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The Effects of Instruction and Experience on the Acquisition of Auditing Knowledge

Sarah E. Bonner
University of Southern California
Paul L. Walker
University of Colorado at Boulder

SYNOPSIS AND INTRODUCTION: Libby (1993) suggests a simple model of the acquisition of expertise where knowledge and ability determine performance, and instruction, experience, and ability determine the acquisition of knowledge. An important implication of the model is that a detailed understanding of the knowledge acquisition process is needed before the practical implications of expertise research are evident (see also Bonner and Pennington 1991; Waller and Felix 1984). Libby's review indicates, however, that the vast majority of studies of the knowledge acquisition process focus on what knowledge auditors acquire during a particular period of time with the firm, but not on what particular aspects of instruction and experience lead to superior knowledge.[1] The latter type of study is necessary before firms can determine how best to organize auditors' training and experiences to allow efficient and effective acquisition of the necessary knowledge.

The importance of analytical procedures in auditing and the popularity of ratio analysis as an analytical procedure are well-documented (e.g., Biggs and Wild 1984; Libby 1985). The current study focuses on the knowledge necessary to perform ratio analysis in audit planning. Specifically, we examine the effectiveness of various combinations of instruction and experience (practice and feedback) in producing this knowledge. The results indicate that combinations of instruction and no experience or of instruction and practice without feedback do not produce knowledge. Practice with explanatory feedback and any form of instruction creates

[1] Two exceptions relate to the specific effects of instruction and experience on the acquisition of frequency knowledge (Butt 1988; Nelson 1993), which has characteristics that do not generalize to most types of knowledge required in auditing. For example, acquisition of frequency knowledge requires less effort than acquisition of other types of knowledge.

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gains in knowledge, but may not always be available in the audit environment. Practice with outcome feedback, on the other hand, does not assist in the acquisition of knowledge *unless* it is preceded by instruction with what we have labeled "understanding rules," making this combination appear to be an adequate substitute for explanatory feedback. Practice with outcome feedback combined with what we call "how-to rules" does not promote knowledge acquisition. Finally, results indicate that ability aids in the acquisition of knowledge, and that this knowledge is related to performance in ratio analysis.

These findings have implications for audit effectiveness and efficiency, and for education and firm training related to ratio analysis. If explanatory feedback can be replaced by a combination of understanding rules and practice with outcome feedback, audit efficiency could be increased since explanatory feedback takes more time and more experienced personnel. Explanatory feedback may also be inaccurate or unavailable, particularly under conditions of time pressure. However, if only outcome feedback is to be provided for ratio analysis, understanding rules must be incorporated into education and training. For the most part, firm training and university education currently provide only how-to rules for ratio analysis (see Bonner and Pennington 1991; Ernst & Whinney 1986). The ideas described above could also be extended to tasks other than ratio analysis for which outcome feedback is available (Solomon and Shields 1993).

Key Words: *Knowledge acquisition, Instruction, Experience, Ratio analysis.*

Data Availability: *Data are available from the first author upon request.*

THE remainder of this paper is organized as follows. The first section reviews the literature on the effects of instruction and experience on knowledge acquisition, and develops hypotheses. The effects of abilities on knowledge acquisition, as well as the effects of knowledge and abilities on performance, are also discussed to examine the other links in Libby's (1993) model. The second section describes the method, and the third section presents the results. The final section discusses the results and presents some directions for future research.

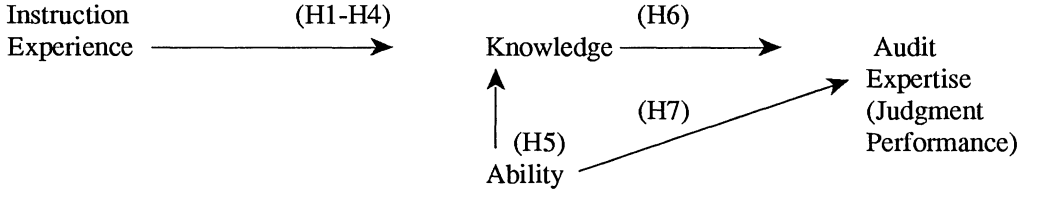
I. Literature Review and Hypothesis Development

According to Libby's (1993) model, auditors acquire knowledge primarily through instruction and experience (see figure 1). Instruction may be received both formally and informally in college and through firm continuing education courses, and varies in length, content, and style. Individuals also might learn from practice in performing tasks and receiving feedback on their judgments. Feedback in auditing comes from reviewers and the environment (Bonner and Pennington 1991; Solomon 1987; Solomon and Shields 1993); again, the quantity and quality of practice and feedback varies. Both practice and feedback are considered part of "experience." In this study, we focus on the acquisition of knowledge through various combinations of instruction and experience.

Several theories of knowledge acquisition make a useful distinction between declarative knowledge and procedural knowledge, both of which may be important to performance in skilled tasks like ratio analysis (e.g., Anderson 1982; Winograd 1975). Declarative knowledge is knowledge of facts and definitions. For example, cash is part of current assets; this knowledge is necessary in ratio analysis because current assets is an element in some ratios. Procedural knowledge consists of rules or steps needed for performing skilled tasks. An example rule for ratio

Figure 1

Libby's (1993) Model of the Acquisition of Audit Expertise and Hypotheses Addressing Each Relation



analysis would be one stating that: "if the gross margin ratio is overstated, consider errors which understate sales, overstate gross margin, or overstate both sales and gross margin by the same amount." Another useful way of thinking about this distinction is that declarative knowledge is similar to data, and procedural knowledge is similar to processes (Rumelhart and Norman 1981; Waller and Felix 1984). As a consequence, declarative knowledge generally must be in place prior to the acquisition of procedural knowledge, so that procedural knowledge can be compiled through interpreting declarative knowledge (Anderson 1982). In auditing, basic declarative knowledge is commonly acquired through formal education, and procedural knowledge is acquired later during one's professional career (Waller and Felix 1984). Therefore, in this study, we focus on the acquisition of procedural knowledge.

Effects of Instruction and Experience on Procedural Knowledge Acquisition

Instruction. Although instruction is not normally considered adequate to create procedural knowledge, the psychology literature has examined whether certain types of instruction can promote knowledge acquisition. Two types of instruction frequently examined are "how-to rules" and "understanding rules." "How-to-rules" consist of lists of steps or procedures to be followed in performing a task; these rules contain little explanation. For example, an audit program might state: "foot the sales journal." "Understanding rules," on the other hand, provide explanations with the steps and, possibly, information about why the steps are performed, how they relate to each other, and so forth. Audit planning workpapers in which audit program steps are derived from risk analyses and audit objectives might provide such information (see, e.g., Arens and Loebbecke 1991, 391).

The effects of how-to rules and understanding rules on procedural knowledge acquisition are unclear for two reasons. First, studies have used performance as a proxy for procedural knowledge; however, performance differences could be due to differences in declarative knowledge or abilities. Second, results are mixed and limited to a few domains, mostly mathematics. Examining how-to rules, Post and Brennan (1976) found that providing geometry students with a list of procedures on how to do geometry proofs did not improve problem-solving performance. On the other hand, LeFevre and Dixon's (1986) results indicated that subjects did as well at series classification problems with how-to rules as with examples. In this study, performance was relatively poor in both groups and no measure of knowledge or performance was made prior to the use of instruction, so it is not clear whether how-to rules promoted procedural knowledge acquisition.

An additional problem with the literature on understanding rules is that the rules normally are part of a learning environment which includes other information, such as sample problems. Sweller and his colleagues, for example, have found that students who study completed mathematics problems can perform as well as or better than students who practice similar problems (e.g., Cooper and Sweller 1987; Sweller and Cooper 1985). However, it is likely that other information in the examples, such as the answers to the problems, accounts for the performance differences. In a study which did not employ examples, Schoenfeld and Hermann (1982) showed that math students had performance gains from understanding-type instruction. However, in that study, students appear to have had significant practice and feedback. Consistent with this idea, Christensen and Cooper's (1991) math students who practiced problems performed better than students receiving only understanding rules. Thus, understanding rules alone are unlikely to promote more than minimal procedural knowledge acquisition.

Popular learning theories (e.g., Anderson 1982; Anzai and Simon 1979; Larkin 1981) generally support the idea that instruction is not conducive to procedural knowledge acquisition. Although largely untested, these theories suggest that instruction can provide only declarative knowledge, and that procedural knowledge must be acquired by compiling declarative knowledge through practice and feedback. Results of the two studies above which employed only how-to rules or understanding rules are consistent with these theories. In auditing, both how-to and understanding rules exist in audit manuals and firm training courses, and staff auditors must initially perform most tasks having had instruction only (Bonner and Pennington 1991). Thus, we examine the effects of both of these types of instruction on the acquisition of procedural auditing knowledge.

Experience. Additionally, individuals can acquire knowledge by doing tasks and receiving feedback after completing the tasks. Popular learning theories agree that some practice is necessary for the acquisition of the procedural knowledge needed for skilled tasks. These theories also require that practice be followed by accurate, complete, and informative feedback for procedural knowledge to be acquired. However, as noted previously, these theories are largely untested. Auditors receive virtually no feedback for some auditing tasks, only outcome feedback for other tasks, and more extensive feedback for tasks like ratio analysis (Bonner and Pennington 1991). Further, the quality and amount of feedback for any given task, such as ratio analysis, depend on the tests performed in a particular audit, the quality of the reviewers, and the surrounding environmental conditions (Waller and Felix 1984). Because of the variety of learning environments auditors face and the lack of research investigating theories about the acquisition of procedural knowledge from experience, we examine the effects of both practice without feedback and practice with various forms of feedback.

The results relating to practice without feedback support the theories' predictions. Schoenfeld and Hermann (1982) employed practice without feedback (and without instruction); in their group of subjects, there were no significant performance gains from semester beginning to semester end. In a meta-analysis of a large number of studies, Ross (1988) found that amount of task practice had no effect on knowledge acquisition. Practice without feedback can retard the acquisition of procedural knowledge and even decrease procedural knowledge for two reasons. First, because people experience cognitive overload while simultaneously inferring procedures and retrieving declarative knowledge (Owen and Sweller 1985), knowledge can be lost from working memory and never committed to long-term memory. Unfortunately, the eliminated knowledge may be relevant knowledge. In addition, without feedback, people simply may infer and maintain in memory inaccurate procedural knowledge. There is evidence that radiologists, progressing from a novice stage to an expert stage by looking at thousands of X-rays, experience

procedural knowledge (and performance) decreases in the "intermediate" stage (Lesgold 1984; Lesgold et al. 1988).

Research also has examined the effects of practice combined with two types of feedback on the acquisition of knowledge. These two types are *outcome feedback*, which provides information about the outcome or correct answer, and *task-properties feedback*, which provides an explanation of why the outcome occurred. The vast majority of results indicate that outcome feedback does not promote procedural knowledge acquisition, even in cases where the relation of inputs to the outcome exhibits little noise (see Balzer et al. 1989 for a review). Knowledge acquisition with outcome feedback is difficult because people change their procedures haphazardly based on what they infer from the outcomes, or simply infer incorrect procedures due to noise in the outcomes. In general then, practice with outcome feedback does not produce procedural knowledge.

In contrast, feedback providing an explanation of the properties of the task or such feedback combined with outcome feedback (called "explanatory feedback" here) generally promotes better acquisition of knowledge than outcome feedback alone (Balzer et al. 1989). Because people are told why the outcome occurred, they do not have to infer the explanation from the outcome.[2] Since people can assimilate the explanations with the outcome and any other information gained while practicing the task, they can acquire an understanding of the rules of the domain, or procedural knowledge (Ross 1988). In auditing, Hirst and Luckett (1992) and Hirst et al. (1992) found that auditors learned very rapidly from explanatory feedback.[3]

Although these findings are widely accepted, more recent research has suggested that outcome feedback can create procedural knowledge as can task-properties feedback or explanatory feedback under certain conditions. The first condition occurs when the task is sufficiently simple to enable subjects to reason backwards from the outcome and develop correct explanations (Hirst and Luckett 1992). This process requires that the task have a small number of information cues, have high predictability, or be simplified in other ways. In accounting, several studies have found results consistent with this idea. Subjects in Harrell's (1977) study learned from outcome feedback in a perfectly predictable personnel evaluation task with a small number of information cues. Auditors performing a similar task in Hirst and Luckett's (1992) study also learned from outcome feedback. Other studies have found learning in tasks which were not perfectly predictable, but which were quite simple on most dimensions. For example, auditors learned from outcome feedback in Ashton's (1990) study, where the task required bond ratings based on an additive combination of three cues. Similarly, subjects learned from outcome feedback in the simplified ratio analysis task used by Nelson (1993).

The second proposed condition occurs when the subject possesses a causal theory of the domain prior to practicing the task and receiving outcome feedback. This knowledge allows the subject to interpret outcomes in a manner which is conducive to testing the relations of the theory and developing explanations (Camerer 1981). Although Camerer's is the only study to examine this idea directly, several studies indirectly support it by showing that subjects who possess this type of knowledge prior to practicing tasks (and receiving outcome feedback) acquire procedural knowledge more readily (Anderson et al. 1981). Hirst and Luckett's (1992) and Hirst et al.'s (1992) results support this view, since their auditor subjects had high previous knowledge

[2] In the laboratory, these explanations can always be made accurately. If explanatory feedback were to come from a reviewer, as might be the case in auditing, the accuracy of the explanation would depend on the quality of the reviewer's knowledge.

[3] In auditing, explanatory feedback (outcome feedback combined with task-properties feedback) is fairly similar to what might be provided by a reviewer. In this study, task-properties feedback cannot be provided without revealing the outcome, so explanatory feedback must be used.

Figure 2

Hypothesized Effects of Instruction and Experience Combinations on Procedural Knowledge

	Instruction		
Experience	*No Instruction (Hypothesis)*	*How-to Rules (Hypothesis)*	*Understanding Rules (Hypothesis)*
No Experience	No change (H1a)	No change (H1b)	No change (H1c)
Practice Alone	No change (H2a)	No change (H2b)	No change (H2c)
Practice with Outcome Feedback	No change (H3a)	No change (H3b)	Increase (H3c)
Practice with Explanatory Feedback	Increase (H4a)	Increase (H4b)	Increase (H4c)

regarding staff evaluations or bankruptcy predictions. Support for the idea also comes from Bonner and Pennington's (1991) finding of a positive correlation of auditors' task performance with the amount of instruction provided *prior* to practice. If procedural knowledge is important to performance, this correlation may reveal that practice with outcome feedback aids in the acquisition of procedural knowledge if instruction as to the causal theory of the domain precedes practice.

Hypotheses about the Combined Effects of Instruction and Experience

Based on the literature reviewed above, predictions can be made about the effects on procedural knowledge of various *combinations* of instruction and experience (these predictions are summarized in figure 2). Examining these hypotheses allows us to specify more clearly the effects of instruction and experience on knowledge in Libby's (1993) model (see figure 1).

Subjects receiving combinations of no experience and any form of instruction will not acquire the procedural knowledge needed to do ratio analysis because neither how-to rules nor understanding rules are expected to create knowledge *per se*. This prediction leads to the following hypotheses:

H1a: Subjects receiving no experience and no instruction will not acquire procedural knowledge.[4]

H1b: Subjects receiving no experience and how-to rules will not acquire procedural knowledge.

H1c: Subjects receiving no experience and understanding rules will not acquire procedural knowledge.

Subjects receiving combinations of practice alone and various forms of instruction are not expected to acquire procedural knowledge because practice without feedback normally does not

[4] In all hypotheses, "procedural knowledge" refers to the procedural knowledge needed for ratio analysis. Specific elements of this knowledge will be described later.

promote learning even if preceded by instruction. The addition of instruction could make the learning more difficult because it provides additional declarative knowledge to keep in mind while doing the task, increasing the chance of memory overload. This position leads to the following hypotheses:

H2a: Subjects receiving practice alone and no instruction will not acquire procedural knowledge.
H2b: Subjects receiving practice alone and how-to rules will not acquire procedural knowledge.
H2c: Subjects receiving practice alone and understanding rules will not acquire procedural knowledge.

Subjects receiving outcome feedback also will not gain the procedural knowledge needed for ratio analysis unless they are provided with understanding rules prior to practicing the task. The other forms of instruction will not provide them with a causal framework within which to interpret the outcomes. The following hypotheses result:

H3a: Subjects receiving practice with outcome feedback and no instruction will not acquire procedural knowledge.
H3b: Subjects receiving practice with outcome feedback and how-to rules will not acquire procedural knowledge.
H3c: Subjects receiving practice with outcome feedback and understanding rules will acquire procedural knowledge.

Finally, subjects with explanatory feedback will gain procedural knowledge irrespective of the form of instruction provided because the explanatory feedback itself provides them with both the outcome and the information needed to infer correct explanations. Thus, the following hypotheses are proposed:

H4a: Subjects receiving practice with explanatory feedback and no instruction will acquire procedural knowledge.
H4b: Subjects receiving practice with explanatory feedback and how to rules will acquire procedural knowledge.
H4b: Subjects receiving practice with explanatory feedback and understanding rules will acquire procedural knowledge.

Effects of Ability on Knowledge Acquisition

A large body of research has shown that people acquire knowledge at different rates due to differences in aptitude (reviewed in Horn 1989; Kyllonen and Shute 1989; Snow 1989). The evidence suggests that general problem-solving ability is the aptitude which has the largest effect on the acquisition of knowledge, and that ability is related to the acquisition of procedural knowledge, specifically in the compilation of procedural knowledge from declarative knowledge (Ackerman 1989; Reber et al. 1991; Snow 1989). Libby and Tan (1993) provide some evidence that ability is related to the acquisition of knowledge in auditing, consistent with Libby's (1993) model (see figure 1). The following hypothesis is proposed:

H5: General problem-solving ability will be positively related to procedural knowledge acquisition.

Effects of Ability and Knowledge on Performance in Ratio Analysis

In Libby's (1993) model, ability and experience affect knowledge acquisition, then knowledge and ability combine to determine performance (see figure 1). Previous research has shown a relation between knowledge and performance in ratio analysis tasks (Bedard and Biggs 1991; Bonner and Lewis 1990; Libby and Tan 1993). We examine that relation, specifically for procedural knowledge, through the following hypothesis:

H6: Procedural knowledge will be positively related to performance in ratio analysis.

Finally, although previous research has found a relation between ability and performance in ratio analysis (Bonner and Lewis 1990; Libby and Tan 1993), no such relation is predicted here. Libby (1993) predicts and Libby and Tan (1993) find support for the idea that ability should be related to performance only in unstructured tasks. The ratio analysis task in previous studies was such an unstructured task. Here, however, the task is structured for subjects. They are provided with four possible answers and a small amount of information adequate for solving the problems. According to Libby and Tan (1993), this task is structured since there are no requirements for generation of alternatives or search for information.[5] The following hypothesis is proposed:

H7: General problem-solving ability will not be related to performance in a structured ratio analysis task.

II. Research Method

Subjects

Subjects for this study were 95 senior undergraduate and graduate students enrolled in the same basic auditing course at a large state university.[6] In this course, subjects discussed the use of ratio analysis in audit planning, but had no previous experience using ratio analysis to detect financial statement errors.[7] Most of these students were pursuing careers in public accounting, so they are similar to new staff accountants who would be converting declarative knowledge into procedural knowledge. More experienced auditors would have already acquired much of this procedural knowledge (Libby and Frederick 1990), so student subjects are appropriate for a study of the initial acquisition of procedural knowledge. Students volunteered to participate in the study in exchange for a $7.50 hourly salary for their time and prizes awarded to the top performers in each session to maintain motivation.[8]

[5] Ratio analysis, as performed by auditors, will not always be as structured as is the case in this study. Auditors must generally generate hypotheses and search for information. As a result, ability may be related to ratio analysis performance when the task is less structured (e.g., Bonner and Lewis 1990).

[6] One hundred and three subjects participated in the experiment. The data for eight subjects were unusable due to computer malfunctions.

[7] This characteristic was verified with the post-study questionnaire.

[8] The incentive scheme, which provided *extrinsic* motivation, was the same for all subjects and was provided because of the length of the study. Further, a measure of *intrinsic* motivation did not differ across subject groups ($F=1.155$, $p=0.331$). This measure was the absolute value of the residual from an ANOVA where the dependent variable was time spent in the study phase, and the independent variable was the experience and instruction group. This residual reveals time spent in the study phase that is not accounted for by the instruction and experience group to which a subject was assigned. Since this additional time does not differ across groups, random assignment was successful in controlling for the effects of intrinsic motivation.

Procedures

The study was programmed for IBM personal computers to standardize instructions. Groups of between six and 24 people were tested in a computer laboratory which seats 40, leaving ample space for subjects to take notes and preventing them from seeing others' computer screens and notes. Subjects were given a code to begin the program; this code represented one of 12 instruction and experience groups to which they were randomly assigned. During the program, they read instructions and questions on the screen and typed their answers in from the keyboard. Subjects were allowed to take notes in a booklet of blank paper and to ask questions; because the computerized program was self-explanatory, few questions were asked. When finished, subjects turned in their disks and completed a questionnaire.

The use of a computer program allowed for the standardization of time spent in the study. Time limits were imposed on each question and each phase to ensure that subjects did not spend undue amounts of time on any. These time limits were pretested and were more than ample for subjects to complete the questions. Thus, incorrect answers were very likely due to a lack of knowledge rather than time pressure. Subjects spent approximately 80 to 140 minutes completing the study.

Task and Measurement of Variables

Combinations of Instruction and Experience. All subjects completed four phases: (1) knowledge pretest, (2) study phase, (3) test phase, and (4) knowledge posttest. The knowledge pretest and posttest and the test phase were the same for all groups of subjects. The study phase incorporated the 12 instruction and experience variable combinations. These combinations were all possible pairings of three types of instruction and four types of experience.

The forms of instruction were no instruction, how-to rules, and understanding rules. In the no instruction groups, no rules or procedures were provided except for general directions and the definitions of the four ratios. The how-to rules groups simply saw a list of procedures to follow in hypothesizing errors from ratio fluctuations, including steps like:

> If there are any "significant" differences, hypothesize possible accounting errors or irregularities that could have caused the pattern of ratio differences you have.
>
> Check your hypotheses before planning further work. Work out the accounting effects of the errors or irregularities you proposed and determine if the ratios would in fact change in the direction you found.

These rules were developed from a former Big Eight firm's audit manual and were, therefore, very similar to the instruction currently provided by some firms (Ernst & Whinney 1986). In addition, they are similar to the how-to rules used in previous research (Post and Brennan 1976).

The understanding rules incorporated the how-to rules and provided more explanation for each step. For the step regarding hypothesizing differences, the understanding rule explained that:

> The best way to do this is to break the ratios down into their numerator and denominator components and think about what could have made the overall ratio be higher than expected or lower than expected.

The rule also explained the conditions under which a ratio would be higher or lower than expected in general, then for the four specific ratios used here. These rules were designed to be something like the procedural knowledge needed to do the task, but were not expected to produce procedural knowledge because of the difficulty of acquiring procedural knowledge through instruction alone. The total time allowed to read instruction screens was similar to the total time allowed for various forms of experience in the study phase.

Both practice and feedback were included in the experience variable, because feedback clearly cannot be provided unless a person has done the task. The four types of practice and feedback were no experience, practice alone, practice with outcome feedback, and practice with explanatory feedback. In the groups receiving something other than no experience, subjects were told that they would work eight problems, each of which contained four ratios, their expected values, and their actual (unaudited) values. They were then told that each problem contained the ratios for a separate widget manufacturer, so that they were to consider each problem independent of other problems. Further, they were told that expected values would be the same in each problem because expectations were developed based on widget industry averages. These instructions are similar to those used by Nelson (1993).

In the three practice alone groups (combined with no instruction, how-to rules, or understanding rules), subjects worked the eight ratio analysis problems.[9] For each problem, subjects had a time limit of four minutes. If they finished before four minutes, they were allowed to proceed. The groups with practice *and* feedback had the same eight problems and subjects proceeded in the same way, except that when subjects typed in their answer, they received feedback regarding whether their answer was correct. Outcome feedback was provided in the form of one of the following statements, which flashed on the screen: "Answer (a) was correct" or "Answer (a) was incorrect. The correct answer was (c)." Once the feedback statement appeared, subjects had up to two minutes to study this information and to take notes. Again, if they were finished before two minutes, they were allowed to proceed. Two minutes was a large amount of time for these subjects, but was provided to equalize total possible time to read feedback given for feedback between the outcome and explanatory feedback groups.[10]

In the three practice with explanatory feedback conditions, the feedback appeared on the next screen and consisted of one of the two statements above, along with an explanation of the answer. That explanation consisted of a description of how the correct error affected financial statement accounts, e.g., "this error causes inventory and accounts payable to be overstated." The explanation then described how those misstatements affected each of the ratios. We only provided this explanation for the correct answer (rather than for the answer the subjects chose) to ensure that all subjects received the same feedback.[11] Subjects could move back and forth between the problem and explanatory feedback screens to make notes before proceeding. Finally, in the no experience groups, subjects worked no problems. In the no instruction, no experience combination, subjects read information on internal control evaluation, which was of approximately the same length as the ratio analysis instruction. This information gave the subjects no opportunity to acquire the procedural knowledge needed for ratio analysis.

Knowledge Pretest and Posttest. The knowledge pretest and posttest were used to measure declarative and procedural knowledge. All the declarative and procedural knowledge questions

[9] Eight problems should be sufficient to acquire some procedural knowledge since other studies have shown that people can acquire this knowledge from one problem (e.g., Ahn et al. 1992; Anderson et al. 1981).

[10] Another approach would be to allow a fixed amount of time to read feedback for both groups and not to allow subjects to move ahead until the time expired. This structure would ensure that actual time spent was equalized across groups. Unfortunately, this procedure runs the risk of inducing boredom and, thus, poorer performance in outcome feedback groups. The approach of allowing subjects to progress at their own speed controls for possible fatigue and boredom effects. On the other hand, time spent in the study may be confounded somewhat with the experience and instruction combinations. In this study, however, actual time spent cannot explain the results. For example, subjects with understanding rules, on average, spent more time in the study than subjects with how-to rules, but generally did not perform better than the latter group. Further, subjects with practice alone generally spent more time than those with no experience, but again did not perform better. Finally, time that subjects spent which is not accounted for by the experience and instruction combinations (the residual) did not differ across groups (see note 8).

[11] In the field, many experienced auditors would likely take the additional time to explain why a staff auditor's chosen answer was incorrect. As a result, our findings for explanatory feedback may be conservative.

were related to the cycles of transactions and accounts reflected by the ratios (sales/accounts receivable, cash receipts, purchases/payables, and cash disbursements). These transaction cycles are the ones students tend to hear about first and those which represent the "typical" company. All questions were multiple-choice with four answers. The order of presentation of questions and answers within questions was randomized and held constant across subjects. The posttest included the same questions as in the pretest, except that the questions (and answers within questions) were randomized to produce a different ordering than that in the pretest.

The declarative knowledge needed to do ratio analysis includes the following: (1) classifications of items on financial statements, such as which accounts comprise current assets; (2) definitions of summary items on financial statements, such as gross margin; (3) journal entries for various transactions; and (4) definitions of financial ratios, such as current ratio = current assets/current liabilities. A total of 12 declarative knowledge questions included two on classification of accounts, three on definitions of summary items, five on journal entries, and two on ratio definitions. (See appendix A.) These 12 questions covered a large part of the factual knowledge needed for the ratio analysis task. About half the questions were taken from CPA exams, and about half were constructed by the authors on the basis of similar CPA questions.[12] The score on this section of the test served as the measure of declarative knowledge.[13]

The procedural knowledge needed for ratio analysis includes the following: (1) rules on the mathematics of ratios, (2) rules for the effects of financial statement errors on account balances, (3) rules showing what types of errors could have caused specific accounts to be overstated or understated, and (4) rules showing what types of errors could have caused individual ratios to be overstated or understated. These rules are not facts normally taught in accounting or auditing classes and must be compiled through interpreting declarative knowledge. For example, rules showing what types of errors could have caused summary account misstatements must be compiled from declarative knowledge of journal entries, definitions of summary accounts, and inferences regarding direction of misstatements. This part of the knowledge test again included 12 questions, three on the effects of numerator/denominator changes on generic ratios, three on the effects of accounting errors on account balances, three on which errors could cause misstatements of accounts, and three on which errors could cause misstatements of ratios. (See appendix B.) Construction of the questions was similar to that described above.[14] The score on these 12 questions served as the measure of procedural knowledge.[15]

Finally, in the knowledge posttest only, general problem-solving ability was measured using the same eight GRE questions validated by Bonner et al. (1992). These eight questions, used on the GRE to measure general ability, included two questions about analogical reasoning ability, three about analytical reasoning ability, and three about data interpretation ability.

Ratio Analysis Problems used in Study Phase and Test Phase. A total of 16 ratio analysis problems were developed, eight for the study phase and eight for the test phase. (See appendix

[12] No measures of reliability are reported for these questions for the following reasons. First, declarative accounting knowledge is an omnibus construct, encompassing several subconstructs such as knowledge of journal entries. An overall reliability measure for the 12 declarative knowledge questions would not be meaningful. An alternative approach would be to determine the reliability of the measures of the subconstructs, but each of these measures encompasses an insufficient number of questions to achieve a reasonable reliability. The time to do all four phases of the study required that the knowledge test be kept to a reasonable length while covering as many pieces of the knowledge as possible. Unfortunately, only a few questions could be devoted to each subconstruct.

[13] Waller and Felix (1984) discuss this type of knowledge when describing the declarative accounting knowledge possessed by students.

[14] The discussion of reliability in footnote 12 applies here as well.

[15] Although the distinction between declarative and procedural knowledge is not always clear, correlations of 0.204 and 0.051 (at pretest and posttest, respectively) between the two measures indicate they are at least measured distinctly.

C.) All subjects did the eight test phase problems; the number of correct answers given to these problems served as the measure of performance in ratio analysis. Subjects in nine of the 12 groups (those other than the three no experience groups) worked problems during the study phase. Each problem presented the names of four financial ratios (current ratio, inventory turnover, receivables turnover, and gross margin ratio) and their expected and actual (unaudited) values, then asked: "Which of the following errors or irregularities could have caused the differences between actual and expected ratios?" Subjects typed in the letter for the answer they thought to be correct, then proceeded to the next problem (after viewing feedback, in the feedback conditions).

The four ratios are among those most commonly used by auditors in doing ratio analysis (Libby 1985). To construct the 16 problems, we generated all possible combinations of changes in the four ratios (higher than expected, as expected, and lower than expected); this gave us 81 possible sets of ratio fluctuations (3^4). Then we matched financial statement errors from Coakley and Loebbecke (1985) to the sets of ratio fluctuations. Several sets were eliminated because we could generate no errors to account for them. After this procedure, there were 20 sets of ratios and errors; the frequencies of these errors were relatively close (at a medium level). To derive our final set of problems, we eliminated four errors that were similar to other errors. Then, the 16 problems were split into two sets of eight problems that had similar distributions of difficulty levels. The expected values of the ratios were constant across problems because the values were chosen to be representative of "typical" manufacturing companies. The unaudited (current) values were set based on the predicted effects of the financial statement errors (higher than expected, as expected, or lower than expected). If the error had no effect on the ratio, the expected value was shown again; no random variation was introduced. If the ratios were not as expected, predetermined higher and lower numbers were presented. Higher (lower) numbers were determined by adding (subtracting) 0.6 to the expected values for the first three ratios and 0.2 for the gross margin ratio. Pilot tests indicated these fluctuations were large enough to be perceived as unusual fluctuations.

In each problem, subjects saw four possible errors as answers and were asked to type the letter for the correct answer. The 16 errors served as the correct answers and also served as incorrect answers in other problems. The incorrect answers were chosen based on their ability to be good distractors, i.e., on the number of ratio fluctuations that they matched. Ninety-six percent of the incorrect answers could explain either two or three (out of four) of the ratio fluctuations.

Post-Study Questionnaire. After turning in their disks, subjects completed a questionnaire which included checks on attention to the instruction and experience types and questions on background variables. The attention checks asked subjects to respond to the following two statements by marking on a seven-point scale (ranging from "strongly disagree" to "strongly agree"): "In Phase 2 (study phase) of this experiment, I was asked to read a series of procedures describing how to do ratio analysis" and "In Phase 2 (study phase) of this experiment, I was asked to work a series of problems relating to ratio analysis." Then, subjects went on to answer questions about their training and experience with ratio analysis, experience in public accounting, current and past degrees, CPA review courses taken, and level of comfort with IBM personal computers.

III. Results

Declarative Knowledge, Background Variables, and Attention Checks

Declarative knowledge was measured at pretest and posttest to ensure that subjects had adequate knowledge of financial accounting facts needed to acquire procedural knowledge and that groups did not differ. An ANOVA with groups as the independent variable indicated that subjects did not differ across groups at pretest (F=0.712, p=0.724) or posttest (F=1.269, p=0.257).

At pretest, the mean level of knowledge was 8.2 correct answers (out of 12). At posttest, the mean was 10.2; this increase was due primarily to subjects' learning the ratio definitions which were provided at the beginning of the study phase.[16] There were also no differences across groups for any of the background variables. Thus, these variables are not included in the analyses. Finally, ratings on the attention check questions indicated that subjects attended to the instruction and experience variables. The average rating of groups with experience ($\bar{x}$=4.08, s.d.=1.213) was higher (F=45.383, p=0.000) than that of groups with no experience ($\bar{x}$=2.00, s.d.=1.477). The instruction groups' average rating was 4.09 (s.d.=1.178), and the no instruction groups' average rating was 2.4 (s.d.=1.336); these were significantly different (F=38.082, p=0.000).

Effects of Instruction and Experience Combinations on Procedural Knowledge Acquisition (Hypotheses H1-H4)

For each instruction/experience group, table 1 presents means (and standard deviations) of procedural knowledge at pretest and posttest arranged according to the hypothesis to which they pertain, signed changes in knowledge from pretest to posttest, and paired, two-tailed t-tests for posttest knowledge versus pretest knowledge. Two-tailed tests are appropriate because of the possibility of both knowledge increases and decreases. Also presented in table 1 are the comparable results from the Wilcoxon signed-ranks test (Siegel 1956).

Hypothesis H1 (No Experience). Hypotheses H1a, H1b, and H1c predict that any combination of instruction and no experience will not increase procedural knowledge. Hypotheses H1a and H1c are supported (with both the parametric and nonparametric test results). Hypothesis H1b is not supported because the group with how-to rules and no experience acquired knowledge.[17]

Hypothesis H2 (Practice Alone). Hypotheses H2a, H2b, and H2c are supported (with both tests) for the groups having combinations of practice alone and, respectively, no instruction, how-to rules, and understanding rules. Since feedback appears to be necessary for the acquisition of procedural knowledge, no combination of practice without feedback and instruction would be expected to promote acquisition of this knowledge.

Hypothesis H3 (Practice with Outcome Feedback). Hypotheses H3a and H3b predict that practice with outcome feedback, combined with either no instruction or minimal how-to instruction, will not assist people in acquiring procedural knowledge. These hypotheses are supported by the results for those two groups, shown in table 1. Hypothesis H3c, on the other hand, predicts that subjects who receive understanding rules prior to practice with outcome feedback will be able to acquire procedural knowledge. Results for both tests support this prediction. Overall then, the effect of practice with outcome feedback on the acquisition of the procedural knowledge needed to do ratio analysis depends on the form of instruction with which it is paired. Understanding rules apparently provide a sufficient causal framework within which to interpret outcomes and infer accurate procedural knowledge of this type. The provision of understanding rules prior to experience is consistent with Blocher et al.'s (1992) suggestion that subjects must have domain knowledge in order to learn to do ratio analysis from outcome feedback.

[16] Since not all declarative knowledge is needed to acquire procedural knowledge, an average of 85 percent is acceptable (c.f., Willingham et al. 1989).

[17] One possible explanation for this result is that one subject in this group, whose knowledge increased substantially, spent almost twice as much time answering questions on the posttest as on the pretest. In contrast, other subjects in this group (and other groups) generally spent either a similar or a smaller amount of time on the posttest. This difference likely reflects the fact that this subject moved too quickly through the pretest, resulting in a pretest score that understated his knowledge and a change from pretest to posttest that substantially overstated his learning. Because of the small group size, this large increase appears to be driving the results.

Table 1
T-Tests and Wilcoxon Signed-Ranks Tests by Group of Procedural Knowledge at Posttest versus Procedural Knowledge at Pretest (n=8 in each group, except first group in which n=7)

Hypothesis	*Experience*	*Instruction*	*Mean Procedural Knowledge at Pretest (s.d.)*	*Mean Procedural Knowledge at Posttest (s.d.)*	*Signed Change in Procedural Knowledge*	*t-Test Probability*	*Ranks Test Probability*
H1a	None	None	7.286 (1.496)	8.429 (1.134)	+1.143	0.121	0.109
H1b	None	How-to Rules	7.250 (1.389)	8.750 (1.389)	+1.500	0.020	0.028
H1c	None	Understanding Rules	7.875 (2.232)	8.375 (1.302)	+0.500	0.563	0.944
H2a	Practice Alone	None	8.750 (1.581)	7.625 (1.302)	-1.125	0.219	0.263
H2b	Practice Alone	How-to Rules	7.500 (1.512)	7.750 (0.886)	+0.250	0.598	0.529
H2c	Practice Alone	Understanding Rules	7.625 (1.061)	8.375 (1.408)	+0.750	0.285	0.310
H3a	Practice w/OF	None	7.500 (1.604)	8.250 (2.188)	+0.750	0.222	0.201
H3b	Practice w/OF	How-to Rules	8.250 (1.389)	8.625 (1.061)	+0.375	0.476	0.463
H3c	*Practice w/OF*	*Understanding Rules*	*7.125 (0.641)*	*9.000 (1.512)*	*+1.875*	*0.006*	*0.018*
H4a	*Practice w/EF*	*None*	*8.125 (0.354)*	*9.625 (1.685)*	*+1.500*	*0.026*	*0.042*
H4b	*Practice w/EF*	*How-to Rules*	*7.500 (0.926)*	*9.625 (1.302)*	*+2.125*	*0.006*	*0.020*
H4c	*Practice w/EF*	*Understanding Rules*	*8.500 (2.070)*	*10.250 (1.282)*	*+1.750*	*0.064*	*0.058*

Hypotheses in *italics* are those with predicted increases in procedural knowledge.
OF=Outcome Feedback
EF=Explanatory Feedback

Hypothesis H4 (Practice with Explanatory Feedback). Hypotheses H4a, H4b, and H4c predict that practice with explanatory feedback will promote knowledge acquisition, irrespective of the form of instruction. These hypotheses are supported by the results shown in table 1. If high quality explanatory feedback is available, instruction may be marginally beneficial, though it may not be necessary.

Additional Analysis. To examine more directly the idea that the combination of understanding rules and practice with outcome feedback promotes knowledge acquisition as well as does explanatory feedback, *post hoc* comparisons were performed. The following two comparisons were made: (1) procedural knowledge in the understanding rules-outcome feedback group (H3c in figure 2) to procedural knowledge in the no instruction-outcome feedback group (H3a), and (2) procedural knowledge in the understanding rules-explanatory feedback group (H4c) to procedural knowledge in the no instruction-explanatory feedback group (H4a). Procedural knowledge should be greater in the H3c group than in the H3a group, showing that the effect of outcome feedback is contingent on the presence of understanding rules. In contrast, there should be no difference in procedural knowledge between the H4c and H4a groups, showing that the effect of explanatory feedback is not contingent on the form of instruction with which it is paired. In combination with the above results indicating increases in procedural knowledge for the H3c, H4a, and H4c groups and no change for the H3a group, these results would suggest that the combination of understanding rules and practice with outcome feedback might be a reasonable substitute for explanatory feedback.

These comparisons were done with both parametric and nonparametric methods, and compared procedural knowledge-posttest in one group to that in the other group (controlling for the effects of procedural knowledge-pretest). Using the Tukey least significant difference approach (Sokal and Rohlf 1969), the comparison of the H3c group to the H3a group showed a marginally significant difference (T=1.125, $0.05<p<0.10$, two-tailed), and the comparison of the H4c group to the H4a group showed a nonsignificant difference (T=0.25, $0.60<p<0.80$, two-tailed). Similar results were found using Kruskal-Wallis one-way ANOVAs (Siegel 1956). These comparisons found a marginally significant, positive difference between H3c and H3a (H=2.79, $0.05<p<0.10$, two-tailed) and no difference between H4c and H4a (H=0.14, $0.70<p<0.80$, two-tailed). Thus, at least for tasks that are not extremely simple, acquisition of auditing knowledge from outcome feedback is not possible unless practice is preceded by understanding rules. On the other hand, acquisition of knowledge under these outcome feedback conditions is similar to knowledge acquisition under the more costly condition of explanatory feedback.

Summary. As predicted, persons receiving either no experience or practice alone, combined with any form of instruction, did not acquire the procedural knowledge needed to do ratio analysis. The only exception was the no experience, how-to rules group (H1b) who appeared to have acquired knowledge. Those receiving outcome feedback also did not acquire procedural knowledge unless they first received understanding rules. The group with understanding rules and outcome feedback posted over a 26 percent increase in performance on a knowledge test during a relatively short period. In contrast, persons receiving explanatory feedback were able to acquire this procedural knowledge, irrespective of the form of instruction, probably because they were able to assimilate the explanations directly and create rules. These groups averaged about a 21 percent increase in their performance on the knowledge test. Based on the additional analyses, understanding rules coupled with practice and outcome feedback appears to be an adequate substitute for explanatory feedback, one that would allow beginning auditors to gain the procedural knowledge needed for ratio analysis.

Table 2

Regression of Procedural Knowledge at Posttest on Procedural Knowledge at Pretest and Problem-Solving Ability (n=95)

Variable	*Coefficient*	*Std. Error*	*t*	*Probability*
Constant	5.739	0.949	6.045	0.000
Procedural Knowledge at Pretest	0.203	0.104	1.956	0.053
Problem-Solving Ability	0.324	0.129	2.518	0.014

R^2=0.109

Effect of Ability on Procedural Knowledge Acquisition (Hypothesis H5)

Table 2 presents a regression of procedural knowledge-posttest on pretest knowledge and ability (pretest knowledge is included to control for differences across individuals). Problem-solving ability is positively related to procedural knowledge at posttest, suggesting that people with higher levels of ability may either gain more procedural knowledge or acquire it more rapidly than those with lower levels of abilities.[18]

Effects of Procedural Knowledge and Ability on Performance (Hypotheses H6 - H7)

To examine the remaining links in Libby's (1993) model, a regression was done with performance in the test phase as the dependent variable and procedural knowledge and problem-solving ability as the independent variables. As shown in table 3, procedural knowledge is positively related to performance and problem-solving ability is not related to performance. The variance explained by procedural knowledge is small, probably because the procedural knowledge test was necessarily short and, therefore, did not capture all the procedural knowledge needed for ratio analysis.[19]

IV. Summary and Conclusions

Using Libby's (1993) model of the acquisition of audit expertise, this paper examined the effects of various combinations of instruction, experience, and general ability on the acquisition of the procedural knowledge needed for ratio analysis, as well as the effects of procedural knowledge and ability on ratio analysis performance. Except for the group of subjects receiving only how-to rules and no experience, results were consistent with the predictions that subjects

[18] None of the regression assumptions were violated. An ANOVA using posttest procedural knowledge as the dependent variable, pretest knowledge and ability as covariates, and the 12 experience and instruction combinations as groups, produces an R^2 of 0.347, suggesting that the procedural knowledge test does not capture all the procedural knowledge needed to perform ratio analysis. Since the test contained only 12 questions, this outcome is likely. Ability was still significant after accounting for the effects of the experience/instruction combinations (p=0.011).

[19] None of the regression assumptions were violated. An ANOVA using ratio analysis performance as the dependent variable, procedural knowledge and ability as covariates, and the 12 experience and instruction combinations as groups, produces an R^2 of 0.304. In this ANOVA, the relation of procedural knowledge to performance was still significant (p=0.055) and the relation of ability to performance was still nonsignificant (p=0.208).

Table 3

Regression of Performance in Ratio Analysis on Procedural Knowledge at Posttest and Problem-Solving Ability (n=95)

Variable	*Coefficient*	*Std. Error*	*t-value*	*Probability*
Constant	2.425	1.030	2.354	0.021
Procedural Knowledge	0.233	0.113	2.074	0.041
Problem-Solving Ability	-0.058	0.146	-0.393	0.695

R^2=0.045

receiving combinations of no experience or practice alone and any form of instruction would not gain procedural knowledge. All other results were as predicted. Practice with outcome feedback, unless combined with understanding rules, did not increase procedural knowledge. However, outcome feedback coupled with understanding rules did increase procedural knowledge. Additional analyses showed that the addition of understanding rules to outcome feedback is what creates these gains. This finding is consistent with previous research in accounting which found learning from outcome feedback in the presence of prior knowledge (e.g., Hirst and Luckett 1992; Hirst et al. 1992). Practice with explanatory feedback and any form of instruction increased procedural knowledge. General ability aided in the acquisition of procedural knowledge. Finally, procedural knowledge was related to performance in ratio analysis, but ability was not.

This study is the first to examine the specific effects on procedural knowledge acquisition of various combinations of instruction and experience available in the audit environment. The study characterizes two forms of instruction that universities and accounting firms currently use—how-to rules and understanding rules—and demonstrates that understanding rules allow auditors to learn under what would normally be considered an impoverished condition, that of outcome feedback. This result, of course, must be interpreted with caution because outcome feedback is not always available for audit tasks other than ratio analysis or on all audits. However, the finding is quite important because time and other pressures faced by auditors in the field often make it difficult to provide high-quality explanatory feedback. Understanding rules provide information similar to explanatory feedback, but are set in a more general context than that of individual problems. As such, they provide an overall causal model which may allow auditors to interpret outcomes in a variety of contexts. How-to rules, on the other hand, do not seem to assist people in acquiring procedural knowledge most of the time; this finding raises concerns since firm training programs and audit manuals may include only how-to rules for ratio analysis and other tasks. General problem-solving ability aids auditors in acquiring the procedural knowledge needed for ratio analysis, a result which may have important implications for hiring and job assignments.

Several avenues for future research are suggested by the results and limitations of this study. First, since this study examined only a subset of the combinations of instruction and experience available to auditors, future research should examine the effects of other forms of instruction, such as examples, and experience, such as working in groups. On the other hand, the examination of several combinations created small group sizes; the number of subjects in each group must be balanced against the number of combinations being examined. Second, experience groups in this

study received immediate feedback; the effectiveness of both outcome feedback and explanatory feedback may be diminished with delays (e.g., Lewis and Anderson 1985). Third, a brief objective knowledge test was used to measure procedural knowledge in this study. Given the previously noted difficulties of measuring procedural knowledge, further effort should be devoted to exploring this issue. Fourth, future research should employ attention and manipulation checks to ensure that subjects attend to their group assignments. Finally, further research should examine the effectiveness of changes in practice and education suggested by the results of this and other studies of auditor learning.

Appendix A
Example Declarative Knowledge Questions

Classification of Items on Financial Statements

Which one of the following is not a current asset?

a. Patent.
b. Inventory.
c. Accounts receivable.
d. Cash.

Definitions of Summary Items on Financial Statements

Which of the following is subtracted from gross accounts receivable to obtain net accounts receivable?

a. Bad debts expense.
b. Sales discounts taken.
c. Bad debts allowance.
d. Sales returns and allowances.

Journal Entries for Transactions

Smith & Co. receives $1,000 from a customer in payment of an account receivable. The journal entry would be:

a. A debit to cash for $1,000 and a credit to sales for $1,000.
b. A debit to sales for $1,000 and a credit to accounts receivable for $1,000.
c. A debit to accounts receivable for $1,000 and a credit to cash for $1,000.
d. A debit to cash for $1,000 and a credit to accounts receivable for $1,000.

Definitions of Financial Ratios

How is net sales used in the calculation of the following?

Receivables Turnover	*Gross Margin Ratio*
a. Numerator	Numerator
b. Denominator	Denominator
c. Not used	Numerator
d. Numerator	Denominator

Appendix B
Example Procedural Knowledge Questions

Rules on the Mathematics of Ratios

Assume that the ratio of P to Q is 6 to 2. What effect would P's decreasing by twice as much as Q have on the ratio?

a. Increase the ratio.
b. Decrease the ratio.
c. No effect on the ratio.
d. Answer cannot be determined from the information given.

Rules for the Effects of Financial Statement Errors on Account Balances

What would be the result of recording sales at year-end even though the goods were not shipped?

a. Overstate accounts receivable.
b. Overstate inventory.
c. Understate cash.
d. Understate sales.

Rules Showing What Types of Errors could have Caused Accounts to be Misstated

Which of the following could have caused inventory to be understated?

a. Failing to record collections from receivables.
b. Goods returned by customers not counted in inventory.
c. Labor and overhead recorded in excess of actual amounts throughout the year.
d. Expensing items that should be recorded as prepaids.

Rules Showing What Types of Errors could have Caused Ratios to be Misstated

Which of the following could have caused the gross margin ratio to be overstated?

a. Recording too many items on the sales invoice and in sales while all shipping documents and inventory entries done correctly.
b. Recording tax accruals twice.
c. Recording more hours than actually worked to manufacture a finished product later sold.
d. Expensing items that should be recorded as prepaids.

Appendix C
Example Ratio Analysis Problem

	1989 Expected	*1989 Actual (Unaudited)*
Current Ratio	2.5	3.1
Inventory Turnover	4.4	5.0
Receivables Turnover	5.5	4.9
Gross Margin Ratio	0.4	0.4

Which of the following errors or irregularities could have caused the differences between actual and expected ratios?

a. Failing to record collections from receivables.

b. Recording sales and related inventory/cost of goods sold entries at year-end even though goods were not shipped.
c. Adjusting perpetual records incorrectly due to failure to count all goods in warehouse (cost of goods sold correct).
d. Recording payments on accounts payable twice.

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