NARRATIVES VERSUS DIAGRAMS:

THE IMPACT OF ALTERNATIVE BUSINESS PROCESS REPRESENTATIONS ON AUDITOR RISK AND CONTROL ASSESSMENTS

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ABSTRACT

This study investigates the effectiveness of alternative methods for documenting business processes for the purpose of performing an assessment of risks and controls. We consider the effects of informationally equivalent textual versus diagrammatic representations of the same business process. Our subjects were 144 higher level accounting undergraduate students in an AIS course. Each was provided either a diagrammatic or textual representation of the business process. The task was a control risk assessment consisting of responding to 24 multiple choice questions based on Borthick, Schneider, and Vance (2010). We also considered the effects of academic ability and self-efficacy in our analysis and whether there is an interaction between presentation format and these factors.

The results indicate that there was no difference in either accuracy or time in performing control risk assessments as a function of the presentation mode for the business process: textual or diagrammatic. This result supporting the null hypothesis is found despite significant test power. Further, the effect of representation on performance is not moderated by either academic ability or individual self-efficacy.

This study indicates that textual representation of a business process can lead to the same outcome as a diagrammatic representation. This further suggests that curriculum design could profitably incorporate instruction in preparation and use of business process textual narratives in addition to or in place of diagrammatic business process representations. Also, business process assessment practices in industry and the accounting profession could realize some of the benefits that are often attributed to diagrams – accuracy and efficiency – by using textual representations.

Key Words: Business process models; business process diagrams; system documentation; audit documentation methods; risk assessment; BPMN; narratives;

Introduction

Business processes are a major topic of interest in several disciplines, including organizational strategy, e-commerce and software engineering. Business processes are an important consideration in business risk and how they relate to risks of material misstatement assessment as discussed in international auditing standards, paragraphs 30-34 of ISA 315, "Understanding the Entity and Its Environment and Assessing the Risks of Material Misstatement" and related appendices (IAASB, 2006). Given the importance of auditor understanding of companies' business processes for the effective assessment of audit risk and control risk, investigation of how best to represent business processes for auditor decision-making is warranted. This topic has been explored in the literature, although the specific diagrammatic method used in this study has not been previously compared to a narrative representation in an audit context.

Documentation techniques are covered in accounting information system (AIS) classes. A variety of graphical diagrammatic techniques seem to appeal to textbook authors and both AIS and auditing instructors as well as practitioners (Bradford, Richtermeyer and Roberts 2007) on the grounds that appropriate representation of business processes may help managers and auditors to better document, understand and accurately and efficiently identify areas of risk. However, according to Gadh, Krishnan, Peters, Abdolmohammadi and Houghton (1993), students often are uninspired by certain diagrammatic documentation techniques and wonder why narrative documentation will not suffice. Although arguments are found in textbooks and journals regarding the advantages of particular diagrammatic documentation techniques over the others, questions persist as to which of these techniques should be taught and used in practice (Jones, Tsay and Griggs 2002). Bradford et al. (2007) note that diagrammatic techniques are being used more predominantly for describing business processes and call for research to compare the effectiveness of various types of methods. Jones et al. (2002) hypothesize that the degree of cognitive fit between tasks and various representation techniques determines the potential value of a technique. However, they compare four diagrammatic techniques and do not extend their study to narrative representations of business processes. Xiong and Martin (2006) describe how two specific system documentation tools can be used to map internal controls, but do not compare them against the use of a narrative representation for the same purpose.

This study focuses on the potential benefits of a diagrammatic business process representation on auditor risk and control judgments compared with a narrative representation of the same process. We had 144 upper level undergraduate accounting students complete the experiment instrument as an in-class exam. Both accuracy and efficiency measures are used to assess performance. We also consider the effects of academic ability and self-efficacy and whether there is an interaction between presentation format and these factors.

Results of our analysis indicate that the method of representing the business process had no effect on participants' accuracy or efficiency in performing control risk assessments. This result supporting the null is found despite significant test power. Further, the effect of representation on performance is not moderated by either academic ability or individual self-efficacy.

The rest of the paper is organized as follows. The next section reviews existing literature on the state of business process representations, as well as studies of the effect of alternative representations on judgment and decision making. This is followed by an outline of our research hypotheses arising from the literature review. The study's research method and participants are then described, followed by analysis and discussion of the results. We then summarize the study's findings and discuss its limitations in the conclusions and limitations section.

Literature Review

Our study is at the nexus of several streams of literature including business process modeling, software engineering and cognitive science, including related studies in accounting and auditing. The business process modeling literature is useful for explaining what needs to be modeled to understand a business process, and demonstrating the feasibility of business process modeling. The cognitive science and external knowledge representation literature can be used to understand why alternative representations, in particular diagrammatic versus textual representations, should affect judgment and decision making. We summarize key findings from each of these areas.

The importance of external representations has been established in research for some time, with early work such as Larkin and Simon (1987) establishing the general importance of external representation in affecting both the efficiency and effectiveness of problem solving. While there are many types of external representation, Larkin and Simon (1987) suggest that the greatest distinction among the forms of external representation is between propositional/sentence-based and diagrammatic representations. The latter is broadly defined as an arrangement of various graphic elements in space (Cheng, Lowe, and Scaife, 2001). We will accordingly focus on these two extremes to provide insight into why and when diagrammatic representations might be better suited for decision making relative to textual sentence-based representations.

Theoretical perspectives. Various authors have identified characteristics that are relevant to the determination of when a diagram will be preferable to a text representation, particularly characteristics of the diagram and characteristics of the user. Little research exists that considers characteristics of the task, domain, and task environment, with discussion of diagram characteristics being the major focus of most research. Table 1, based on Alencar, Boritz and Carnaghan (2004), summarizes the issues.

Empirical evidence. In addition to the theoretical perspectives discussed previously, a number of empirical studies have been carried out to determine when a diagram might be preferable to a textual representation, and vice-versa (e.g. Holliday, 1976; Vessey and Weber, 1986; Cuniff and Taylor, 1987; Dunn and Gerard, 2001; Gilmore and Smith, 1984). Tasks that have been studied include recall, classification, ordering, recognition, knowledge transfer, search, reasoning/inference, translation into and choice of a particular representation, comprehension, and decision making/problem solving. Some key findings from these studies include:

- Often, but not always, performance using diagrams is superior to performance using text. In particular, accuracy was generally better (although sometimes the same or worse) using diagrams relative to text, and generally speed (efficiency) was also improved with more diagrammatic approaches.

- The findings of the studies focusing on differences in user characteristics suggest that in some but not all cases the expertise of the user makes a difference in the impact of the representation or how it is used. Dunn and Gerard (2001) found that when there was a high degree of locational indexing, experience was not a factor, but that experience became an increasingly important factor as the degree of locational indexing decreased.

- Studies of the effects of diagrams on those with apparent expertise (Vessey and Weber, 1986; Dunn and Gerard, 2001; Scanlan, 1989) seemed to find improved performance using diagrams, although how "performance" was measured varied. For these studies, proxies such as fewer errors, less time for the task, greater satisfaction, and ease of use were used. Studies of the effects of diagrams when used by novices (Holliday, 1976; Mayer, 1989; Guthrie, Weber, and Kimmerly, 1993; Cunniff and Taylor, 1987; Guri-Rozenblit, 1989; Bauer and Johnson-Laird, 1993; Gobert and Clement, 1999; Brooke and Duncan, 1980; Krohn, 1983) generally also found beneficial effects of diagrams, with proxies used for performance including correctness and the time to perform the task.

- Jones et al. (2002) hypothesize that the degree of cognitive fit between tasks and various representation techniques determines the potential value of a technique. “Cognitive fit” is defined as the degree to which a particular diagramming technique is representative of a problem space, and Jones et al. (2002) assume that cognitive fit can be quantified by the correctness of a person’s responses to questions about the underlying processes as well as the length of time taken to complete a response. They empirically examine the cognitive fit between four modeling techniques that are typically part of an AIS curriculum: data flow (DFD), process mapping (PM), resources-events-agents (REA), and flowchart (FC) diagrams. The strongest results in this study indicated that the PM technique appears to be suitable for tasks requiring an analysis of process as measured by score. However, Jones et al. (2002) do not extend their study to narrative representations of business processes.

The above points suggests that while it is often claimed that diagrams are *always* better than textual sentence-based representations (i.e., more natural and intuitive), this is not always the case (Cheng, Lowe, and Scaife, 2001). Judgment and decision-making errors can result when domain structures or relationships cannot

be represented because of limits in the representational language, or because organization and formatting of the diagram are poorly matched to the cognitive processes relating to searching the representation, finding relevant information, and drawing inferences (Larkin and Simon, 1987). The efficacy of diagrams in various contexts thus remains an open question.

External Knowledge Representation and Auditor Judgment

While the research cited above examines external representations of information in general, audit research has examined external representation issues in the context of auditor judgment, given that most audit problems, including risk assessment, are usually ill-structured or semi-structured (Boritz, 1981). As a result, there have been various studies examining efforts to improve the structuring of information for audit decision making. Rose (2002) summarizes much of the research related to external representations, which has generally found that organizing information to better suit task or cognitive characteristics does help auditor judgment. Like the more general external representation literature cited earlier, however, there may be tradeoffs in computational complexity and judgment effectiveness. For example, a study by Boritz (1984) examined the effects of information structure on audit judgments by comparing auditors' responses to information cues about internal controls arranged according to a hierarchically structured template versus cues arranged in a simple list. The findings suggested that particular information structures did appear to play a role in auditor judgments, but also contributed significantly to the difficulty of making judgments. Some other studies of information representation include Dunn and Gerard (2001), who examine auditor judgment contrasting an REA model to a more structured text-based model and find a diagrammatic representation to be superior; and Amer (1993) who compared auditor judgment across different representations, including diagrammatic ones, for reviewing accounting transaction processing cycles.

Business Process Modeling for Auditor Assessments of Internal Control

As discussed in the foregoing review of literature, it is generally thought that the use of appropriate methods of representing business processes may help managers and auditors to better document, understand and efficiently and effectively identify areas of risk. Bradford et al. (2007) report on surveys of textbooks, AIS and

auditing instructors, and practitioners with respect to use of various system diagramming techniques. Bradford et al. (2007) note that diagrammatic methods are being used more predominantly for describing business processes and call for research to compare the effectiveness of various types of methods. Carnaghan (2006) analyzes the attributes of several business process diagramming techniques and assesses their strengths and weaknesses for meeting auditors' requirements for performing assessments of risks and internal controls. Xiong and Martin (2006) describe how two specific system documentation tools (REA and DFD) can be used to map internal controls, but do not compare them with the use of a narrative representation for the same purpose. Jones et al. (2002) assess student performance across four modeling techniques that are typically part of an AIS curriculum: data flow (DFD), process mapping (PM), resources-events-agents (REA), and flowchart (FC) diagrams. The strongest results in this study indicated that the PM technique appears to be suitable for tasks requiring an analysis of process; however, they do not compare diagrammatic representations to textual representations.

This study is specifically designed to determine the relative merits of diagrammatic and narrative representations of a business process for use in identifying and assessing control risks as discussed in International Auditing Strandard (IAS) 315… (hereafter we refer to this process simply as "risk assessment"). We study risk assessment outcomes since we wish to understand the impact of the process representations on the accuracy and efficiency of control risk judgments and conclusions.

Research Hypotheses

While previous studies suggest that diagrammatic representations might improve auditor judgment, none of the published research to date has examined the comparative benefits of Business Process Modeling Notation (BPMN) for the representation of business processes and simple narratives in a somewhat difficult but common audit task requiring the assessment of controls. Interviews we conducted with Big 4 technical audit partners suggested that difficulties with risk assessment stemmed in part from how the information was documented. We interpreted these issues as issues of information presentation, hypothesizing that diagrammatic business models could enhance the effectiveness and efficiency of risk assessment. Since both the theory and

evidence discussed in the literature review section suggest that capability/expertise plays an important role in the way diagrams are used, we incorporate this factor in our study as well.

As noted earlier, prior work in cognitive science has established that diagrammatic representations can improve problem solving for particular types of problems relative to sentence-based representations. However, the prior research provides mixed evidence and has not tested the representation of a business process against a narrative representation of the same business process.

The two main research hypotheses are:

H1: Diagrammatic representation of a business process will result in participants performing with higher accuracy in assessing internal control risks and completing the task more efficiently than with textual representation.

H2: Class term grade and self-efficacy impact the effect of business process representation methods' effect on participants' performance in assessing internal controls.

Research Method

Our 2 (process model) x 1 between subjects experiment was conducted as a midterm multiple-choice in-class exam for an upper level undergraduate accounting and information systems course at a large university in Canada. The experiment was administered across three sections[1] to a total of 144 students. Students were informed prior to the exam that only their mark on the exam will count towards their grade and that they may choose to answer none, any, or all of the process measures asked. This resulted in some unequal sample sizes throughout our analysis.

Motivation

Students' marks on the exam represented 10% of their final grade in the course. Further, to incentivize performance on both accuracy and efficiency, students also earned lottery tickets towards a draw for $250 as a performance bonus. Lottery tickets were earned based on an equally weighted combination of their exam mark

[1] There are no performance differences between the three sections (p=0.415) nor interactions between condition and section (n=138, p=0.559, mse=6.61). As a result, section is removed from any further analyses.

and the inverse of the time spent to complete the exam. That is, the higher a student's mark, the more lottery tickets earned; the less time a student took to complete the exam, the more lottery tickets earned.

The Experimental Procedure

At the start of class, students were distributed the exam and provided oral instructions describing the exam, the component of the exam that would directly affect their grade, the lottery to motivate performance, and their option to answer any of the additional process measures. The two versions of the exam were randomly distributed within each of the three sections of the course. Students were informed that they had a maximum of 60 minutes to complete the exam although using all the time would result in no lottery tickets earned for time bonus. After all of the students' questions regarding the exam and the lottery were answered, the exam was administered.

Experimental Task

The exam, adopted from Borthick et al. (2010), asked students to use documentation of an accounts payable process for a fictitious convenience store '24/7' to answer 24 multiple choice questions regarding control weaknesses and their potential effect. The two between-subject conditions relate to the method of documenting the procure-to-pay process within the payable process. The first condition, referred to as the textual condition, documents the procure-to-pay process with narrative (Appendix 1). In the second condition, referred to as the diagrammatic condition, students view a BPMN diagram representing the process (Appendix 2). BPMN is similar to the process mapping that is included in AIS textbooks, AIS courses and auditing courses as well as being used in practice (Bradford et al. 2007). Carnaghan (2006) summarizes the attributes of BPMN and compares it with several other methods for diagramming business processes. BPMN was selected to maintain consistency with Borthick et al. (2010). Both conditions included a narrative documenting the company's application development approach and access controls (Appendix 3).

After examining the documentation of the accounts payable process, but prior to starting the multiple choice questions, students were asked questions designed to serve as manipulation checks and process measure questions to allow for appropriate covariate and mediating analysis (Appendix 4). The manipulation checks

asked about the emphasis of process diagrams, narratives, risk in business process, and internal controls using an 11-point scale from -5 to +5. Further, we asked participants the ease of understanding the case and how realistic the case was given their experience. The process measures included participants' efficacy regarding identifying internal control weaknesses on a 100-point scale (Bandura, 1977; Bandura, 2006) and their length and type of experience using/preparing/assessing business processes.

Students then proceeded to answer the 24 multiple-choice questions of the exam (Appendix 5). The questions and their order were identical for both conditions. Once they completed the exam, participants responded to exit survey questions (Appendix 6) on an 11-point scale (-5 to +5) about whether they had sufficient time to complete the exam and how difficult the multiple-choice questions were to answer. After completing these questions, students returned their exams to one of the researchers, who then documented completion times. Accuracy or the raw score on the exam and Efficiency or the less time it takes to complete the exam are our two dependent variables measured.

Results

Manipulation Checks

Descriptive results and tests of significant differences discussed below appear in Table 1.Students in the textual (diagrammatic) condition rated the narrative being stressed as 3.7 (1.3) and the diagram being stressed as -2.7 (0) on -5 to +5 point Likert scale. Both manipulation checks are significantly different between conditions ($p<0.01$, two-tail), suggesting the independent variable manipulation was appropriately applied. As an additional manipulation check, the 24 questions can be sub-divided into two groups: those based on the application narrative both conditions receive (10 questions) and those based on information contained in the textual or diagrammatic manipulation (14 questions). Analysis on the application group shows that accuracy was not different between the two conditions ($p=0.948$, two-tail).[2]

[2] The 10 questions based on the common application narrative are questions 9, 11, 12, 13, 14, 15, 16, 18, 21, 23. Analysis of the remaining 14 questions by condition is statistically similar to those to follow in supporting the null ($p=0.818$, two-tail). This result also remains with the inclusion of expertise covariates ($p=0.977$, two-tail).

Process Measures

To ensure the two business process representations did not differ in information content, a number of questions were asked (Appendix 4). The task was found to be equally realistic in both conditions (p=0.35, two-tail). The representation of the accounts payable process was found to equivalently emphasize risks in the business process (p=0.76, two-tail) and the internal controls over the business process (p=0.57, two-tail). Finally, participants in both conditions found the business process representations equivalent in ease of understanding (p=0.23, two-tail), the exam questions to be equivalent in difficulty to answer (p=0.24, two-tail), and equivalent in sufficient time to complete the exam (p=0.34, two-tail). None of the measured responses above were found to interact with condition type (textual or diagrammatic) to alter their effect on performance on the exam; as a result, none are included as covariates in further analyses below.[3]

Testing of Hypothesis 1

The first hypothesis predicts that diagrammatic representation will result in better performance than textual representation on two performance measures: accuracy and efficiency. As shown in Table 2a, accuracy on the exam was found to not differ between the two conditions (F=0.047, p=0.41, one-tail). The average (standard deviation) score on the exam for the textual and diagrammatic conditions was 12.79 (2.54) and 12.88 (2.59), respectively. Since the maximum score was 24, these results indicate that the task was challenging for the subject group.[4] The high difficulty should bias in the direction of finding results that support hypothesis 1 because condition has significant opportunity to improve performance.

As shown in Table 2b, efficiency on the exam was found to not differ between the two conditions (F-0.269, p=0.30, one-tail). The average (standard deviation) time of completion on the exam for the textual and diagrammatic conditions was 47.13 (10.30) and 46.26 (9.67), respectively. Since the maximum amount of time available was 60 minutes, these results indicate that the exam allowed for sufficient time to complete, again providing the opportunity for condition type to affect performance.

[3] Easeease of understanding is positively correlated with accuracy on the exam (p=0.03, two-tail),), although there is, however, no interaction between -condition (p=0.541, two-tail).

[4] Additional analysis, not tabulated, on the questions identified by the professor of the course as directly containing material covered in the course (13 questions) showed significantly higher average accuracy in both conditions but similar to our results, accuracy did not differ between conditions on the 13 questions.

The evidence above refutes our first hypothesis that representation type affects participants' performance relating to accuracy and efficiency in assessing internal control risks.[5] Failure to reject the null hypothesis is often considered to stem from using a low powered test. To test power sufficiency, a post hoc power analysis is often used. This approach, however, may be flawed since it is impossible to fail to reject the null hypothesis and maintain a high retrospective power, as there is a 1:1 relationship between p-values and post-hoc power calculations (Hoenig and Heisey, 2001). Instead, confidence limits on parameters of interest should be calculated to determine if the test offers sufficient power to support a null conclusion (Howell, 2010; Hoening and Heisy, 2001).

Results from our experimental design suggest a 95% confidence interval in the statistical difference of *accuracy* by condition is $-0.884 \leq \mu_1 - \mu_2 \leq 0.801$. This implies that a difference in accuracy between the textual and the diagrammatic conditions on the exam of -0.88 or 0.80 is required to reject the null hypothesis. Given that these limits are significantly low, less than one mark difference between the two conditions, our test appears to offer sufficient power to reject the null. When analyzing the difference in *efficiency* between the textual and the diagrammatic conditions, the 95% confidence interval in statistical difference is $-2.435 \leq \mu_1 - \mu_2 \leq 4.169$. That is, the difference in time to complete the exam between the textual and diagrammatic condition would have to be -2.44 or 4.17 minutes to reject the null hypothesis. Again, given that these limits are sufficiently low, our test appears to offer sufficient power.

Additional support for retaining the null is found by completing a non-parametric run test around the median of accuracy and efficiency by condition. Results suggest the two conditions are the same across accuracy and efficiency as the asymptotic significance for both is $p>0.05$.[6]

[5] Accuracy and efficiency are typically negatively correlated. That is, greater accuracy is often achieved at the cost of efficiency and greater efficiency at the cost of accuracy. The Pearson correlation coefficient for these two variables is -0.103 (p=0.11, two-tailed). Including either as a covariate while the other is the dependent measure does not alter the results presented above.

[6] These overall results are robust to individual question analysis. The asymptotic significance are $p>0.05$ for all individual questions.

Testing of Hypothesis 2

Hypothesis two predicts participants' actual and perceived expertise moderates the effect of condition on their performance on the exam. Participants' actual expertise was measured using their final grade for the AIS course, obtained directly from the professor of the course. As shown in Figure 1, the final average grade for the textual (diagrammatic) condition is 80.76 (80.99) on a zero-to-100 scale. Participants' average final grade did not differ between the two conditions ($p=0.872$, two-tail). As shown in Table 3, participants' actual expertise is found to have a significantly positive effect on their accuracy on the exam ($p<0.01$, two-tail) and to have no effect on their efficiency on the exam ($p=0.19$, two-tail).

Participants' self-efficacy or perceived level of expertise, measured with four questions after the treatment of the independent variable but prior to performance, is a function of both the independent variable manipulation and idiosyncratic differences between participants. Confirmatory factor analysis indicates that the four questions regarding participants' efficacy or perceived level of expertise represents a uni-dimensional construct in our setting, with all loadings greater than 0.86 and an eigenvalue (variance explained) of 3.2 (80%) (Stevens 1996). As a result, the efficacy measure is calculated as the average of all four measures. As shown in Table 1, the average efficacy for the textual (diagrammatic) condition is 59.65 (56.36) on a zero-to-100 scale. Efficacy is found to not differ between the two conditions ($p=0.278$, two-tail). These results support the conclusion that participants were sufficiently randomized between conditions. As shown in Table 4, perceived expertise had no effect on participants' accuracy ($p=0.52$, two-tail) and no effect on their efficiency ($p=0.19$, two-tail).

Including both actual and perceived expertise measures as covariates in a multiple regression with the representation condition as the independent variable and accuracy and efficiency as the dependent variable generally supports the above analysis (Table 5). That is, course grade has a positive effect on accuracy ($p<0.01$, two-tail) and a negative effect on efficiency ($p=0.02$, two-tail). Further, efficacy is found to have no effect on accuracy ($p=0.64$, two-tail) and no effect on efficiency ($p=0.461$, two-tail). Of most importance, including both as covariates supports our conclusion above that representation type had no effect on accuracy ($p=0.995$, two-tail) or efficiency (0.461, two-tail).

Concluding Remarks and Future Research

This study investigated whether the method of representing a business process affected the accuracy and efficiency of risk and control assessments of accounting students at different levels of expertise. Specifically, this study compared informationally equivalent versions of business process representations using a simple narrative and a diagram in BPMN.

Results of our analysis indicate that the method of representing the business process had no effect on participants' accuracy or efficiency in performing control risk assessments. This result supporting the null hypothesis is found despite the significant power of our tests. Further, the effect of representation on performance is not moderated by either academic ability or individual self-efficacy.

These results suggest that a textual representation of a business process can lead to the same outcome as a diagrammatic representation. This further suggests that curriculum design could profitably incorporate instruction in preparation and use of business process textual narratives in addition to or in place of diagrammatic business process representations. It could be that too much emphasis is being placed on diagrammatic representations of business process when textual narratives can lead to the same performance.

This study contributes to the existing literature in several ways. First, it contributes to the more general literature on external representations and their effect on problem solving, by examining the effects of alternative representations on audit risk and control assessment. This study indicates that an informationally equivalent textual presentation can possess some of the benefits often associated with diagrammatic representations.

However, our study is silent on how easy it is to obtain such benefits through deliberate structuring of the textual and diagrammatic presentations. The results may contribute to curriculum development by providing guidance on whether diagrammatic techniques such as those explored in the study require the emphasis they are given in accounting information systems courses and textbooks. The results may also contribute to the assessment of techniques that are most useful for auditing use. Finally, the results of the study may also help managers and auditors determine how best to document business processes.

This study has several limitations that should be considered in conjunction with the findings reported in this paper. Although both textual narratives and diagrammatic representations led to the same performance, the performance on the experimental task was generally weak despite the comparatively strong overall grades in the course. An extension of this study would be to provide students with additional presentation formats to determine whether performance could be improved.

We did not investigate the effects of requiring paarticipants to create different representations. Instead, we investigated the impact on participants' risk and control assessments of their use of textual and diagrammatic representations prepared by others. We created a textual representation that was informationally equivalent to the diagrammatic representation of the case company's business process. We did not assess the relative costs, difficulties and benefits of creating such informationally equivalent representations. An extension of this study would be to have subjects create diagrammatic and narrative representations methods and have other subjects use them to assess risks and controls to determine whether the representations would lead to different results under such circumstances. We deliberately chose a diagrammatic format that was used in the accounting information system textbook used by the students. It may be that the case was too complex or too difficult to capture the benefits of using diagrams. An extension of this study would be to use a simpler case.

Finally, our subjects were accounting students with limited audit experience. We cannot tell whether auditors and managers with more experience would have different outcomes. Thus, an extension of this study would be to have practitioners (auditors and managers) perform the task to compare their accuracy and efficiency with those of students.

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Figure 1

Theory Supporting the Superiority of Diagrams

Factor	***Explanation***
Specificity:	A key concept in evaluating the desirability of a diagram is what Stenning and Oberlander (1995) refer to as specificity. The general idea here is that it is easier to use a diagram where the number of possible interpretations is limited, since this reduces cognitive load.
Cognitive load:	Cognitive load is also reduced when a diagram represents information in the form into which the user would have to learn to transform information provided in another form. Salomon (1994) suggests that this concept of supplantation (similar to what Scaife and Rogers [1996] refer to as cognitive offloading) thus reduces mental effort and improves accuracy. A diagram may thus compensate in some circumstances for poor mastery of a skill (Brna et al. 2001).
Highlighting:	If a particular diagram does not capture the constraints of the problem well, it is unlikely to be of much use. Effective modeling that reduces cognitive load is facilitated by a representation that highlights the more important information and downplays or omits other less relevant aspects of the problem (thus reducing noise). Appropriate highlighting includes the idea that important relationships and objects are made explicit in the diagram.
Recognition:	This general issue of how well the diagram maps to the important features of the domain corresponds to what Larkin and Simon (1987) refer to as recognition. Stenning and Lemon (2001) refer to this as the availability to the users of the constraints operating within the representation, given the semantic interpretation the user has made. Their point is that the utility of a particular diagram will depend on whether "a user with certain competencies and knowledge may learn to exploit the constraints on expressiveness inherent in the intended interpretation of a diagram" (p. 31).
Locational indexing:	Another important consideration in representation choice is that of locational indexing, which implies that task informational needs have been considered in the way that the elements of the representation have been organized7. A related point made by Larkin and Simon (1987) is that diagrams can explicitly capture the spatial relations of the domain, while a text representation typically does not. Appropriate organization and specificity should improve the user's ability to quickly recognize key relationships and make inferences
Concretization:	The inherent requirement to reflect properties such as proximity and existence in a diagram capture the "concretization" characteristic referred to by Olivier (2001). Concretization reduces ambiguity, and also helps to rule out potential interpretations by demonstrating that certain configurations of elements cannot physically be created. For example, certain spatial arrangements that may seem plausible in a text representation simply cannot be represented in a diagram, which implies that such an arrangement is impossible.
Inference:	The issue of ease of inference needs to be considered. Larkin and Simon (1987) make the point that inference rules to be applied to diagrams may be either more or less powerful than the equivalent rules applied to text. Larkin and Simon suggest that diagrams will have an advantage when the necessary inferences can rely on perceptual results that can be easily recognized from the diagram (i.e. determining the equilibrium price and quantity and the effects of a change in either of these in a supply and demand relationship represented as a diagram).
Interaction:	The user's ability to interact with the representation is likely important, although the theoretical perspectives underlying this view are not well articulated. Even basic acts like underlining and making notations may be an important part of sensemaking for users. The construction of the diagram by the user likely represents the extreme form of interaction. The need for interaction may have ramifications for preferred media and for the complexity of the representation notation.
User cognitive processes and expertise:	Scaife and Rogers (1996) point out the importance of the users having "operators" that match the representation being used, and note that this suggests that the value of diagrams will depend on the experience and expertise of the user. In particular, a user with lots of experience manipulating representations of a particular type (e.g. text-based), may gain little from having representation translated to a diagrammatic form. Scaife and Rogers stress the importance of the user being able to '"...read' and comprehend the significance of the content of the [diagram] in relation to the other information that is being presented verbally or as text and to assimilate this to their current understanding of the domain" (p. 201). Cheng et al. (2001) raise the possibility that experts may make use of more of the provided functional roles of particular diagrams than do novices, and notes prior research on the importance of compatibility between diagrams and the users' mental models based on work by Lowe (1999).

[7] Spatial information organization is not unique to diagrams, as Cheng et al (2001) point out. It also occurs in certain forms of structured English, and in equations. The issue here is that diagrammatic ERs typically make use of spatial organizations of information to a greater degree than do text ERs.

Table 1: Descriptive Results[1]

	Condition[2]			
	Textual	*Diagrammatic*	*Difference*[3]	
Average Raw Score	53.3%	53.7%	-0.4%	
Standard Deviation	10.6%	10.8%		
N	76	68		
Average Time to Complete	47.13	46.26	0.87	
Standard Deviation	10.295	9.672		
N	76	68		
Average Self-Efficacy	59.65	56.36	3.29	
Standard Deviation	16.68	18.84		
N	76	68		
Average Course Mark	80.8%	81.0%	-0.2%	
Standard Deviation	6.0%	5.1%		
N	76	68		
Flowchart Emphasized	-2.67	-0.05	-2.62	***
Standard Deviation	2.695	2.496		
N	76	65		
Narrative Emphasized	3.66	1.29	2.37	***
Standard Deviation	1.943	2.303		
N	76	65		
Risk Emphasized	1.33	1.46	-0.13	
Standard Deviation	2.749	2.359		
N	76	65		
Internal Controls Emphasized	2.07	1.86	0.21	
Standard Deviation	2.211	2.038		
N	76	65		
Ease of Understanding	-1.22	-1.03	-0.19	
Standard Deviation	2.711	2.537		
N	76	65		
Realistic Task	1.22	0.88	0.34	
Standard Deviation	2.213	2.233		
N	75	64		
Sufficient Time to Complete	2.02	2.24	-0.22	
Standard Deviation	3.114	2.727		
N	57	49		
Difficulty of the Exam	3.56	3.45	0.11	
Standard Deviation	1.803	1.308		
N	57	49		

1 The variables include participants' percentage score calculated as their raw score on the exam out of 24, the time taken to complete the exam bounded by 60 minutes, average self-efficacy on a scale of 1 to 100, the final percent grade in the course on a scale of 1 to 100, the extent flowcharts, narrative, audit risks, and internal controls were emphasized on a scale of -5 to +5, the ease of understanding the business process on a scale of -5 to +5, how realistic the task is on a scale of -5 to +5, Experience with textual and flowchart descriptions of business processes on a scale of 1 to 10, whether there was sufficient time to complete the exam on a scale of -5 to +5, and how difficult the exam was on scale of -5 to +5.
2 Results are shown separately based on condition. Textual condition received business process information in the form of a descriptive narrative. Diagrammatic condition received business process information in the form of a BPMN model.
3 Difference between the textual and diagrammatic conditions.
*** The average difference is significantly different from 0 at $p<0.001$

Table 2: Demographics by Condition[1]

	Condition[2]			
	Textual	*Diagrammatic*	*Difference[3]*	
Number of Male Participants	32	29	3	
Number of Female Participants	42	35	7	
Months of Work Experience	8.64	9.46	-0.82	
Standard Deviation	2.188	4.071		
N	73	63		
# of Accounting Courses	11.78	9.078	2.702	
Standard Deviation	10.610	7.407		
N	73	63		
Experience with Textual	4.37	3.41	0.96	*
Standard Deviation	2.536	2.631		
N	73	63		
Experience with Flowcharts	3.59	2.95	0.64	
Standard Deviation	2.549	2.504		
N	73	63		

1 The variables below by condition include participants' gender, months of prior work experience in accounting, the number of previous accounting courses taken, professional experience with textual and flowchart representations on a 0 to 10 scale.
2 Results are shown separately based on condition. Textual condition received business process information in the form of a descriptive narrative. Diagrammatic condition received business process information in the form of a BPMN model.
3 Difference between the textual and diagrammatic conditions.
* The average difference is significantly different from 0 at $p<0.10$

Table 3: Analysis of Variance

3A: Analysis of Variance with the Dependent Variable of Accuracy[1]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[4]
Intercept	23652.31	1	23652.31	3604.876	<0.001
Conditon[3]	0.31	1	0.31	0.047	0.414
Error	931.69	142	6.561		
Total	24648	144			

3B: Analysis of Variance with the Dependent Variable of Efficiency[2]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[4]
Intercept	313053.969	1	313053.969	3127.034	<0.001
Conditon[3]	26.969	1	26.969	0.269	0.605
Error	14215.92	142	100.112		
Total	328590	144			

---

1 The dependent variable accuracy is calculated as the raw score on the exam out of 24.
2 The dependent variable efficiency is calculated as amount of time taken to complete the exam to a maximum of 60 minutes.
3 The two conditions tested include business process represented by textual or by diagrammatic.
4 Shown as two-tailed.

Table 4: The Effect of Actual Expertise on Performance

4A: The Dependent Measure of Accuracy[1]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[4]
Intercept	11644.618	1	11644.618	2228.697	<0.001
Course Mark[3]	315.467	25	12.619	2.415	<0.001
Error	616.533	118	5.225		
Total	24648	144			

4B: The Dependent Measure of Efficiency[2]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[4]
Intercept	151390.309	1	151390.309	1591.695	<0.001
Course Mark[3]	3019.598	25	120.784	1.27	0.197
Error	11223.291	118	95.113		
Total	328590	144			

---

1 The dependent variable accuracy is calculated as the raw score on the exam out of 24.
2 The dependent variable efficiency is calculated as amount of time taken to complete the exam to a maximum of 60 minutes.
3 The variable course mark represents the grade students received for the course on a 0 to 100 scale.
4 Shown as two-tailed.

Table 5: The Effect of Perceived Expertise on Performance

5A: The Dependent Measure of Accuracy[1]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[4]
Intercept	11690.847	1	11690.847	1854.532	<0.001
Efficacy[3]	189.235	31	6.104	0.968	0.523
Error	674.521	107	6.304		
Total	23658	139			

5B: The Dependent Measure of Efficiency[2]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[4]
Intercept	153213.322	1	153213.322	1645.294	<0.001
Efficacy[3]	3650.633	31	117.762	1.265	0.189
Error	9964.072	107	93.122		
Total	313935	139			

---

1 The dependent variable accuracy is calculated as the raw score on the exam out of 24.
2 The dependent variable efficiency is calculated as amount of time taken to complete the exam to a maximum of 60 minutes.
3 The variable efficacy represents an average efficacy measure on a 0 to 100 scale.
4 Shown as two-tailed.

Table 6: The Effect of Condition on Performance (Controlling for Expertise)

6A: The Dependent Measure of Accuracy[1]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[6]
Intercept	0.156	1	0.156	0.029	0.866
Efficacy[3]	1.226	1	1.226	0.225	0.636
Course Mark[4]	123.488	1	123.488	22.639	<0.001
Conditon[5]	0	1	0	0	0.995
Error	736.379	135	5.455		
Total	23658	139			

6B: The Dependent Measure of Time[2]

Variable	Type III Sum of Squares	df	Mean Square	F	Sig.[6]
Intercept	251.972	1	251.972	2.624	0.108
Efficacy[3]	53.296	1	53.296	0.555	0.458
Course Mark[4]	527.223	1	527.223	5.489	0.021
Conditon[5]	52.388	1	52.388	0.545	0.461
Error	12965.896	135	96.044		
Total	313935	139			

1 The dependent variable accuracy is calculated as the raw score on the exam out of 24.
2 The dependent variable efficiency is calculated as amount of time taken to complete the exam to a maximum of 60 minutes.
3 The variable efficacy represents an average efficacy measure on a 0 to 100 scale.
4 The variable course mark represents the grade students received for the course on a 0 to 100 scale.
5 The two conditions tested include business process represented by textual or by diagrammatic.
6 Shown as two-tailed.

Appendix 1: Narrative version of the exam

Procure-To-Pay Process

Customers enter stores 24 hours a day, 7 days a week. They select items and bring them to the clerk at the cash register, who scans the items and accepts the customer's payment. The scanning process updates the store sales and inventory files.

Daily between noon and 2 pm, each store manager takes inventory with a handheld computer, synchronizes inventory with the in-store computer, predicts what the store needs for the next day, and orders it. The store manager signs off on the store order by 2 pm. At that time, 24-Seven Company Corporate polls stores electronically for sales, inventory, and orders, and analyzes scanner data by store, region, and overall. Based on the sales analyses, Corporate enhances store orders and posts orders for vendors.

After 3 pm, vendors retrieve orders from 24-Seven Corporate's Web site. Small local vendors, such as artisans making locally-themed souvenirs, use a Web browser to retrieve orders while all other vendors retrieve orders programmatically. All vendors except the small local vendors deliver orders directly to stores as they arrange with store managers. All other vendors deliver orders to distribution centers.

Distribution centers assemble shipments for stores. Each store gets one delivery before 5 am each day from one of the distribution centers. Store clerks shelve all shipments of inventory.

Monthly, vendors prepare invoices for 24-Seven Company. The small vendors, i.e., the souvenir makers, complete a Web form and submit it. Once validated, the invoice goes to the invoice file. When stores take delivery, the store clerk indicates receipt to the system. All other vendors upload invoices programmatically.

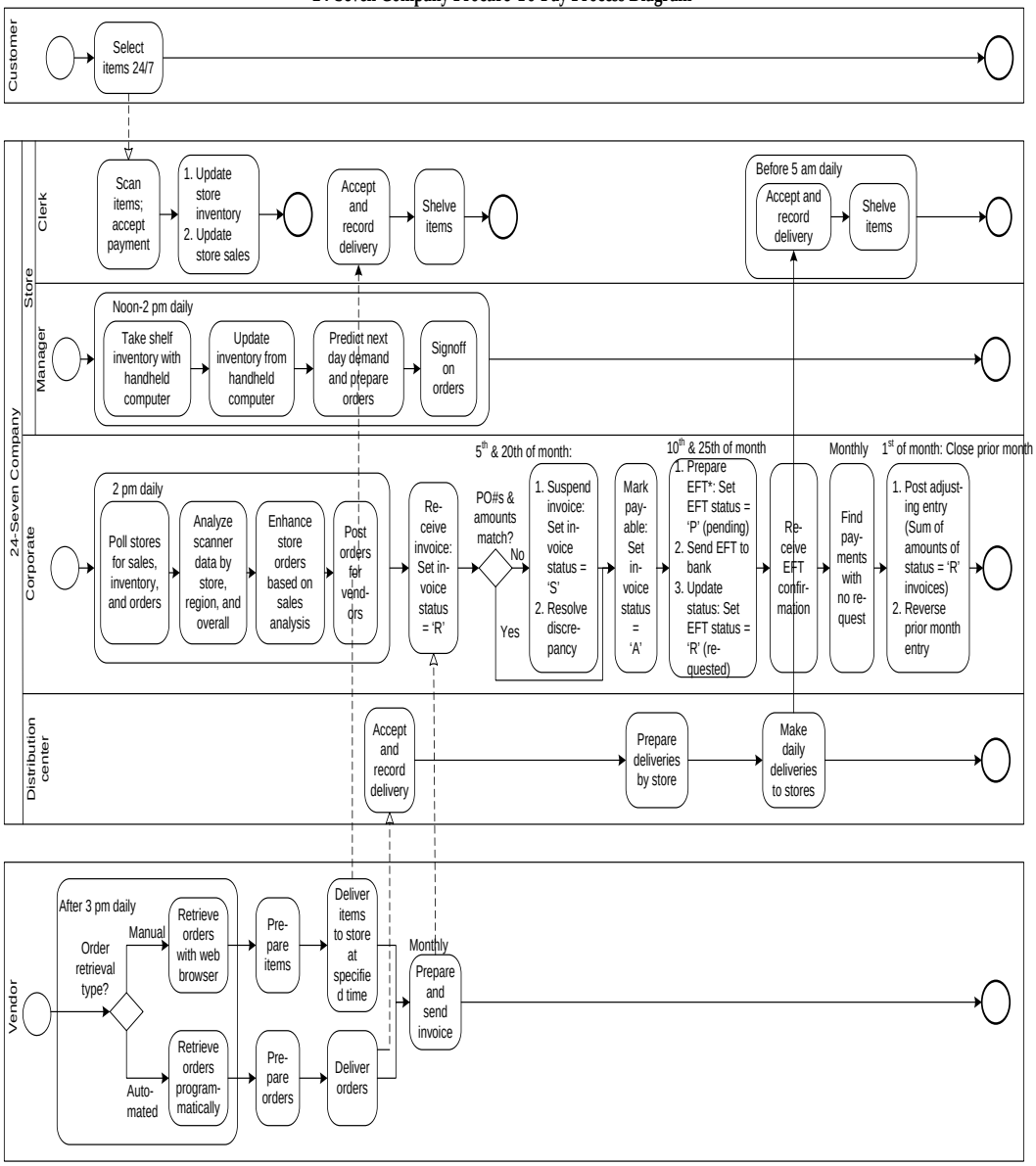
When 24-Seven Corporate receives an invoice from a vendor, the system sets status to 'R' for 'received.' On the 5th and 20th of the month, the system matches all unprocessed invoices to purchase orders. PO number on the invoice is matched to PO number on the PO, and PO and invoice amounts are matched. When an invoice cannot be matched, invoice status is set to 'S' for 'suspended', and payables staff resolve the mismatch and set status to payable. When matched, invoice status is set to 'A' for payable.

On the 10^{th} and 25^{th} of the month, electronic funds transfer (EFT) requests are prepared. Before the EFT request goes to the bank, the system sets the EFT status for an invoice to 'P' for 'pending'. After the system sends a batch of EFT requests to the bank, it changes the EFT status for each one in the batch to 'R' for 'requested'. After making payments, the bank returns EFT confirmations to 24-Seven Corporate. As part of closing the month, a report is run that verifies that payments were made only for valid requests.

To close the prior month, an accounts payable staff member sums the amounts of invoices with status equal to 'R'. The sum becomes the amount for the adjusting entry to the general ledger (GL) that enters the payables amount for the month being closed. Each month, the prior month's entry is reversed.

Appendix 2: BPMN version of the exam

FIGURE 1
24-Seven Company Procure-To-Pay Process Diagram



* EFT = electronic funds transfer

Appendix 3: Application Development Approach and Access Control (Both Conditions)

Application Development and Access Control

In 24-Seven Company's system development process, users and management agree on application functions. After they sign off on them, the developers sometimes suggest changes based on the difficulty and cost of implementing features. Analysts develop the specs in more detail. If they encounter surprises, they go back to users with them and work them out.

A few years ago, a new CIO (chief information officer) helped management develop a strategic IT plan for supporting the business. Part of the plan is the requirement that every user proposal be vetted against the plan. If it is at odds with the plan, the proposal has to go to the IT steering committee. If the proposal improves on the plan, the committee is likely to incorporate it into the plan. If not, the committee suggests changes users might make.

Programmers develop programs, test them, and check them into the development program library. Once a week, all the programs are compiled together into a build, and integration tests are run against all the programs in that build. Any programs that break the build are returned to programmers for rework. When the build is deemed complete, stress testing is conducted, i.e., sufficient transactions are input to the system to determine how many transactions it can process in a day and how fast it can process them. Once an application passes stress testing, users evaluate it in user acceptance testing. When users sign off on testing, an application goes to QA (quality assurance), which occasionally finds things that need fixing. From there, QA authorizes the DBAs to install the application in the production library.

Only operations personnel can run programs from the production library. When programmers need data for the next program iteration, the data extracts they need are made available to them in their development libraries.

Adhering to the strategic IT plan decreased the applications backlog. Users are writing more of their own ad hoc reports although IT staff members are skeptical of their quality, especially the ones developed with spreadsheets rather than BI (business intelligence) tools. For example, an accounts payable staff member uses a spreadsheet to prepare the monthly adjusting entry to accounts payable. To close the prior month, an accounts payable staff member downloads the payables file to a spreadsheet that sums the amounts of invoices with status equal to 'R'. The sum becomes the amount for the adjusting entry to the general ledger (GL) that enters the payables amount for the month being closed. Each month, the prior month's entry is reversed. The spreadsheet resides on Bern's PC because Bern (an accounts payable staff member) developed it. Pat, the accounts payable manager, looked over test results based on the month before the spreadsheet was first used, and everything looked fine. When Bern is absent, other accounts payable staff members go to Bern's PC to run it. When 24-Seven Company spins off a subsidiary, accounts payable finds out about it when the download contains no data for it. Acquisitions usually come to the staff's attention through press releases. Bern adds and deletes columns in the spreadsheet as the subsidiaries are acquired and spun off. Because the subsidiaries are all different, entries calculated in the spreadsheet have never been cross-checked against the trial balances of the subsidiaries.

An IT analyst wrote the first reports with the BI tools in SQL, and accounts payable supervisors and the manager learned to modify reports to satisfy new reporting needs. They keep modifying reports until they run to their satisfaction. Some reports, e.g., one that shows purchases by inventory item ID grouped by vendor, are made available to users outside accounts payable, although they have not been updated in the user libraries.

Users are happy that IT protects their desktops against viruses and bots, but they want to install new software before IT can vouch for its good behavior. Users can plug in external media like USB drives.

When employees are hired, their managers specify the access privileges they get based on existing profiles, such as a base level profile for entry-level accounts payable staff. When employees move to different positions, their managers authorize additional privileges consistent with their new roles. The IT security manager removes access for terminated employees daily after receiving a list from the human resources group of terminated employees.

All the payables staff (8 full-time and 4 part-time) have read access to payables transactions and reports. All the staff can edit payables transactions. Only the two supervisors and the accounts payable manager (Pat) can develop reports that run against the transactions in the database or enter adjusting entries. Depending on their job functions, payables staff members can run reports, e.g., to identify groups of similar payables so they can be inspected visually for potential duplicates and to match employee addresses to vendor addresses.

Similarly, a vendor only has access to orders intended for it. A vendor can only access orders meant for it because each one has a unique userID and password for accessing its view of the order database on 24-Seven's Corporate Web site.

The systems support manager is in the process of protecting over a hundred servers that had been identified as vulnerable to penetration from outsiders. The process includes eliminating default settings and requiring stronger passwords. Personal technologies like smart phones may be creating access vulnerabilities.

Appendix 4: Process Measures Questions[8]

Manipulation Checks

Students are asked to "Please indicate the extent of your agreement with each of the following statements"[9]:

1) Process diagrams (BPD) were emphasized in this case.
2) Process narratives were emphasized in this case.
3) Risks in business processes were emphasized in this case.
4) Internal controls over business processes were emphasized in this case.
5) The case was easy to understand.
6) The case was very realistic.

Efficacy Process Measures

Students are asked to "Please rate how certain you are that ***you can do*** the things discussed below"[10]:

1) How certain are you that *you can* properly evaluate *the effectiveness of* a business process using the process information that was provided in this case?
2) How certain are you that *you can* properly evaluate *the business risks* in a business process using the process information that was provided in this case?
3) How certain are you that *you can* properly evaluate *the audit risks* in a business process using the process information that was provided in this case?
4) How certain are you that *you can* properly evaluate *the internal controls* in a business process using the process information that was provided in this case?

Demographic Questions

1) Gender (Male/Female)
2) Number of months of full time work experience: _____
3) Number of post-secondary *accounting* courses taken: _____
4) Students are asked to "Please estimate your experience using/preparing/assessing process diagrams"[11]
5) Please estimate your experience using/preparing/assessing process narratives"[12]

[8] Asked prior to completing the exam
[9] Using a scale from -5 (strongly disagree) to +5 (strongly agree)
[10] By writing the degree of certainty using the 0 (Cannot do at all) to 100 (Highly certain can do) scale
[11] Using a 10 point scale from 0 (no previous experience) to 10 (extremely experienced)
[12] Using a 10 point scale from 0 (no previous experience) to 10 (extremely experienced)

Appendix 5: Multiple Choice Questions

Answer the following questions based on the process diagram in Figure 1 of 24-Seven Company's procure-to-pay system and the explanation of 24-Seven's approach to application development and access control.

1. The way purchase orders and invoices are handled:
   a. Ensures that inventory items paid for were received
   b. Ensures that financial statements include all payables
   c. Allows payment for inventory items not received
   d. Allows payment for invoices that are suspended

2. Payables staff could verify that the bank made all the payments represented by the EFT requests by running a query that reconciled EFT confirmations with:
   a. EFT requests for invoices with EFT status 'R'
   b. EFT requests for invoices with EFT status 'R' or 'P'
   c. invoices with invoice status 'R'
   d. invoices with invoice status 'R' or 'A'

3. Verifying that each EFT confirmation has a corresponding EFT request would ensure the:
   a. Validity of payments
   b. Completeness of payments
   c. Valuation of payments
   d. Validity and completeness of payments

4. The way the month-end adjusting entry for payables is calculated ensures that the payables account is:
   a. Likely to contain some inaccurate transactions
   b. Likely to be complete with respect to transactions
   c. Unlikely to contain only authorized transactions
   d. Unlikely to be complete with respect to transactions

5. Suppose a table EFTrequests with primary key EFTrequstID contains EFT requests. Suppose a table EFTconfirms with primary key EFTconfirmID and foreign key EFTrequestID contains EFT confirmations. Implementing the control for verifying that payments are made only for valid EFT requests would likely include:
   a. Joining the tables by default on EFTrequestID
   b. Joining the tables with a left outer join on EFTrequestID from EFTconfiirms to EFTrequests
   c. Joining the tables with a left outer join on EFTrequestID from EFTrequests to EFTconfiirms
   d. Joining the tables by Cartesian product

6. Suppose a report that matches employee addresses and vendor addresses identified a list of potential matches. The best course of action with respect to the list would be for 24-Seven to:
   a. Cease doing business with the vendors and terminate the identified employees
   b. Investigate employee-vendor combinations for employees not authorized as vendors
   c. Authorize employees to be vendors in cases where deliveries have been on time
   d. Require the vendors to do business without the involvement of the employees

7. Compared to manually-completed invoices that would be mailed or faxed to 24-Seven, the use of Web forms represents:
   a. A weakness because web completion of the forms would increase vendors' workload
   b. A weakness because the forms have to be complete before the system will accept them
   c. A strength because editing checks can be performed before the forms are submitted
   d. A strength because Web completion of the forms would decrease vendors' workload

8. 24-Seven could strengthen control over the validity of payables by:
    a. Comparing prices on purchase orders with prices on invoices
    b. Requiring purchase orders to be sent to pre-approved vendors
    c. Eliminating the requirement for vendors to use leased lines
    d. Matching purchase orders, receiving reports, and invoices

9. In 24-Seven Company, users and IT system development staff negotiate features of a new or changed system, a practice that represents a:
    a. Weakness in that development projects may tend to take more elapsed time
    b. Weakness in that system features are less stable during development
    c. Strength in that system features are aligned better with strategic objectives
    d. Strength in that users and IT development staff become more acquainted

10. An approach to minimizing the likelihood of store managers colluding with souvenir vendors to inflate invoice quantities fraudulently would be to:
    a. Require store managers to take more frequent inventories with their handheld computers
    b. Require store managers to report counts of souvenirs received in each delivery to Corporate
    c. Base store manager bonuses on the combination of store sales and the percent increase in sales
    d. Base store manager bonuses on the percent increase in store sales adjusted for shrinkage

11. In 24-Seven Company, systems being developed are subjected to stress testing, which is a:
    a. Strength because it guarantees that systems are deployed without errors
    b. Strength because it determines maximum transaction rates and volumes
    c. Weakness because DBAs are responsible for installing the applications
    d. Weakness because testing consumes more development resources

12. In 24-Seven Company, the IT security manager gets a daily list of employees that need new privileges because their job duties changed and adds the new privileges to the employees' profile. This practice is likely to:
    a. Place a high administrative load on security administrators
    b. Create lags in removing privileges for terminated employees
    c. Restrict programs with superuser capabilities to a few employees
    d. Allow employees to have privileges for incompatible functions

13. 24-Seven Company's system development practice of returning programs that fail tests designed to identify programs not operating correctly with other programs to programmers for rework:
    a. Minimizes the number of programming errors that have to be corrected
    b. Maximizes the number of programming errors that have to be corrected
    c. Increases the cost of correcting errors in integration and stress testing
    d. Decreases the likelihood of new applications being implemented on time

14. The action least likely to reduce unauthorized access to 24-Seven Company's systems by outsiders that are never physically on the premises would be to:
    a. Reset default passwords to strong passwords
    b. Ask employees not to write down passwords
    c. Run anti-virus software on all company PCs
    d. Require employees to use long passphrases

15. In 24-Seven Company, users want flexible systems and IT staff members want secure systems. The conflict can be best addressed by:
    a. Users and IT staff negotiating, on a continuing basis, capabilities supported on PCs
    b. Users being allowed to install only PC software from approved software vendors
    c. IT disabling all connections on PCs that would support devices like USB flash drives

d. IT educating users about the risks of inadvertent disclosure of company information

16. The quickest way to determine how good access control is in keeping outsiders out of 24-Seven Company's internal systems would be to:
    a. Examine the security plan for all servers, other computers, and user PCs
    b. Scan the list of machines to verify their patch update status for access control
    c. Interview the chief security officer to determine the security implementation
    d. Conduct a penetration test of perimeter security including Internet domains

17. 24-Seven would be least likely to be able to use data that are available to it to become aware of which of the following potential situations:
    a. Items being stolen from store shelves
    b. Vendors failing to deliver orders timely
    c. Missed sales from not carrying a product
    d. Incomplete taking of store shelf inventory

18. Suppose that after IT systems support staff began protecting servers, several users were unhappy. The least likely reason for their unhappiness would be that protected servers:
    a. Are subject to more control by IT
    b. Represent loss of user autonomy
    c. Get security patches when needed
    d. Require more stringent access control

19. The process for calculating the monthly adjusting entry to accounts payable is:
    a. Correct because it sums unpaid invoices with status 'R' or 'S'
    b. Correct because it sums unpaid invoices with status 'R'
    c. Incorrect because it sums unpaid invoices with status 'R' or 'S'
    d. Incorrect because it sums invoices with status 'R'

20. Suppose a new control were implemented with a left outer join of the table of EFT requests and the table of EFT confirmations on EFTrequestID (the primary key in the EFT request table and a foreign key in the EFT confirmation table). The query result would show:
    a. Only EFT requests that match EFT confirmations on EFTrequestID
    b. Only EFT confirmations that match EFT requests on EFTrequestID
    c. All EFT confirmations including ones for which there is no EFT request
    d. All EFT requests including ones for which there is no EFT confirmation

21. Suppose IT staff members expressed concern about the quality of users' ad hoc reports. Their concern reflects the risk of:
    a. Ill-advised decisions being made based on erroneous results in the reports
    b. Users distributing information to people not authorized to have access to it
    c. Servers being threatened with unauthorized access by insiders or outsiders
    d. Desktops being controlled such that users have difficulty doing their work

22. Suppose the systems support manager discovered that an unauthorized outsider had gained access to the server containing the EFT transaction files but not to the server containing invoice files. To verify that fraudulent payments had not been made, payables staff could run queries that verified that:
    a. All EFT confirmations matched EFT requests
    b. All EFT confirmations matched invoices
    c. All invoices matched EFT requests
    d. All invoices matched EFT confirmations

23. The significance of the IT systems support manager identifying over a hundred unprotected servers is that:
    a. It would not be possible to protect such a large number of servers in the company
    b. The programs and data on the unprotected servers had already been corrupted
    c. Departments should not be permitted to host their own servers on the network
    d. It would be easy for outsiders to get into or take control of the entire system

24. Suppose Kiran and Pat went through the closing process again, one step at a time. They would be most likely to conclude that:
    a. The adjusting entries are correct provided the data downloading and spreadsheet calculations are correct
    b. The correct payables balance at month end would be the sum of invoices with status ‘R’, ‘S’, or ‘A’
    c. The correct payables balance at month end would be the sum of invoices with status ‘R’ or ‘S’ minus the sum of invoices with EFT status of ‘R’
    d. The correct payables balance at month end would be the sum of invoices with status ‘R’, ‘S’, or ‘A’ minus the sum of invoices with EFT status of ‘R’

Appendix 6: Post Experiment Questions

Students are asked to "Please indicate the extent of your agreement with each of the following statements"[13]:
1) I had sufficient time to read the case and answer the multiple choice questions.
2) This case and the multiple-choice questions were very difficult to do.

[13] Using a scale from -5 (strongly disagree) to +5 (strongly agree)