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RESEARCH ARTICLE

The effects of part-task and whole-task instructional approaches on acquisition and transfer of a complex cognitive skill

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Abstract This study was designed to investigate the effects of two instructional approaches (whole-task versus part-task) and two levels of learner prior knowledge (lower versus higher) on learner acquisition and transfer of a complex cognitive skill. Participants were 51 undergraduate pre-service teachers. In the part-task condition, a complex skill (preparing a grade book using Excel) was decomposed into a series of smaller tasks, each of which was demonstrated and practiced separately. In the whole-task condition, which was based on the 4C/ID-model (van Merriënboer 1997), learners were exposed to the entire complex skill from the beginning of the instruction and were required to practice performing a series of whole tasks throughout the unit. Results indicated that the whole-task group performed significantly better than the part-task group on a skill acquisition test and a transfer test. Possible reasons for these findings and suggestions for future research are discussed.

Keywords 4C/ID-model · Complex cognitive skill · Transfer of learning · Whole-task approach · Teacher education

Introduction

A major goal of schooling is to prepare students for flexible adaptation to new problems and settings. Gagné (1970) states that capabilities learned in school should provide students with the background and skills to accomplish practical things in their lives or occupations.

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It is especially important to understand the kinds of learning experiences that lead to transfer, which is defined as the ability to extend what has been learned in one context to new contexts (e.g., Byrnes 1996).

Recently, traditional instructional systems design methodologies have been criticized as being relatively ineffective in promoting transfer of learning, particularly in teaching complex cognitive skills. Several authors (e.g., de Croock et al. 2002; van Merriënboer 1997, 2007) argue that this is the result of an *atomistic* approach where the learning domain is described in terms of a large number of objectives, each of which focuses on a rather small learning task, and instructional methods are designed for reaching each of the separate objectives. This "part-task" instructional approach may lead to fragmented instruction, the inability to integrate what has been learned in new situations, and poor transfer of learning.

In addition, several researchers have noted that the traditional atomistic, part-task approach is less suitable for teaching complex cognitive skills that are characterized by highly integrated sets of learning objectives that require a more holistic approach to instruction (Spector and Anderson 2000; van Merriënboer et al. 2003). By most definitions, complex cognitive skills consist of many constituent skills, each of which must be performed in a coordinated and integrated fashion using high-level schemas or organizing strategies, and at least some of which involve *conscious processing*, such as decision making, problem-solving, or reasoning (Carlson et al. 1989; Gopher et al. 1989; Peck and Detweiler 2000; van Merriënboer 1997). Therefore, recent instructional theories tend to focus on authentic and whole learning tasks that require learners to address real-world problems as the driving force for transfer of learning (Merrill 2002, 2007; van Merriënboer and Kirschner 2001). The main idea is that such tasks help learners to integrate the knowledge, skills, and attitudes necessary for effective task performance; give them the opportunity to learn to coordinate the constituent skills that make up complex task performance; and eventually enable them to transfer what is learned to their daily life or work settings (van Merriënboer and de Croock 1992).

Even though several instructional approaches and models that focus on whole learning tasks have been proposed (e.g., Collins et al. 1989; Jonassen 1999; Merrill 2002, 2007; van Merriënboer 1997, 2007), little empirical evidence exists with regard to the effects of the application of these whole-task approaches on the acquisition and transfer of complex cognitive skills. The primary purpose of this study was to investigate how one such whole-task approach, the 4C/ID-model (the four component instructional design model), developed by van Merriënboer (1997), as compared to the use of a part-task instructional methodology, would affect learner acquisition and transfer of a complex cognitive skill—preparing a grade book using Microsoft Excel. The 4C/ID model was chosen for this comparison because (a) the model is posited as particularly suitable for complex learning and transfer, and (b) its description includes considerably more detailed instructional design guidelines than other similar models. Furthermore, some authors describe the 4C/ID-model as the most comprehensive instructional design methodology for complex learning that is yet available (e.g., Merrill 2002).

The 4C/ID-model: four key components

According to van Merriënboer (1997, 2007), the 4C/ID instructional model consists of four major components: (1) learning tasks, (2) supportive information, (3) procedural information, and (4) part-task practice. Each of these components is described below and is illustrated by an example.

Learning tasks

Learning tasks are the key component of the model. Concrete, authentic and meaningful whole-task experiences are provided to learners to promote the construction of cognitive schemata and enable the learners to achieve a desired learning goal. These tasks may take many different forms, such as problems, practice activities, case studies, projects and so forth. Learning tasks are organized in a simple-to-complex order, and these learning tasks are categorized by *task classes*, with a simpler version of the whole task serving as task class 1, a more complex version of the whole task serving as task class 2, and so on (van Merriënboer 1997, 2007; van Merriënboer and Kirschner 2007). For example, if the complex whole task involves conducting a search for literature on a given topic, a simple version of the whole task class would involve searching in a topic area in which the concepts are clearly defined, working with one database and employing only a few search terms, yielding a limited number of relevant articles. The more complex version of the task class would be a case in which concept definitions within the topic area are unclear, and in which full-text searches have to be performed in several relevant databases and with many search terms interconnected by Boolean operators, so to reduce the number of irrelevant articles likely to be identified (van Merriënboer et al. 2003).

Learning tasks that belong to 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. In other words, using the previous example, the first task class required learners to conduct a simple literature search; therefore, all learning tasks (or problems) that belong to that task class would have the same learning goal—conducting a simple literature search in which the search is performed in a topic area in which the concepts are clearly defined, working with one database with only few search terms and yielding a limited number of relevant articles (van Merriënboer et al. 2003). Furthermore, learning tasks within the same task class start with a high level of built-in learner support, which slowly decreases and totally disappears at the end of the task class (i.e., a process of "scaffolding"). For example, in each task class, learners may first be presented with an instructor demonstration (a *modeling example*) of how a particular literature search should be conducted. Learners would then be required to perform the same literature search. This activity would then be followed by requiring learners to perform a different search involving the same level of complexity but without the instructor demonstration provided previously (van Merriënboer et al. 2003).

As importantly, learning tasks within the same task class must show high variability in terms of the contexts or conditions in which the task has to be performed. For example, learning tasks for the literature search example may differ with regard to the field of study in which the search is performed and the bibliographical databases that need to be searched (van Merriënboer and Kirschner 2007). The reason for including variable learning tasks is to encourage learners to engage in "mindful abstraction" of schemas by focusing on the underlying deep structure of the problems, rather than on surface features that are often irrelevant to solving the task at hand (van Merriënboer et al. 2002). Several research studies have shown that variability of practice usually results in beneficial effects on transfer of training (e.g., Cormier and Hagman 1987; Shapiro and Schmidt 1982; Singley and Anderson 1989).

Supportive information

As the second component of the model, supportive information helps the learning of *non-recurrent* aspects of learning tasks, that is, non-routine aspects that require reasoning and problem solving. This information, which is usually presented before learners start work in a particular task class, explains how to approach various types of problems within that class. For instance, an experienced researcher or instructor can describe his or her cognitive strategies or rules of thumb for converting research questions into relevant search terms (van Merriënboer et al. 2003).

Procedural information

Procedural information, the third component of the model, is necessary for learning *recurrent* constituent skills of learning tasks, that is, routine aspects that can be algorithmically performed according to domain-specific rules or procedures. This information, which is often referred to as *just-in-time information*, is usually presented in the form of step-by-step instructions that are presented to learners the first time they need to perform a particular constituent skill, and is only presented again if learners cannot recall it when they must apply the skill in subsequent situations (van Merriënboer 1997, 2007; van Merriënboer and Kirschner 2007). For example, a recurrent task in the previous example would be learner ability to compose search queries with Boolean operators. The first time they had to do so, learners would be presented with the step-by-step process for composing such queries. During subsequent instances, they would be told how to do so only if they requested that information (van Merriënboer et al. 2003).

Part-task practice

The fourth component of the model, part-task practice, may be necessary for selected recurrent constituent skills for which automaticity is desired. Part-task practice begins after the learner has practiced performing the whole task, so that the learner performs this additional practice activity within a context that is meaningful to him or her (van Merriënboer 1997, 2007; van Merriënboer and Kirschner 2007). For example, after learners practice how to search relevant literature, the instructor may provide them with part-task practice on using Boolean operators, so as to help learners achieve automaticity of that skill (cf. Carlson et al. 1989).

There are several reasons why the 4C/ID approach has been hypothesized as promoting better transfer performance. First, the model, by emphasizing whole-task practice, focuses on the integration and coordination of all the skills that constitute a complex cognitive skill and concurrently promote understanding (i.e., schema construction) of the complex skill. By doing so, the instructional program aims at transfer of learning—the ability to apply the complex cognitive skill in a wide variety of new real-life situations (van Merriënboer 1997, 2007; van Merriënboer and Kirschner 2007).

Another reason that the use of the 4C/ID approach is supposed to promote transfer of learning is because of task variability. As stated earlier, the learning tasks presented to learners should be highly different from each other, taking into consideration the many possible real world contexts that may be encountered by experts in the subject matter domain. This high variability of whole-task practice should enable learners to develop rich cognitive schemata, which should allow for schema-based transfer of learning (e.g., Paas and van Merriënboer 1994; Quilici and Mayer 1996; Schilling et al. 2003, van Merriënboer et al. 2006). As noted earlier, one of the primary purposes of this study was to examine whether such transfer would occur when the 4C/ID approach was used to teach learners a complex cognitive skill.

Effects of prior knowledge

In addition to considering effective instructional strategies for promoting learning and transfer, instructional designers must also take into account learner prior knowledge in a domain. According to Cognitive Load Theory (Sweller 1988), due to the limitations to the processing capacity of the human working memory, instructional designers have to be careful so as not to overwhelm learners at the initial stages of skill acquisition by inducing overly high cognitive load. This fact is particularly important to consider when novice learners are involved because studies have revealed that such learners often apply a means-ends analysis approach to problem solving, a strategy to solve a problem backwards from the problem goal to the initial information given, thus imposing an unnecessary cognitive load (Owen and Sweller 1985; Sweller and Levine 1982; Sweller 1988). Therefore, presenting abundant support to novice learners is important because it provides them with the necessary cognitive resources for learning new skills.

Yet, research has shown that as learners progress in their skill development, the additional supports required by novice learners become redundant or even hinder learning because more advanced learners already have well-established schemas that they can use when solving problems. This effect is called the *expertise reversal effect*, that is, the positive effects of various instructional strategies observed with novice learners disappear and may even hinder learning as learners further develop their skills (Kalyuga et al. 2003).

A number of empirical studies have provided evidence for the expertise reversal effect. For example, Kalyuga et al. (1998) found that advanced learners benefited more from an instructional program that consisted solely of a diagram without any additional explanation in text. On the contrary, novice learners learned better from illustrations consisting of diagrams and text information. This finding indicates that additional text explanation was unnecessary for advanced learners and thus seemed to hinder their learning. Tuovinen and Sweller (1999), in a study with education majors, compared a guided-discovery approach with worked-examples practice in learning to use a database program. They found that students with no prior database knowledge benefited substantially from the worked-examples approach in comparison with guided discovery, while the type of practice made no difference to students with prior knowledge of databases because they could draw on their existing schemas to guide their learning in the more exploratory guided-discovery approach.

Previous research on the expertise reversal effect has focused primarily on single instructional strategies in isolation, such as use of worked examples or combining diagrams with additional text-based information. Rather than focusing on specific parts of the instruction (e.g., practice problem format), the present study was designed to examine the whole-task instructional approach from a holistic perspective. One of the issues addressed was whether the expertise reversal effect would occur under such conditions. Thus, the overall purpose of this study was to investigate the effects of two instructional approaches (whole-task versus part-task) and two levels of learner prior knowledge (lower- versus higher-prior knowledge) on learner acquisition and transfer of a complex cognitive skill—preparing a grade book using Microsoft Excel. The main hypothesis of this study was that a whole-task approach would yield higher whole-task achievement and transfer test performance than a part-task approach because of the key emphasis in the 4C/ID model on whole-task practice. The effects of both approaches on part-task achievement, attitudes and the time spent on tests were also measured, and possible interactions between levels of learner prior knowledge and the two instructional approaches on these additional variables were also explored.

Method

Participants

Participants in the study were 51 undergraduate students (*M* age = 20.6 years; freshmen = 4%, sophomores = 29%, juniors = 37%, seniors = 28%; 82% female) enrolled in four sections of an introduction to educational technology course in a large southeastern university in the United States. The learners, all of whom were pre-service teachers required to take the course, were expected to learn how to use various software application programs, such as Microsoft Excel, so as to improve their effectiveness as teachers. Learners in all four sections were taught by the same instructor. They participated in the study during their regularly scheduled classes. Participation in the experiment was considered a course requirement. The learners received a grade for their test performance.

Independent variables

Instructional approach (part-task versus whole-task)

For both instructional conditions, instruction consisted of two 60-min lessons. The manner in which the first portion of each lesson was conducted was the same across both conditions. Namely, the instructor began each lesson by (a) stating what topics would be covered; (b) providing a general overview of the lesson; (c) briefly describing the concepts and skills to be learned; and (d) showing learners examples of Excel-prepared grade books where those concepts and skills had been used. The second portion of the lesson, which varied between the conditions, then began.

In the part-task condition, the instructor described and demonstrated 22 constituent skills involved in preparing a grade book in Excel: 15 fairly basic skills, which were taught during the first lesson, and 7 more advanced skills, which were taught during the second lesson. Thus, 22 demonstrations were presented to the learners. The demonstrations included: entering data, merging cells, inserting a chart, copying a formula, and so forth. As each skill was being demonstrated, learners were asked to perform exactly the same skill (with the same data) at their own workstation. In each of the two lessons, after the instructor completed demonstrating all of the skills, learners were asked to complete a set of practice activities. The set of practice activities (a total of 20 practice items) during the first lesson focused on the basic skills to use Excel (e.g., enter data, label data, format cells) and the skills needed to prepare statistical information (e.g., calculate a sum or average). The set of practice activities (a total of nine practice items) during the second lesson focused on advanced skills to prepare statistical information (e.g., write a formula, calculate weighted averages) and to prepare graphical information (e.g., create a bar chart;

select the type of chart to use). At the end of the second lesson, the learners were also asked to complete a practice activity that required them to prepare a grade book (the whole-task to which the part-task practice activities were related).

Instruction for whole-task approach was designed and developed based on the 4C/ID-model (van Merriënboer 1997, 2007; van Merriënboer and Kirschner 2007). Under this approach, each of the two lessons focused on a different task class (creating unweighted grade books and creating weighted grade books). At the beginning of the second portion of each lesson, the instructor provided a *modeling example* (van Merriënboer and Kirschner 2007), describing how to use Excel to create the type of grade book being studied. Thus, in this case, constituent skills were taught in the context of the whole task and not as isolated procedures (as in the part-task approach). Upon completion of the demonstration, learners were required to create the same grade book that the instructor had just created. After learners had done so, they were required to work on a second task in the same task class, creating another grade book of the same type, but with a different set of data and without being presented with an instructor demonstration of how to prepare that grade book. However, as per 4C/ID principles, part of the task was already done for the learners, namely, the data was already arrayed in a spreadsheet. In 4C/ID terminology, this type of task is called a *completion problem*, a problem for which learners are given a partial solution (van Merriënboer and Kirschner 2007).

Several other key components of the 4C/ID approach were built into the second half of each of the two lessons presented to the learners in whole task condition. For example, at the start of the second half of the second lesson, prior to when the learners had to select and create various types of grade charts, the instructor provided them with *supportive information* by describing examples of similar situations and discussing how and why decisions in those cases were made. Moreover, *procedural information* was provided to learners whenever they needed it to perform particular constituent skills. For example, the first time a learner needed to sort students' names alphabetically, he or she was told the step-by-step process for performing this function. During subsequent times learners had to engage in a sorting task, they were only told how to sort if they requested that information.

In summary, the key differences between the part-task and whole task conditions included the following:

- *Instructor demonstrations*. In the part-task condition, during both lessons the instructor demonstrated each of the part-task skills learners were expected to learn during that lesson. In contrast, during both lessons in the whole-task condition, instead of demonstrating the part-task skills out of context, the instructor provided a modeling example of how to perform the whole-task (creating a simple version of a grade book during the first lesson, and a more complex version during the second lesson).
- *Student practice activities*. In the part-task condition, most of the practice activities required learners to focus on part-task skills. That is, as each skill was being demonstrated, learners were asked to perform exactly the same skill, and after all of the skills were taught, learners were given practice problems requiring them to demonstrate each skill separately. At the end of the second lesson, learners were finally given a practice problem that required them to perform the whole task (preparing a grade book). In contrast, all of the practice activities in the whole task condition required learners to create grade books. That is, during both lessons, the learners first created a grade book by following the instructor's demonstration and then were given a *completion problem* that required them to create another grade book with a different set of data and without being presented with an instructor demonstration. Throughout these

activities, supportive information was provided for the acquisition of non-recurrent skills and procedural information was provided for the acquisition of recurrent skills.

Level of learner prior knowledge (lower versus higher)

The levels of learner prior knowledge were determined by using the data obtained from a prior-knowledge test (pretest). The pretest measured whether or not a participant could already perform certain skills (e.g., create an Excel formula) that were the focus of the instruction. On the pretest worksheet an incomplete grade book was presented in which the average and total scores were not calculated, and learners were required to create a similar worksheet using Excel by performing a series of tasks (e.g., add text, delete a row, create a simple formula, and so on), involving a total of 16 basic and advanced skills. A maximum of 16 points could be earned on the pretest, one for each of the 16 skills a learner performed correctly. Based on data from pilot research, if a participant was able to perform at least six basic skills (e.g., add text, delete a row) and one advanced skill (e.g., write a formula, sort data, create a chart) correctly, he or she was classified as a higher-prior knowledge learner; otherwise he or she was classified as a lower-prior knowledge learner. Based on the pretest results, there were 29 lower-prior knowledge learners and 26 higher-prior knowledge learners. The mean pretest scores for both of these groups of learners were relatively low; the mean score for the higher-prior knowledge group was 56% ($M = 9.1$, $SD = 0.46$), while the mean score for the lower-prior knowledge group was 20% ($M = 3.1$, $SD = 0.74$).

Dependent variables

Skill acquisition

Learner acquisition of the complex skill taught during the instructional unit was measured by two *achievement tests*: a part-task achievement test and a whole-task achievement test. The part-task achievement test required learners to perform 16 separate part-tasks. The whole-task achievement test required learners to prepare a grade book that incorporated a given set of features, each of which had been covered in the lessons each group participated in. On both tests, some of the features the learners created could simply be scored as correct or incorrect, but in several other cases a scoring rubric was used to judge the quality of a particular feature on a three-point or five-point scale. Learners could earn a maximum of 34 points on the part-task test and 36 points on the whole-task test.

Transfer

Ability to transfer the skills they had been taught was measured by a transfer test that presented learners with a set of data and required them to use Excel to prepare a budget that incorporated a variety of features. This task was not one that was addressed during the instructional unit, but did require the use (transfer) of the same set of skills the learners had been taught during the unit. As was the case with the achievement tests, some of the features learners were required to incorporate into the budget were simply scored as correct or incorrect, but in other cases a scoring rubric was used to score particular features on either a three-point or five-point scale. Learners could earn a maximum of 35.5 points on the transfer test.

Two raters carried out the scoring of the tests. Interrater reliabilities for each achievement test (part-task and whole-task) and the transfer test were computed using Cohen's Kappa. The analysis yielded Kappa coefficients of 0.70, 0.66, and 0.62, respectively. By convention, $\kappa = 0.40$–0.59 is moderate interrater reliability, 0.60–0.79 is substantial, and 0.80 or higher outstanding (Landis and Koch 1977). Test reliabilities for the part-task and whole-task achievement tests and the transfer test were calculated using Cronbach's alpha and resulted in reliability indices of 0.74, 0.78, and 0.85, respectively. In general, alpha should be 0.70 or higher for a set of items to be considered an "adequate" measure (Ebel 1951).

Time on tests

The time each learner took to complete each test was measured by asking the learners to record their start and end times on each of the two achievement tests and on the transfer test.

Learner attitudes

The attitude of the learners toward the instruction was measured by a 30-item Likert-type questionnaire adapted from the Instructional Material Motivational Survey (Keller 1993). The IMMS provides a situational measure of learners' motivational reactions to instructional materials. It was developed on the basis of Keller's ARCS model (1987a, b) and required learners to report their degree of agreement with a variety of statements concerning their attention (e.g., "the lesson included things that stimulated my curiosity"), relevance (e.g., "the contents of the lesson were related to things I already knew"), confidence (e.g., "as I worked on the lesson, I was confident that I could learn how to prepare a grade book in Excel") and satisfaction (e.g., "completing the practice activities during the lesson gave me a feeling of accomplishment"). Learners responded to these statements by using a five-point Likert scale (1 = not true, 5 = very true). Of those 30 items, the total number of items pertaining to each construct was as follows: attention (eight items), relevance (eight items), confidence (nine items), and satisfaction (five items).

The overall survey used in this study had a reliability of 0.93, as measured by Cronbach's alpha. Furthermore, questions pertaining to attention had a reliability of 0.78, those pertaining to relevance had a reliability of 0.77, those measuring confidence had a reliability of 0.83, and those pertaining to satisfaction had a reliability of 0.89. Thus, reliability was generally high for this instrument.

Procedures

The study was conducted in a university computer lab. The four class sections, each of which normally met in the lab, were randomly assigned to one of the two treatment conditions (part-task or whole-task), with a total of two sections being assigned to each treatment. As noted earlier, the same instructor taught all four sections of the class. Two days before conducting the study, the pretest was given to the learners to determine their level of prior knowledge with regard to using the Excel program to create a grade book.

As noted above, two 60-min lessons were presented to each treatment group. In both treatment conditions both lessons were presented on the same day, 2 days after the pretest was administered. After the first lesson, learners were given a 5-min break. The second lesson then began. As previously indicated, both lessons consisted of two parts, the first of which was the same for both treatment groups and the second of which differed by group (part-task approach versus whole-task approach). Two days after the two lessons were presented to them, the learners were asked to complete the attitude survey and then were asked to complete the two achievement tests and the transfer test.

Data analysis

To examine differences between the two groups on the part-task achievement test, the whole-task achievement test, and the transfer test, we conducted a two-way (instructional approach $\times$ level of prior knowledge) multivariate analysis of variance (MANOVA). To examine the attitude data, we also conducted a two-way MANOVA, this time with four dependent variables—one for each sub-scale on the attitude survey. The time spent on each test was compared across groups via three two-way ANOVAs, one for each of the three tests.

Results

Skill acquisition

Part-task achievement

As can be seen in Table 1, both groups performed well on the 34-item part-task achievement test. The mean score for learners in the whole task condition was 91% ($M = 30.9$, $SD = 3.14$), whereas learners in the part task condition had a mean score of 92% ($M = 31.3$, $SD = 1.95$). Although MANOVA revealed a significant overall main effect for instructional approach on skill acquisition and transfer, *Wilks Lambda* = 0.7, $F\ (3, 45) = 6.38$, $p < 0.05$, $\eta^2 = 0.3$, a follow-up ANOVA, using a Bonferroni adjusted alpha level of 0.017, yielded no significant main effect for the instructional approaches on the part-task achievement test. Prior knowledge did not have a significant main effect on achievement on the part-task achievement test, nor was there a significant interaction between the treatment conditions and level of prior knowledge.

Whole-task achievement

As shown in Table 1, both groups performed fairly well on the 36-item whole-task achievement test. Learners in the whole-task condition had a mean score of 89% ($M = 32.2$, $SD = 5.0$), whereas learners in the part-task condition had a mean score of 80% ($M = 28.7$, $SD = 5.72$). Based on the significant main effect for instructional approach detected by the MANOVA, we conducted a follow-up ANOVA, using a Bonferroni adjusted alpha level of 0.017. This test revealed that learners in the whole-task condition scored significantly higher on the whole-task achievement test than did their counterparts in the part-task condition, $F\ (1, 47) = 6.12$, $p < 0.017$, $\eta^2 = 0.12$. The effect size estimate was $d = 0.71$, indicating a moderately strong effect (medium effect:

Table 1 Means and standard deviations of dependent variables across groups

Dependent measures	Treatment					
	Whole-task approach			Part-task approach		
	Low[a] (n = 14) M (SD)	High (n = 11) M (SD)	Total (n = 25) M (SD)	Low (n = 15) M (SD)	High (n = 11) M (SD)	Total (n = 26) M (SD)
Skill acquisition						
Part-task achiev. test[b]	30.5 (3.59)	31.5 (2.53)	30.9 (3.14)	31.3 (2.31)	31.2 (1.42)	31.3 (1.95)
Whole-task achiev. test[c]	30.4 (5.24)	34.5 (3.74)	32.2 (5.00)	28.4 (5.53)	29.1 (6.22)	28.7 (5.72)
Transfer						
Transfer test[d]	30.0 (5.18)	32.1 (2.84)	30.9 (4.36)	22.2 (6.56)	27.8 (5.56)	24.6 (6.67)
Time on test (min)						
Part-task achiev. test	14.4 (6.51)	12.2 (3.82)	13.4 (5.50)	13.8 (4.83)	8.9 (1.70)	11.7 (4.50)
Whole-task achiev. test	22.7 (7.31)	26.2 (10.02)	24.2 (8.59)	20.5 (7.48)	20.4 (9.69)	20.4 (8.30)
Transfer test	18.6 (6.02)	21.4 (6.92)	19.8 (6.44)	18.0 (6.90)	15.5 (6.39)	16.9 (6.68)
Attitudes[e]						
Attention	3.8 (0.72)	3.8 (0.65)	3.8 (0.67)	3.5 (0.61)	3.8 (0.77)	3.6 (0.68)
Relevance	3.8 (0.67)	3.9 (0.64)	3.8 (0.64)	3.6 (0.54)	4.0 (0.67)	3.7 (0.62)
Confidence	3.9 (0.96)	4.6 (0.27)	4.2 (0.81)	3.8 (0.42)	4.4 (0.60)	3.8 (0.72)
Satisfaction	3.6 (0.88)	3.8 (1.06)	3.7 (0.94)	3.5 (0.89)	3.9 (0.76)	3.6 (0.85)

[a] These descriptors refer to learner level of prior knowledge

[b] Maximum possible score was 34

[c] Maximum possible score was 36

[d] Maximum possible score was 35.5

[e] A five-point scale ranged from 1 (*not true*) to 5 (*very true*)

$0.40 \leq d < 0.75$; Thalheimer and Cook 2002). As was the case on the part-task achievement test, prior knowledge did not have a significant main effect. Nor was there a significant interaction between the treatment conditions and level of prior knowledge.

Transfer

On the transfer test (maximum possible score = 35.5), the mean score for the whole-task group was 86% (M = 30.9, SD = 4.36), while the mean score for the part-task group was 68% (M = 24.6, SD = 6.67). A follow-up ANOVA, using a Bonferroni adjusted alpha level of 0.017, revealed that the whole-task group scored significantly higher than the part-task group, $F(1, 47) = 15.87$, $p < 0.017$, $\eta^2 = 0.25$. The effect size estimate was $d = 1.14$, indicating a very large effect (Thalheimer and Cook 2002).

With regard to the levels of learner prior knowledge, a follow-up ANOVA revealed that there was a statistically significant main effect on the transfer test, with the mean score of the higher-prior knowledge learners ($M = 30.0$, $SD = 4.8$) being significantly greater than the mean score of the lower-prior knowledge learners ($M = 25.9$, $SD = 7.04$), F (1, 47) $= 6.57$, $p < 0.017$, $\eta^2 = 0.12$. No interaction was found between the two instructional approaches and the two levels of learner prior knowledge.

In addition to examining overall performance on the transfer test, we decided, on a post hoc basis, to also examine learner performance on those portions of the transfer test that assessed learner ability to apply those constituent non-recurrent Excel skills that are performed differently from one problem situation to another. One such skill involved selecting the appropriate type of chart (e.g., bar or pie chart) to best depict particular types of data. This skill was assessed by two items (worth a total of two points) on the transfer test, and learners in the whole-task condition scored significantly better ($M = 1.8$, $SD = 0.47$) on this skill than did learners in the part-task condition ($M = 1.1$, $SD = 0.99$), F (1, 47) $= 10.3$, $p < 0.05$, $\eta^2 = 0.18$.

Learner attitudes

The 30-item attitude survey consisted of four sub-scales, including attention, relevance, confidence, and satisfaction. As shown in Table 1, for each sub-scale, learners in each treatment group expressed fairly positive attitudes (group means on each subscale were generally in the range of 3.6–3.8 on a five point scale, with five being the most positive). For analysis purposes, an overall mean score was computed across all items for each sub-scale. These mean scores are included in Table 1. MANOVA revealed no significant overall effect for instructional approach on attitudes, indicating that there was no significant difference between the two groups in their attitude scores with regard to attention, relevance, confidence, and satisfaction. However, MANOVA revealed that level of learner prior knowledge did have a significant overall effect on learner attitudes, *Wilks Lambda* $= 0.77$, F (4, 44) $= 3.38$, $p < 0.025$, $\eta^2 = 0.24$. A more conservative alpha level (0.025) was set for this analysis as Lavene's test for a confidence measure indicated a violation of the assumption of homogeneity of variance. A follow-up ANOVA, using a Bonferroni adjusted alpha level of 0.005, yielded a main effect for the levels of learner prior knowledge on confidence, F (1, 47) $= 13.46$, $p < 0.005$, $\eta^2 = 0.22$, indicating that, regardless of the instructional approach employed, the higher-prior knowledge learners were significantly more confident about what they had learned ($M = 4.5$ out of 5, $SD = 0.47$) than were the lower-prior knowledge learners ($M = 3.8$, $SD = 0.72$). Concerning the interaction effect on overall attitudes, MANOVA yielded no interaction between the two instructional approaches and the two levels of learner prior knowledge.

Time on tests

ANOVAs revealed no main effect for instructional approach on time spent on the achievement tests (whole-task and part-task) and the transfer test. However, with regard to time spent on the part-task test, learners with higher-prior knowledge spent significantly less time ($M = 10.5$ min, $SD = 3.33$) than learners with lower-prior knowledge ($M = 14.1$ min, $SD = 5.61$), F (1, 47) $= 6.97$, $p < 0.025$, $\eta^2 = 0.13$. A more conservative alpha level (0.025) was set for this analysis as Lavene's test for a confidence measure indicated a violation of the assumption of homogeneity of variance. There was no significant interaction between the two instructional approaches and the two levels of prior knowledge with regard to the time spent on any of the tests.

Discussion

Effects of instructional approaches on skill acquisition and transfer

Results of the present research support the notion that a whole-task instructional approach is an effective means of promoting the acquisition and transfer of skills such as those examined in this study. Learners in the whole-task instructional condition performed significantly better on the whole task achievement test than did their counterparts in the part-task instructional condition. This finding is likely due to the fact that these learners had more opportunities to engage in whole task practice activities and thus had more opportunities to integrate and coordinate the constituent skills throughout the instruction than those in the part-task approach. Moreover, learners in the whole-task condition performed equally well on the part-task achievement test as those in the part-task group. It appears that by having the opportunity to practice part-task skills within the context of performing a whole task, learners in the whole-task condition received enough practice to enable them to perform those skills as well as the part-task learners whose practice activities focused much more heavily on those part tasks.

Learners in the whole-task instruction group were also much better able than the part-task learners to transfer the skills they learned to a new situation, in this case preparing a budget using Excel. This result may be due to the fact that the whole-task instructional approach put an emphasis on promoting learners' schema construction for non-recurrent aspects of a complex skill, that is, those constituent skills that are performed differently from one problem situation to another. For example, in the whole-task condition emphasis was placed on selecting the appropriate type of chart (e.g., bar or pie chart) to best depict particular types of data. As noted in the results section, this skill was assessed on the transfer test, and learners in the whole-task condition performed the skill significantly better than did learners in the part-task condition.

The superior transfer performance of the whole-task group may also be due to the fact that the whole-task approach varied the contexts in which the various tasks had to be performed, one of the most critical tactics for enhancing transfer of learning. As noted earlier, in the present study learners in the whole-task condition were presented with four problem scenarios (two in each of the two lessons) in which they had to use Excel to create a grade book, with each problem taking place in a different context. Perhaps as a result of solving these various whole-task problems, learners were able to develop rich schemata that facilitated transfer of the skills they were taught. This notion is supported by previous research where variability in the types of practice problems learners received was identified as a likely reason for their superior transfer test performance (Shapiro and Schmidt 1982; Singley and Anderson 1989).

Effects of prior knowledge on skill acquisition and transfer

This study was also designed to examine how learners' prior knowledge would affect skill acquisition and transfer. We were especially interested in examining the interaction between level of prior knowledge and the two treatment conditions so as to determine whether the expertise reversal effect found in previous studies would be found in the present study. Results on the two achievement tests and the transfer test revealed no significant interactions. Why weren't the higher-prior knowledge learners adversely affected by the whole-task approach, as would have occurred if there was an expertise reversal effect? A likely answer is that, as explained below, we may have misclassified many of the learners as higher-prior knowledge learners.

As noted earlier, although their pretest performance was considerably better than that of the lower-prior knowledge learners, the higher-prior knowledge learners had a mean pretest score of only 56% correct. Moreover, the pretest did not assess learner ability to perform a number of the higher-order constituent skills taught in the second lesson and assessed on the achievement and transfer tests, such as calculating weighted averages, sorting data, and selecting appropriate types of charts. In retrospect, it would have been beneficial to have assessed these and the other higher-order constituent skills on the pretest, and to have classified as higher-prior knowledge learners only those learners who could perform most of these skills. If we had done so, the group of higher-prior knowledge learners that were identified would, in all likelihood, have better represented those individuals who possessed high prior knowledge of the necessary constituent skills. In such a case, conclusions regarding the presence or absence of an expertise reversal effect would be more justified.

Effects on learner attitudes and time on tests

Results of this study revealed that learners in the whole-task instructional approach did not have more positive attitudes toward the instruction than learners in the part-task instructional approach. Indeed, learners in both instructional treatment groups expressed relatively positive attitudes toward the instruction they received. This finding is likely due to the relevance of the skill (creating a grade book) that these learners (pre-service teachers) were being taught.

Results also revealed no differences between the two treatment groups in the amount of time spent on each of the tests. This result appears to rule out the possibility that the superior performance of the whole-task group on the whole-task achievement test and the transfer test may have been due to differences between the two groups in the amount of time they spent creating the documents the tests called for.

Future research

The findings of this study suggest several directions for future research. First, 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. For example, it is not clear whether learners in the whole-task condition outperformed their part-task counterparts because they were exposed to more whole-task practice occasions, because they engaged in varied learning tasks, or both.

Based on the results of this study we also suggest that in future studies, researchers should carefully consider the difficulty of the task learners are expected to learn, as well as the degree of prior knowledge the learners possess. With regard to task difficulty, as evidenced by their low scores on the pretest and their relatively high scores on the part-task and whole-task achievement tests, it is possible that the primary learning task examined in this study—creating a grade book using Excel—may have been a relatively easy one for the target learners. Thus the results may only apply to the training of low complexity technical skills that may be acquired in a short period of time. To increase generalizability, additional studies using more complex tasks that require longer training times should be conducted to see whether similar results are found. With regard to learner prior knowledge, in future studies researchers should pay careful attention to the skills they assess on a pretest and to the criteria they use to classify lower- and higher-prior knowledge learners so as to insure that learners are properly classified.

In addition, future studies should include the collection of more qualitative data. The results of the current study do not provide us with concrete answers as to how the treatments affected the learners' learning processes. For example, it is uncertain what sort of schema, if any, the learners developed or if they actually used those schemas when they performed the transfer task. Also, we do not know the extent to which learners in the whole task condition made use of the supportive and procedural information that was available to them. Gathering data of this nature would help provide a clearer picture of how the whole task condition affected learners' learning strategies and the extent to which the various components of the whole-task condition were beneficial.

Conclusion

As indicated earlier, in recent years, much has been written about the potential value of employing whole-task instructional approaches (e.g., Collins et al. 1989; Jonassen 1999; Merrill 2002, 2007; van Merriënboer 1997, 2007), but little research has been conducted in this area. The present study provides support for the notion that whole-task approaches may facilitate skill acquisition and transfer. However, a great deal of additional research is necessary in order to determine whether these promising findings hold true across a wide range of cognitive skills and learners. For example, it is important to identify which components of a whole-task approach are essential in promoting learning and transfer, and to examine how the learning strategies learners employ are affected by this type of approach. We believe that researchers who build upon the present study, following the suggestions we have offered, will help provide a richer picture of the benefits a whole-task instructional approach may afford.

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