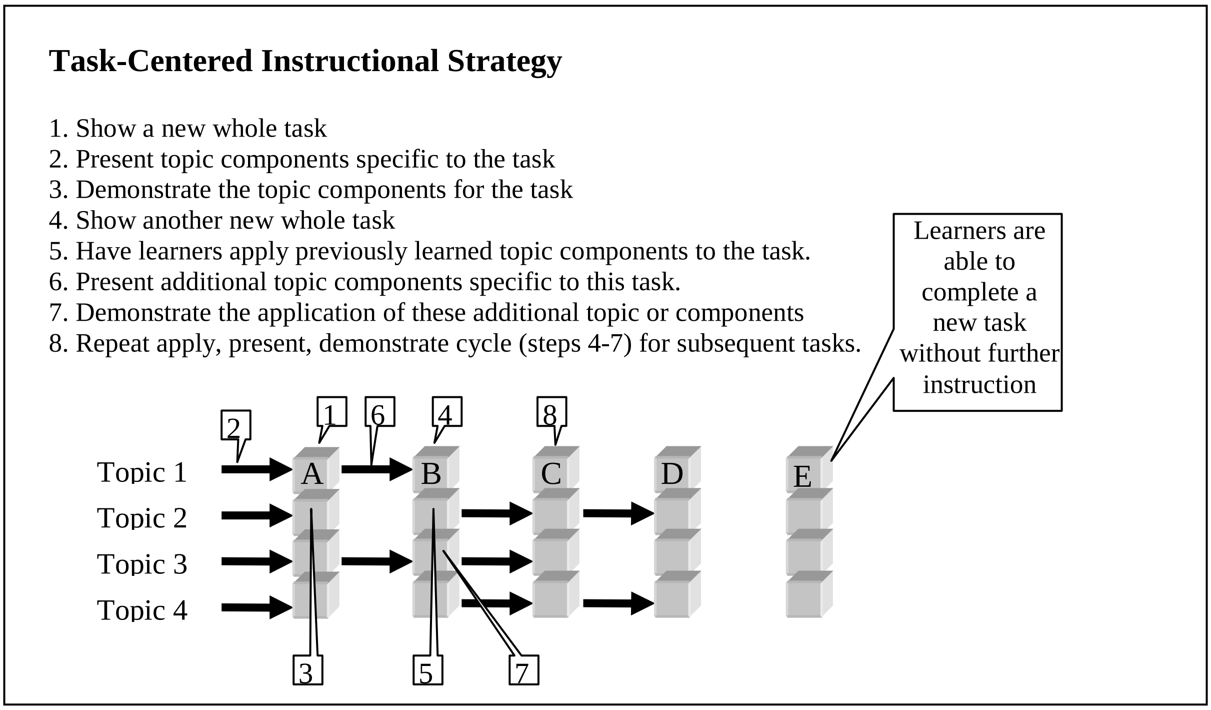


Figure 2.8 Traditional Topic-Centered Instructional Strategy (Merrill, 2007b)



1. Show a new whole task
2. Present topic components specific to the task
3. Demonstrate the topic components for the task
4. Show another new whole task
5. Have learners apply previously learned topic components to the task.
6. Present additional topic components specific to this task.
7. Demonstrate the application of these additional topic or components
8. Repeat apply, present, demonstrate cycle (steps 4-7) for subsequent tasks.

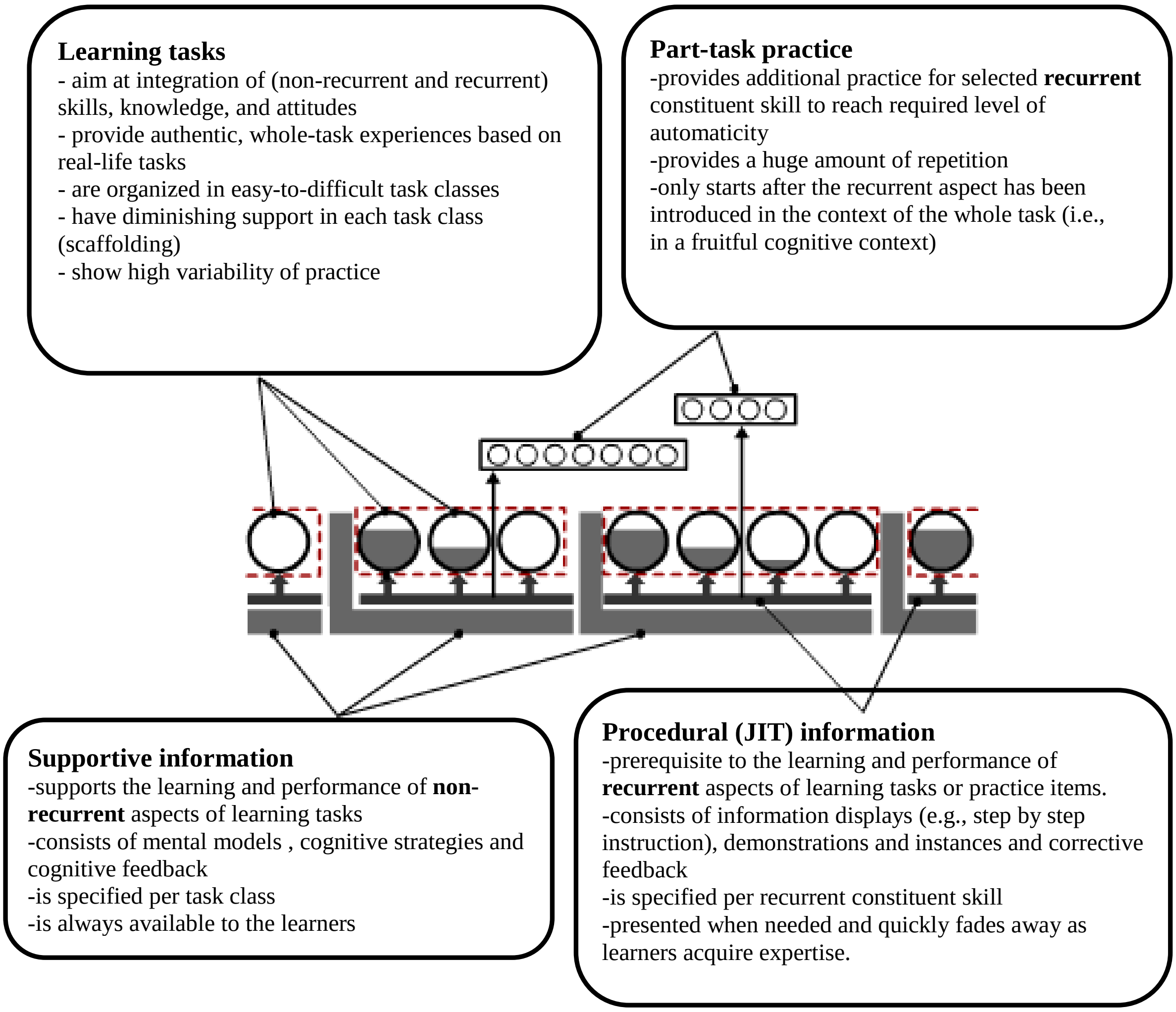
Figure 2.9 Merrill’s Task-Centered Instructional Strategy (Merrill, 2007b)

The Four-Component Instructional Design (4C/ID) Model

The four-component instructional design model (4C/ID-model) was developed specifically for the design of training programs for complex skills (van Merrienboer, 1997). It resembles Merrill’s Pebble-in-the-Pond approach in many aspects and especially in the sense that the contents-to-be-learned and not the abstract learning objectives are specified first. According to van Merrienboer (1997), complex learning is always involved with achieving integrated sets of learning goals (i.e., multiple performance objectives). It has little to do with learning different skills separately as seen in traditional models, but rather with coordinating and integrating the separate skills that comprise real-life task performance. Thus, the 4C/ID model focuses on the integration and coordinated performance of task-specific constituent skills rather than on knowledge types.

Constituent skills are classified as either *nonrecurrent* (novel effortful) or *recurrent* (routine). The fundamental learning process for nonrecurrent skills is *schemata constructions,* whereas the fundamental learning process for recurrent skills is *rule automation*. The combination of those two learning processes promote transfer of learning, or in other words the ability to apply the complex cognitive skill in a wide variety of new real-life situations (van Merrienboer, Clark, & de Croock, 2002). More specifically, *schemata* are constructed through presentation of mental models, cognitive strategies, and cognitive feedback. *Rule automation* is achieved by two processes being *compilation* (learning the rules and procedures) and *strengthening* (achieving automaticity by increasing the strength of a rule each time it is successfully applied) (Anderson, 1983, 1993).

To implement those learning strategies, the 4C/ID model proposes four interrelated components that are central to complex learning. The four blueprint components refer to: (a) learning tasks, (b) supportive information, (c) procedural\just-in-time (JIT) information, and (d) part-task practice (see Figure 2.10).



Learning tasks
- aim at integration of (non-recurrent and recurrent) skills, knowledge, and attitudes
- provide authentic, whole-task experiences based on real-life tasks
- are organized in easy-to-difficult task classes
- have diminishing support in each task class (scaffolding)
- show high variability of practice

Part-task practice
-provides additional practice for selected **recurrent** constituent skill to reach required level of automaticity
-provides a huge amount of repetition
-only starts after the recurrent aspect has been introduced in the context of the whole task (i.e., in a fruitful cognitive context)

Supportive information
-supports the learning and performance of **non-recurrent** aspects of learning tasks
-consists of mental models , cognitive strategies and cognitive feedback
-is specified per task class
-is always available to the learners

Procedural (JIT) information
-prerequisite to the learning and performance of **recurrent** aspects of learning tasks or practice items.
-consists of information displays (e.g., step by step instruction), demonstrations and instances and corrective feedback
-is specified per recurrent constituent skill
-presented when needed and quickly fades away as learners acquire expertise.

Figure 2.10 A Graphical View on the Four Components: (a) Learning Tasks, (b) Supportive Information, (c) Just-in-Time (JIT)\Procedural Information, and (d) Part-Task Practice. Adapted from (van Merrienboer, Clark, & de Croock, 2002) and (van Merrienboer & Kirschner, 2007)

Component 1: Learning Tasks

Schema construction is promoted through *learning tasks*, which are concrete, authentic, whole-task experiences that aim at the integration of skills, knowledge, and attitudes. A sequence of learning tasks (represented as circles in Figure 2.10) provides the backbone of the 4C/ID training model for complex learning. These tasks can take many forms, including case studies, worked-out examples, completion problems, and conventional problems in which the learners need to find the solution themselves. Task classes (represented as dotted rectangles around the circles) are used to define simple-to-complex categories of learning tasks. Learning tasks within the same task class are equivalent to each other in the sense that they can be performed on the basis of the same body of knowledge (i.e., mental models and cognitive strategies). In addition, learning tasks within the same task-class are characterized by high variability (i.e., different problem situations), and by diminishing learner support or "scaffolding" (support is represented by the dark area within each task). Learning tasks promote schema construction of nonrecurrent skills by inductive processing – "constructing schemata through mindful abstraction from the concrete experiences that are provided by the learning tasks" (van Merrienboer, Clark, & de Croock, 2002, p. 43).

Component 2: Supportive Information

The second component, *supportive information*, is described as the body of knowledge that is supportive to the learning and performance of non-recurrent aspects of the learning tasks, which are the aspects that require reasoning or problem solving. It is the information or "theory" which is often presented in study books and lectures. The information should be presented in ways that encourage students to connect newly presented information to already existing schemata, thus, engaging the students in the process of *elaboration*. In concrete terms, this information explains how a domain is organized (i.e., mental models) and how problems in that domain are (or should be) approached (i.e., cognitive strategies). As noted by van Merrienboer, "it provides the bridge between learners' prior knowledge and the learning tasks" (van Merrienboer, Clark, & de Croock, 2002, p. 43). Supportive information is defined per task class rather than per learning task since all learning tasks within the same task class reflect the same body of knowledge. The supportive information provides an addition to or an elaboration of the previous information for each subsequent task class.

Component 3: Procedural Information (Just-in-Time Information)

The third component, *procedural information*, also named *just-in-time information* in earlier versions of the model (van Merrienboer, 1997), is primarily concerned with constituent skills that have been classified as *recurrent*, that is, routine aspects that can be performed according to domain-specific rules or procedures, and that are performed in a highly similar way over different problem situations. Concerned with the process of *rule automation*, procedural information provides step-by-step knowledge that is necessary to perform the recurrent skills (i.e., *compilation*) and is typically provided during the first learning task for which that skill is relevant and then faded away for subsequent learning tasks. The process of forming the rules through practice is facilitated when the relevant information becomes available to the working memory precisely when learners need it, or Just-in-Time (JIT). JIT information is organized in small units called information displays, which help to prevent processing overload during practice. Information displays include description of the rules along with demonstration instances (van Merrienboer, 1997).

Component 4: Part-task Practice

In the last component, *part-task practice*, practice items are provided to learners to help them reach a very high level of automaticity for selected routine aspects of a task, which is typically achieved through huge amounts of repetition and include compilation and subsequent strengthening. Part-task practice only starts after the routine aspect has been introduced in the context of a whole, meaningful learning task (van Merrienboer, Clark, & de Croock, 2002).

The Ten Steps to Complex Learning

The 4C/ID model was formally presented in 1997 in the book *Training Complex Cognitive Skills* (van Merrienboer, 1997). Even though the book was well received in the academic field of learning and instruction, it was criticized by practitioners in the field of instructional design of being hard to systematically design educational programs based on the four components. Consequently, published in 2007, the book *The Ten Steps to Complex Learning* (van Merrienboer & Kirschner, 2007) presents instructional design process that complement the 4C/ID model and that can be more easily used and understood by students, practitioners (both instructional designers and teachers) and researchers. The ten steps and their corresponding component of the 4C/ID are presented in table 2.7. Visiting back on Merrill's Pebble-in the-Pond approach to instructional design (see Figure 2.7) it is interesting to notice a clear resemblance between the models (with the first 3 steps identical). Indeed van Merrienboer and Kirschener noted that "M. David Merrill (2002a) proposed a pebble-in-the-pond approach for instructional design that is fully consistent with the Ten Steps" (van Merrienboer & Kirschner, 2007, p. 33) and that Merrill's pebble-in-the-pond principle was used as a framework for ordering the activities into the Ten Steps (van Merrienboer & Kirschner, 2007).

Table 2.7: Four Blueprint Component of 4C/ID and the Ten Steps (van Merrienboer & Kirschner, 2007)

Blueprint Component of 4C/ID	**Ten Steps to Complex Learning**
Learning Tasks	1. Design Learning Tasks
	2. Sequence Task Classes
	3. Set Performance Objectives
Supportive Information	4. Design Supportive Information
	5. Analyze Cognitive Strategies
	6. Analyze Mental Models
Procedural Information	7. Design Procedural Information
	8. Analyze Cognitive Rules
	9. Analyze Prerequisite Knowledge
Part-task Practice	10. Design Part-task Practice

Cognitive Load Considerations

Similar to constructivism, Merrill’s task-centered instructional strategy and the 4C/ID model use real-world tasks as the backbone of instruction. As mentioned before, authentic tasks, which in nature integrate different knowledge, skills, and attitudes, can help the learner construct a schemata, which can reduce working memory load (van Merrienboer & Sweller, 2005). “Acquiring knowledge and skill components out of context makes it very difficult for learners to form mental models about how this information applies in the real world. Acquiring this skill in the context of whole tasks makes it more likely that learners will form mental models for how these individual skills are integrated into a complete performance” (Merrill, 2007b, p. 15). Nevertheless, in real-world complex problems intrinsic cognitive load may be too high for novice learners; not leaving them enough resources for schema construction (Sweller, van Merrienboer, & Paas, 1998).

To control the *intrinsic cognitive load* associated with real-world problems or tasks, both models propose progression from simple to complex tasks. van Merrienboer and Kirschner (2007, p. 23) indicated that “intrinsic cognitive load is managed by organizing the learning tasks in easy-to-difficult task classes. For learning tasks within an easier task class, less elements and interactions between elements need to be processed simultaneously in working memory; as the task classes become more complex, the number of elements and interactions between the elements increases". Likewise, Merrill (2007b, p. 9) indicated that "in a good progression each succeeding task is more complex than the preceding task…To manage cognitive load it is advisable to introduce only a limited number of new components or revised components for each succeeding task".

In addition, several strategies are proposed by the models to control *extraneous cognitive load*. For example, in the 4C/ID model several recommendations are provided to control extraneous cognitive load: (a) providing a large amount of support and guidance ("scaffolding") for the first learning task(s) in a task class, which decreases as learners gain more expertise ("fading"), (b) supported information should be presented before and not while working on the learning tasks, and should be accessible to the learners during the practice. "Simultaneously performing a task and studying the information would almost certainly cause cognitive overload" (van Merrienboer & Kirschner, 2007, p. 23), (c) procedural information should be presented precisely when learners need it (JIT) because it typically has lower element interactivity than supportive information and also because studying this information forehand has no added value, and (d) part-task practice should be used to automate particular recurrent aspects of a complex skill, which may decrease the cognitive load associated with performing the whole learning tasks and decrease the chance of making errors due to cognitive overload.

Furthermore, both of the models recommend sequencing learning tasks in variable order to increase *germane cognitive load*. This variability is also referred to as *contextual interference*, which is "a type of variability in which contextual factors inhibit a quick and smooth mastery of a skill" (van Merrienboer & Kirschner, 2007, p. 279). In low contextual interference the learning tasks are presented in a blocked order (e.g., a-a-a, b-b-b, c-c-c), whereas in high contextual interference the learning tasks are presented in a random order (e.g., b-a-c, b-b-a, c-a-c). Thus, when adjacent learning tasks cause learners to practice different versions of constituent skills, it is said that *contextual interference* is high. Even though high contextual interference increase cognitive load during training, it also improve transfer performance (van Merrienboer & Sweller, 2005). The high variability is necessary to promote the development of rich cognitive schemata, which increase schema-based transfer from training to the real world (van Merrienboer, Clark, & de Croock, 2002).

Motivational Considerations

Inherent to both the 4C/ID and the Peddle-in-the-Pond models is management of student's self-efficacy. According to Bandura (1986), judgments of self-efficacy are based on four principal sources of information being actual experience, vicarious experiences, verbal persuasion, and psychological state. First, being task-centered, both of the models provide extensive actual experience. However, unlike constructivism, taking into account that using highly complex learning tasks from the start have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998), both of the models propose progression of tasks from simple to complex, thus assuring that the actual experience is truly a positive experience, and that the psychological state of the students is kept positive. Vicarious experiences is also suggested by van Merrienboer et al. (2002, p. 46), for example: "Highest process-oriented support is provided by a modeling example, which confronts the learner with an expert who is performing the task and simultaneously explaining why the task is performed as it is performed".

Both Merrill (2007b) and van Merrienboer (1997) attribute high intrinsic motivational value to the inherent task-centered characteristic of their models. According to Merrill (2007b), traditional instruction is often not clear with regard to how the knowledge and skill components will eventually be applied ("you won't understand it now but later it will be really important to you…"), causing the instruction to lack the necessary relevance for the learner. Merrill also noted that "Current instruction literature has much to say about the importance of motivation. Often glitz, animation, multimedia, and games are justified as motivational elements of an instructional product. However, for the most part, these aspects have temporary effect on motivation" (Merrill, 2002a, p. 50). Instead, according to Merrill, "The real motivation for learners is learning…Whenever learners acquire new skills, their first desire is to show a close friend or associate their newly acquired ability. Learning is the most motivating of all activities when the learner can observe his or her own progress" (Merrill, 2002a, p. 50).

Likewise, van Merrienboer (1997, p. 32) noted that "For whole-task practice, intrinsic motivation (natural satisfaction with task accomplishment) will usually be relatively high, because there is a clear resemblance between practice and post-instructional performance". Moreover, the high intrinsic motivation "diminishes the need for extrinsic motivation such as explicit praise, encouragement, and incentives. If such extrinsic motivators are used, they will typically concern the recurrent aspects of whole-task performance” (van Merrienboer, 1997, p. 260).

In summary, both of the models inherently provide an interesting and engaging environment, and at the same time manage the difficulty levels of the tasks, thus assuring high self-efficacy. These inherent motivational characteristics are contrary to a more traditional instructional strategy. For example, in the conditions of learning (see Table 2.2) Gagné provides motivational guidance for attitudes (e.g., “establish an expectancy of success associated with the desired attitude), nevertheless, motivational considerations are not inherently build into the nine events of instructions (see Table 2.3). In the task-centered approaches described in this section on the other hand, the motivational aspects of the models are truly inherent to the models structure, thus, following the basic guidelines of the models are sufficient to cover the motivational considerations as well.

Learning Programming

In considering Jonassen’s (2000b) classification of problems by structuredness, programming is in most cases a well-structured problem. Usually all elements of the problem are presented to the learner and require the application of a limited number of regular and well-structured rules. Yet, in terms of complexity (i.e., the number of issues, functions, or variables involved in the problem, the degree of connectivity among those properties), programming is a complex problems. Similar to playing chess, even though the number of rules may be limited, and the problem is well defined, each problem requires different application of the language rules and may require high level of creativity. In terms of domain specificity, even though each language may have different rules, there are abstract schemas that are valid across programming languages (e.g., the concept of class hierarchy). Thus, one of the characteristics of expert programmers is not their familiarity with languages rules but their ability to learn a new language in a short period of time, using their already established schemas. Learning those schemas is usually achieved through experience and not explicitly through instructions. In terms of Gagné’s taxonomy of learning outcomes, programming is an intellectual skill, which is the equivalent of procedural knowledge, and in particular higher order rules (i.e., applying a new combination of rules to solve a complex problem).

Consequently, novices who do not posses programming related schemas may experience high cognitive load when attempting to learn a new programming language rules, as they cannot relate the language rules to already existing schemas. High cognitive load in turn may decrease their self-efficacy, anxiety and therefore motivation to learn.

Computer Self-Efficacy

As mentioned before, Bandura (1986, p. 391) defined self-efficacy as “People’s judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not only with the skills one has but with judgments of what one can do with whatever skills one possesses”. Computer self-efficacy, then, refers to “a judgment of one’s capability to use a computer. It is not concerned with what one has done in the past, but rather with judgments of what could be done in the future. Moreover, it does not refer to simple component subskills, like formatting diskettes or entering formulas in a spreadsheet. Rather, it incorporates judgments of the ability to apply those skills to broader tasks” (Compeau & Higgins, 1995b, p. 192). Compeau and Higgins

(1995b) further defined the dimensions of self-efficacy in the context of computers. Those dimensions include: (a) *Magnitude*: the level of capability expected (i.e., individuals with high computer self-efficacy might believe that they can accomplish more difficult tasks); (b) *Strength*: the level of conviction about the judgment; and (c) *Generalizability:* the degree to which the judgment is limited to a particular domain of activity (e.g., using a specific software vs. using any software).

According to Bandura (1986), judgments of self-efficacy are based on four principal sources of information being actual experience, vicarious experiences, verbal persuasion, and psychological state. In accordance with Bandura's theory of self-efficacy, Compeau and Higgins (1995b) found that an individual's self-efficacy and outcome expectations were influenced by encouragement of others in their work groups, as well as other's use of computers. In addition, they found that computer self-efficacy influenced actual computer use, expectations of the outcomes of using computers, and emotional reactions to computers such as anxiety. Several studies have revealed a significant relationship between self-efficacy and computer anxiety (e.g., Brosnan, 1998; Meier, 1985; Wilfong, 2004). For example, Meier (1985) confirmed that high levels of computer anxiety reduce levels of self-efficacy which in turn lowers computer-based performance attainment. Thus, one of the sources that determine the level of computer self-efficacy is the measure of computer anxiety discussed next.

Computer Anxiety

Computer anxiety is commonly defined as emotional fear related to computers when using the computers, or when considering the possibility of computer use (Chua, Chen, & Wong, 1999). Computer anxiety is a kind of 'state anxiety' as opposed to 'trait anxiety', which can therefore be changed (e.g., Rosen, Scars, & Weil, 1993). Anxiety concerning the use of computers has been investigated and recognized since the early eighties (e.g., Brosnan, 1998; Cambre & Cook, 1985; Raub, 1981) and has been identified in diverse populations including computing students (Brosnan, 1998; Connolly, Murphy, & Moore, 2009). According to Bronson and Davidson (1994) around one third of the individuals within most populations and as high as 50% of college students experience computer anxiety to some degree, ranging from a preference not to use computers to even palpitations at the thought of using computers. Those findings have significant implications in both educational settings and the industry as technology is rapidly changing and the use of computers in the classroom has increased.

In terms of computer anxiety consequences, in general, high anxiety states impair performance. Students with high anxiety have less effective study skills than students with lower anxiety (Naveh-Benjamin, McKeachie, & Lin, 1987; Topman, Kleijn, van der Ploeg, & Masset, 1992), as they tend to devote cognitive capacity to off task efforts such as worrying, thus reducing their available working memory that can be devoted for task performance. In addition, individuals with high anxiety are more prone to avoidance as a coping strategy (Stipek, 2002; Zeidner, 1994). For example, Weil and Rosen (1995) found that teachers' avoidance of computers is caused by computer anxiety. Nevertheless, there is lack of consistency in the literature with respect to consequences. For example, Darke (1988) found that anxious individuals spent more time on tasks, but did not necessarily make more errors. Bronsan (1998) on the other hand found that computer anxiety directly influenced the number of correct responses. According to Bronson (1998), the lack of consistency between anxiety and computer performance is due to the fact that self-efficacy moderates this relationship (i.e., anxiety predict levels of self-efficacy, which in turn predict performance).

Individual Differences

According to Chua et al. (1999) the three most commonly examined correlates to computer anxiety are gender, age, and computer experience.

Gender Differences

There are inconsistent results with respect to the relationship between computer anxiety and gender. Some studies report gender differences in computer self-efficacy and computer anxiety with females reporting higher levels of anxiety and lower levels of self-efficacy (e.g., Bozionelos, 1996; Brosnan & Davidson, 1996; Chu & Spires, 1991; Miura, 1987; Raub, 1981; Rosen & Weil, 1995). Likewise, a meta-analysis of studies of gender differences in computer-related attitudes and behavior (Whitley, 1997) revealed that men and boys exhibited greater sex-role stereotyping of computers, higher computer self-efficacy, and more positive affect about computers than did women and girls. Nevertheless, other studies found the relationship between anxiety and gender to be non-significant (Carlson & Wright, 1993; B. T. Cohen & Waugh, 1989; Dyck & Smither, 1994).

Age

Contrary to common beliefs that computer anxiety is positively correlated to age, many studies do not find this relationship to be significant (e.g., Henderson, Deane, Barrelle, & Mahar, 1995). Only studies with a very wide age range, for example seniors citizens vs. undergraduates, report a significant difference (e.g., Dyck & Smither, 1994), where older age is associated with higher computer anxiety.

Experience

There is little agreement in the literature on a precise definition of computer experience (Doyle, Stamouli, & Huggard, 2005). Different studies investigated different types of computer experience, which are not necessarily related to each other. For example, researchers define computer experience by the number of years of computer use, number of computer courses, ownership of computers, and the hour’s usage per week (Chua, Chen, & Wong, 1999; Doyle, Stamouli, & Huggard, 2005; Garland & Noyes, 2004).

Doyle et al. (Doyle, Stamouli, & Huggard, 2005) found that when computer experience increases, self-efficacy also increases whereas computer anxiety decreases. Likewise, according to a meta analysis by Chua et al. (1999), in general computer anxiety is inversely related with computer experience. Nevertheless, experience was also found to exacerbate an individual’s level of anxiety (Bozionelos, 2001). Of course, based on Bandura’s (1986) self-efficacy theory, actual experience is the most important factor to influence self-efficacy, nevertheless the experience should be positive in order to increase self-efficacy. Unfortunately, for many people, the experience with computers is negative, thus it may negatively influence anxiety and self-efficacy.

Training Method Effects

Computer training is widely recognized as an essential contributor to the productive use of computer systems in organizations and to effective computer use (e.g., Benson, 1983; Cheney, Mann, & Amoroso, 1986; Simon, Grover, Teng, & Whitcomb, 1996). Nevertheless, the preferred type of training is still debated. For example, supporters of classroom training claim that it is superior, since it is cost effective whereas supporters of individual training methods, such as self-paced tutorials, claim that these methods are superior since they allow individuals to progress at their own pace (Compeau & Higgins, 1995a). In this section studies that compare task-centered-like instruction to topic-centered-like instruction for teaching computer skills are reviewed.

One of the early instances of task-centered instruction can be seen in behavior-modeling training (BMT), which was developed in the 1970s and was grounded on Bandura's principles of Social Learning Theory (Bandura, 1969, 1977b). BMT is a task-focused method that involves a visual observation of the behaviors of a model performing a task (Chou, 2001). The main characteristics of BMT include: (a) presenting a set of well-defined behaviors (skills) to be learned, (b) providing a model(s) displaying the effective use of those behaviors, and (c) providing opportunities for practice of those behaviors followed by feedback (Taylor, Russ-Eft, & Chan, 2005). Thus, behavior-modeling method "employs an inductive approach that teaches by hands-on demonstrations first followed by complimentary lectures" (Chou, 2001, p. 53). In contrast to task-centered instruction approaches described in previous sections, the theoretical rationale for BMT is grounded in Bandura's (1986) notion of self-efficacy and in particular the notion that vicarious experiences of observing the performance of others affect self-perceptions of efficacy leading to better performance. Nonetheless, implementation of BMT results in instruction that similar to task-centered instructional strategies is content driven (i.e., the task and not the abstract learning objectives are specified first).

BMT has been applied in various areas such as customer service skills, sales, development of supervisory, as well as complex computer training (Taylor, Russ-Eft, & Chan, 2005). Gist et al. (1988) found that behavioral modeling training method yielded consistently superior computer software mastery compared with non-modeling approach. In another study, Gist et al. (1989) found that behavioral modeling approach resulted in higher self-efficacy scores, better computer software performance, more ease with the task, more satisfaction, and less frustration compared to tutorial approach. Furthermore, they found that participants low in self-efficacy reported greater confidence in their ability to master the software training in the modeling compared with the tutorial condition. Compeau and Higgins (1995a) compared the effect of behavior modeling training program to a more traditional, lecture-based program on self-efficacy, outcome expectations, and performance of computer skills. They found that behavior modeling resulted in higher self-efficacy and higher performance in Lotus 1-2-3 than the traditional method.

Simon and Werner (1996) compared three approaches to computer training: behavior modeling, self-paced study, and lecturing. Measures of cognitive learning and skill demonstration, as well as satisfaction were highest for behavior modeling followed by the self-paced condition. Furthermore, the results were similar for measures collected immediately after training and 1 month after training. Simon et al. (1996) compared traditional (instruction and exploration) and nontraditional training techniques (behavior modeling which was an enhanced combination of instruction and exploration) with regard to computer related training. Their results revealed that hands-on training methods, in particular behavior modeling, resulted in better retention of knowledge, better transfer of learning, and higher end-user satisfaction. Likewise, Chou (2001) compared the effects of instruction-based vs. behavior modeling training method and computer anxiety on learners' computer self-efficacy and learning performance. He found that the behavior-modeling training method resulted in superior performance and higher computer self-efficacy.

Previous studies relating to van Merrienboer’s (1997) 4C/ID-model, have focused mainly on investigating particular aspects of the 4C/ID-model, including problems sequencing (e.g., Paas & van Merrienboer, 1994), information presentation timing (e.g., Kester, Kirschner, van Merriënboer, & Baumer, 2001), and learning tasks optimal step sizes (e.g., Nadolski, Kirschner, & van Merrienboer, 2005; Nadolski, Kirschner, van Merrienboer, & Hummel, 2001). However, they did not investigate the effects of the 4C/ID-model in comparison to topic-centered instruction. The only study that compared the two approaches was conducted by Lim et al. (2009) who investigated the effects of the two instructional approaches and learner prior knowledge on learner acquisition and transfer of a complex cognitive skill (preparing a grade book using Microsoft Excel). The part-task condition included a complex skill that was decomposed into a series of smaller tasks, each of which was demonstrated and practiced separately. The whole-task condition, which was based on the 4C/ID-model included the same complex skill only this time learners were exposed to the entire complex skill from the beginning of the instruction and were required to complete a series of whole tasks throughout the unit. They found that the whole-task group performed significantly better than the part-task group on a skill acquisition test and a transfer test. While Lim et al. found the 4C/ID-model superior, they were not able to determine which element of the 4C/ID-model is responsible of its superiority, as indicated by Lim et al. (2009, p. 74), “future researchers may want to examine which particular aspects of the 4C/ID approach facilitate student learning and transfer. Because the study examined, from a holistic perspective, the effects of an instructional program based on the 4C/ID instructional approach, it is uncertain what specific aspects of that approach promoted student learning and transfer.” In addition, Lim et al. did not include in their study a measure of self-efficacy, thus, it is not possible to determine whether performance is mediated and can be explained by increase in self-efficacy.

A pilot study (see Appendix A) examined the effect of instructional strategy type (part-task vs. whole-task) on acquisition of a complex cognitive skill – developing an application in Flash using Actionscript. Of particular interest were the effects of the instructional strategy type on task performance, transfer, time on task, cognitive load, and attitudes. Six females and four males volunteered to participate in a pilot study that was conducted online and were randomly assigned to one of the two conditions. Although the observed differences were not statistically significant, as hypothesized, participants in the whole-task condition performed better on the module and on a transfer test than participants in the part-task condition. In addition, participants in the whole-task spent more time on the module and test and reported higher cognitive load. Finally, participants in the whole-task condition were significantly more satisfied with the module. Overall, the initial results support the use of whole-task instructional strategy for teaching complex cognitive skills. A limitation of this pilot study is the fact that while in the whole task condition the content was indeed presented in the context of a task, it included only one task and not a progression of tasks from easy to difficult (see Figure A.2). Instead, the progression was within the task, thus, the learners first placed the relevant element (text, buttons, and a movie-clip) in the Flash file, then they changed the characteristics of each element, and finally they wrote the action script that connect those elements and by doing that completed the whole task. Although learning the content in the context of a task was still beneficial, it is very likely that completing three tasks that start with a simple task (yet complete) and progress to more complex tasks would have enhanced the students’ motivation as well as their mental model construction as their sense of accomplishment as well as their understanding of how the elements relate to each other will be fulfilled earlier.

Research Model and Hypothesis

The purpose of the proposed study was to investigate whether and why a task-centered approach might be superior to a topic-centered approach for problem solving learning. As mentioned before, according to Mayer (1998), successful problem solving depends on three components: skill, metaskill, and motivation. According to Social Cognitive Theory (Bandura, 1986), the effects of the environment on human behavior are assumed to be mediated by cognitions with a continuous reciprocal interaction between the environment in which an individual operates, personal factors, and behavior. Accordingly, in the context of the current study the environmental difference between the conditions is the instructional strategy, personal factors include motivational (i.e., self-efficacy, interest, anxiety) and cognitive (i.e., prior experience) considerations, whereas behavior can be viewed as the observable performance. Unlike the original model by Bandura (1986), in the context of this study, the environment (i.e., instructional strategy) is predefined and cannot be altered by personal factors and behaviors. Thus, the arrows that exit the environment are unidirectional (see figure 2.11).

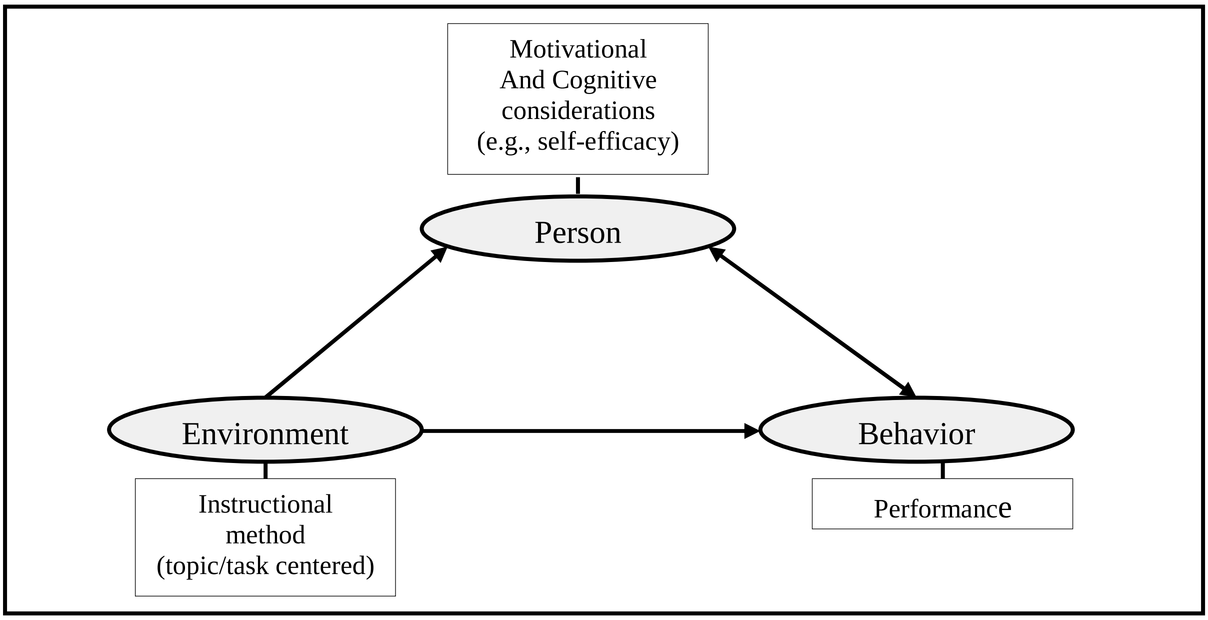


Figure 2.11 Application of Bandura’s Triadic Reciprocality

The research model proposed below (see Figure 2.12) is an elaboration of Bandura's triadic model above. According to the proposed model, two reciprocal interactions are in the heart of task-centered instructions: performance-motivation (behavior-person) reciprocal interaction and performance-cognition (behavior-person) reciprocal interaction. These interactions can be viewed as two positive feedback loops.

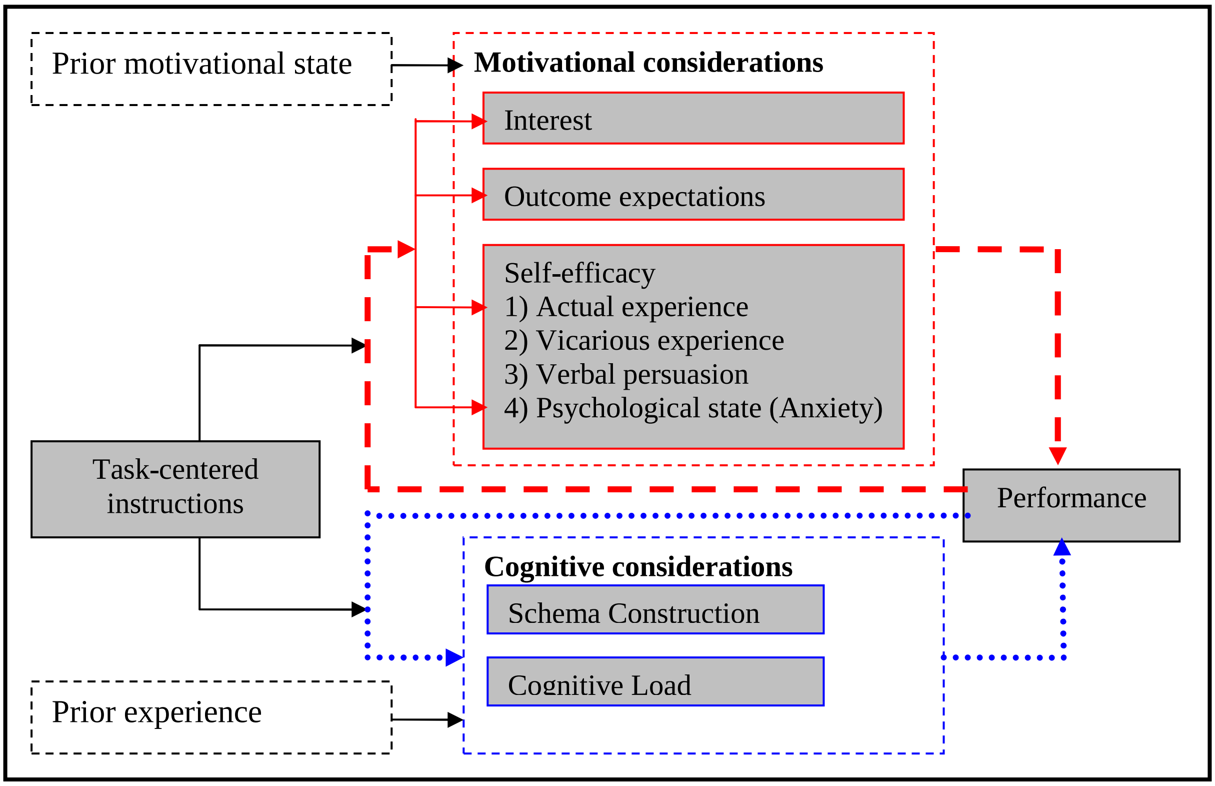


Figure 2.12 Research Model

In the *performance-motivation loop* (dashed loop in Figure 2.12), the progression of tasks from easy to difficult increases the likelihood of successful completion of each task. Successful performance will positively influence self-efficacy through actual experience, which is according to Bandura the most important source of self-efficacy. In turn, increased self-efficacy will positively influence performance. As mentioned before, high self-efficacy is associated with longer persistence at tasks (Bouffard-Bouchard, 1990), effort put in completing the task on hand (Bandura, 1986), use of constructive strategies for learning (Pintrich & De Groot, 1990), and positive emotions and reduced fear and anxiety (Zimmerman, 1995), all of which affect achievement outcomes. Thus, each successful performance will in turn increase self-efficacy, and each increase of self-efficacy will increase the likelihood of successful performance, resulting in a positive feedback loop. In addition to self-efficacy, task-centered instruction is likely to positively influence outcome expectations as the learners get a very clear sense of how the tool (in this case Flash) can be used to achieve their goals. Finally, the existence of real world tasks is likely to increase the level of interest which is likely to result in better performance as "students think harder and process the material more deeply when they are interested rather than uninterested" (Mayer, 1998, p. 57). According to Mayer (1998), interest theory is consistent with the practice of teaching skills in context, which can be implemented by using real world tasks as done in the task-centered approach.

In the *performance-cognitive loop* (dotted loop in Figure 2.12), authentic-tasks, which characterize task-centered instructions, can help the learner construct schemata not only of all the components of the tasks but also of the way the different components interact with and relate to each other. As noted by Merrill (2007b), acquiring a skill in the context of whole tasks makes it more likely that the learners will form mental models for how these individual skills are integrated into complete performance. In turn, schemas provide a mechanism for knowledge organization and storage and help reduce working memory load, which may result in better performance. The risk of authentic-tasks is that the learner may be faced with extremely high levels of cognitive load which was found to have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). This risk is minimized in the task-centered approach by gradually progressing from a simplified version of the whole-task to the final complex task. In addition, the task-centered approach is characterized by random practice schedule, or in other words, in each tasks the topics appear in random order. According to van Merrienboer & Swelller (2005), it was found that high contextual interference (i.e., a random practice schedule) increased cognitive load during training nevertheless improved transfer performance. Thus, improved transfer performance is an expected outcome of the task-centered condition.

In addition to instructional strategy, other factors that may influence performance in the proposed model are prior motivational state and prior experience. Prior motivational state, and in particular computer self-efficacy and computer anxiety are likely to predict performance. Higgins (1995b) found that computer self-efficacy influenced actual computer use, expectations of the outcomes of using computers, and emotional reactions to computers such as anxiety. Several studies have revealed a significant relationship between self-efficacy and computer anxiety (e.g., Brosnan, 1998; Meier, 1985; Wilfong, 2004). In terms of computer anxiety consequences, high anxiety states are considered to impair performance (Naveh-Benjamin, McKeachie, & Lin, 1987; Topman, Kleijn, van der Ploeg, & Masset, 1992). For example, Meier (1985) found that high levels of computer anxiety decrease levels of self-efficacy leading to lower computer-based performance.

Prior experience is also likely to influence performance. In particular, it is possible that an interaction will occur between prior experience and instructional strategy. As described before, according to the *expertise reversal effect* (Kalyuga, Ayres, Chandler, & Sweller, 2003), the positive effect of reducing cognitive load on learning is only true for learners with very low level of knowledge or skills (i.e., novices) (Kalyuga, 2007). It is not clear however what will be the interaction in the proposed study. While the task-centered approach may decrease cognitive load through schema construction, it is not necessary that it will lead to redundancy for experts. On the other hand, it is also possible that the task-centered approach will increase cognitive load due to the random practice schedule. Therefore, no specific hypotheses were formulated for level of expertise and instructional strategy.

In summary, the task-centered approach is expected to result in higher performance and transfer as well as higher motivation as measured by Keller's (1993) Instructional Materials Motivational Survey (IMMS). This survey consists of four categories being attention, relevance, confidence, and satisfaction, all of which are directly related to the variables described above. Thus, attention and relevance may increase due to the authentic nature of the task; confidence may increase as a direct outcome of the increased self-efficacy, and satisfaction may increase as a consequence of positive performance experiences. Table 2.8 summarizes the derived research questions and associated hypotheses.

Table 2.8 Research Questions and Associated Hypotheses

Research questions and hypothesis
Research question 1 What are the effects of instructional strategy (task-centered vs. topic-centered) on: (1) performance (skill-development performance, process-development performance (near and far transfer)), (2) cognitive load, (3) time on task, and (4) Attitudes (computer self-efficacy, computer anxiety, and motivation)?
Associated hypotheses: **H.1.1** Learners who receive task-centered training will perform better on the skill-development test than learners who receive topic-centered training. **H.1.2** Learners who receive task-centered training will perform better on the process-development test than learners who receive topic-centered training. **H.1.3** Learners who receive task-centered training will report lower cognitive load on completing the test than learners who receive topic-centered training. No difference in the perceived cognitive load is expected for completing the module itself. **H.1.4** Learners who receive task-centered training will spend less time on the near and far transfer process-development tests than learners who receive topic-centered training. No time difference is expected for completing the module and for the skill-development test. **H.1.5** Learners who receive task-centered training will report higher self-efficacy than learners who receive topic-centered training. **H.1.6** Learners who receive task-centered training will report lower computer anxiety than learners who receive topic-centered training. **H.1.7** Learners who receive task-centered training will express higher motivation towards the training than learners who receive topic-centered training.
Research question 2 What are the relationships between computer anxiety, computer self-efficacy and: (1) performance (skill-development performance, process-development performance (near and far transfer)), (2) cognitive load, (3) time on task, and (4) attitudes toward training?
Associated hypotheses: **H.2.1** Learners' self-efficacy will be positively correlated to skill-development performance test regardless of the training condition. **H.2.2** Learners' self-efficacy will be positively correlated to process-development performance test regardless of the training condition. **H.2.3** Learners' self-efficacy will be positively correlated to lower cognitive load. **H.2.4** Learners' self-efficacy will be positively correlated to better attitudes towards the training regardless of the training condition. **H.2.5** Learners' computer anxiety will be negatively correlated to learners' computer self-efficacy.
Research question 3 Does self-efficacy mediate the effects of instructional strategy on: (1) skill-development performance, (2) near transfer process-development performance, and (5) far transfer process-development performance? No specific hypotheses were formulated
Research question 4 Is there an interaction between learner's level of expertise and treatment condition with regard to: (1) computer self-efficacy, (2) computer anxiety (3) learners satisfaction (4) cognitive load (5) skill-development performance, (6) process-development performance (near and far transfer), and (7) time on task? No specific hypotheses were formulated

CHAPTER III: METHOD

Participants

Sixty five students (age *M* = 21.46 years, *SD* = 4.1; 80% female) from a large southeastern university in the United States volunteered to participate in the study that took place in a computer laboratory setting. Of the participants 9 were freshmen, 18 were sophomore, 21 were junior, 11 were senior, and 6 were graduate students. No prior knowledge was required to participate in the study. The participants were randomly assigned to one of two conditions. Each participant received $15 for his\her participation in addition to two credit points for the College of Education subject pool.

Materials

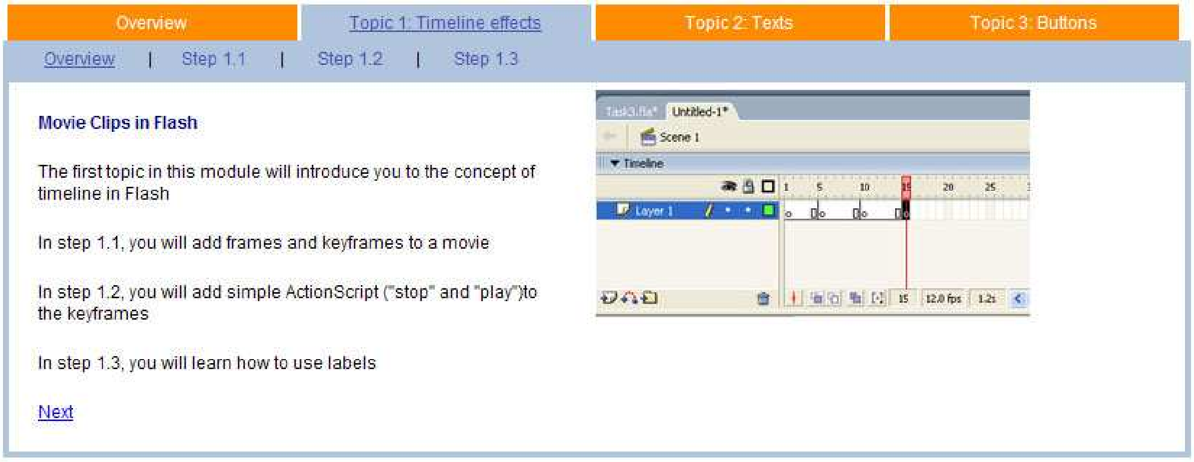
All participants completed a two hours Flash module that took place in a computer lab. An online module (see Figure 3.1 for a sample screenshot) was developed for each of the study conditions (topic-centered and task-centered). In both of the conditions, the module included three sections, each consisting of three subsections (overall nine subsections). The participants progressed from section to section by clicking on the “next” button. While the context of the instructions differs between conditions (i.e., context of tasks vs. context of topics), the description of procedural knowledge is identical for both of the conditions.

The complete modules can be viewed under:

http://myweb.fsu.edu/rr05/Dissertation/FlashModule/FlashStudy.html

Topic-Centered Condition

The participants in the topic-centered condition completed the module without task context; and the sections were ordered by topics (see Table 3.1).



Movie Clips in Flash

The first topic in this module will introduce you to the concept of timeline in Flash

In step 1.1, you will add frames and keyframes to a movie

In step 1.2, you will add simple ActionScript ("stop" and "play")to the keyframes

In step 1.3, you will learn how to use labels

Next

Figure 3.1 Screenshot of Topic 1

Table 3.1 Topics Covered in the Module by Order.

Topics:
1. Timeline effects 1.1 Using frames and keyframes 1.1.1 Adding image to a frame 1.1.2 Adding new keyframes 1.2 Adding ActionScript (stop, play) 1.3 Using Labels (gotoAndStop)
2. Text 2.1 Static text 2.2 Dynamic text – Properties 2.3 Dynamic text - ActionScript
3. Buttons 3.1 Creating a button from text (change over, down) 3.2 Creating a button from image + sound 3.3 Adding ActionScript to buttons. 3.3.1 on (press) 3.3.2 on (rollover, rollout)

Task-Centered Condition

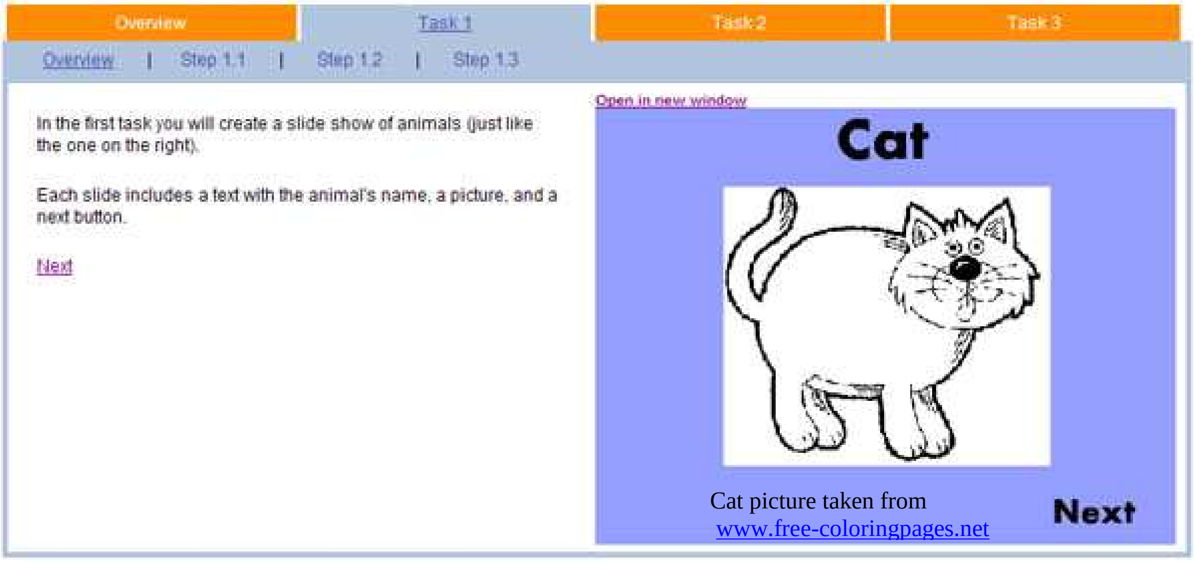
Participants in the task-centered condition completed the module in the context of three tasks (from easy to difficult), which determined the order of the topics to be presented. Table 3.2 describes which topics were covered in each task. The letters under the task columns (i.e., a, b, etc.) represent the order of topics within each task, and the numbers that appear inside the brackets represent the step, with three steps for each task. Following is a detailed description of the three tasks.

Table 3.2 Topics Covered in each Task.

Topic	**Task 1**	**Task 2**	**Task 3**
1. Timeline effects			
1.1 Using frames and keyframes			
1.1.1 Adding image to a frame	b (1)	a(1)	c(2)
1.1.2 Adding new keyframes	c(2)		d(2)
1.2 Adding ActionScript (stop, play)	d (2)		e(2)
1.3 Using Labels (gotoAndStop)			f(3)
2. Text			
2.1 Static text	a (1)		a(1)
2.2 Dynamic text – Properties		b (1)	
2.3 Dynamic text – ActionScript		e(3)	
3. Buttons			
3.1 Creating a button from text (change over, down)	e (3)		b(1)
3.2 Creating a button from image + sound		c (2)	
3.3 Adding ActionScript to buttons.			
3.3.1 on (press)	f (3)		g(3)
3.3.2 on (rollover, rollout)		d(3)	

Task 1

In task 1, the participants created a slideshow of animals (see Figure 3.2). The topics that were presented in task 1 and their order of presentation are described in Table 3.3.



In the first task you will create a slide show of animals (just like the one on the right).

Each slide includes a text with the animal's name, a picture, and a next button.

Cat picture taken from www.free-coloringpages.net

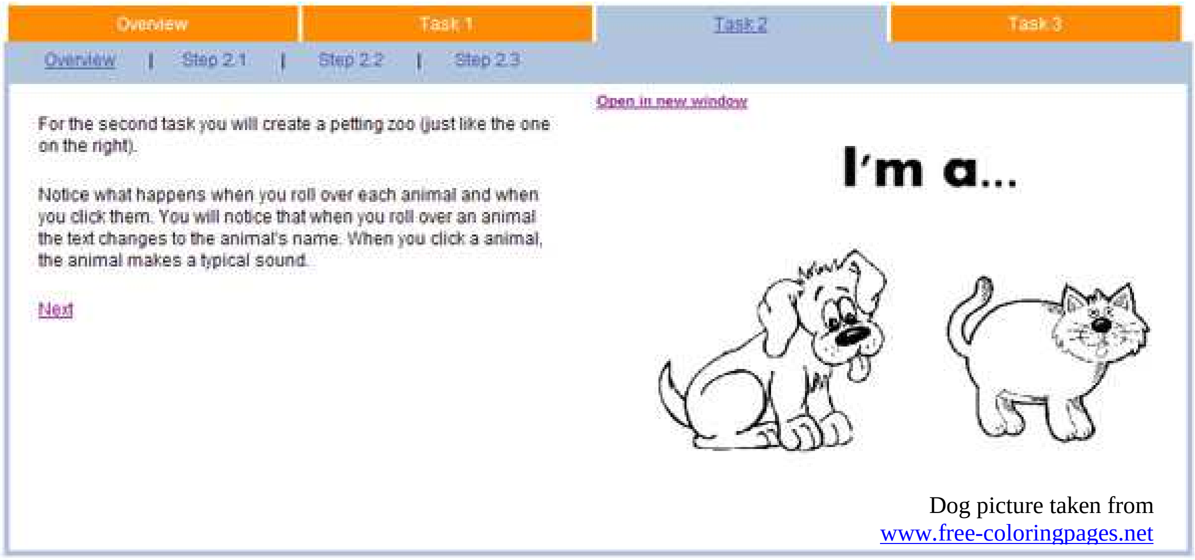
Figure 3.2 Screenshot of Task 1.

Table 3.3 Order of Topics Presented for Task 1

Step 1	(a) Adding static text
	(b) Adding image to a frame
Step 2	(c) Adding new keyframes
	(d) Adding ActionScript (stop, play)
Step 3	(e) Creating a button from text
	(f) Adding simple ActionScript (“on (press)”) to the button

Task 2

In task 2, the participants created a virtual “petting zoo” (see Figure 3.3, frog picture was taken from www.animal-coloring-pages.com). When moving the mouse over (“petting”) an animal the text changes to the name of the animal and the animal size increases. When clicking on an animal, it makes a typical sound (e.g., meow). The topics that were presented in task 2 and their order of presentation are described in Table 3.4.



For the second task you will create a petting zoo (just like the one on the right).

Notice what happens when you roll over each animal and when you click them. You will notice that when you roll over an animal the text changes to the animal's name. When you click a animal, the animal makes a typical sound.

Dog picture taken from www.free-coloringpages.net

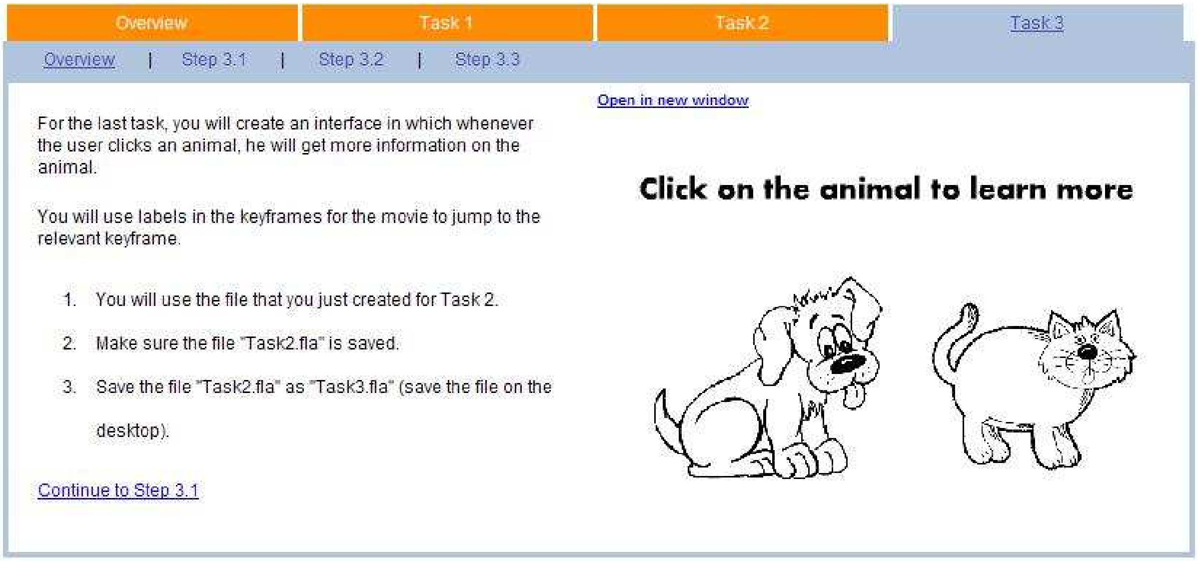
Figure 3.3 Screenshot of Task 2

Table 3.4 Order of Topics Presented for Task 2

Step 1	(a) Creating a movie clip and inserting images of the animals
	(b) Setting dynamic text properties
Step 2	(c) Creating a button from image + sound
Step 3	(d) Adding ActionScript to the buttons that change the dynamic text when the user moves the mouse over an animal (rollover, and rollout).
	(e) Adding ActionScript to the change dynamic text

Task 3

In task 3, the participants created a navigation system in which whenever the user clicks an animal, he will move to see the information page regarding the animal. The topics that are presented in task 3 and their order of presentation are described in Table 3.5.



For the last task, you will create an interface in which whenever the user clicks an animal, he will get more information on the animal.

You will use labels in the keyframes for the movie to jump to the relevant keyframe.

1. You will use the file that you just created for Task 2.
2. Make sure the file "Task2.fla" is saved.
3. Save the file "Task2.fla" as "Task3.fla" (save the file on the desktop).

Continue to Step 3.1

Click on the animal to learn more

Figure 3.4 Screenshot of Task 3

Table 3.5 Order of Topics Presented for Task 3

Step 1	(a) Inserting static text
	(b) Creating buttons from text
Step 2	(c) Adding images to frames
	(d) Adding new keyframes
	(e) Adding ActionScript to the frames
Step 3	(f) Using labels
	(e) Adding ActionScript to the jump to a label

Independent Variables

Instructional Strategy (Task-centered vs. Topic-centered)

Two computer-based instructional strategies were employed. In the **task-centered** condition, the learners were be first presented with three tasks with increasing levels of difficulty. Each of the three topics included all the elements of the whole-task, thus, in step one, for example, the learners learned the basics of timeline, texts, and buttons. In the **topic-centered** condition, on the other hand, no tasks were presented to the learners up front.

Instead, objectives were presented to the learners at the beginning of each topic section (timeline, dynamic texts, and buttons). Thus, in the topic-centered condition, each of the three steps referred to only one of the topics, for example, in step one, the learners learned only about timeline effects (see Table 3.1, Figure 3.5). It is important to note that while the order and the context of the instruction are different, the content (e.g., how to create a button) was identical for both conditions.

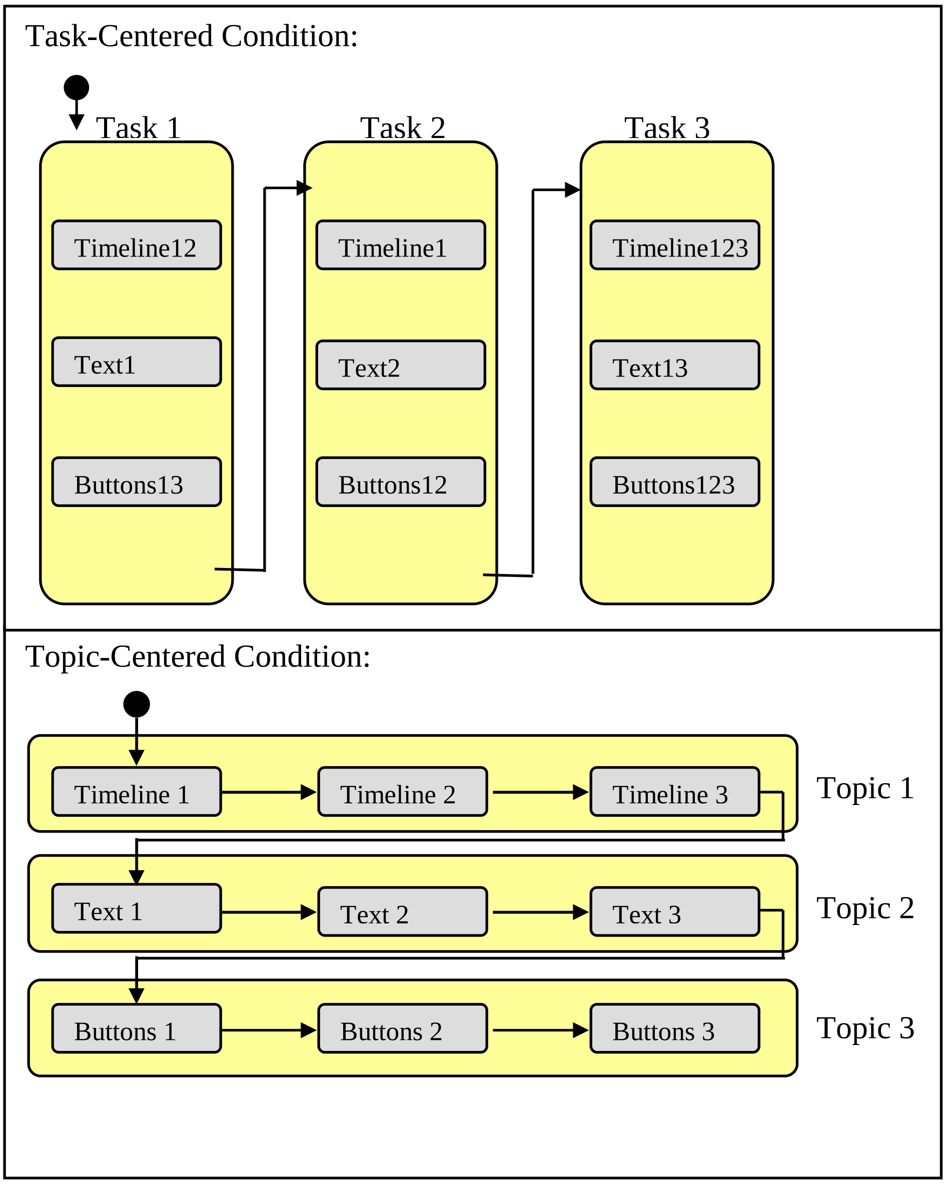


Figure 3.5 Illustration of the Sequence of Topics within each Condition

Level of Expertise

The level of expertise (ranging from 0-9) of the participants was measured using a self-report questionnaire that included experience in developing Internet applications, experience developing in Flash, and programming experience (see Table 3.6).

Table 3.6 Calculation of Level of Expertise

	Category		Points assigned
1	Experience in developing Internet applications	1) No experience at all	0
		2) I can create a simple page in html	1
		3) I can use many of the html functions	2
		4) I am an experienced Internet programmer\developer	3
2	Experience developing in Flash	1) I never used Flash before	0
		2) I used Flash for creating simple graphics	1
		3) I have created simple applications in Flash	2
		4) I can use ActionScript in Flash	3
3	Programming experience	1) I have no experience at all	0
		2) I have some very limited programming experience	1
		3) I can program in one or more languages	2
		4) I am an experienced programmer	3
Total score (minimum-maximum)			0-9

Dependent Variables

Performance

The participants' performance was assessed for:

(1) Performance on module tasks

At the end of each of the sub-steps (each task for the task-centered condition and each topic for the topic-centered condition) the participants completed a flash file that was later evaluated. Completing each of the three topics\tasks on the module earned the participants 0-10 points with zero being complete failure and 10 being complete success. The purpose of the module task measures is to control for module completion and time. No differences are expected between the conditions.

(2) Performance on Post Test

The post test is identical for both the condition and included three parts:

(1) Skill Development: This task assessed the acquisition of the separate skills that were covered in the module. Students had to develop a simple Flash application by following specific instructions.

(2) Process Development – Near Transfer: Students were given a Flash application that was similar to the examples they have seen in the module and had to provide an explanation (narrative) on how to create this application given the skills they have acquired. Their answers were graded on a 0-10 scale. Having a mental model of what strategy should be used to create a certain application is the most important stage in approaching to program an application. Even though it would have been preferable that the students actually would have created these applications, it would be unreasonable as these tasks may be extremely time-consuming (at least several hours). At the same time understanding the solution can be assessed relatively quickly by an explanation and still represent the students' level of schema construction.

(3) Process Development – Far Transfer: Students were given a Flash application that was different than the examples they have seen in the module yet requires the same skills, and had to provide an explanation (narrative) on how to create those applications. Their answers were graded on a 0-10 scale.

Cognitive Load

The participants' perceived cognitive load was measured using a single item self-rated scale developed by Paas and Van Merrienboer (1994) (see appendix B). Using a nine-point Likert-type scale, the participants were asked to identify the amount of mental effort they invested on completing each step of the instruction and the transfer task. In this study, the reliability of the cognitive load scale was .854, which was estimated with Cronbach's alpha.

Time on Task

Overall six time measures were recorded: (1) the time to complete the three module parts, (2) the time to complete each of the three post-test tasks.

Computer Anxiety

Anxiety was measured by the 19-items Computer Anxiety Rating Scale (CARS) developed by Heinssen et al. (1987). This scale was found to be valid for measuring computer anxiety (Chu & Spires, 1991). The original instrument was modified to update the item descriptions for changes in technology since 1987 and an additional scale item added based on suggestions from prior researchers (Rosen & Weil, 1995). Students responded to a series of statements, such as “I feel apprehensive about using computers”, based on how anxious the statements made them feel (from 1= Strongly disagree to 5= Strongly agree) (see Appendix C). In this study, the reliability of the computer anxiety scale was .858, which was estimated with Cronbach’s alpha.

Computer Self-Efficacy

Computer self-efficacy was measured by a 10-item instrument developed by Compeau and Higgins (1995b). The instrument was found to be valid and reliable for measuring computer self-efficacy (Compeau & Higgins, 1995b; Compeau, Higgins, & Huff, 1999). Students indicated whether they could use an unfamiliar software package under a variety of condition (e.g., “…if someone showed me how to do it first”). Then, for the conditions that were be answered as “yes,” the students indicated their level of confidence about their judgment on a ten-point scale (see appendix D). In this study, the reliability of the computer self-efficacy scale was .892, which was estimated with Cronbach’s alpha.

In addition, the participants were asked to answer the question “I feel confident in my ability to use the information I learned in this step” after each step of the module and the question “I feel confident in my ability to develop similar tasks” after each question of the post test on a 5 point scale (1-strongly disagree, 5-strongly agree).

Attitudes toward Instructions

After completing the module, the learner’s attitudes were measured using a 5-point, Likert-type scale adjusted Kellers’ (1993) Instructional Materials Motivational Survey (IMMS) (see Appendix E), which consists of four categories: attention ($\alpha = .89$; e.g., “The way the information is arranged on the pages helped keep my attention”) relevance ($\alpha = .81$; e.g., “Completing this lesson successfully was important to me”), confidence ($\alpha = .90$; “As I worked on this lesson, I was confident that I could learn the content”), and satisfaction ($\alpha = .92$; “Completing the exercises in this lesson gave me a satisfying feeling of accomplishment”).

Procedure

Participants completed the module in a lab setting with a proctor present. First, the participants completed a questionnaire that included the computer anxiety scale, and the computer self-efficacy scale. Estimated completion time was about ten minutes. Then, the participants were instructed to follow the directions in the module and to complete it. There is no limit on the time allowed to complete the module; however the estimated time was ~60 minutes. Following each of the nine sub steps of the module, the time to complete the step was recorded as well as the perceived mental effort to complete the step and confidence level. While time differences between the conditions were not expected, time was collected to control for such differences if they do occur. During the module, the learners were asked to develop different elements in Flash, which resulted in three functional applications in the task-centered condition and three separate flash files in the topic-centered condition. Following the module, the participants filled the Instructional Material Motivational Survey (Keller ,1993), the computer self-efficacy scale, and the computer anxiety scale and questions about their expertise level as well as general demographic information (age, gender, and occupation). Finally, the participants completed a 15-minutes post test and reported the time it took to complete it and their perceived mental effort and confidence level. See table 3.7 for an overview of the procedure.

Table 3.7 Overview of the Procedure

	Pre-Module survey		**Time**
1	Computer Self-Efficacy Survey (pre)		10 min
2	Computer Anxiety Survey (pre)		
	Instructional Module		
3	*Task-Centered Condition* - Task 1 (steps 1,2,3) Cognitive load measurement Time measurement Performance measurement - Task 2 (steps 1,2,3) Cognitive load measurement Time measurement Performance measurement - Task 3 (steps 1,2,3) Cognitive load measurement Time measurement Performance measurement	*Topic Centered Condition* - Topic 1 (steps 1,2,3) Cognitive load measurement Time measurement Performance measurement - Topic 2 (steps 1,2,3) Cognitive load measurement Time measurement Performance measurement - Topic 3 (steps 1,2,3) Cognitive load measurement Time measurement Performance measurement	60 min
	Post-module Survey		
4	Cognitive load measurement (summary)		15 min
5	Instructional Materials Motivational Survey (IMMS)		
6	Computer Self-Efficacy Survey (post)		
7	Computer Anxiety Survey (post)		
8	Background survey (demographics + level of expertise)		
	Post test		
9	Post test Cognitive load measurement Time measurement Performance measurement		20 min
	Total time		**105 min**

Data Analysis

This study was designed as a one-way factorial design. The independent variable was instructional strategy with task-centered and topic-centered conditions. The dependent variables were: (1) performance (skill-development performance, process-development performance (near and far transfer)), (2) cognitive load, (3) time on task, and (4) Attitudes (computer self-efficacy, computer anxiety, and motivation).

Data analysis was performed to examine whether the research hypotheses (see Chapter II) is validated. First, preliminary data analysis was conducted to identify outliers, missing data, test groups equivalence, and test the assumptions for the parametric tests. Main tests included analysis of variance (ANOVA), analysis of covariance (ANCOVA), multiple analysis of variance (MANOVA), as well as mediation analysis and correlations. Detailed description of the data analyses methods that were used is to follow in the next chapter of this manuscript.

CHAPTER IV: RESULTS

This study examined the effects of instructional strategy (task-centered vs. topic-centered) on performance, cognitive load, time on task, and attitudes. To explain the instructional effects, this study examined the relationships between self-efficacy and performance, cognitive load, time on task, and attitudes toward training. Then, this study inspected whether self-efficacy mediates the effects of instructional strategy on performance.

This chapter first describes results of the preliminary data analyses. The preliminary data analysis section includes examination of missing data and outliers, verification of the equivalence of treatment groups, and tests for assumptions of the parametric statistics. Next, in the primary data analyses section, results of the statistical tests are discussed for each research question.

Preliminary Data Analyses

Preliminary data analysis was conducted to examine missing data and outliers, verify the equivalence of treatment groups, and tests for assumptions of the parametric statistics.

Missing Data

One student did not complete the post-test, one student did not complete the post computer self-efficacy scale and one student did not complete the post anxiety scale. Those students were excluded from the relevant analyses.

Case Analysis

The major data analysis methods employed in this study were ANOVAs and MANOVAs. While ANOVAs requires detection of univariate outliers, MANOVAs requires both detection of univariate and multivariate outliers. Thus, case analysis included detection of univariate and multivariate outliers accordingly.

First, univariate outliers were detected by calculating Z-standardized values (z-scores). Outliers are commonly defined as cases which are more than plus or minus three standard deviations from the mean of the variable. Based on z-score inspection no extreme valued were found on post-test performance variables, cognitive load variables, and attitudes variables. One outlier was found on performance on module, one outlier was found on skill-development post test time, and one outlier was found on process-development (near transfer) post test time. Follow up analyses indicated that dropping these outliers did not have any influence on the statistical results and therefore these outliers were retained.

Second, multivariate outliers were detected using Mahalanobis distance measure for detection of extreme values with respect to multiple variables. One outlier was found for task time. The critical value for Mahalanobis distance with four variables was 18.47 whereas the maximum value detected was 20.752. Nevertheless, follow up analyses indicated that dropping this outlier did not have any influence on the statistical results and therefore this outlier was retained. No outliers were found for performance, cognitive load, and attitudes.

Groups Equivalence Test

In this study, participants were randomly assigned to one of two conditions. Each computer in the study room was randomly set up with one of the conditions and each participant who entered the room was assigned to the next available computer. In order to validate the groups' equivalence statistically three variables were used to find whether there were pre existing differences between the groups. The three variables were pre computer anxiety, pre computer self-efficacy, and level of experience. One-way ANOVA revealed no significant difference of pre computer anxiety between the topic-centered and the task-centered conditions, $F(1,63) = .11$, $p = .741$, $\eta^2 = .002$. One-way ANOVA also revealed no significant difference of pre computer self-efficacy between the topic-centered and the task-centered conditions, $F(1,63) = .322$, $p = .573$, $\eta^2 = .005$. Last, one-way ANOVA revealed no significant difference of prior experience between the topic-centered and the task-centered conditions, $F(1,63) = .762$, $p = .386$, $\eta^2 = .012$.

Tests for Assumptions of the Parametric Statistics

Six assumptions were tested for ANOVA and MANOVA tests.

(1) Normal Distribution Assumption

To detect the violations of this assumption, visual inspection of graphical representations of the data and an examination of formal statistical analyses were conducted for each dependent variable. As for the formal statistical analyses, the Shapiro-Wilk normality test was used. Results indicated that a few dependent measures were not normally distributed. Nevertheless, it was suggested that ANOVA and MANOVA are robust enough to moderate violations of this assumption.

(2) Independence Assumption

A critical assumption of ANOVA and MANOVA requires that each observation or measurement must not be influenced by any other observation or measurement. Measures were taken in the study to ensure that different individuals will not affect the outcomes of the others in the study. In particular, each participant worked individually on a different computer, and students were not allowed to interact with each other.

(3) Interval Scale Assumption

Each dependent variable in this study that was used in an ANOVA/MANOVA analysis was measured at the interval level, using a continuous scale, rather than discrete categories.

(4) Homoscedasticity (homogeneity of variance-covariance assumption)

This assumption requires that variance and covariance are equal across populations in different cells. Levene's test was performed to test the assumption of homogeneity of variance for each of the dependent variables. Results indicated that performance in the third part of the module and performance in the skill development post test violated the homogeneity of variance assumption and therefore a more conservative alpha level (alpha = .025) was set to determine the significance of these variables instead of the conventional .05 level. Box's test was performed to test the null hypothesis that the observed covariance matrices of the dependent variables were equal across treatment groups. There was no evidence of a violation of the constant covariance matrix assumption as the Box's tests were not significant.

(5) Linearity

For MANOVAs, it is assumed that there is a straight-line relationship between each pair of dependent variables. The linearity assumption was tested by inspecting scatterplots between each pair of variables. The visual inspection of scatterplots did not show any evidence of non-linearity, therefore the linearity assumption was satisfied.

(6) Multicollinearity

For MANOVAs, multicollinearity occurs when the dependent variables are highly correlated. Inspection of the correlations and the strength of the correlations among dependent variables did not reveal correlations above .8, therefore, the multicollinearity assumption was satisfied.

Primary Data Analyses

Research Question 1

What are the effects of instructional strategy (task-centered vs. topic-centered) on: (1) Performance (skill-development performance, process-development performance (near and far transfer)), (2) Cognitive load, (3) Time on task, and (4) Attitudes (computer self-efficacy, computer anxiety, and motivation)?

To answer the first research question, a series of MANOVAs with instructional strategy (topic-centered vs. task-centered) as the independent variable were conducted for each of the dependent variables groups.

Performance

Performance was measured on the module and on the post test that included skill-development test (completing a task with guidelines that were similar to the topics covered in the module), near transfer process-development test (explaining how to develop a given application that is similar to the ones given in the module but with no guidelines), and far transfer process-development test (explaining how to develop a given application that is different than the examples on the module yet requires the same skills). All the test scores had a maximum value of 10 points.

It was hypothesized that learners who received task-centered training would perform better on the skill-development test and on the process-development test than learners who receive topic-centered training (H.1.1 & H.1.2). No differences between the conditions were expected for module performance. A one-way MANOVA was used to test these hypotheses.

Regarding the module, as expected, there was no significant difference between the conditions in performance on the module for part 1, $F(1,63) = .186$, $p = .668$, $\eta^2 = .003$, and for part 2, *F*(1,63) = .425, *p* = .517, η^2 = .007. Overall, both of the conditions performed very well on the first two parts. Nevertheless, participants in the task-centered condition performed significantly better than participants in the topic-centered condition in part 3, *F*(1,63) = 6.303, $p < .05$, η^2 = .092, Cohen's *d* = .635, a medium effect. Table 4.1 shows the means and standard deviations of the performance measures for each condition.

Regarding the post-test, as expected, MANOVA results revealed a statistically significant difference of performance between the topic-centered and the task-centered conditions, *Wilk's Lambda* = .727, *F*(4,57) = 3.572, $p < .01$, η^2 = .273. Between subject effects test results indicated that participants in the task-centered condition performed significantly better on the skill-development test, *F*(1,63) = 5.442, $p < .025$, η^2 = .081, Cohen's *d* = .587, a medium effect, performed significantly better on the near transfer process development test, *F*(1,63) = 18.04, $p < .001$, η^2 = .225, Cohen's *d* = 1.065, a large effect, and performed significantly better on the far transfer process development test, *F*(1,63) = 15.99, $p < .001$, η^2 = .205, Cohen's *d* = 1.004, a large effect.

Table 4.1 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for Performance.

	Task-Centered Approach (N=31)		Topic-Centered Approach (N=33)		Total (N=64)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Module performance:						
Part 1	9.581	1.254	9.394	2.091	9.485	1.726
Part 2	9.636	1.334	9.359	1.977	9.493	1.689
Part 3*	9.697	1.067	8.390	2.706	9.023	2.167
Post test performance:						
Skill-development*	8.960	2.007	7.508	2.866	8.211	2.574
Process-development near transfer**	8.258	1.731	6.272	1.989	7.234	2.106
Process-development far transfer**	7.903	1.837	5.787	2.345	6.812	2.353

* Significant difference between topic-centered and task-centered conditions, $p < .025$
** Significant difference between topic-centered and task-centered conditions, $p < .001$

Cognitive Load

The participants' perceived cognitive load was measured using a single item self-rated scale developed by Paas and Van Merrienboer (1994). Using a nine-point Likert-type scale, the participants were asked to identify the amount of mental effort they invested on completing each step of the instruction and the post test.

It was hypothesized that learners who received task-centered training would report lower cognitive load on completing the test than learners who received topic-centered training. No difference in the perceived cognitive load was expected for completing the module itself (H.1.3). A one-way MANOVA was used to test this hypothesis.

MANOVA results revealed a significant difference of cognitive load between the topic-centered and the task-centered conditions, *Wilk's Lambda* = .468, $F(4,57) = 10.82$, $p < .001$, $\eta^2 = .532$ (see Table 4.2). In contrast to the hypothesis, between subject effects test results indicated that there was a significant difference between the conditions in cognitive load during the module on part 1, $F(1,63) = 4.44$, $p < .05$, $\eta^2 = .067$, Cohen's $d = .526$, a medium effect, on part 2, $F(1,63) = 5.72$, $p < .05$, $\eta^2 = .085$, Cohen's $d = .6$, a medium effect, and on part 3, $F(1,63) = 16.509$, $p < .001$, $\eta^2 = .210$, Cohen's $d = 1.023$, a large effect. While in part 1 and part 2 cognitive load was higher for the task-centered condition, in part 3 cognitive load was higher for the topic-centered condition. Post-hoc Bonferroni tests revealed that for the task-centered condition there was a significant decrease in cognitive load from part 1 to part 2 ($p < .05$), and for the topic-centered condition there was a significant increase in cognitive load from part 1 and 2 to part 3 ($p < .001$).

Regarding the post-test, again in contrast to the hypothesis, no significant differences were found for cognitive load at skill-development test, $F(1,63) = 1.166$, $p = .284$, $\eta^2 = .018$, cognitive load at near transfer process-development test, $F(1,63) = .452$, $p = .504$, $\eta^2 = .007$, and cognitive load at far transfer process-development test , $F(1,63) = .521$, $p = .473$, $\eta^2 = .008$.

Table 4.2 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for Cognitive Load.

	Task-Centered Approach (N=31)		Topic-Centered Approach (N=33)		Total (N=64)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Cognitive load on module:						
Part 1*	4.946	1.342	4.303	1.09	4.615	1.253
Part 2*	4.597	1.232	3.788	1.454	4.179	1.401
Part 3**	4.624	.980	5.949	1.548	5.307	1.456
Overall	4.725	1.065	4.680	1.202	4.702	1.129
Cognitive load on post test:						
Skill-development	5.548	1.207	5.151	1.679	5.344	1.472
Process-development near transfer	5.742	1.316	6.00	1.714	5.875	1.528
Process-development far transfer	5.951	1.624	6.257	1.759	6.109	1.689

* Significant difference between topic-centered and task-centered conditions, $p < .05$
** Significant difference between topic-centered and task-centered conditions, $p < .001$
Note: Maximum possible score for cognitive load was 9.

Time on Task

Time on task was measured by asking the participants to fill the start time and finish time for each of the module steps and for each of the post test questions. It was hypothesized that learners who received task-centered training would spend less time on the near and far transfer process-development tests than learners who received topic-centered training. No time difference was expected for completing the module and for the skill-development test. (H.1.4). A one-way MANOVA was used to test this hypothesis.

MANOVA results revealed a statistically significant difference of time on task between the topic-centered and the task-centered conditions, *Wilk's Lambda* = .468, $F(4,59) = 10.82$, $p < .001$, $\eta^2 = .532$ (see Table 4.3). Regarding the module, between subject effects test results indicated that students in the task-centered condition spent significantly more time on Part 1, $F(1,63) = 18.826$, $p < .001$, $\eta^2 = .233$, Cohen's $d = 1.023$, a large effect, significantly more time on Part 2, $F(1,63) = 6.48$, $p < .05$, $\eta^2 = .095$, Cohen's $d = .634$, a medium effect, and significantly less time on Part 3, $F(1,63) = 69.937$, $p < .001$, $\eta^2 = .530$, Cohen's $d = 2.104$, a large effect. It should be noted that as expected overall there was no significant difference in the overall time spent on the module between the conditions, $F(1,63) = .606$, $p = .439$, $\eta^2 = .010$. Post-hoc Bonferroni tests revealed a significant difference between all the parts for the topic-centered condition ($p < .001$) and a significant difference between part 1 and parts 2 and 3 for the task-centered condition ($p < .001$).

Regarding the post-test, as expected, there was no significant difference between the conditions for time spent on the skill-development test, $F(1,63) = .110$, $p = .742$, $\eta^2 = .002$. In contrast to the hypothesis, no significant differences were found for time on the near transfer process-development test, $F(1,63) = .044$, $p = .834$, $\eta^2 = .001$, and for time on far transfer process-development test , $F(1,63) = .601$, $p = .441$, $\eta^2 = .010$.

Table 4.3 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for Time on Task (in minutes).

	Task-Centered Approach (N=31)		Topic-Centered Approach (N=33)		Total (N=64)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Time spent on module:						
Part 1*	30.742	12.714	19.727	6.929	25.062	11.495
Part 2*	18.225	5.702	15.000	4.387	16.562	5.282
Part 3**	17.871	6.672	35.757	9.996	27.094	12.374
Overall	66.838	18.885	70.484	18.583	68.718	18.671
Time spent on post test:						
Skill-development	6.903	3.902	7.273	4.932	7.094	4.432
Process-development near transfer	7.290	4.002	7.091	3.583	7.187	3.762
Process-development far transfer	11.225	5.364	10.151	5.701	10.672	5.523

CHAPTER IV: RESULTS

Attitudes

Attitudes were measured with four different variables. First, computer anxiety was measured using the Computer Anxiety Rating Scale (CARS) developed by Heinssen et al. (1987) (see Appendix C). Second, computer self-efficacy was measured by a 10-item instrument developed by Compeau and Higgins (1995b) (see Appendix D). The computer anxiety and computer self-efficacy instruments were administered twice, before (pre) and after (post) the module. To further evaluate self-efficacy, the participants were asked to answer the question "I feel confident in my ability to use the information I learned in this step" after each step of the module and the question "I feel confident in my ability to develop similar tasks" after each question of the post test. Last, after completing the module, learner's motivation was measured using a 5-point, Likert-type scale adjusted Kellers' (1993) Instructional Materials Motivational Survey (IMMS) (see Appendix E), which consists of four categories: attention, relevance, confidence, and satisfaction.

It was hypothesized that learners who received task-centered training would report higher self-efficacy (H.1.5), report lower computer anxiety (H.1.6), and express higher motivation towards the training (H.1.7) than learners who receive topic-centered training.

An additional variable (delta) was calculated to express the difference between the post scale and the pre scale results. To test the hypothesis that participants in the task-centered condition reported lower computer anxiety after the module than participants in the topic-centered condition repeated measures analysis with pre and post computer anxiety was used. As expected, repeated measures analysis results revealed a significant time interaction between condition and computer anxiety, $F(1,62) = 4.507$, $p < .05$, $\eta^2 = .068$, Cohen's $d = .528$, a medium effect (see Table 4.4). Figure 4.1 illustrates the values of pre computer anxiety and post computer anxiety by condition. As expected, ANOVA results revealed that there was no statistically significant difference of pre computer anxiety between the topic-centered and the task-centered conditions, $F(1,63) = .11$, $p = .741$, $\eta^2 = .002$. The effect of the treatment condition is dependent on time.

Table 4.4 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for Computer Anxiety Scale.

	Task-Centered Approach (N=32)		Topic-Centered Approach (N=32)		Total (N=64)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pre Computer Anxiety Scale	1.916	0.522	1.953	0.409	1.935	0.464
Post Computer Anxiety Scale [a] *	1.747	0.423	1.966	0.546	1.860	0.499
Delta Computer Anxiety Scale*	-0.169	0.371	0.012	0.312	-0.075	0.351

[a] Analysis was performed with Pre Computer Anxiety Scale as covariant.
* Significant difference between topic-centered and task-centered conditions, $p < .05$
Note. Maximum possible value for the Computer Anxiety Scale is 5.

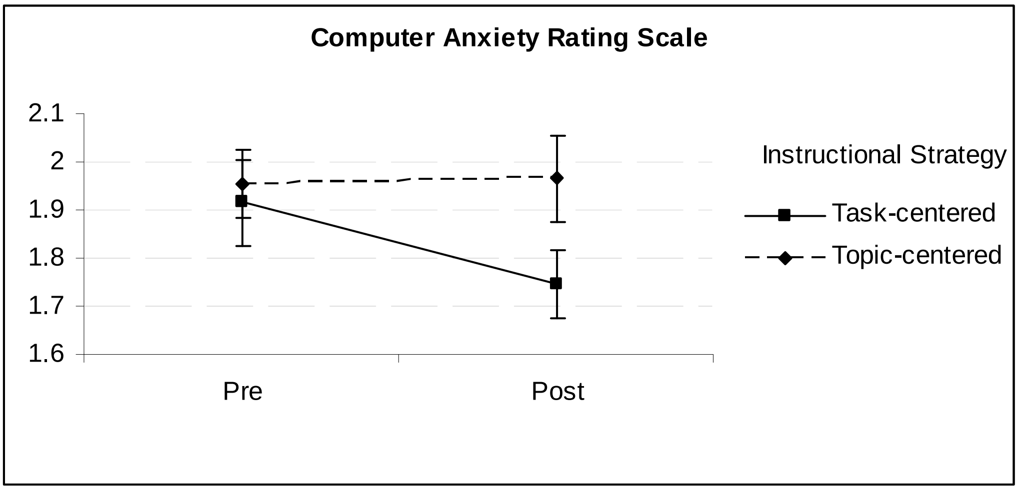


Figure 4.1 Pre and Post Computer Anxiety Means and SDs by Instructional Strategy

Table 4.5 shows the means and standard deviations of computer self-efficacy for each condition. An additional variable (delta) was calculated to express the difference between the post scale and the pre scale results. As expected, ANOVA results revealed that there was no statistically significant difference of pre computer self-efficacy between the topic-centered and the task-centered conditions, $F(1,63) = .322$, $p = .573$, $\eta^2 = .005$. To test the hypothesis that participants in the task-centered condition reported higher computer self-efficacy after the module than participants in the topic-centered condition repeated measurement analysis with pre and post computer self-efficacy was used. Repeated measures analysis did not reveal a significant interaction between condition and computer self-efficacy, $F(1,62) = 2.095$, $p =$

.153, η^2 = .033. Figure 4.2 illustrates the values of pre computer self-efficacy and post computer self-efficacy by condition.

Table 4.5 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for Computer Self-Efficacy Scale.

	Task-Centered Approach (N=32)		Topic-Centered Approach (N=32)		Total (N=64)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Pre Computer Self-Efficacy Scale	6.093	1.469	6.222	1.567	6.158	1.508
Post Computer Self-Efficacy Scale	6.637	1.901	6.237	1.785	6.437	1.841
Delta Computer Self-Efficacy Scale	0.544	1.689	0.015	1.185	0.279	1.472

Note. Maximum possible value for the Computer Self-Efficacy Scale is 10.

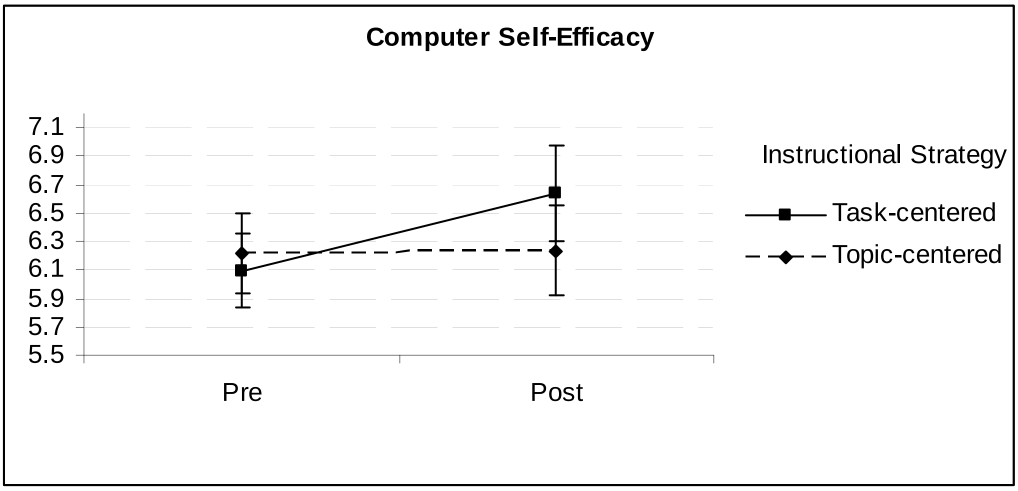


Figure 4.2 Pre and Post Computer Self-Efficacy Means and SDs by Instructional Strategy

The Computer Self-Efficacy scale concerns computers in general and was not specific to the subject of the module. To test the participants' self-efficacy with respect to the specific elements covered in the module the participants were asked after each step of the module (with overall nine steps) to rate the statement "I feel confident in my ability to use the information I learned in this step" on a 1-5 rating scale (1-strongly disagree, 5-strongly agree). The average of the participants' responses for each part was calculated to assess their self-efficacy concerning their ability to use the information learned in the module (see Table 4.6). As expected, one-way MANOVA results revealed that participants in the task-centered condition reported significantly higher confidence during the module than participants in the topic-centered condition, $F(1,64) = 3.847$, $p < .01$, $\eta^2 = .210$. Between subject effects test results indicated that students in the task-centered condition reported significantly higher confidence on part 3, $F(1,63) = 9.849$, $p < .01$, $\eta^2 = .139$, Cohen's $d = .789$, approaching a large effect. There was no significant difference between the conditions in reported confidence on part 1, $F(1,63) = .777$, $p = .382$, $\eta^2 = .013$, and on part 2, $F(1,63) = 1.334$, $p = .253$, $\eta^2 = .021$. Post-hoc Bonferroni tests revealed a significant difference between parts 1 & 2 and part 3 ($p < .001$) for the topic-centered condition.

In addition, after each question in the post-test the participants were asked to rate the statement "I feel confident in my ability to develop similar tasks" on a 1-5 rating scale (see table 4.6). In contrary to the hypothesis, one-way MANOVA results revealed that there was no significant difference between the conditions in participants' reported confidence during the post test, $F(1,63) = .981$, $p = .408$, $\eta^2 = .047$.

Table 4.6 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for Learners' Confidence.

	Task-Centered Approach (N=31)		Topic-Centered Approach (N=33)		Total (N=64)	
	M	*SD*	*M*	*SD*	*M*	*SD*
Confidence level on module:						
Part 1	4.052	.862	3.86	.872	3.958	.862
Part 2	4.255	.806	4.032	.722	4.145	.768
Part 3*	4.088	.838	3.322	1.087	3.711	1.034
Overall*	4.138	.765	3.738	.804	3.941	.804
Confidence level on post test:						
Skill-development	3.935	1.062	3.818	1.130	3.875	1.091
Process-development Near transfer	3.322	1.351	3.364	1.14	3.344	1.237
Process-development far transfer	2.967	1.303	2.697	1.103	2.828	1.202

Significant difference between topic-centered and task-centered conditions, $p < .05$
Possible values for confidence level were 1-5

Last, learners' attitudes toward instruction were measured using a 5-point, Likert-type scale adjusted Kellers' (1993) Instructional Materials Motivational Survey (IMMS), which consists of four categories: attention, relevance, confidence, and satisfaction. One-way MANOVA was used to test the hypothesis that learners who received task-centered training would express higher motivation towards instruction than learners who received topic-centered training (see Table 4.7).

As expected, MANOVA results revealed a statistically significant difference of attitudes toward instruction between the topic-centered and the task-centered conditions, *Wilk's Lambda* = .847, $F(4,59) = 2.711$, $p < .05$, $\eta^2 = .153$. Between subject effects test results indicated that participants in the task-centered condition indicated significantly higher level of relevance, $F(1,63) = 4.631$, $p < .05$, $\eta^2 = .068$, Cohen's $d = .535$, a medium effect, and significantly higher level of confidence, $F(1,63) = 4.006$, $p < .05$, $\eta^2 = .06$, Cohen's $d = .498$, approaching a medium effect. Nevertheless, there was no significant difference between the conditions in reported level of attention, $F(1,63) = 2.95$, $p = .092$, $\eta^2 = .045$ and in reported level of satisfaction, $F(1,63) = .261$, $p = .611$, $\eta^2 = .004$.

Table 4.7 Mean Scores and Standard Deviations of Task-Centered and Topic-Centered Approach for IMMS Survey.

	Task-Centered Approach (N=32)		Topic-Centered Approach (N=33)		Total (N=65)	
	M	*SD*	*M*	*SD*	*M*	*SD*
IMMS - Attention	3.656	.518	3.435	.516	3.544	.525
IMMS – Relevance*	3.340	.519	3.032	.628	3.183	.593
IMMS – Confidence*	3.973	.732	3.588	.812	3.778	.792
IMMS - Satisfaction	3.291	.572	3.209	.718	3.249	.647

* Significant difference between topic-centered and task-centered conditions, $p < .05$
Note. Maximum possible score for IMMS categories is 5.

Research Question 1 Summary

A summary of the results for research question 1 is presented in Table 4.8. Overall, there were significant main effects of instruction strategy on performance, cognitive load, time on task and on attitudes. Figure 4.3 illustrates module and post test performance, cognitive load, and confidence by condition

Table 4.8 Summary of Research Question 1 Results

Dependent variables	Task-Centered Approach	Topic-Centered Approach	Cohen's d Effect Sizes
Performance			
Module Part 1			
Part 2			
Part 3	^{M}Task>Topic*		.635
Post-Test Skill-development	^{M}Task>Topic*		.587
Process-development – near transfer	^{L}Task>Topic**		1.065
Process-development – far transfer	^{L}Task>Topic**		1.004
Cognitive Load			
Module Part 1	^{M}Task>Topic*		.526
Part 2	^{M}Task>Topic*		.600
Part 3	^{L}Task<Topic**		1.023
Post-Test Skill-development			
Process-development – near transfer			
Process-development – far transfer			
Time on Task			
Module Part 1	^{L}Task>Topic**		1.023
Part 2	^{M}Task>Topic*		.634
Part 3	^{L}Task<Topic**		2.104
Post-Test Skill-development			
Process-development – near transfer			
Process-development – far transfer			
Attitudes			
Post Computer Anxiety Scale	^{M}Task<Topic*		.528
Post Computer Self-Efficacy Scale			
Confidence Module Part 1			
Part 2			
Part 3	^{L}Task>Topic*		.789
Confidence Test Skill-development			
Process-development – near transfer			
Process-development – far transfer			
IMMS – Attention			
IMMS – Relevance	^{M}Task>Topic*		.535
IMMS – Confidence	^{M}Task>Topic*		.498
IMMS – Satisfaction			

* *p* < .05; ** *p* < .001

M-Medium, L-Large effect size based on eta squared score (J. Cohen, 1988, p. 283)

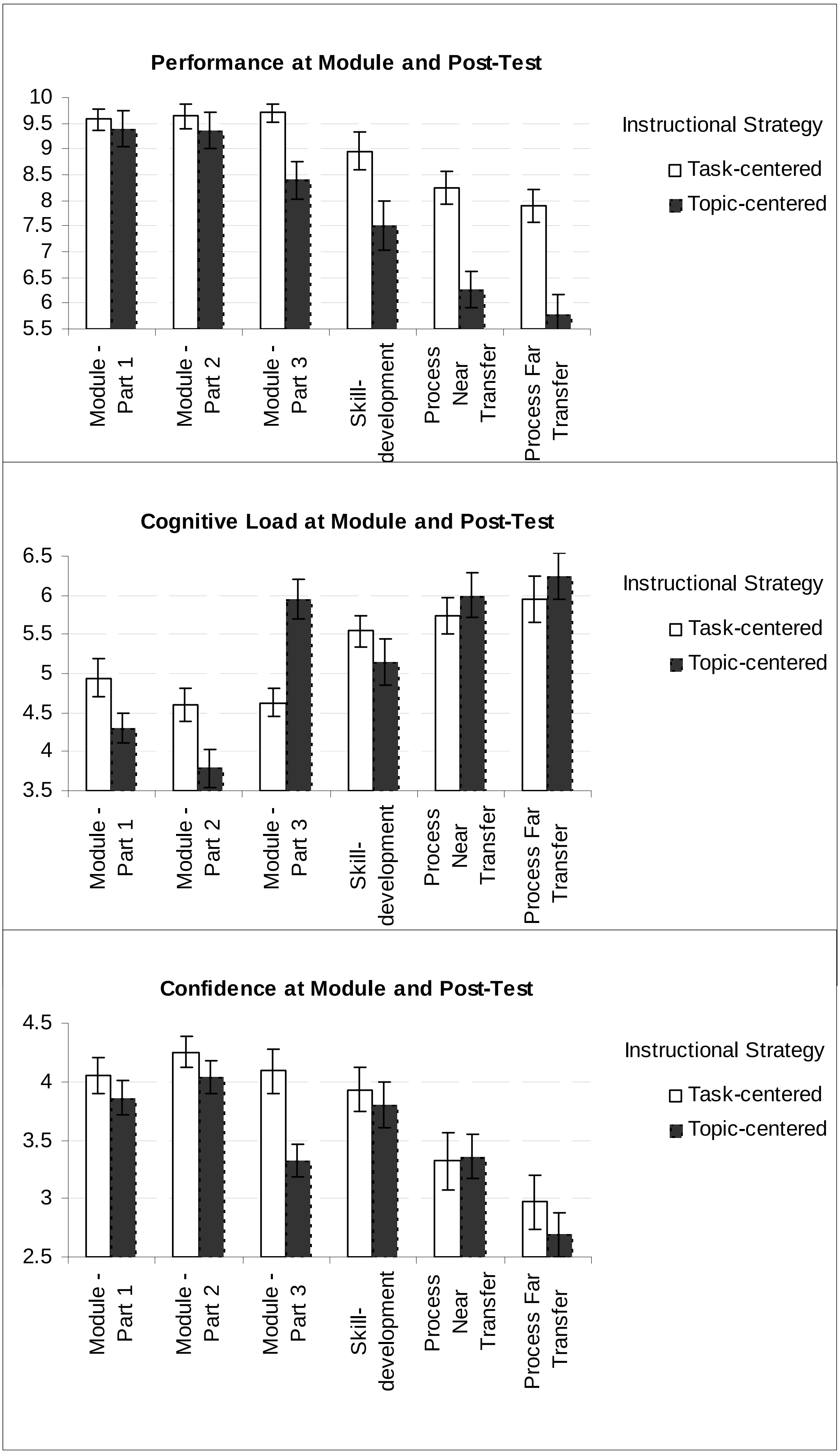


Figure 4.3 Means and SDs for Module and Post Test Performance, Cognitive Load, and Confidence by Instructional Strategy

Research Question 2

What are the relationships between computer anxiety, computer self-efficacy and: (1) performance (skill-development performance, process-development performance (near and far transfer)), (2) cognitive load, (3) time on task, and (4) attitudes toward training?

It was hypothesized that learners' self-efficacy will be positively correlated to skill-development and process development performance tests (H.2.1 & H.2.2), to lower cognitive load (H.2.3), and to better attitudes towards the training (H.2.4) regardless of the training condition. In addition, it was hypothesized that learners' computer anxiety will be negatively correlated to learners' computer self-efficacy (H.2.5). To answer the second research question, correlations between self-efficacy related variables and the dependent variables were calculated.

Performance Relationships

Table 4.9 presents correlations between the self-efficacy related variables and the performance measures. Confidence levels on module and on post test were positively correlated to performance on the post test and performance on part 3 of the module. There was no correlation between confidence level on test and performance on module.

There was no correlation between pre computer anxiety and performance. As expected, post computer anxiety was negatively correlated to performance on the post test, and to performance on part 1 of the module. Delta computer anxiety was also negatively correlated to performance including performance on the module (parts 1 and 3).

Pre computer self-efficacy was not correlated to performance (module and post test). Post computer self-efficacy was positively correlated to performance on part 3 of the module and performance on the post test. Delta computer self-efficacy was positively correlated to performance on parts 1 and 3 of the module and performance on the post test.

Table 4.9 Pearson‘s Correlations Coefficients for Performance (Module and Post Test) with Confidence, Computer Anxiety, and Computer Self-Efficacy.

	Module Performance			Post Test Performance		
	Part 1	Part 2	Part 3	Skill-develop.	Process-develop. Near transfer	Process-develop. Far transfer
Confidence Level on Module	-.013	-.055	.291*	.307*	.471*	.441**
Confidence Level on Test	-.014	-.002	.127	.351*	.327**	.401**
Pre Computer Anxiety	-.063	.068	.072	-.203	-.048	-.084
Post Computer Anxiety	-.254*	.081	-.229	-.445**	-.286*	-.355*
Delta Computer Anxiety	-.279*	.024	-.421**	-.358**	-.343**	-.391**
Pre Computer Self-Efficacy	-.080	-.226	-.107	.104	.099	.017
Post Computer Self-Efficacy	.125	.067	.366**	.366*	.333*	.274*
Delta Computer Self-Efficacy	.251*	.162	.430**	.293*	.287*.	.347*

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Cognitive Load Relationships

Table 4.10 presents correlations between the self-efficacy related variables and the cognitive load measures. As expected, confidence level on the module was negatively correlated to cognitive load at the module and to cognitive load at the skill-development test. Confidence level on test was negatively correlated to cognitive load on the module (parts 2 and 3) and post-test. Post computer anxiety and delta computer anxiety were positively correlated to cognitive load at module (part 3). There were no correlations between computer anxiety and cognitive load for the post-test. Pre and post computer self-efficacy were negatively correlated to cognitive load at the module (parts 2 and 3). There were no correlations between self-efficacy and cognitive load at the post-test.

Table 4.10 Pearson‘s Correlations Coefficients for Cognitive Load (Module and Post Test) with Confidence, Computer Anxiety, and Computer Self-Efficacy.

	Module Cognitive Load			Post Test Cognitive Load		
	Part 1	Part 2	Part 3	Skill-develop.	Process-develop. Near transfer	Process-develop. Far transfer
Confidence Level on Module	-.380**	-.473**	-.598**	-.257*	-.120	-.087
Confidence Level on Test	-.174	-.256*	-.346**	-.458**	-.256*	-.336**
Pre Computer Anxiety	-.003	.100	.111	-.032	-.077	-.219
Post Computer Anxiety	.106	.199	.390**	.085	-.017	-.076
Delta Computer Anxiety	.154	.151	.408**	.160	.082	.196
Pre Computer Self-Efficacy	-.182	-.307*	-.288*	-.115	-.220	-.069
Post Computer Self-Efficacy	-.219	-.324**	-.329**	-.218	-.128	-.064
Delta Computer Self-Efficacy	-.073	-.114	-.121	-.142	-.077	-.010

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Overall, cognitive load at the module was significantly correlated to confidence level on the test, post computer anxiety, and post computer self-efficacy indicating that cognitive load might affect performance through self-efficacy related variables. This finding is in accordance to hypothesis H.2.3 - it was expected that cognitive load at the module would negatively affect self-efficacy. To further examine these findings, correlations between cognitive load on the module and the self-efficacy related variables were calculated separately for each condition (see Table 4.11). While overall there were significant correlations between cognitive load on the module and the self-efficacy related variables, interestingly, these correlations only existed in the topic-centered condition and not in the task-centered condition. For the task-centered condition, cognitive load on the module was only correlated to lower confidence level on the module.

Table 4.11 Pearson‘s Correlations Coefficients for Cognitive Load on Module with Confidence, Computer Anxiety, and Computer Self-Efficacy for each Condition.

	Module Cognitive Load					
	Task-Centered Training			Topic-Centered Training		
	Part 1	Part 2	Part 3	Part 1	Part 2	Part 3
Confidence Level on Module	-.619**	-.507**	-..464**	-.351*	-.652**	-.625**
Confidence Level on Test	-.202	-.130	-.117	-.189	-.434*	-.554**
Pre Computer Anxiety	-.035	-.032	-.051	.075	.275	.235
Post Computer Anxiety	-.191	-.058	-.076	.178	.427*	.460**
Delta Computer Anxiety	.267	.115	.158	.212	.386*	.495**
Pre Computer Self-Efficacy	.158	-.152	-.358*	-.186	-.408*	-.363*
Post Computer Self-Efficacy	-.211	-.216	-.118	-.332	-517**	-.468**
Delta Computer Self-Efficacy	-.100	-.110	-.179	-.187	-.265	-.259

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Correlations between cognitive load on the module and performance on the module and on the post-test were also calculated for each condition (see Table 4.12). Likewise, correlations between cognitive load at the module and post-test performance only existed in the topic-centered condition, but not in the task-centered condition.

Table 4.12 Pearson‘s Correlations Coefficients between Performance and Cognitive Load on Module.

	Module Cognitive Load					
	Task-Centered Training			Topic-Centered Training		
	Part 1	Part 2	Part 3	Part 1	Part 2	Part 3
Module performance:						
Part 1	.005	.002	-.006	-.044	-.009	.017
Part 2	.018	-.211	.028	-.169	.041	-.031
Part 3	-.391*	-.334	-.105	-.493**	-.309	-.183
Post test performance:						
Skill-develop.	-.008	.097	.011	-.361*	-.379*	-.231
Process-develop. Near Tr.	-.338	-.150	-.288	-.355*	-.397*	-.354*
Process-develop. Far Tr.	-.196	.004	-.052	-.271	-.372*	-.494**

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Time on Task

Table 4.13 presents correlations between the self-efficacy related variables and time on task. Confidence level on module was positively correlated to process-development test (near and far transfer) completion time. In addition, post computer anxiety was negatively correlated to process-development test (far transfer). However, apart from these correlations, no correlations were found between the self-efficacy related variables and time on task.

Table 4.13 Pearson‘s Correlations Coefficients for Time on Task (Module and Post Test) with Confidence, Computer Anxiety, and Computer Self-Efficacy.

	Module completion time	Skill-development test completion time	Process-development test (near transfer) completion time	Process-development test (far transfer) completion time
Confidence Level on Module	-.130	.006	.283*	.252*
Confidence Level on Test	-.082	-.177	.144	.191
Pre Computer Anxiety	.078	-.020	-.080	-.125
Post Computer Anxiety	.127	.015	-.122	-.284*
Delta Computer Anxiety	.073	.044	-.063	-.232
Pre Computer Self-Efficacy	-.038	-.149	.073	.114
Post Computer Self-Efficacy	-.042	-.052	.150	.148
Delta Computer Self-Efficacy	-.038	.072	.076	.070

*. Correlation is significant at the 0.05 level (2-tailed).

Attitudes

Learner’s attitudes toward instruction were measured using Kellers’ (1993) Instructional Materials Motivational Survey (IMMS), which consists of four categories: attention, relevance, confidence, and satisfaction. Table 4.14 presents correlations between self-efficacy related variables and attitudes toward training. Overall, self-efficacy related variables were strongly correlated to all the IMMS categories. The exceptions were pre computer anxiety that was not correlated to IMMS-Relevance and IMMS-Confidence, and pre computer self-efficacy that was not correlated to IMMS-Relevance and IMMS-Satisfaction.

Table 4.14 Pearson‘s Correlations Coefficients for Instructional Materials Motivational Survey (IMMS) with Confidence, Computer Anxiety, and Computer Self-Efficacy.

	IMMS - Attention	IMMS - Relevance	IMMS - Confidence	IMMS - Satisfaction
Confidence Level on Module	.334**	.424**	.709**	.549**
Confidence Level on Test	.172	.278*	.541**	.421**
Pre Computer Anxiety	-.330**	.-191	-.186	-.273*
Post Computer Anxiety	-.352**	-.356**	-.551**	-.480**
Delta Computer Anxiety	-.064	-.254*	-.536**	-.321*
Pre Computer Self-Efficacy	.288*	.193	.272*	.165
Post Computer Self-Efficacy	.447**	.408**	.591**	.524**
Delta Computer Self-Efficacy	.266*	.289*	.471**	.450**

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Last, table 4.15 presents the inter correlations between the self-efficacy related variables. As expected, computer anxiety was negatively correlated to computer self-efficacy and to confidence levels.

Table 4.15 Inter Correlations between Confidence, Computer Anxiety, and Computer Self-Efficacy.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(1) Confidence Level on Module	1	.623**	-.313*	-.558**	-.377**	.371	.537**	.316*
(2) Confidence Level on Test	.623**	1	-.180	-.415**	-.341**	.272*	.393**	.234
(3) Pre Computer Anxiety Scale	-.313*	-.180	1	.736**	-.276*	-.303*	-.432**	-.264*
(4) Post Computer Anxiety Scale	-.558**	-.415**	.736**	1	.447**	-.273*	-.585**	-.484**
(5) Delta Computer Anxiety Scale	-.377**	-.341**	-.276*	.447**	1	.013	-.259*	-.334**
(6) Pre Computer Self-Efficacy Scale	.371**	.272*	-.303*	-.273*	.013	1	.630**	-.237
(7) Post Computer Self-Efficacy Scale	.537**	.393**	-.432**	-.585**	-.259*	.630**	1	.605**
(8) Delta Computer Self-Efficacy Scale	.316*	.234	-.264*	-.484**	-.334**	-.237	.605**	1

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Research Question 3

Does self-efficacy mediate the effects of instructional strategy on: (1) skill-development performance, (2) near transfer process-development performance, and (3) far transfer process-development performance?

To answer the third research question, a mediation test (Baron & Kenny, 1986) was performed to examine whether self-efficacy is a significant mediator of the instructional strategy effects on performance. In other words, this test examined whether instructional strategy influences performance by first improving self-efficacy. A Sobel test was followed to confirm the results (Sobel, 1982).

Four initial steps are necessary in establishing mediation. It is necessary to show that: (1) the IV significantly affects the mediator (A in Figure 4.4), (2) the IV significantly affects the DV in the absence of the mediator (C in Figure 4.4), (3) the mediator has a significant unique effect on the DV (in the presence of the IV) (B in Figure 4.4), and (4) the effect of the IV on the DV shrinks upon the addition of the mediator to the model (C-C’ in Figure 4.4) (Baron & Kenny, 1986; Mackinnon & Kenny, 2001).

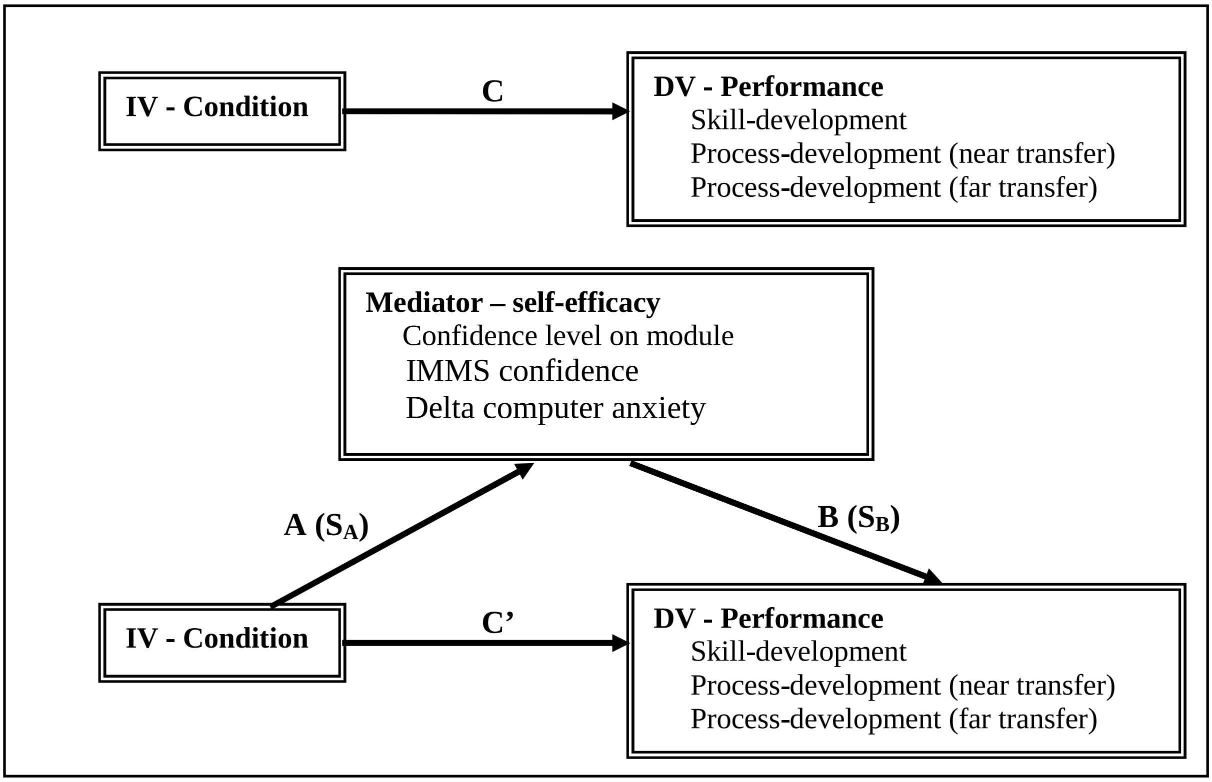


Figure 4.4 Illustration of the Mediation Effect Expected in the Current Study

A = raw (unstandardized) regression coefficient for the association between IV and mediator.
S_A = standard error of A
B = raw (unstandardized) regression coefficient for the association between the mediator and the DV (when the IV is also predictor of the DV).
S_B = standard error of A

The variables that were considered to represent self-efficacy and therefore as mediators for this model were confidence level on module, IMMS-confidence, post computer anxiety, delta computer anxiety, post computer self-efficacy, and delta computer self-efficacy. These variables represent the participants’ level of self-efficacy at the end of the module and before the post test. It should be noted that the meditational model is a causal model, thus, the mediator is presumed to cause the outcome and not vice versa. For that reason, confidence level on test was not considered as a possible mediator because it is possible that performance on the post-test influenced this variable and not vice versa as desired. In addition, pre computer anxiety and pre computer self-efficacy were not considered as mediators because it was not possible to claim that the IV (instructional strategy) had an effect on these variables (that were measured prior to training).

To test the first step, regressions with the IV predicting the mediators were performed to test whether the IV significantly affects the mediators (see Table 4.16). Results indicated that instructional strategy significantly affected confidence level on module, $t = 2.042$, $p = .045$, significantly affected IMMS-confidence, $t = 2.002$, $p = .05$, which is the level of confidence the learners felt with respect to the instructional materials, and significantly affected delta computer anxiety, $t = -2.123$, $p = .038$. Nevertheless, instructional strategy did not have a significant effect on post computer self-efficacy, $t = .867$, $p = .389$, delta computer self-efficacy, $t = 1.447$, $p = .153$, and post computer anxiety, $t = -1.784$, $p = .079$.

Table 4.16 Results of Regressions with the IV Predicting the Mediators

Mediators	*b*	*t*	*p*
Confidence level on module	.414	2.042	.045
IMMS-confidence	.384	2.002	.05
Post computer anxiety	-.219	-1.784	.079
Delta computer anxiety	-.182	-2.123	.038
Post computer self-efficacy	.400	.867	.389
Delta computer self-efficacy	.528	1.447	.153

For the second step, it was already established in research question one that instructional strategy has a significant effect on skill-development performance and process-development (near and far transfer) performance in the absence of a mediator. For the third step, it was necessary to show that the mediator has a significant unique effect on the DV in the presence of the IV. To test this question, regressions were conducted predicting performance with condition entered in the first step and the potential mediator entered in the second step. Results indicated that all the mediators had a significant unique effect on all the performance measures in the presence of the IV as predictor (see column B in Table 4.17). For IMMS confidence, although condition predicted skill-development performance in the first step, $t(1,63) = 2.33$, $p < .05$, in the second step IMMS confidence was a significant predictor, and condition was no longer significant, $p = .129$. Nevertheless, for all the other variables, condition remained a significant predictor indicating a partial mediation effect.

Lastly, a Sobel test was performed to test whether the partial effect of the IV on the DV via the mediator is significantly bigger than zero for confidence level on module and for

IMMS-confidence as the mediators, and significantly lower than zero for delta computer anxiety as the mediator (see Table 4.17). Results indicated that confidence level on module was a significant mediator of the effect of instructional strategy on near transfer process-development performance, $z = 1.764$, $p = .038$, and far transfer process-development performance, $z = 1.716$, $p = .043$. Likewise, IMMS-confidence was a significant mediator of the effect of instructional strategy on skill-development performance, $z = 1.769$, $p = .038$, near transfer process-development performance, $z = 1.877$, $p = .03$, and far transfer process-development performance, $z = 1.785$, $p = .037$. Last, delta computer anxiety was not found to be a significant mediator of skill-development performance, $z = 1.595$, $p = .055$, near transfer process-development performance, $z = 1.457$, $p = .072$, and far transfer process-development performance, $z = 1.623$, $p = .052$, although results were close to significance. Overall, results indicated that self-efficacy is a significant mediator of the effect of instructional strategy on performance.

Table 4.17 Coefficients used for the Sobel Test

Mediator	DV – Performance	A	SE_A	B	SE_B	Sobel Test	*p*
Confidence level on module	Skill-development	.414*	.203	.766*	.375	1.443	.074
	Process-development (near transfer)	.414*	.203	.933***	.265	1.764	.038
	Process-development (far transfer)	.414*	.203	.970**	.305	1.716	.043
IMMS confidence	Skill-development	.384*	.192	1.398***	.368	1.769	.038
	Process-development (near transfer)	.384*	.192	1.374***	.252	1.877	.03
	Process-development (far transfer)	.384*	.192	1.23***	.310	1.785	.037
Delta computer anxiety	Skill-development	-.182*	.086	-2.151*	.886	1.595	.055
	Process-development (near transfer)	-.182*	.086	-1.375*	.684	1.457	.072
	Process-development (far transfer)	-.182*	.086	-1.918*	.758	1.623	.052

$^*p < .05$; $^{**}p < .01$, $^{***}p < .001$
A = raw (unstandardized) regression coefficient for the association between IV and mediator.
SE_A = standard error of A
B = raw (unstandardized) regression coefficient for the association between the mediator and the DV (when the IV is also predictor of the DV).
SE_B = standard error of B
Note: Sobel P is based on one-tailed probability

Research Question 4

Is there an interaction between learner's level of expertise and treatment condition with regard to: (1) computer self-efficacy, (2) computer anxiety (3) learners satisfaction (4) cognitive load (5) skill-development performance, (6) process-development performance (near and far transfer), and (7) time on task?

The level of expertise (ranging from 0-9) of the participants was measured using a self-report questionnaire that include experience in developing Internet applications, experience developing in Flash, and programming experience (see Table 3.6). Most of the participants in this study had very low prior level of expertise. Of the 65 participants, 45 (69.2%) received the score 0, 12 (18.5%) received the score 1, six (9.2%) received the score 2, one received the score 3 and one received the score 5. Because most of the participants (96.9%) reported low level of expertise (less than 3 out of 9) it was not possible to use level of expertise as a factor in a 2x2 ANOVA analysis.

CHAPTER V: DISCUSSION

The purposes of the current study were to (a) investigate whether and why a task-centered approach might be superior to a topic-centered approach for problem solving, (b) attempt to reveal emotional and cognitive processes behind complex learning in the domain of technological skills, and (c) provide recommendations for effective training methods while considering individual differences. In particular, it was of interest to investigate (1) what are the effects of instructional strategy (task-centered vs. topic-centered) on performance, cognitive load, time on task, and attitudes (computer self-efficacy, computer anxiety, and motivation), (2) what are the relationships between computer anxiety, computer self-efficacy and performance, cognitive load, time on task, and attitudes toward training, (3) whether self-efficacy mediate the effects of instructional strategy on performance, and (4) is there an interaction between learner's level of expertise and treatment condition with regard to the dependant variables.

To achieve the study purposes two computer-based instructional strategies, task-centered and topic-centered, were employed. Performance, cognitive load, confidence, and time on task were measured on the module and on the post test. In addition, computer anxiety and computer self-efficacy instruments were administered twice, before (pre) and after (post) the module. Last, after completing the module, learner's motivation was measured using Kellers' (1993) Instructional Materials Motivational Survey (IMMS) (see Appendix E), which consists of four categories: attention, relevance, confidence, and satisfaction.

Next, findings are discussed starting with the effects of instructional strategy on the dependent variables, continuing with the relationships between self-efficacy related variables and the dependent variables, and concluding with the mediation effect of self-efficacy on performance. Discussion of the study limitations, implication, and suggestions for future research conclude this chapter.

Research Findings

According to Mayer (1998) effective instructions for problem solving should address three components: skill, metaskill, and will. These components according to Mayer are best learned within personally meaningful contexts where the problem solvers' motivational needs are addressed and emotional support is provided. These three components are addressed in a task-centered instructional strategy. Rooted in Bandura’s (1986) Social Cognitive Theory in which the effects of the environment on human behavior are assumed to be mediated by cognitions with a continuous reciprocal interaction, in the current model two reciprocal interactions are assumed to be in the heart of task-centered instructions.

These interactions that can be viewed as two positive feedback loops include performance-motivation loop and performance-cognition loop (see Figure 2.12). In the performance-motivation loop, the progression of tasks from easy to difficult increases the likelihood of successful completion leading to an increase in self-efficacy, which in turn should influence performance further (e.g., Bouffard-Bouchard, 1990). In the performance-cognitive loop, authentic-tasks, which characterize task-centered instructions, can help the learner construct schemata, which may reduce working memory and lead to better performance, which in turn may further increase schemata construction. Thus, it was expected in the current study that task-centered instruction would result in better performance as a result of motivational and cognitive considerations.

Main Effects of Instructional Strategy

Effects of Instructional Strategy on Performance

Regarding the instructional modules, as expected, there was no significant difference between the conditions in performance on the module for part 1, and for part 2, which were performed very well by both conditions. Nevertheless, participants in the task-centered condition performed significantly better than participants in the topic-centered condition in part 3. It should be noted that the participants were graded for different performances in the two conditions which are not comparable. Yet, performance on module parts was compared to identify different patterns of performance behavior in the two conditions. In the topic-centered condition, the participants learned a single topic on each part. In part 3 they were then first introduced to buttons which is the most difficult topic. This resulted in a decrease in performance, which was significantly lower than the performance of participants in the task-centered condition for part 3. In the task-centered condition, on the other hand, participants were faced with a complete task that involved all the topics starting from part 1 of the module. Thus, participants were introduced to the topic of buttons starting from part 1 and were gradually introduced to more difficult elements of the topic on each part. Even though this difficult topic was introduced starting at the first step for the task-centered condition, there was no significant difference in performance between the conditions for parts 1 and 2.

Regarding the post test, as expected, participants in the task-centered condition performed significantly better on the skill-development test, performed significantly better on the near transfer process development test, and performed significantly better on the far transfer process development test. In the proposed model for this study, it was assumed that the task-centered instructional strategy will influence motivational (self-efficacy, anxiety, interest, outcome expectations) and cognitive (schema construction, cognitive load) factors resulting in increased performance as found. This model will be further tested in the following sections.

Effects of Instructional Strategy on Cognitive Load

Regarding the instructional modules, in contrast to the hypothesis, there was a significant difference between the conditions in cognitive load during the module on part 1, on part 2, and on part 3. While on part 1 and part 2 cognitive load was significantly higher for the task-centered condition, on part 3 cognitive load was significantly higher for the topic-centered condition.

Authentic-tasks can help the learner construct schemata, which provide a mechanism for knowledge organization and storage and help reduce working memory load and therefore cognitive load. Nevertheless, the risk of authentic-tasks is that the learner may be faced with extremely high levels of cognitive load that was found to have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). In parts 1 and 2, participants in the task-centered condition reported significantly higher cognitive load that was likely a result of the fact that they were introduced to whole tasks that involved different topics. In particular, for the task-centered condition, cognitive load on part 1 was significantly higher than on part 2. Nevertheless, in contrast to previous findings (Sweller, van Merrienboer, & Paas, 1998), the higher cognitive load was not accompanied by reduced performance. Another explanation for the increased cognitive load on the first two parts is that task-centered approach is characterized by random practice schedule, or in other words, in each task the topics appear in random order. According to van Merrienboer & Sweller (2005), it was found that high contextual interference (i.e., a random practice schedule) increased cognitive load during training nevertheless improved transfer performance. Thus, the existence of contextual interference in the task-centered condition was also a possible cause for the increased cognitive load accompanied by better transfer performance. Nevertheless, while the initial cognitive load in the task-centered condition was higher, it was reduced in part 2 and part 3. In the topic-centered condition, on the other hand, initial cognitive load was lower, nevertheless, when the participants were introduced to the complex topic of buttons in part 3 their cognitive load increased significantly and was indeed accompanied by reduced performance.

Regarding the post test, it was expected that since the participants in the task-centered condition may have acquired better schemata, their cognitive load would be lower during the post test, yet no significant differences were found for cognitive load. Still, even though there was no significant difference in cognitive load between the conditions during the post test, performance was significantly higher for the task-centered condition. These findings are consistent with the findings reported by Lim et al. (2009) who found significant difference in performance between part-task and whole-task conditions yet no difference in perceived cognitive load.

Effects of Instructional Strategy on Time on Task

Regarding the instructional modules, while as expected there was no difference between the conditions in the overall total completion time of the modules, participants in the task-centered condition spent significantly more time on part 1, significantly more time on part 2, and significantly less time on part 3 than participants in the topic-centered condition. These results are consistent with the results found for cognitive load and performance. For the task-centered condition, part 1 was the most demanding, as they had to develop a whole task for the first time. In the following parts, cognitive load and completion time were reduced and performance increased. For the topic-centered condition, parts 1 and 2 were relatively easy, however part 3 in which the topic of buttons was introduced resulted in higher cognitive load, longer time, and reduced performance.

Regarding the post test, as expected, there was no significant difference between the conditions for time spent on the skill-development test. In contrast to the hypothesis, no significant differences were found for time spent on the near transfer process-development test, and on the far transfer process-development test. It was expected that the superior performance of the task-centered condition will also result in faster performance. It is possible that participants in the task-centered condition were more motivated and spent longer time to make sure they were successful. It should be noted that while there was no significant time difference between the conditions, performance was significantly higher for the task-centered condition, indicating they were able to complete the tasks more successfully yet in the same time.

Effects of Instructional Strategy on Attitudes

Consistent with the hypothesis, participants in the task-centered condition reported significantly lower computer anxiety after the module than participants in the topic-centered condition. In contrary to the hypothesis, there was no significant difference in computer self-efficacy between the conditions. The computer self-efficacy scale concerns computers in general and was not specific to the subject of the module. It is possible that it did not reflect accurately the participants' sense of self-efficacy with respect to the specific content of the module (i.e., developing with Flash).

To test the participants' self-efficacy with respect to the specific elements covered in the module the participants were asked after each step of the module to report their level of confidence. Participants in the task-centered condition reported significantly higher confidence on part 3 than participants in the topic-centered condition. There was no significant difference between the conditions in reported confidence on parts 1 and 2. Again, these findings are consistent with the findings for performance, cognitive load, and time on task. For the topic-centered condition, part 3 was the most challenging and resulted in increased cognitive load, increased time, reduced performance and reduced confidence. It should be noted that for the task-centered condition, even though the first part involved significantly higher cognitive load and significantly longer time, it did not result in reduced performance or reduced confidence. In fact, confidence level on module for the task-centered condition remained constantly high throughout the module (see Figure 4.3).

Participants' level of confidence was also measured on the post-test. In contrary to the hypothesis, there was no significant difference between the conditions in participants' reported confidence during the post test. Apparently, the post test was difficult for all the participants as indicated by the increased cognitive load and reduced level of confidence. Yet, participants in the task-centered condition performed significantly better on all the post-test items.

Last, learners' attitudes toward instruction were measured using Kellers' (1993) Instructional Materials Motivational Survey (IMMS), which consists of four categories: attention, relevance, confidence, and satisfaction. As expected, participants in the task-centered condition indicated significantly higher level of relevance, and significantly higher level of confidence. Nevertheless, there was no significant difference between the conditions in reported level of attention and in reported level of satisfaction.

These findings strengthen the research model with respect to cognitive and motivational considerations. Regarding relevance, in the task-centered condition the use of authentic and relevant problems is very likely to provide for an interesting learning environment increasing motivation and sense of relevance. As noted by Merrill (2007b), traditional instruction is often not clear with regard to how the knowledge and skill components will eventually be applied, causing the instruction to lack the necessary relevance for the learner. Regarding confidence, according to Bandura (1986), actual experiences is the most important source of self-efficacy (Stipek, 2002) whereas task-centered instruction provide extensive actual experiences. In addition, an authentic task can help the learner construct schemata not only of all the components of the tasks but also of the way the different components relate to each other which may increase performance and again as a result increase self-efficacy and confidence.

Regarding attention and satisfaction, while the task-centered condition was expected to report higher attention and satisfaction levels it is possible that as a result of a novelty effect there were no differences between the conditions in attention and satisfaction. In particular, in both the conditions the participants were asked to complete an engaging online module in which they learned completely new software. This exposure may have been engaging enough for both the condition that may be the reason for the similar attention and satisfaction levels.

Correlations between Self-Efficacy and the Dependant Variables

According to Social Cognitive Theory (Bandura, 1986), the effects of the environment on human behavior are assumed to be mediated by cognitions with a continuous reciprocal interaction between the environment in which an individual operates, personal factors, and behavior. Personal factors in the current study include motivational and cognitive factors, whereas behavior can be viewed as the observable performance. Regarding motivational factors, the task-centered approach may increase self-efficacy through positive actual experience. High self-efficacy is associated with longer persistence at tasks (Bouffard-Bouchard, 1990), effort put in completing the task on hand (Bandura, 1986), use of constructive strategies for learning (Pintrich & De Groot, 1990), positive emotions, and reduced fear and anxiety (Zimmerman, 1995), all of which affect achievement outcomes. Regarding cognitive factors, authentic-tasks, can help the learner construct schemas that provide a mechanism for knowledge organization and storage and help reduce working memory load, which may result in better performance. Thus, cognitive load for example may influence performance that can then influence self-efficacy, which in turn can further influence performance.

Accordingly, it was hypothesized that learners' self-efficacy will be positively correlated to skill-development and process development performance tests, to lower cognitive load, and to better attitudes towards the training regardless of the training condition. In addition, it was hypothesized that learners' computer anxiety will be negatively correlated to learners' computer self-efficacy.

Correlations between Self-Efficacy and Performance

Regarding the module, confidence level on module, delta computer self-efficacy, and post computer self-efficacy were positively correlated to performance on part 1 and especially to part 3 of the module. Accordingly, delta computer anxiety was negatively correlated to performance on part 1 and especially on part 3 of the module. Overall, it appears that performance on the third part of the module influenced self-efficacy, confidence, and anxiety. It was also expected that pre computer self-efficacy and pre computer anxiety would influence performance on the module; nevertheless, there were no correlations between pre computer anxiety and pre computer self-efficacy and performance on the module. A possible explanation could be that there was not a lot of variability in performance in the module (especially on parts 1 and 2). Thus, overall most of the students performed extremely well, disabling a correlation to occur.

Regarding the post-test, confidence level on module, delta computer self-efficacy, and post computer self-efficacy were positively correlated to performance on the post-test. Delta computer anxiety was negatively correlated to performance on the post-test. There were no correlations between pre computer anxiety and pre computer self-efficacy and performance on the post-test. Apparently, by the time the students reached the post test, their self-efficacy has already changed, and was indeed positively correlated to their performance on the post-test.

Overall, these findings are consistent with the continuous reciprocal interaction indicated in Bandura's Social Cognitive Theory (Bandura, 1986). Apparently, performance on the third part of the module influenced self-efficacy, confidence, and anxiety, which in turn influenced performance on the post test.

Correlations between Self-Efficacy and Cognitive Load

Cognitive load was found to have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). Thus, it was expected that self-efficacy will be negatively correlated to cognitive load. Overall, as expected, high cognitive load resulted in lower self-efficacy and confidence and higher computer anxiety. Unlike performance, for cognitive load pre computer self-efficacy was correlated to cognitive load on parts 2 and 3 of the module, suggesting that cognitive load may be more sensitive to prior psychological state than performance.

Confidence level on test was negatively correlated to cognitive load on the module (parts 2 and 3) and post-test. Confidence level on the module was negatively correlated to cognitive load at the skill-development test. Nevertheless, there were no correlations between computer anxiety and self-efficacy and cognitive load for the post-test. It is possible that cognitive load during the module affected self-efficacy which in turn affected performance on the post-test.

To further examine these findings, correlations between cognitive load on the module and the self-efficacy related variables were calculated separately for each condition. While overall there were significant correlations between cognitive load on the module and the self-efficacy related variables, interestingly, these correlations only existed in the topic-centered condition and not in the task-centered condition. For the task-centered condition, cognitive load on the module was only correlated to lower confidence level on the module. A possible explanation is that computer self-efficacy and computer anxiety which were measured right after the end of the module were most influenced by cognitive load on the third part of the module. For the topic-centered condition, the third part was the most demanding in terms of cognitive load, thus having greater influence. It is also possible that cognitive load in the task-centered condition was not perceived negatively as in the topic-centered condition and indeed, in parts 1 and 2 cognitive load was significantly higher for the task-centered condition yet their performance and confidence were not lower (in fact they were also higher although not significantly). Accordingly, correlations between cognitive load at the module and performance at the post-test only existed in the topic-centered condition, but not in the task-centered condition.

Correlations between Self-Efficacy and Time on Task

Confidence level on module was positively correlated to process-development test (near and far transfer) completion time. In addition, post computer anxiety was negatively correlated to process-development test (far transfer). However, apart from these correlations, no correlations were found between the self-efficacy related variables and time on task. Overall it appears that the time spent on the test was slightly correlated to confidence on module and computer anxiety. It is possible that higher confidence increased the participants' motivation to spend more time on the post test

Correlations between Self-Efficacy and Attitudes

Learner's attitudes toward instruction were measured using Kellers' (1993) Instructional Materials Motivational Survey (IMMS). Overall, self-efficacy related variables were strongly correlated to all the IMMS categories. These results were expected and can serve as evidence to the validity of the various scales used in this study as measured of motivation. In addition, as was found by Zimmerman (1995), self-efficacy was negatively correlated to computer-anxiety.

Mediation Effect of Self-Efficacy on Performance

Confidence level on module was found to be a significant partial mediator of the effect of instructional strategy on near and far transfer process-development performance. Likewise, IMMS-confidence was a significant mediator of the effect of instructional strategy on skill-development performance, and near and far process-development performance. Lastly, delta computer anxiety was not found to be a significant mediator of performance, although results were close to significance.

Overall, results indicated that self-efficacy is a significant partial mediator of the effect of instructional strategy on performance. These results are in alignment with Bandura's

(1986) Social Cognitive Theory, in which the effects of the environment on human behavior are assumed to be mediated by cognitions. It should be noted that the effect of instructional strategy on performance was reduced but still existed after adding the mediators to the regression model. This indicates that while self-efficacy plays an important role in influencing performance, there are additional aspects of the instructional strategy that influence performance as well. Thus, for example, the task-centered instructional strategy might facilitate schema construction that also has an important influence on performance.

Limitations

There are several limitations to this study. First, the duration of the intervention was ~105 minutes. Ideally, comparison of the two instructional approaches should span over a longer period of time. According to van Merrienboer et al. (2007, p. 10) their model “will typically be used to develop training programs of substantial duration - ranging from several weeks to several years”. Nevertheless, significance differences were found in similar comparisons that also did not span over a long period of time (e.g., Lim, Reiser, & Olina, 2009), indicating that differences between the approaches might be found even after a short intervention as was the case in the current study.

Second, because participants volunteered to take part in this study, it was possible that participants who volunteer for this study have higher self-efficacy, lower computer anxiety and more experience than the general population. However, it turned out that the majority of participants in this study did not have any prior experience, making it impossible to generalize the findings to populations with higher prior experience and to explore the interactions between prior experience and instructional strategy.

Third, also concerning generalizability, the domain of this study was programming, thus, further studies are needed to generalize the observed differences between the instructional approaches to other domains.

Last, performance in this study was rated by only one examiner. The reason for that was that the domain of the module required specific programming skills in Flash for rating the participants’ answers and it was not possible to find more than one rater qualified for the task. To control for rating reliability, a specific grading scale was defined for each question.

Implications

In terms of theoretical implications, as mentioned before, rooted in Bandura's (1986) Social Cognitive Theory, in the proposed theoretical model two reciprocal interactions were assumed to be in the heart of task-centered instructions. These interactions that can be viewed as two positive feedback loops include performance-motivation loop and performance-cognition loop (see Figure 2.12). The results of this study support the proposed theoretical model. Task-centered instructional strategy resulted in better performance while completing the module, which led to an increase in self-efficacy, which then led to better performance on the post-test. The superior performance on the post-test was also likely a result of cognitive considerations including advanced schemata construction in the task-centered condition. This theoretical model can be used to further investigate the cognitive and motivational factors that are in the heart of complex learning.

This study holds practical implication for educators in general and for the field of instructional design. Overall, findings of this study demonstrate the important role of motivation in learning. In particular, self-efficacy was found to be a mediator of performance and should be considered carefully by educators. In addition, findings of this study demonstrate the advantages of the task-centered instructional strategy (Merrill, 2007b). The task-centered instructional strategy was designed specifically for the purpose of teaching complex problem-solving skills and emphasizes teaching in the context of a concrete real world task. Nevertheless, unlike other problem-centered instructional methods (e.g., constructivism) the task-centered instructional strategy is a form of direct instruction but in the context of authentic, real-world tasks (Merrill, 2009).

Unlike traditional part-task instructional strategies (e.g., Gagné, 1968), which assume that any task can be broken down into a collection of instructional objectives that need to be mastered, the task-centered instructional strategy is content-centered meaning the content-to-be-learned and not the objectives are specified first. Specifically, a progression of complete tasks with increasing complexity is specified and serves as the backbone of instruction. Thus, while topic-centered instructional strategies usually teach the content in a hierarchical fashion (i.e. only one topic is taught at a time, until all the component skills have been taught), in task-centered instructional strategies a simplified version of the whole task is demonstrated right up front and the instructions that follow provide the necessary information to complete this task. Findings of this study suggest using the task-centered instructional strategy for the purpose of teaching complex problem-solving skills with far-transfer needs.

Future Research

Several directions for future research should be considered. First, in the current study, a theoretical model which assumed two positive feedback loops (performance-motivation loop and performance-cognition loop) was investigated and overall the findings supported this model. Nevertheless, due to its limited time of the intervention, in the current study there were only several main measures of performance, cognitive load, and motivation, including performance and cognitive load on the module and post-test and attitudes before, during, and after the module. Future studies should further investigate this theoretical model by employing longer periods of instruction that could enable a better understanding of the reciprocal interactions between performance, cognition, and motivation.

Second, in the task-centered instructional strategy, which is a content-centered approach, a progression of complete tasks with increasing complexity is specified first. In the current study, which involved programming in Flash, three tasks from easy to hard were specified for the task-centered condition. Future research should further investigate the process of specifying the progression of tasks. For example, a too slow progression may have negative consequences for learning due to decrease in interest. A too fast progression may have negative consequences for learning due to too high cognitive load. Thus, future research should provide recommendations for how to specify a progression of complete tasks that maximize learning.

Third, this study revealed interesting findings with respect to cognitive load. It was found that using highly complex learning tasks, which involve high cognitive load have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). In the current study, indeed, cognitive load was higher for the task-centered conditions in the first two parts of the module. Nevertheless, the performance and confidence in these two parts were not lower than the performance and confidence of the topic-centered condition. Moreover, while cognitive load in the topic-centered condition was negatively correlated to self-efficacy and post-test performance in the topic-centered condition, these correlations did not exist in the task-centered condition. Yet, it should be noted that the high cognitive load in the third part of the module for the topic-centered condition was indeed associated with decreased performance and decreased confidence. These findings indicate that cognitive load under certain circumstances may not have negative effects on learning, performance, and motivation. Future research should further investigate the conditions under which cognitive load may have an overall positive effect. For example, it is possible that for the task-centered condition the high cognitive load in the first two parts of the module was germane in its nature, whereas for the topic-centered condition the high cognitive load in the third part of the module was extraneous in its nature. Future research should also aim at finding measurement of cognitive load that can identify the exact nature of the cognitive load reported (e.g., intrinsic cognitive load, extraneous cognitive load, or germane cognitive load).

Forth, in the current study, the superiority of the task-centered instructional strategy was demonstrated in settings that involved learning Flash individually by completing a computerized module. Future research should extend the findings to other settings. For example, in constructivism, learning settings often include working in collaboration. Thus, future research should investigate the effect of task-centered instructional strategy in settings that involve working in collaboration, class settings, and so on. In addition, future research should consider other domains in addition to programming as well as other populations including young children.

APPENDIX A. PILOT STUDY

Abstract

The purpose of this study was to examine the effect of instructional strategy type (part-task vs. whole-task) on acquisition of a complex cognitive skill – developing an application in Flash using ActionScript. In particular, we measured the effects of the instructional strategy type on task performance, transfer, time on task, cognitive load, and attitudes. Expertise levels of the learners were also considered. Six females and four males volunteered to participate in a pilot study that was conducted online and were randomly assigned to one of the two conditions. Although the observed differences were not significant, participants in the whole-task condition performed better on the module and on a transfer test than participants in the part-task condition. In addition, participants in the whole-task spent more time on the module and test and reported higher cognitive load. Finally, participants in the whole-task condition were significantly more satisfied with the module. Overall, the initial results support the use of whole-task instructional strategy for teaching complex cognitive skills.

Introduction

The importance of using real-world authentic tasks, especially in the context of complex cognitive learning, is evident in recent instructional strategies (Merrill, 2002a; van Merrienboer, 1997). Complex learning aims at the integration of knowledge, skills, and attitudes; the coordination of qualitatively different constituent skills; and the transfer of what is learned to other tasks (van Merrienboer, Kirschner, & Kester, 2003).

Authentic tasks, which in nature integrate different knowledge, skills, and attitudes, can facilitate the process of not only learning various skills but also integrating and coordinating the different component for effective task performance. Specifically, authentic tasks can help the learner to construct a schemata (van Merrienboer & Sweller, 2005). Practical educational approaches that focus on authentic tasks include project-based education, the case method, problem-based learning, and competency-based learning (van Merrienboer, Kirschner, & Kester, 2003). Similarly, theoretical models that focus in real-world authentic tasks include Collins, Brown, and Newman’s (1989) theory of cognitive apprenticeship learning, Jonassen's (1999) theory of constructive learning environment, Nelson's (1999) theory of collaborative problem solving, and Schank, Berman, and MacPerson's (1999) theory of goal-based scenario.

The main risk of those approaches is that the learner may be faced with extremely high levels of cognitive load when trying to solve an authentic real-world complex problem. Cognitive load theory (CLT) assumes a limited working memory that stores about 7 elements (±2) but operates on just two to four elements. Working memory load may be affected either by the intrinsic nature of the learning tasks (*intrinsic* cognitive load) or by the manner in which the tasks are presented (*extraneous* cognitive load) (van Merrienboer & Sweller, 2005).

Based on the assumption that extraneous cognitive load is not necessary for learning, traditional approaches for reducing cognitive load focused on different ways to reduce the extraneous cognitive load of instruction. Sweller et al. (Sweller, van Merrienboer, & Paas, 1998) presented those main effects that can be used to reduce extraneous cognitive load, which include the worked example effect, the completion problem effect, the split attention effect, the modality effect, and the redundancy effect (Mayer & Moreno, 2003). Nevertheless, those methods to decrease extraneous cognitive load may not be sufficient in the case of real-world complex problem where the intrinsic cognitive load may be too high for novice learners; not leaving them enough resources for schema construction. It was found that using highly complex learning tasks from the start have negative effects on learning, performance, and motivation (Sweller, van Merrienboer, & Paas, 1998). On the other hand, authentic-task can help the learner construct schemata not only of all the components of the tasks but also of the way the different components relate to each other. From CLT perspective, in addition to helping organize and store knowledge, schemata heavily reduce working memory load because even a high complex schema can be dealt with as only one element in working memory (van Merrienboer & Sweller, 2005). For example, de Groot (1966) found that expert chess players, remember a chess position as a single element, and encode them as a single chunk (Chi, Glaser, & Farr, 1988).

The high intrinsic cognitive load that is associated with real-world tasks, led to the development of other instructional approaches that aim at reducing the intrinsic cognitive load of the task. Instructional theories developed in the 1960s and 1970s typically advocate the use of part-task approaches to prevent overloading the learners with too complex problems at an early stage (Reigeluth, 1983; van Merrienboer, Kirschner, & Kester, 2003). *Part-task* approaches part the different components of the complex task and teach them separately. Although sometimes the learners are given the opportunity to put together several of the steps during the course of the program, only when the learners reach the end of the instructional unit, do they get the opportunity to practice the whole task. Even though this strategy can be beneficial (Pollock, Chandler, & Sweller, 2002) there has been accumulating evidence that part-task approaches do not work well for complex performances that requires integration of skills, knowledge, and attitudes and the extensive coordination of constituent skills in new problem situations (Goettl & Shute, 1996; Peck & Detweiler, 2000; van Merrienboer, 1997; van Merrienboer, Kirschner, & Kester, 2003). Based on the part-task approach the intrinsic cognitive load of the materials should be reduced by eliminating the interactions among the information elements until the learners master all the separate elements.

Whole-task approaches, on the other hand, attend to the coordination and integration of constituent skills from the very beginning. The learner develops first a holistic vision of the task (the global skills) and only afterwards the local skills (van Merrienboer, Kirschner, & Kester, 2003). Both the part-task and the whole-task approaches aim to reduce intrinsic cognitive load by manipulating the level of interactions among the elements. However, while the part-task approach is doing that by first eliminating completely the interactions and then presenting them at the end, the whole-task approach progresses from a simplified version of the interactions (i.e. simplified version of the whole-task) to a more complex version of the task that includes more complex interactions.

In his work to identify the first principles of instruction (the *demonstration* principle, the *application* principle, the *task-centered* principle, the *activation principle*, and the *integration* principle) Merrill (2002a) stressed the importance of instruction to be in the context of authentic, real-world problems or tasks. In particular, Merrill made the distinction between a *task-centered* and *topic-centered* instructional strategy. While topic-centered instructional strategies usually teach the content in a hierarchical fashion (i.e. only one topic is taught at a time, until all the component skills have been taught), in task-centered instructional strategies a simple whole task is demonstrated right up front and the instructions that follow provide the necessary information to complete this task. According to Merrill, a truly effective task-strategy involves a progression of task complexity and a corresponding decreasing amount of learner guidance. In general, it is possible to claim that task-centered strategies reflect a whole-task approach, while topic-centered strategies reflect a part-task approach.

One of the most comprehensive instructional design methodology for complex learning that is yet available (Clark & Estes, 2001) is the four-component instructional design model (the 4C/ID model) (van Merrienboer, 1997) that stresses the use of authentic whole-tasks for the acquisition of complex learning skills. According to the 4C/ID model, complex learning has little to do with learning separate skills in isolation, but it is foremost dealing with learning to coordinate and integrate the separate skills that constitute real-life task performance (van Merrienboer, Clark, & de Croock, 2002). Even though the 4C/ID model stresses the use of whole-task, part-task practice can sometimes be used to support very complex "whole-task" learning.

At this time, few studies have contrasted the two approaches. Lim and Reiser (2006) compared part-task and whole-task approaches for teaching a complex cognitive skill (preparing a grade book using Microsoft Excel). They found no significant difference between the groups on the near-transfer test and on the part-task achievement test, but more importantly, their study found that students in the whole-task instructional approach performed significantly better on the whole-task achievement test and on the far-transfer test. Nonetheless, there is still a need for more studies that contrast those two approaches in other complex fields.

Purpose of Study

The purpose of this study was to examine the effect of instructional strategy type (part-task vs. whole-task) on acquisition of a complex cognitive skill – developing an application in Flash using ActionScript. In particular, we measured the effects of the instructional strategy type on task performance, transfer, time on task, cognitive load, and attitudes, while controlling for individual differences in level of prior expertise. The instructions were presented in the form of an online self-paced module. In both conditions the final task was to program the same application on Flash using ActionScript. In the part-task strategy condition, only one component of the task was presented on each step of the instructions. In the whole-task strategy condition, all the components were presented starting from the first step of instructions and varied in their complexity (i.e. the first task was a partial version of the last task, and yet, this task included all the relevant components). The components included functionality of buttons, dynamic texts, and movie clips objects.

Task performance was measured by assessing the learners' artifacts (i.e. Flash file which is the output of creating an application in a Flash environment). The assessment was done on the basis of functionality (i.e. is the learner final application is functioning appropriately?) and on the basis of quality (i.e. is the code well written, organized, and efficient?). After completing the module the learners were given an additional task, which aimed to measure transfer. This task involved using the information that was learned in the module in a new way. Assessment of the transfer task was identical to the assessment of the previous tasks. Time on task was measured for completing each of the module sub-tasks (each module consisted of nine sub-tasks) as well as for completing the transfer task. After each step on the module and after completing the transfer task, learners reported their perceived level of cognitive load using a 9-point scale developed by Paas and Merrienboer (1994). The learner's attitude was measured using Kellers' (1993) Instructional Materials Motivational Survey (IMMS), which consists of four categories: attention, relevance, confidence, and satisfaction (Keller, 1993). Finally, the learners' level of expertise was measured using a short three questions background questionnaire.

It was expected that learners in the whole-task instructional approach would perform better on the module task as well as on the transfer task based on the assumption that presenting the learners a whole-task from the beginning would promote schema acquisition. The risk of overloading the cognitive system of the learners in the whole-task instructional approach was controlled by gradual progression of the tasks in terms of their difficulty level.

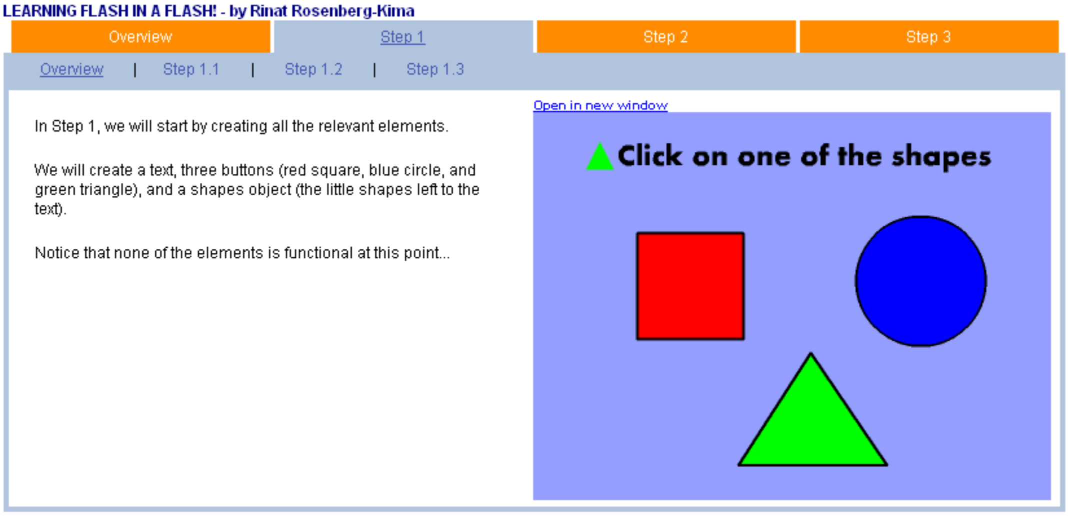
Method

Participants

Six females (age M = 27.4, SD = 3.7), and four males (age M = 29.2, SD = 5.3) volunteered to participate in the pilot study that was conducted online. Of the participants, five were categorized as having high experience in programming, and five as having low experience. Eight of the participants came from a large university in Israel, and two of the participants came from a big southeastern university in the United States. I used convenience sampling with the intention of getting as much variety as possible in terms of level of expertise and background. One of the participants did not complete the module and was therefore removed from the analysis. The participants were randomly assigned to one of two conditions.

Materials

All participants completed a two-hour online instructional module. One module was developed for each of the study conditions (whole-task and part-task). In both of the conditions, the participants were instructed to go over three steps, each consisting of three sub steps. Thus, overall, all the learners completed nine sub-steps (see figure 1 for a sample screenshot). Each of the sub-steps included a task that the participants had to complete by the end of the sub-step (e.g., "Draw three shapes: red square, blue circle, and green triangle"). Both of the modules included exactly the same instructions and tasks. The difference between the modules were in the order of the topics presentation, and the presence of a whole-task.



In Step 1, we will start by creating all the relevant elements.

We will create a text, three buttons (red square, blue circle, and green triangle), and a shapes object (the little shapes left to the text).

Notice that none of the elements is functional at this point...

Figure A.1 Sample Screenshot

The complete module can be viewed under
http://myweb.fsu.edu/rr05/Dissertation/FlashModule/FlashStudy.html

Independent Variables

Instructional Strategy (whole-task vs. part-task)

Two computer-based instructional strategies were employed. In the **whole-task** condition, the learners were first presented with a whole-task (creating colors and shapes game). Each step of the instructions referred to this whole-task, and by the end of the instructions, the participants should have completed it. Moreover, each of the three steps included all the elements of the whole-task, thus, in step one, for example, the learners learned the basics of dynamic texts, buttons, and movie clips objects. In the **part-task** condition, on the other hand, no whole-task was presented to the learners. Instead, they were told that they would learn about three topics (dynamic texts, buttons, and movie clips objects). Each of the three steps referred to only one of the topics, for example, in step one, the learners learn only about dynamic texts (see Table 1, figure 2).

Table A.1 Sequence of Topics Presented for each of the Conditions

	Level of Code Difficulty			
	Level 1	Level 2	Level 3	
Topic				Part-task condition
Dynamic Text	T1 [a]	T2 [b]	T3 [c]	Step 1
Buttons	B1 [d]	B2 [e]	B3 [f]	Step 2
Movie Clip Objects	M1 [g]	M2 [h]	M3 [i]	Step 3
Whole-task condition	Step 1	Step 2	Step 3	

a. Create a text on the screen (T1)
b. Create dynamic text and read its content (T2)
c. Dynamically change the value of a variable (T3)
d. Draw a button figure (B1)
e. Convert the figure to a button (B2)
f. Use the functions “on pres”, “roll over”, “roll out” (B3)
g. Create a movie object. Add keyframes and change their shape (M1)
h. Stop and play a movie object (M2)
i. Go to a specific label in a movie and stop (M3)

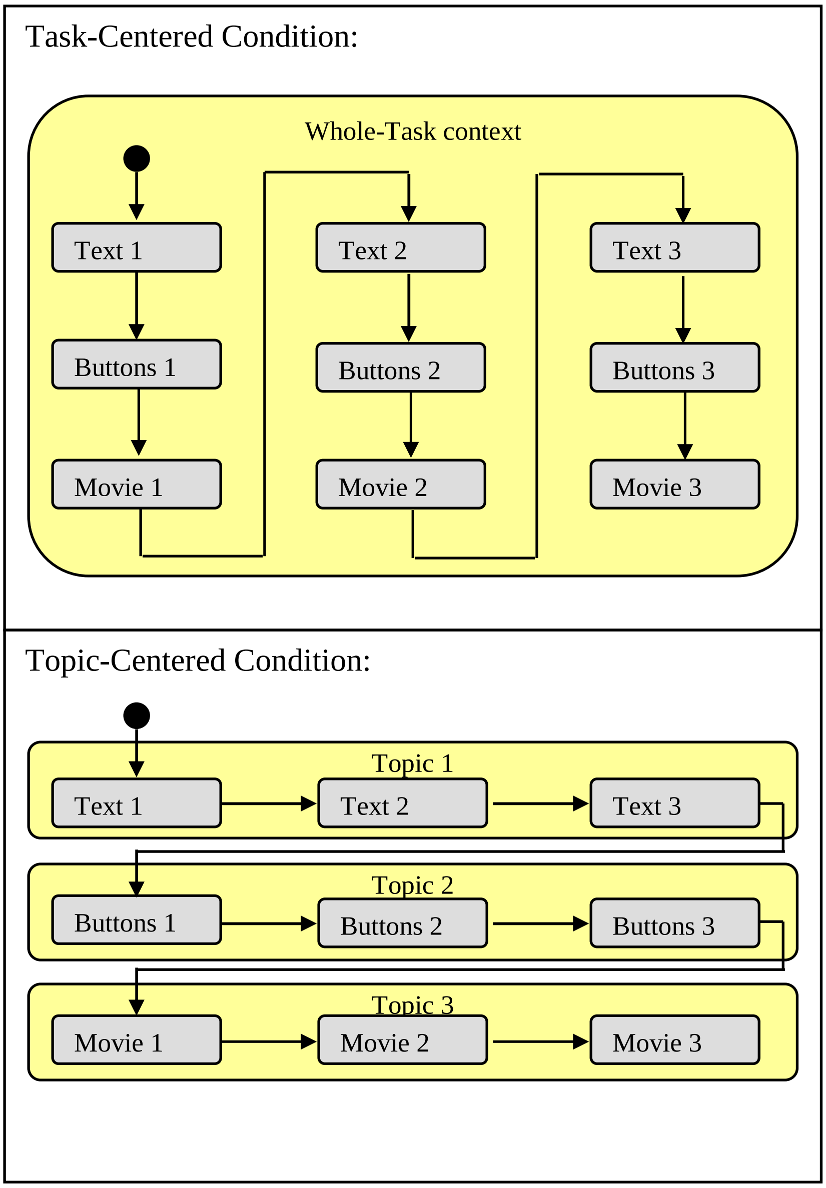


Figure A.2 Illustration of the Sequence of Topics within each Condition

Level of Expertise

The level of expertise of the participants was measured using a self-report questionnaire that included experience in developing Internet applications (No experience at all, I can create a simple page in html, I can use many of the html functions, I am an experienced Internet developer), experience developing in Flash (I never used Flash before, I used Flash for creating simple graphics, I created simple applications in Flash, I can use

ActionScript in Flash), and programming experience (I have no experience at all, I have some very limited experience in basic programming, I can program in one or more languages, I am an experienced programmer). Based on their total score to the three questions, the participants were categorized into two levels of expertise (high and low).

Dependent Variables

Performance

The participants performance was measured for (1) Performance on module tasks – by the end of each of the sub-steps the participants completed a flash file that was then evaluated. Completing each of the nine steps on the module earned the participants one point. Thus, the participants could get up to nine points. (2) Performance on transfer task –the learners were given an additional task, which aimed to measure transfer. This task involved using the information that was learned in the module in a new way. These flash files were assessed for functionality on a 5-points scale.

Cognitive Load

The participants' perceived cognitive load was measured using a single item self-rated scale developed by Paas and Van Merrienboer (1994). Using a nine-point Likert-type scale, the participants were asked to identify the amount of mental effort they invested on completing each step of the instruction and the transfer task. In the present study, the reliability of the cognitive load scale was .86, which was estimated with Cronbach's alpha.

Time on Task

Overall ten time measures were recorded: (1) the time to complete each of the nine sub-steps of the module, (2) the time to complete the transfer task.

Learner Attitudes

After completing the transfer task, the learner's attitudes were measured using a 5-point, Likert-type scale Kellers' (1993) Instructional Materials Motivational Survey (IMMS), which consists of four categories: attention (α = .89; e.g., "The way the information is arranged on the pages helped keep my attention") relevance (α = .81; e.g., "Completing this lesson successfully was important to me"), confidence (α = .90; "As I worked on this lesson, I was confident that I could learn the content"), and satisfaction (α = .92; "Completing the exercises in this lesson gave me a satisfying feeling of accomplishment").

Procedures

The study was conducted individually for each subject who in turn individually completed the module. First, the participants completed a questionnaire that included questions about their expertise level as well as general demographic information (age, gender, occupation). The participants completed the questionnaire in about five minutes. Then, the participants were instructed to follow the directions in the module and to complete it. There was no limit on the time allowed to complete the module. Following each of the nine sub steps of the module, the participants reported the time it took to complete the step and their perceived mental effort to complete it. During the module, the learners were asked to develop different elements in Flash, which resulted in a complete application. Following the module, the participants filled the Instructional Material Motivational Survey (Keller ,1993), which took about 10 minutes to complete. Finally, the participants completed a 15-minutes transfer task and reported the time it took to complete it and their perceived mental effort.

Results

Performance

Performance on Module Task

Performance on module task was measured by evaluating the final Flash file the participants produced by the end of the module. Completing each of the nine sub steps earned the participants one point. Thus, the maximum points possible were nine. Table 2 presents the means and standard deviations of each group (low and high level of expertise) in each of the two conditions (whole-task and part-task) on the module task. A review of the data revealed that there was not equal distribution of the participants’ level of expertise between the conditions. That was because the assignment to conditions occurred prior to getting the information on the participants’ level of expertise.

The data were analyzed using a 2 (level of expertise) x 2 (whole-task or part-task) analysis of variance (ANOVA). Results of the ANOVA revealed no significant difference between the groups. But more importantly, participants in the whole-task condition scored higher than the participants in the part-task condition, even though most of the participants in the whole-task condition had low level of expertise and most of the participants in the part-task condition had high level of expertise. The standardized difference between these means was $d=1.5$, a large effect. Overall, given the small sample size, these results supported the hypothesis that the participants in the whole-task condition would perform better than the ones in the part-task condition.

Performance on Transfer Test

Performance on the transfer test was measured by evaluating the final file the participants produced for the transfer test. The maximum points possible were five. Table 2 presents the means and standard deviations of each group (low and high level of expertise) in each of the two conditions (whole-task and part-task) on the transfer test. Again, there was not equal distribution of the participants’ level of expertise between the conditions.

The data were analyzed using a 2 (level of expertise) x 2 (whole-task or part-task) analysis of variance (ANOVA). Results of the ANOVA revealed no significant difference between the groups. Nevertheless, participants in the whole-task condition scored higher than the participants in the part-task condition, even though most of the participants in the whole-task condition had low level of expertise and most of the participants in the part-task condition had high level of expertise. The standardized difference between these means was d = .85, a large effect. Overall, given the small sample size, these results supported the hypothesis that the participants in the whole-task condition would perform better than the ones in the part-task condition.

Time on Task

Time was recorder by the participants at the beginning and end of each of the sub-steps, as well as the beginning and end of the transfer test. Table 2 presents the means and standard deviations of each group (low and high level of expertise) in each of the two conditions (whole-task and part-task) on the time on tasks. The data were analyzed using a 2 (level of expertise) x 2 (whole-task or part-task) analysis of variance (ANOVA).

Time on Module Task

Results of the ANOVA revealed no significant difference between the groups. Nevertheless, participants in the whole-task condition spent more time on the module than participants in the part–task condition. The standardized difference between these means was d = .80, a large effect.

Time on Transfer Test

Results of the ANOVA revealed significant difference between levels of expertise, F(1, 9) = 9.19, $p < .05$). Participants with low level of expertise spent significantly more time on the transfer test (M=18.25, SD=2.87) than those with high level of expertise (M=11.8, SD=2.28). The standardized difference between these means was d=2.48, a large effect. Results of the ANOVA revealed no significant difference between the conditions. Nevertheless, participants in the whole-task condition spent more time on the transfer test than participants in the part–task condition. The standardized difference between these means was d=1.14, a large effect.

Cognitive Load

Cognitive Load was measured by a single item self-rated scale developed by Paas and Van Merrienboer (1994). Using a nine-point Likert-type scale, the participants were asked to identify the amount of mental effort they invested on completing each step of the instruction and the transfer test. Table 2 presents the means and standard deviations of each group (low and high level of expertise) in each of the two conditions (whole-task and part-task) on the cognitive load. The data were analyzed using a 2 (level of expertise) x 2 (whole-task or part-task) analysis of variance (ANOVA).

Cognitive Load on Module Task

Results of the ANOVA revealed no significant difference between the groups. Nevertheless, participants in the whole-task condition reported higher cognitive load than the participants in the part-task condition. The standardized difference between these means was d = .78, a moderate-large effect.

Cognitive Load on Transfer Test

The data were analyzed using a 2 (level of expertise) x 2 (whole-task or part-task) analysis of variance (ANOVA). Results of the ANOVA revealed no significant difference between the groups. Nevertheless, participants in the whole-task condition reported higher cognitive load than the participants in the part-task condition. The standardized difference between these means was d = .78, a moderate-large effect.

Learners Attitudes

The learner’s attitudes were measured using a 5-point, Likert-type scale Kellers’ (1993) Instructional Materials Motivational Survey (IMMS), which consists of four categories: attention, relevance, confidence, and satisfaction. Table 2 presents the means and standard deviations of each group (low and high level of expertise) in each of the two conditions (whole-task and part-task) on learners’ attitudes. The data were analyzed using a 2 (level of expertise) x 2 (whole-task or part-task) analysis of variance (ANOVA). Despite the small number of participants, results of the ANOVA revealed significant difference between the conditions in the learners satisfaction from the module, $F(1, 9) = 7.18$, $p < .05$). Participants in the whole-task condition were significantly more satisfied than those in the part-task condition. The standardized difference between these means was d=2.25, a large effect. There was no significant difference between the groups on learners’ attention, relevance, and confidence.

Table A.2 Means and Standard Deviations for the Dependent Variables

	Whole-Task Approach			Part-Task Approach		
	Expertise Level			Expertise Level		
	Low (N=3)	High (N=1)	Total (N=4)	Low (N=1)	High (N=4)	Total (N=5)
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Performance						
Module [a]	8.6 (2.8)	9.0 (0)	8.8 (.28)	9.0 (0)	6.1 (2.5)	6.7 (2.5)
Transfer Test [b]	4.0 (1)	5.0 (0)	4.2 (.96)	5.0 (0)	2.0 (2.5)	2.6 (2.5)
Time On Task [c]						
Module	161.9(42)	96.0 (0)	145.4(47)	144.8(0)	107.9(21)	115.3(25)
Transfer Test	17.7 (3.2)	15.0 (0)	17.0 (2.9)	20.0 (0)	11.0 (1.6)	12.8 (4.3)
Cognitive Load						
Module [d]	5.3 (1.5)	3.0 (0)	4.7 (1.7)	3.9 (0)	3.6 (.64)	3.7 (.57)
Transfer Test [d]	8.3 (.47)	6.0 (0)	7.8 (1.3)	7.0 (0)	6.0 (2.2)	6.2 (1.9)
Attitudes [e]						
Attention	4.7 (.33)	3.7 (0)	4.4 (.57)	4.0 (0)	3.5 (1.04)	3.6 (.92)
Relevance	3.8 (.76)	1 (0)	3.1 (1.5)	4.0 (0)	2.0 (1.68)	2.4 (1.71)
Confidence	3.5 (.95)	4.28 (0)	3.7 (.87)	4.0 (0)	3.9 (.54)	3.97 (.47)
Satisfaction	4.9 (.19)	2.7 (0)	4.3 (1.12)	2.0 (0)	2.0 (1.05)	2.0 (.91)

a. Maximum score was 9.
b. Maximum score was 5.
c. Time in minutes.
d. A nine-point scale ranging 1 (very, very low mental effort) to 9 (very, very high mental effort).
e. A five-point scale ranged from 1 (not true) to 5 (very true).

Discussion

The purpose of this study was to examine the effect of instructional strategy type (part-task vs. whole-task) on acquisition of a complex cognitive skill – developing an application in Flash using Actionscript. In particular, we measured the effects of the instructional strategy type on task performance, transfer, time on task, cognitive load, and attitudes.

Rooted in the four-component instructional design model (the 4C/ID model) (van Merrienboer, 1997), and in Merrill (2002a) work to identify the first principles of instruction, in which he stressed the importance of instruction to be in the context of authentic, real-world problems or tasks, it was expected in the current study that learners in the whole-task instructional approach would perform better on the module task as well as on the transfer task based on the assumption that presenting the learners a whole-task from the beginning would promote schema acquisition (van Merrienboer & Sweller, 2005). In accordance with our hypothesis, participants in the whole-task performed better on both the module and the transfer task.

Even though the differences were not significant, which was expected due to the low number of participants, the standardized difference between the means revealed a large effect size. Those results support the hypothesis even stronger given the fact that most of the participants in the whole-task condition had low level of expertise and most of the participants in the part-task condition had high level of expertise. Even though we expected that the participants in the whole-task condition would perform better, it is also expected that participants with higher levels of expertise would perform better, as was found in previous studies (e.g., Lim & Reiser, 2006). Therefore, it might be that if the distribution of participants between the groups was equal, then the results would have been even more supportive of our hypothesis.

Participants in the whole-task on general spent more time on both the module and the final task. Even though the differences were not significant, which again was expected due to the low number of participants, the standardized difference between the means revealed a large effect size. It should be noted that both the conditions incorporated exactly the same instructions, only in different order.

One reason for that finding could be that the participants in the whole-task had lower levels of expertise and therefore needed more time to complete the tasks. Indeed, there was a significant difference between the two levels of expertise with respect to completing the transfer test. Another explanation for that finding could be that the participants in the whole-task were more motivated to complete the task, and was therefore willing to put more efforts and time in it. This explanation is supported by the fact that participants in the whole task condition reported significantly more satisfaction from the instructions than those in the part-task condition. Yet another explanation for that finding is that the whole-task condition required more effort and therefore more time than the part-task condition.

Participants in the whole-task also reported higher cognitive load on both the module and the final task. Even though the differences were not significant, which again was expected due to the low number of participants, the standardized difference between the means revealed a large effect size. Using high complex learning tasks from the start is associated with high cognitive load (Sweller, van Merrienboer, & Paas, 1998). Other explanations could be the lower level of expertise in the whole-task group and the higher level of motivation that in turn caused the participants in the whole-task condition to invent more mental effort in the task.

One of the major limitations of this current study was the small number of participants, with one of the participants not completing the study. The small number of participants negatively affected the power of the study and the extent to which it can be generalized. In addition, the fact that the level of expertise was not equally distributed between the conditions also limited the conclusions of this study. Nevertheless, the fact that most of the participants in the whole-task condition had low level of expertise and still performed better than the participants in the part-task condition, strengthen our initial hypothesis.

This study aimed to compare whole-task to part-task strategies. Nevertheless, this comparison is somewhat problematic because it takes into account two factors. More specifically, the conditions differed in two ways; first, in the whole-task condition a whole-task was presented right at the beginning of the instructions. Second, the order of instructions was different. While the order of instructions in the whole-task condition focused on completing the task, the order if instructions in the part-task condition focused on the topics to be taught. The fact the condition differ in two ways makes it difficult to determine which of the factors is more critical. Future research may aim to answer this question by presenting a whole-task, while keeping the order of instructions topic oriented.

In summary, while this study revealed some interesting initial results that may have future implication in terms of the way complex problems should be taught, it is necessary to conduct further research with a larger sample.

APPENDIX B. COGNITIVE LOAD MEASUREMENT

Indicate the amount of mental effort that you spent on the task you have just finished. Circle the corresponding number below.

1	2	3	4	5	6	7	8	9
Very, very low mental effort	Very low	Low	Rather low	Neither low nor high	Rather high	High	Very high	Very, very high mental effort

APPENDIX C. MODIFIED COMPUTER ANXIETY RATING SCALE

Please indicate your agreement with the following sentences (1 = strongly disagree; 5 = strongly agree)

1.	I feel insecure about my ability to interpret and use a new computer application.	1	2	3	4	5
2.	I look forward to using a computer on my job.	1	2	3	4	5
3.	I do not think I would be able to learn a computer programming language.	1	2	3	4	5
4.	I am confident I can learn computer skills.	1	2	3	4	5
5.	Anyone can learn to use a computer if they are patient and motivated.	1	2	3	4	5
6.	Learning to operate a computer is like learning any new skill --- the more you practice the better you become.	1	2	3	4	5
7.	I am afraid that if I begin to use computers I will become dependent on them and lose some of my reasoning skills.	1	2	3	4	5
8.	I am sure that with time and practice I will be as comfortable working with computers as I am working with basic word processing software.	1	2	3	4	5
9.	I feel that I will be able to keep up with the advances happening in the computer field.	1	2	3	4	5
10.	I dislike working with machines that are smarter than I am.	1	2	3	4	5
11.	I feel apprehensive about using computers.	1	2	3	4	5
12.	I have difficulty in understanding how a computer works.	1	2	3	4	5
13.	It scares me to think that I could cause the computer to destroy a large amount of information by hitting the wrong key.	1	2	3	4	5
14.	I hesitate to use a computer for fear of making mistakes that I cannot correct.	1	2	3	4	5
15.	You have to be a genius to understand all the special commands contained in most computer software.	1	2	3	4	5
16.	If given the opportunity I would like to learn about and use computers.	1	2	3	4	5
17.	I have avoided computers because they are unfamiliar and somewhat intimidating to me.	1	2	3	4	5
18.	I feel computers are necessary tools in both educational and work settings.	1	2	3	4	5
19.	The challenge of learning computers is exciting.	1	2	3	4	5
20.	I feel that understanding computers will make me a more productive individual.	1	2	3	4	5

(Broome & Havelka, 2002; Heinssen, Glass, & Knight, 1987)

APPENDIX D. COMPUTER SELF-EFFICACY MEASURE

(Compeau & Higgins, 1995b)

Often in our jobs we are told about software packages that are available to make work easier. For the following questions, imagine that you were given a new software package for some aspect of your work. It doesn't matter specifically what this software package does, only that it is intended to make your job easier and that you have never used it before.

The following questions ask you to indicate whether you could use this unfamiliar software package under a variety of conditions. For each of the conditions, please indicate whether you think you would be able to complete the job using the software package. Then, for each condition that you answered "yes," please rate your confidence about your first judgment, by circling a number from 1 to 10, where 1 indicates "Not at all confident," 5 indicates "Moderately confident," and 10 indicates "Totally confident."

For example, consider the following sample item:

I COULD COMPLETE THE JOB USING THE SOFTWARE PACKAGE...

			NOT AT ALL CONFIDENT				MODERATELY CONFIDENT					TOTALLY CONFIDENT
Q1	…if there was someone giving me step by step instructions	[✓ Yes…] No	1	2	3	4	[✓ 5]	6	7	8	9	10

The sample response shows that the individual felt he or she could complete the job using the software with step by step instructions (YES is circled), and was moderately confident that he or she could do so (5 is circled).

APPENDIX D. COMPUTER SELF-EFFICACY MEASURE

I COULD COMPLETE THE JOB USING THE SOFTWARE PACKAGE...

			NOT AT ALL CONFIDENT				MODERATELY CONFIDENT					TOTALLY CONFIDENT
Q-1	...if there was no one around to tell me what to do as I go	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-2	...if I had never used a package like it before.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-3	... if I had only the software manuals for reference.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-4	...if I had seen someone else using it before trying it myself.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-5	...if I could call someone for help if I got stuck.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-6	...if someone else had helped me get started.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-7	...if I had a lot of time to complete the job for which the software was provided.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-8	...if I had just the built-in help facility for assistance.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-9	...if someone showed me how to do it first.	Yes… No	1	2	3	4	5	6	7	8	9	10
Q-10	if I had used similar packages before this one to do the same job.	Yes… No	1	2	3	4	5	6	7	8	9	10

APPENDIX E: INSTRUCTIONAL MATERIALS MOTIVATIONAL SURVEY (IMMS)

Please think about each statement in relation to the instructional materials you have just studied, and indicate how true it is. Give the answer that truly applies to you, and not what you would like to be true, or what you think others want to hear. Think about each statement by itself and indicate how true it is. Do not be influenced by your answers to other statements.	Not True	Slightly True	Moderately True	Mostly True	Very True
1. When I first looked at this lesson, I had the impression that it would be easy for me.	1	2	3	4	5
2. There was something interesting at the beginning of this lesson that got my attention.	1	2	3	4	5
3. This material was more difficult to understand than I would like for it to be.	1	2	3	4	5
4. After reading the introductory information, I felt confident that I knew what I was supposed to learn from this lesson.	1	2	3	4	5
5. Completing the exercises in this lesson gave me a satisfying feeling of accomplishment.	1	2	3	4	5
6. It is clear to me how the content of this material is related to things I already know.	1	2	3	4	5
7. Many of the pages had so much information that it was hard to pick out and remember the important points.	1	2	3	4	5
8. These materials are eye-catching.	1	2	3	4	5
9. There were stories, pictures, or examples that showed me how this material could be important to some people.	1	2	3	4	5
10. Completing this lesson successfully was important to me	1	2	3	4	5
11. The quality of the writing helped to hold my attention.	1	2	3	4	5
12. This lesson is so abstract that it was hard to keep my attention on it.	1	2	3	4	5
13. As I worked on this lesson, I was confident that I could learn the content.	1	2	3	4	5
14. I enjoyed this lesson so much that I would like to know more about this topic.	1	2	3	4	5
15. The pages of this lesson look dry and unappealing.	1	2	3	4	5
16. The content of this material is relevant to my interests.	1	2	3	4	5
17. The way the information is arranged on the pages helped keep my attention.	1	2	3	4	5
18. There are explanations or examples of how people use the knowledge in this lesson.	1	2	3	4	5
19. The exercises in this lesson were too difficult.	1	2	3	4	5
20. This lesson has things that stimulated my curiosity.	1	2	3	4	5

21. I really enjoyed studying this lesson.	1	2	3	4	5
22. The amount of repetition in this lesson caused me to get bored sometimes.	1	2	3	4	5
23. The content and style of writing in this lesson convey the impression that its content is worth knowing.	1	2	3	4	5
24. I learned some things that were surprising or unexpected.	1	2	3	4	5
25. After working on this lesson for awhile, I was confident that I would be able to pass a test on it.	1	2	3	4	5
26. This lesson was not relevant to my needs because I already knew most of it.	1	2	3	4	5
27. The wording of feedback after the exercises, or of other comments in this lesson, helped me feel rewarded for my effort.	1	2	3	4	5
28. The variety of reading passages, exercises, illustrations, etc., helped keep my attention on the lesson.	1	2	3	4	5
29. The style of writing is boring.	1	2	3	4	5
30. I could relate the content of this lesson to things I have seen, done, or thought about in my own life.	1	2	3	4	5
31. There are so many words on each page that it is irritating.	1	2	3	4	5
32. It felt good to successfully complete this lesson.	1	2	3	4	5
33. The content of this lesson will be useful to me.	1	2	3	4	5
34. I could not really understand quite a bit of the material in this lesson.	1	2	3	4	5
35. The good organization of the content helped me be confident that I would learn this material.	1	2	3	4	5

APPENDIX F. CONSENT FORM

From: Thomas L. Jacobson, Chair

Re: Re-approval of Use of Human subjects in Research Effects of task-centered vs. topic-centered instructional strategy approaches on complex skills acquisition

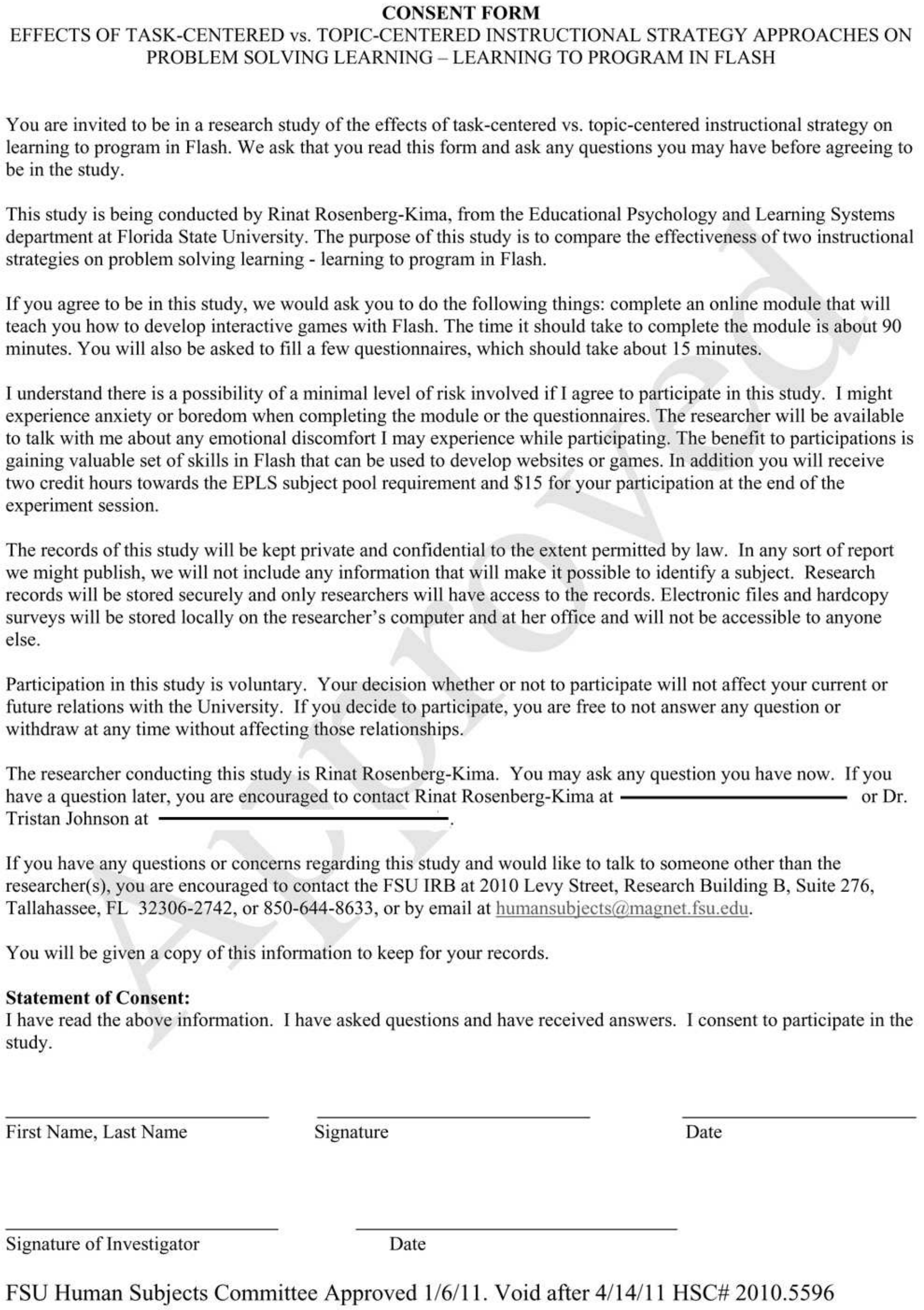
Your request to continue the research project listed above involving human subjects has been approved by the Human Subjects Committee. If your project has not been completed by 3/22/2012, you must request a renewal of approval for continuation of the project. As a courtesy, a renewal notice will be sent to you prior to your expiration date; however, it is your responsibility as the Principal Investigator to timely request renewal of your approval from the committee.

If you submitted a proposed consent form with your renewal request, the approved stamped consent form is attached to this re-approval notice. Only the stamped version of the consent form may be used in recruiting of research subjects. You are reminded that any change in protocol for this project must be reviewed and approved by the Committee prior to implementation of the proposed change in the protocol. A protocol change/amendment form is required to be submitted for approval by the Committee. In addition, federal regulations require that the Principal Investigator promptly report in writing, any unanticipated problems or adverse events involving risks to research subjects or others.

By copy of this memorandum, the Chair of your department and/or your major professor are reminded of their responsibility for being informed concerning research projects involving human subjects in their department. They are advised to review the protocols as often as necessary to insure that the project is being conducted in compliance with our institution and with DHHS regulations.

HSC No. 2011.5752

APPENDIX F. CONSENT FORM



CONSENT FORM

EFFECTS OF TASK-CENTERED vs. TOPIC-CENTERED INSTRUCTIONAL STRATEGY APPROACHES ON PROBLEM SOLVING LEARNING – LEARNING TO PROGRAM IN FLASH

You are invited to be in a research study of the effects of task-centered vs. topic-centered instructional strategy on learning to program in Flash. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by Rinat Rosenberg-Kima, from the Educational Psychology and Learning Systems department at Florida State University. The purpose of this study is to compare the effectiveness of two instructional strategies on problem solving learning - learning to program in Flash.

If you agree to be in this study, we would ask you to do the following things: complete an online module that will teach you how to develop interactive games with Flash. The time it should take to complete the module is about 90 minutes. You will also be asked to fill a few questionnaires, which should take about 15 minutes.

I understand there is a possibility of a minimal level of risk involved if I agree to participate in this study. I might experience anxiety or boredom when completing the module or the questionnaires. The researcher will be available to talk with me about any emotional discomfort I may experience while participating. The benefit to participations is gaining valuable set of skills in Flash that can be used to develop websites or games. In addition you will receive two credit hours towards the EPLS subject pool requirement and $15 for your participation at the end of the experiment session.

The records of this study will be kept private and confidential to the extent permitted by law. In any sort of report we might publish, we will not include any information that will make it possible to identify a subject. Research records will be stored securely and only researchers will have access to the records. Electronic files and hardcopy surveys will be stored locally on the researcher's computer and at her office and will not be accessible to anyone else.

Participation in this study is voluntary. Your decision whether or not to participate will not affect your current or future relations with the University. If you decide to participate, you are free to not answer any question or withdraw at any time without affecting those relationships.

The researcher conducting this study is Rinat Rosenberg-Kima. You may ask any question you have now. If you have a question later, you are encouraged to contact Rinat Rosenberg-Kima at [redacted] or Dr. Tristan Johnson at [redacted].

If you have any questions or concerns regarding this study and would like to talk to someone other than the researcher(s), you are encouraged to contact the FSU IRB at 2010 Levy Street, Research Building B, Suite 276, Tallahassee, FL 32306-2742, or 850-644-8633, or by email at humansubjects@magnet.fsu.edu.

You will be given a copy of this information to keep for your records.

Statement of Consent:
I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

First Name, Last Name ____ Signature ____ Date ____

Signature of Investigator ____ Date ____

FSU Human Subjects Committee Approved 1/6/11. Void after 4/14/11 HSC# 2010.5596

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Zimmerman, B., & Bandura, A. (1994). Impact of self-regulatory influences on writing course attainment. *American Educational Research Journal, 23*(614-628).

BIOGRAPHICAL SKETCH

EDUCATION

2011	Ph.D., Florida State University Field of study: Educational Psychology and Learning Systems. Dissertation title: “Effects of Task-Centered vs. Topic-Centered Instructional Strategy Approaches on Problem Solving – Learning to Program in Flash”.
2004	M.A., Tel-Aviv University, Israel. Field of study: Psychology, focus in Psychobiology. Thesis title: “Assessment of Executive Control in School-Age Children with the “Balloons”: Psychometric, Developmental and Predictive Characteristics”. Magna Cum Laude.
1999	B.A., Tel-Aviv University, Israel Field of study: Computer Sciences and Economics. Magna Cum Laude.

TEACHING EXPERIENCE

2010	Teaching Assistant, Florida State University Course name: “EDP5216: Theories of Learning and Cognition in Instruction” Under the direction of Dr. Amy L. Baylor.
2007-2008	Teaching Assistant, Florida State University Course name: “EME6403: Designing for Online Collaborative Learning” Under the direction of Dr. Allan Jeong. (Online course).
2007-2008	Teaching Assistant, Florida State University Course name: “EDP5216: Learning Theories & Cognition.” Under the direction of Dr. Allan Jeong. (Online course).
2006	Instructor, Florida State University Course name: “FOL3930: Intermediate Hebrew II”.
2005-2006	Instructor, Florida State University Course name: “HBR2200-01: Intermediate Modern Hebrew”.
2003-2004	Instructor, The department of Computer Sciences, The Open University, Israel. Course name: “Computer Networks”.
2002-2003	Teaching Assistant, The department of Psychology, Tel-Aviv University. Course name: “Research Methods and Statistics” (graduate level)

1999-2004 Instructor, The department of Computer Sciences, The Open University, Israel.
Course name: “Algorithms”.
(also designed and developed online materials).

1997-1999 Instructor, The department of Computer Sciences, The Open University, Israel.
Course name: “Assembler”.

DEVELOPMENT EXPERIENCE

2009-2011 Programmed a plug-in algorithm and interface in C# to be used by the United States Air Force Research Lab (AFRL). The Learning Systems Institute, Florida State University.

2009-2010 Developed instructional materials using Adobe Flash CS3 Professional, Adobe Captivate 4, SCORM, and Moodle. The College of Communication, Florida State University.

2005-2008 Team leader of the development team at RITL - Center for Research and Innovative Technologies for Learning at LSI (Learning Systems Institute). Florida State University. Developed applications that use pedagogical agents for changing attitudes (Developed with Macromedia Flash action script, SQL server, .ASP, VB script, Java Script, Poser).

2003-2004 Developed educational multimedia as a freelance for private companies in Israel
(Programmed using Macromedia Flash, Director, Visual Basic, Visual Studio, ASP).

1997-2003 Programmer and Team Leader in the Center for Educational Technology (CET). Designed and developed multimedia software in geometry, math, sciences, literature, geography, and history. Lead the process of translating the software to 5 different languages. (Developed with TASS, Visual Basic).

RESEARCH EXPERIENCE

2008-2011 Research Assistant
Research assistant at LSI- Learning Systems Institute. Florida State University.
Under the supervision of Dr. Tristan Johnson. Developed C# Algorithm for IMPRINT.

2005-2008	Research Assistant Research assistant at RITL- Center for Research and Innovative Technologies for Learning at LSI (Learning Systems Institute). Florida State University. Under the supervision of Dr. Amy L. Baylor.
2005-2006	Research Assistant Developer at KCRG- Knowledge Community Research Group at LSI. Florida State University. Under the supervision of Dr. Ian Douglas.
2002-2004	Statistical Consultant Provided statistical support for graduate students at Tel-Aviv University and Bar-Ilan University (Software include StatView, Statistica).
2000-2004	Research Assistant Developed experiments for Prof. Matti Mintz, Prof. Avi Sadeh, Prof. Reuven Dar, and Dr. Yair Bar-Haim. The Department of Psychology, Tel-Aviv University (Developed with Visual Basic, Matlab, html, Java Script).

HONORS AND AWARDS

2010	Recipient of the Gagne/Briggs Outstanding Doctoral Student Award. Department of Educational Psychology and Learning Systems, Florida State University, Tallahassee, FL.
2010	Recipient of the Ruby Diamond Future Professor Award. Department of Educational Psychology and Learning Systems, Florida State University, Tallahassee, FL.
2009-2011	Recipient of the Florida Israel Institute scholarship (merit-based award).
2009	Finalist for the Liliana Mulhman Masoner award for excellent performance as an international student in the instructional systems program. Department of Educational Psychology and Learning Systems, Florida State University, Tallahassee, FL.
2007	Finalist for Ruby Diamond future professor award for excellent performance in the instructional systems doctoral program. Department of Educational Psychology and Learning Systems, Florida State University, Tallahassee, FL.
2007	Selected to participate in Pittsburgh Science of Learning Center (PSLC) summer school. Carnegie Mellon University.

PUBLICATIONS

Refereed Journal Articles:

Rinat B. Rosenberg-Kima, Avi Sadeh (2010). Attention, Response Inhibition and Face Information Processing in Children: The Role of Task Characteristics, Age and Gender. *Child Neuropsychology, 16(4), 388-404*

Rinat B. Rosenberg-Kima, E. Ashby Plant, Amy L. Baylor, Celeste E. Doerr (2010). The role of computer based models race and gender on female students' attitudes and beliefs towards engineering. *Journal of Engineering Education*, 99(1).

Plant, E. A., Baylor A. L., Doerr, C., & Rosenberg-Kima, R. (2009). Changing Middle-School Students' Attitudes and Performance Regarding Engineering with Computer-based Social Models. *Computers and Education*, 53(2), 209-215.

Rinat B. Rosenberg-Kima, Amy L. Baylor, E. Ashby Plant, Celeste E. Doerr (2008). Interface agents as social models for female students: The effects of agent visual presence and appearance on female students' attitudes and beliefs. *Computers in Human Behavior*. 24(6), 2741-2756.

Refereed Proceedings:

Rosenberg-Kima, R. B., Plant, E. A., Baylor, A. L. & Doerr, C. (2007). Changing Attitudes and Performance with Computer-generated Social Models. Proceedings of Artificial Intelligence in Education (AI-ED), Marina Del Ray, California. Frontiers in Artificial Intelligence and Applications, Vol. 158, (pp. 51-58), IOS Press.

Rosenberg-Kima, R. B., Baylor, A. L., Plant, E. A., Doerr, C. (2007). The importance of interface agent visual presence: Voice alone is less effective in impacting young women's attitudes toward engineering. Proceedings of Persuasive 2007, Stanford, California. Lecture Notes in Computer Science, Vol. 4744, (pp. 214–222), Springer.

Baylor, A. L., Rosenberg-Kima, R. B., & Plant, E. A. (2006). Interface agents as social models: the impact of appearance on females' attitude toward engineering. Proceedings of International Conference on Human Factors in Computing Systems (CHI 2006), Montreal, Canada. (pp. 526-531), ACM Press.

Baylor, A. L., & Rosenberg-Kima, R. B. (2006). Interface agents to alleviate online frustration. Proceedings of the 7th International Conference on Learning Sciences, (pp.30-36), Bloomington, Indiana: ISLS.

Papers Presented at Conferences:

Turel, Y. K., Johnson, T., Rosenberg-Kima, R. B (2011, November). Validation of a Team Process Model. Paper presented at AECT (Association for Educational Communications and Technology), Jacksonville, FL.

Johnson, T., Karaman, S., Rosenberg-Kima, R. B. (2010, October). Computer Modeling of Teams Learning: An Agent Based Social Simulation of Team Learning (SSTeL). Paper presented at AECT (Association for Educational Communications and Technology), Anaheim, CA.

BIOGRAPHICAL SKETCH

Rosenberg-Kima, R. B., Plant, E. A., Doerr, C.E., & Baylor, A. L. (2010, May). The impact of interface agent race and gender on female students' attitudes and beliefs towards engineering. Paper presented at AERA (American Educational Research Association), Denver, Colorado.

Johnson, T., Sikorski, E. G., Rosenberg-Kima, R. B., Novak, E., & Andrews, D. E. (2010, May). Development of a training effects algorithm for use within an agent-based modeling and simulation tool. Paper presented at AERA (American Educational Research Association), Denver, Colorado.

Rosenberg-Kima, R. B., Plant, E. A., Doerr, C.E., & Baylor, A. L., (2010, March). The impact of interface agent race and gender on female students' attitudes and beliefs towards engineering. Poster presented at the Marvalene Hughes Research in Education Conference, Tallahassee, FL.

Doerr, C.E., Plant, E. A. Rosenberg-Kima, R. B., & Baylor, A. L. (2008, June). Engineering Inclusiveness: Pedagogical Agents Improve Female Students' Attitudes Toward Engineering. Paper presented at the 7th Biennial Society for the Psychological Study of Social Issues Conference, Chicago, IL.

Rosenberg-Kima, R. B., Baylor, A. L., Plant, E. A., & Doerr, C.E. (2008, March). The importance of interface agent visual presence and appearance in impacting young women's attitudes toward engineering. Paper presented at AERA (American Educational Research Association), New York, NY.

Doerr, C.E., Plant, E. A. Rosenberg-Kima, R. B., & Baylor, A. L. (2008, February) Increasing young women's interest in engineering: Targeting autonomy, relatedness, and competence. Paper presented at the 9th Annual Meeting of the Society for Personality and Social Psychology. Albuquerque, NM.

Baylor, A. L. & Rosenberg-Kima, R. (2007, April) Interface Agents to Alleviate Frustration in Online Learning. Paper presented at AERA (American Educational Research Association), Chicago, IL.

Baylor, A. L. & Rosenberg-Kima, R. (2007, April) Interface agents as social models: the impact of appearance on females' attitude toward engineering. Paper presented at AERA (American Educational Research Association), Chicago, IL.