Coming to Grips with the Management of Information: A Classroom Exercise

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ABSTRACT

Managers and decision makers often claim to be starved for good information while they are also victims of "information overload." The challenge for most decision makers in the early 21st century is the tsunami of data and information received from a multitude of internal and external sources that must be managed on an almost constant basis. The difficulty is distinguishing the good information from the bad, and in developing criteria to assist in this process. This experiential exercise has been used for undergraduate, graduate, MBA, and management training and development courses. The exercise introduces participants to some of the basic concepts about information and the importance of managing information as a resource. It addresses evaluating information on the basis of its quality (i.e., accuracy), quantity, timeliness, and relevance. In addition, the exercise helps participants to recognize the different information needs of managers in different functional areas of the organization as well as at different levels within the organization. This paper provides the reader with the instructions and materials to use this exercise in the classroom setting and discusses related examples from business.

Keywords: information resource, quality, quantity, timeliness, relevance, information overload

1. INTRODUCTION

Information - managers and decision makers often claim to be starved for good information. Ironically, many are also victims of what is often called "information overload," contradicting the idea that more information is better (Krill 2000; Schick, Gordon, and Haka 1990). The challenge for most decision makers in the early 21st century is the tsunami of data and information that must be managed on an almost constant basis (Groner 2000). The abundance of published resources, the increase in organizational computing and information systems, the proliferation of desktop computers and other electronic communication technologies, the flood of e-mail, and the explosion of the Internet have added to the daunting challenge of discerning the good information from the bad (Kaye 1998; Shenk 1997). Much of this data and information, however, is of little or no real usefulness to the ultimate decisions that are made. From both internal and external sources, the challenge is to understand the distinction between good, or useful, information and material that is not very supportive of good decision-making. An important part of this challenge is to promote understanding of what makes good information and, by extension, the development of methods to ensure people get the information they need.

Many of the current foundation textbooks in Management Information Systems (MIS) and Information Technology (IT) (cf. Haag, Cummings, & Dawkins 2000; Laudon & Laudon 2000; O'Brien 1999; Oz 2002; Schultheis & Sumner 1998; Stair & Reynolds 2001; Turban, McLean, & Wetherbe 1999; Turban, Rainer, & Potter 2001) include a significant portion of a chapter on the concept of information. These discussions generally include an exploration of topics

such as the definition and meaning of information, and the attributes, characteristics, or dimensions of information. Table 1 provides a comparison of several of these characterizations. Fundamentally, information is data that has been processed and organized to provide meaning for a particular use or a specific end user (Haag, Cummings, & Dawkins 2000; O'Brien 1999; Schultheis & Sumner 1998; Stair & Reynolds 2001). In this context, information effectively becomes a resource just like materials, labor, and capital. Ideally, the information resource must be managed like these other resources. As can be expected, most undergraduate- and many masters-level students have only a minimal amount of experience in understanding the issues related to managing and using information. Even many managers seem to have some difficulty grasping this conceptual point about information. Currently there are few in-class experiential exercises on this topic. Leifer & DeHaemer (1986) and McLeod (1985) have both called for more experiential activities to assist students in appreciating the important role that information plays in organizations and the decision-making that must be done in organizations.

According to the Kolb (1976) model, all learning is experiential in nature. Learning involves experiencing some event or situation, reflecting on that experience, developing a theory of how things are related based upon that reflection, and, finally, using that theory when encountering the event or situation again. Successfully transforming experience to learning often requires both the instructor and the students to connect the experience with what is already known by testing new insights from the experience. Research has shown that when the instructor takes adequate time to process the experience, transformation from experience to learning does occur (Roland, Wagner, & Weigand 1995; Warren, Sakofs, & Hunt 1995).

In the sections that follow, an experiential exercise is described that is intended to assist in this learning process. This exercise has been used in undergraduate, graduate, MBA, and management training and development classes ranging in size from 10 to over 250. It has been used primarily in an Introduction to MIS course environment, but has been used in other domains as well. Through the activity of a simulated organization, participants are allowed to work in a situation and through that experience gain perspective on the complex issues surrounding information as a resource. The debriefing process is presented in some detail to show the variety and richness that this exercise provides. Several real world examples are presented to anchor the concepts and to add clarity to the experience. Suggestions for how the exercise can be incorporated into the learning environment are also provided.

2. THE EXERCISE

The exercise has four primary objectives. Upon completion of the exercise, the participants should be able to:

1) Given an objective or decision criteria, identify basic information needs for a specific situation or individual,
2) Appreciate the complexity of the information flow in an organization,
3) Explain why managers at different levels of the organization have different information needs, and
4) Evaluate information on the basis of its quality, quantity, timeliness, and relevance for different levels of the organization.

These will be discussed in greater detail in the section on Debriefing the Exercise.

2.1 The Organization – Solutions Diversified, Inc.

Solutions Diversified, Inc. is an organization that produces two products: completed (i.e., correctly solved) math problems, which are done by the SolTech division, and completed connect-the-dot line drawings, which are done by the SolGraph and SolArt divisions.

The participants function as employees of Solutions Diversified. It is an organization made up of six separate roles, consisting of the President, Quality Control, Inventory Control, SolTech, SolGraph, and SolArt. An organization chart is provided in Figure 1.

A general description of the roles is provided below. The detailed role descriptions given only to the appropriate participants are provided in Appendix 1.

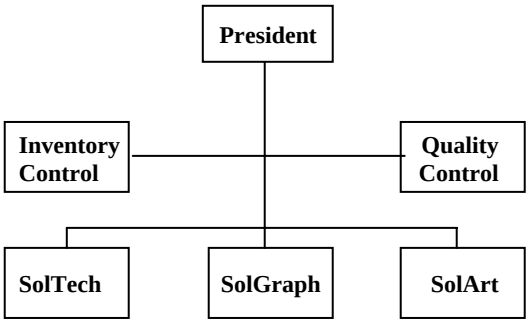

FIGURE 1
Solutions Diversified Organization Chart

Table 1
Characteristics, Attributes, or Dimensions of Information

O'Brien (1999)	Schultheis & Sumner (1998)	Stair & Reynolds (2001)	Haag, et al. (2000)
Time Dimension	Frequency	Accurate	Form (How)
Timeliness	Dependability of Results	Complete	Level of Detail?
Currency	Time Period Covered	Economical	Form of Presentation?
Frequency	Level of Detail	Flexible	Time (When)
Time Period	Source of Data	Reliable	Timely?
Content Dimension	Nature of Data	Relevant	Current?
Accuracy	Accuracy	Simple	Content (What)
Relevance	Typical User	Timely	Accurate?
Completeness	Level of Decision	Verifiable	Relevant?
Conciseness		Accessible	Complete?
Scope		Secure	
Performance			
Form Dimension			
Clarity			
Detail			
Order			
Presentation			
Media			

2.2 The Roles

President: The President of Solutions Diversified, Inc. has the responsibility of monitoring and ensuring operational efficiency in the organization. The President is free to adjust personnel and operations, including the physical layout, within the organization as needed. All questions related to the operations of the organization are directed to the President. The President receives reports from SolTech on the number of completed math problems sent to Quality Control every 10 minutes, reports from Inventory Control on inventory levels every 20 minutes, and reports on the number of incorrect math problem solutions from Quality Control every 20 minutes.

Inventory Control: Inventory Control (IC) initially possesses the raw materials. More specifically, the raw materials are the unsolved math problems and the incomplete connect-the-dot line drawings. IC maintains a log of inventory transactions and forwards the log to the President every 20 minutes. The Inventory Log form is provided in the exercise's setup materials. IC also receives the completed connect-the dot drawings from SolArt and the completed, checked, and correctly answered math problems from Quality Control.

Quality Control: Quality Control (QC) receives completed math problems from SolTech and checks them against an answer key. The key is provided by the exercise facilitator from the setup materials. Correctly answered problems are forwarded to Inventory Control. Reports on the number of rejected, i.e., incorrect, math problems are sent to the President every 20 minutes. The QC report form is provided.

SolTech: SolTech (Tech) receives math problems in packages of 12 from Inventory Control upon request. They then solve these problems. Several sample problems are provided in Appendix 2A. Completed problems are sent to Quality Control. A report on the number of problems completed is forwarded to the President every 10 minutes. This report form is provided for the participants.

SolGraph: SolGraph (Graph) receives line drawings in packages of 10 from Inventory Control upon request. These drawings are completed (i.e., the dots on the connect-the-dot drawings are connected) and forwarded to SolArt. A sample is provided in Appendix 2B. Some additional details will be provided on SolGraph and SolArt later in the discussion.

SolArt: SolArt (Art) finishes the line drawings received from SolGraph by applying three colors to each drawing. Completed drawings are forwarded to Inventory Control for shipping.

Observers: If extra people or late arrivals for the exercise are available, they can function as impartial observers of the activities. This external perspective can be useful during debriefing.

2.3 Setup

The room should be arranged prior to the start of the exercise.[1] If multiple organizations will be active, the arrangement of the desks and chairs should reflect this. When multiple organizations are used, different physical configurations of the organizations can provide

the opportunity for discussion. Required materials, including division labels and position nametags (e.g., SolTech, SolGraph, Quality, etc.), can be placed on the work areas at this time. (It can be useful to designate different organizations with a different color identifier. These can be indicated on the division labels, which indicate a division work area, and position nametags provided for each participant.)

All participants should receive a copy of the half-page description and organization chart for Solutions Diversified. These descriptions are similar to the general descriptions provided above. Note that the organization chart does not necessarily represent the physical layout of the organization, nor does it portray the actual flow of material or information within the organization. Instead, the physical layout of the organization is flexible, ranging from a replication of the organization chart to a nonsensical or random arrangement of organizational divisions.

Participants should also receive a description of their specific role in the organization. The roles can be assigned and descriptions distributed in a session prior to the exercise or immediately before the exercise begin. Both approaches have been used.[2] Participants should be encouraged to read the distributed material prior to the start of the exercise.

The fictitious organization has been run with as few as 6 people, one for each role in the organization. However, it works best with a minimum of nine people and as many as seventeen per organization. Table 2 suggests variations on the potential staffing of the roles in the organization. Multiple organizations can be run simultaneously, injecting the possibility of competitors in the external environment. As noted above, late arrivals and additional people not assigned to a role in one of the organizations can function as independent observers

Table 2
Variations on the Potential Staffing of the Roles in the Organization

	Suggested Minimum Staffing	Suggested Maximum Staffing
President	1	1
Quality Control	1 *	2
Inventory Control	1 *	2
SolTech	1	4
SolArt	1	4
SolGraph	1	4
Total	6	17

* It is possible to combine Quality Control and Inventory Control into a single position.

2.4 Time Required

The exercise requires the Solutions Diversified organization to operate for approximately 50 minutes. This allows for at least two rounds of reports from all relevant divisions. As currently equipped, the initial inventory typically allows for an inventory shortfall to occur during operations within this time fame as well. It typically takes a few minutes to get the exercise underway, plus an additional five to ten minutes to collect performance data at the conclusion of the exercise. Therefore, the exercise can work in a 1-hoursetting, but it is better executed in a 75-minute session. Debriefing can add an additional 30 to 60 minutes to the total process. It is also possible to run the exercise during one 50-minute class period and then do the debriefing during the next class period. If this approach is taken, it is useful to ask the participants to complete a one-page reaction paper immediately after the exercise. This reaction paper acts as a good stimulus for the debriefing session.

2.5 Materials Required [3]

A full set of the required descriptive and work materials includes the half-page description of the organization and an organization chart, position descriptions, inventory log forms, reporting forms (for SolTech and Quality Control), math problems, connect-the-dot line drawings, and solutions to the math problems. At least one package of eight crayons for each organization is required for use by SolGraph and SolArt. If Observers are available, observation sheets (i.e., questions for the observers to consider) and a complete set of instructions for the organization are required for each observer.

2.6 Exercise Instructions

Each participant should receive the half-page description of Solutions Diversified either in a session prior to the exercise or shortly before the exercise begins. Reading this description of the organization and its units should be required for each participant. Role assignments can be made in advance, as participants enter the room, or by participant self-selection according to where they sit as they enter the room. Participants should also receive a separate more detailed description of their role in the organization. This can be distributed when the roles are assigned or as people take their seats prior to the start of the exercise.

Start the exercise. Note the start time so all required reports can be generated according to their instructions. Remind all participants to be alert for information issues they encounter.

Once the exercise starts, the President is allowed to reassign people and to reorganize or reconfigure the organization. Any changes should be noted, with the President able to answer why the decision was made, what sources of information were used to make the decision, the information that was actually used, and how the information was obtained.

Some procedures for the various roles throughout the organization are intentionally left vague in the instructions. This forces questions to be asked and decisions to be made during the exercise. Note how the group resolves issues of missing or confusing information. All decisions pertaining to the operations and activities of the organization should be left to the President.

Remind the participants to fulfill their reporting duties to the President on a timely basis. As the exercise comes to a close, remind the President to get summary information for the production status of the organization. Formally conclude the exercise leaving several minutes for the President to acquire the desired information. (The time used by the President is an excellent opportunity to collect some of the supplies, e.g., crayons, unit labels, etc., and to pick up some of the paper material produced during the exercise.)

2.7 Common Issues That May Arise During the Exercise

A number of common situations occur during the operations of this exercise. Many of these situations require the input of and/or decisions being made by the President, although some units may be proactive in resolving questions on their own. These situations include restructuring the organization, with options such as combining functions, creating new functions, relocating work spaces, and reassigning people. The most common issue is many people find themselves working in a job, specifically solving the math problems for SolTech, for which they do not feel qualified. Others may find themselves in jobs in which they get bored, e.g., connecting the dots for SolGraph. The President may also want to revise the various reporting procedures by changing the content or timing of the reports from Inventory Control, Quality Control, and SolTech. One key concern is how inquisitive or proactive the President should be, or whether the President should allow problems to come to them.

Procedures with Inventory Control may compel attention, such as determining how to fill in the Inventory Transaction Log. The Log form is purposely designed to 'look' good, but it does not function well. This design issue is worth additional exploration in the debriefing. Knowledge of form design and screen design skills has become increasingly necessary as more people do their own design work on personally developed reports and on-line websites. In addition, there can be tremendous variation in personal design preferences in how information is presented.

Attention may be requested from the production divisions (i.e., SolTech, SolGraph, and SolArt) in defining the appropriate make-up of resource packs for math problems and line drawings. This is one of the ambiguous situations mentioned above. For example, math problems are organized six to a page. They are supposed to be distributed to SolTech in packs of 12. It is not entirely clear whether that means twelve pages or twelve problems (i.e., two pages). Connect-the-dot line drawings are two to a page. They are supposed to be distributed to SolGraph in packs of 10. It is not entirely clear whether that means ten pages or ten drawings (i.e., five pages). In addition, the initial inventory may run short during the organization's existence, with line drawings or math problems running in short supply. An inventory shortage can be a useful situation to create, forcing the President to decide what to do with the idle labor. Also, the initial inventory of line drawings does not work out to an even set or pack for distribution, i.e., the initial inventory of line drawings is not evenly divisible by 10. Inventory Control must determine how to manage these issues.

Additional inventory issues concern whether finished goods inventory should be maintained in original packs or whether the completed products can be checked in individually. Should Inventory Control maintain data on work-in-process inventory? In other words, should IC keep track of the location and status of the materials as they move through the production process? If IC does not actively follow work-in-process, there may be a substantial amount of idle time once the initial rush in supplying SolTech and SolGraph is concluded.

Other issues that are often encountered during execution of the exercise are often related to Quality Control. QC personnel sit idle for a fair portion of the exercise. Even when the math problems begin to arrive for checking, there is a substantial amount of nonproductive time. It is worth noting whether there is a better way to use these personnel. QC must determine the appropriate batch size for testing (i.e., checking for correctness) the math problems received from SolTech. When math problems are determined to be incorrect, can SolTech rework the incorrect math problems? Should QC be an additional step for the line drawings between SolArt and Inventory? Currently there is no quality control for the line drawings.

Common issues for SolGraph and SolArt often are related to a shortage of inventory near the end of the exercise session and the internal organization and distribution of labor within the division. Additional issues include meeting the work performance requirements. For example, in SolGraph it is not clear how 'neat' the lines need to be, what color the lines should be, whether there can be color variations for the lines within the same drawing or on the two drawings on the same page, what to do about missing or extra dots, etc. In SolArt the drawings are to be completed using three colors. How neat does the coloring need to be? Do all drawings need to be the same three colors? Does an individual always need to use the same three colors? Finally, for both SolGraph and SolArt what about errors in the raw material or when errors are made during production? This will be addressed further in the

debriefing section below.

SolTech has its own set of common problems. As noted above, the most common issue is many people find themselves working in a job, specifically solving the math problems, for which they do not feel qualified. Are calculators a 'legal' tool? Can SolTech people consult with others in the organization?

The material above notes some of the most common issues encountered during the operation of the Solutions Diversified organization(s). How these issues are addressed creates opportunities for discussion during the debriefing. The next section covers and makes suggestions for debriefing the exercise. This is followed by a discussion of several examples that can be used to connect the exercise to events in real organizations.

3. DEBRIEFING THE EXERCISE

3.1 Debriefing

Debriefing can be performed immediately after the completion of the exercise or in a session to follow the exercise on a later date. There are benefits to each approach.

An immediate debriefing provides the participants the opportunity to process their experiences in the exercise without delay. The immediacy of the discussion should allow for the details of the exercise to be fresher in the participant's minds. However, fatigue of the participants may be a factor. Questions can be immediately provided for the participants to consider based on their respective roles in the organization, i.e., questions specific to SolArt can be provided, questions specific to SolTech can provided, etc. One common question is for the participants to map out both the flow of products through the organization and the flow of information throughout the organization.

A delayed debriefing provides the participants some time to process their experiences on their own prior to engaging in an active discussion. At the conclusion of the exercise several questions can be provided for each participant to consider prior to the discussion. (Written responses to these questions can be required at the instructor's discretion.) This approach creates the opportunity for a richer discussion, subject to the probable loss of some detail affiliated with the delay between the exercise and discussion. It also allows the participants some time to consider integrating their experiences with content material from their course.

3.2 Suggested Debriefing Topics

As with most activities, as experience is gained with this exercise new opportunities for discussion will emerge based on the facilitator's and the participants' experiences. Although a plan for the debriefing should be in place, including the key points that you wish to cover, having a flexible approach will allow for a richer discussion. Building on the objectives identified above, several common debriefing themes that may arise during the exercise are described below. The objectives can be covered in any order.

Objective 1 – Given an objective or decision criteria, identify basic information needs for a specific individual: This is a good starting point. What are the specific information needs for each role or position in the organization? Are the people in those positions receiving the information they need? For example, the job descriptions for most of the roles are rather broad and vague. Most people find them to be of minimal guidance. Yet, they must begin work and continue to function with this limited information. Given the limited information, how do they go about locating the information they need to do their job? You should probe people for similar, or different, experiences in their own job experiences. Many will often admit that their most recent job was not that dissimilar in terms of the information provided on what they were supposed to do. It is also quite common for the participants to recognize their limited perspective on how both information and product actually flow through the organization.

For example, as noted in the description of the job above, the job of the President is focused on the operational efficiency of the organization. What kind of information is needed to successfully accomplish this role? Is the President receiving this type of information? Or, stated another way, what kind of information is the President actually receiving and can it be easily used to monitor operational efficiency? Similar issues can be explored for all roles in Solutions Diversified, particularly in Inventory Control and Quality Control.

Objective 2 – Appreciate the complexity of the information flow in an organization: This is a good question to consider between the exercise and the debriefing. Have each participant map out the flow of information throughout the organization. Most will have knowledge only on what precedes their role and what immediately follows. Some will lack even this basic knowledge. In this exercise even the President often has incomplete knowledge of how the organization works. Explore how you can be in a job, even a relatively simple one, yet have only a limited perspective on the activities and flow of information around you. Note also that the flow of information may not, and often does not, match the flow of a product through the organization. Here you can explore how organizations provide job descriptions and orientations for new employees and for those who have transferred within an organization. Again query participants on their own experiences in their past and current jobs.

Objective 3 – Explain why managers at different

levels of the organization have different information needs: What are the differences in information needs between the President of Solutions Diversified and the specific needs of other roles, such as SolArt or Inventory Control? Why do these differences exist? This is an opportunity to discuss the differences between 'data' and 'information,' where what some would perceive as data from their particular needs would be information for someone else's needs. This is also an opportunity to consider the design and presentation of information for decision-making, including issues of good design for both paper- and electronic-based information systems and individual preferences.

Objective 4 – Evaluate information on the basis of its quality, quantity, timeliness, and relevance for different levels of the organization: These concepts may have been explored prior to the exercise. Have the participants review the meaning and relationships among these concepts. Note again the various configurations and categories of the characteristics, attributes, or dimensions of information that are presented in Table 1.

Table 3
Layout of Performance Measures for the Organization During Debriefing

	Blue Org.	Red * Org.	Green Org.
Initial Inventory			
Math Problems	_____	_____	_____
Line Drawings	_____	_____	_____
Work-in-Process			
Math Problems			
@ SolGraph	_____	_____	_____
@ Quality Control	_____	_____	_____
Line Drawings			
@ SolGraph	_____	_____	_____
@ SolArt	_____	_____	_____
Finished Inventory			
Math Problems			
Successfully Completed	_____	_____	_____
Completed with Errors	_____	_____	_____
Line Drawings			
Successfully Completed	_____	_____	_____
Completed with Errors	_____	_____	_____

* When multiple organizations are used, it is useful to present their performance data side by side. All organizations begin with the same initial inventory, yet these figures are often different. The Finished Inventory is often dramatically different, and in many cases, when added to the Work-in-Progress, does not add up to the Initial Inventory.

For example, consider the differences in quality information for the President versus someone in SolArt or Quality Control. Consider each of these four concepts for the different roles in the organization. Next, explore how these four characteristics contribute to assessing and understanding the performance of individuals, units, and the organization as a whole.

Organizational Productivity: As the exercise is drawing to a close, the President should be reminded to collect information that will represent how well the organization has performed during the approximately 50-minute time period. Other discussion may begin while this information is organized. Have the President report on standard performance criteria, such as initial inventory, work-in-process, and completed inventory. More specifically, examine each of these categories for the two different product lines, i.e., for the math problems and for the line drawings. (See Table 3 for a general layout.) Can the President provide accurate information? Can SolArt provide a summary to the President? Even with careful monitoring and normal reporting, it is rare for this to be successfully accomplished. Several issues can arise from this situation.

First, how long did it take the President, often in collaboration with Inventory Control and Quality Control, to collect the information and derive these numbers? Information was regularly communicated to the President, so much of this information should have been quickly available. If not, the discussion can consider issues related to information quality, quantity, timeliness, and relevance. Was the President receiving 'good' information? Was there too much or too little information being provided? Was it really 'data' instead of information? Was it arriving in a timely fashion? Was the information being received actually relevant to the types of decisions required of the President?

Second, if multiple organizations have been running in parallel, displaying the performance data for all of the organizations side-by-side, as shown in Table 3, can provide a useful comparison. Do the organizations have the same Initial Inventory numbers? If the exercise packets have been identically prepared, the starting numbers should be the same. Yet, they are often different. This is due to simple miscounting of the initial inventory or to a different interpretation of individual items and packs of math problems or line drawings. Why these differences occur is a useful addition to the exploration of data quality.

Third, do the numbers for Work-in-Process and Finished Inventory match or add up to the Initial Inventory numbers? It is a common occurrence that the numbers don't add up. If not, then either the data is incorrect at some point or some of the product has gotten 'lost' or 'misplaced' during production.

Whatever the reason, this again points to issues related to data and information quality.

At this point in the debriefing it is often useful to note that in about 50 minutes of operations the organization has gone from a known quantity (at least by the facilitator) for the Initial Inventory to a very questionable set of numbers on the organization's performance and productivity during this period. How can an organization lose track of its inventory information so quickly?! Note that the system for providing the data and information to the appropriate decision makers must function well; a poorly functioning system can provide misleading and incorrect data very quickly. Finally, does the inventory and work-in-process information accurately reflect the true status of the organization's products?

At some point, it is useful to let the President, Inventory Control, and Quality Control 'off the hook,' for they have an almost impossible task. Not only is the reporting system significantly flawed, with difficult-to-use reporting forms, the actual production process is designed to create flawed products and, by extension, erroneous data. Recall that the initial flow of work for the line drawings is from Inventory Control to SolGraph to SolArt back to Inventory Control upon completion of the drawings. As the organization is initially structured, at no point is the line-drawing product formally checked for accuracy, i.e., quality. In fact, the job description instructions for SolGraph indicate that "on approximately one project in five you should expect to make an error by skipping a dot or otherwise connecting dots out of sequence." In other words, they are to introduce an error rate of approximately 20 percent in their part of the production process. And, they are not to tell the President and are to continue this error rate unless instructed to change by the facilitator, not the President. SolArt has a similar instruction, in that they are to use "two or four colors instead of the correct three," and that these are "not necessarily the ones received in error." These two error rates combined create a situation where from 20 percent to 40 percent of the finished product may have been produced with flaws. In addition, some of the raw material in initial inventory is also flawed with missing dots or numbers in the connect-the-dot sequence. In fact, without a detailed quality control process, it is impossible to know exactly how many of the finished line drawings were successfully completed according to product standards.

Another topic to consider for the line drawings is a definition of what is meant by the three-color requirement. The finished product is described as consisting of three colors. But what are these colors to be? Should they be the colors added by SolArt? Would the line colors done by SolGraph be counted as a color? In addition, what about the white background (i.e., the paper) and the black lines and dots that come with the raw material input? One viable interpretation is that the white and black initial colors may count as two of the three colors. This set of questions can stir up some debate on defining the initial conditions of the raw material and the expected end product.

The math problems create a different set of problems. They are somewhat difficult, although any college-level participant should have been able to adequately solve these problems at some point in the past. The questions have been derived from sources such as ACT and SAT prepatory study materials. Yet, for many people, these skills are rusty or long forgotten. Therefore, as previously noted, many participants find themselves working in a position for which they feel they are neither qualified nor particularly interested. This can provide some interesting discussion.

Once the math problems have been completed they are forwarded to Quality Control for checking against the answer sheet. What should happen to correct answers? Should they be separated from the incorrect ones and sent on to Inventory? Or should the original packets be maintained intact? How should they be packaged? Should the incorrect problems be returned to SolTech for another attempt? What about the problems that were not even attempted?

One issue that arose unexpectedly was the ultimate use of the answer key. A question for the facilitator is whether the entire key or only the currently needed parts of the key should be distributed. As a facilitator, you are busy observing the activities through the exercise. So, it is disruptive to have to continually distribute a small part of the answer key. However, how will the key be used if it is released in its entirety? On at least a few occasions, several people within the organization have taken advantage of having the answer key, using it to provide correct answers to the math problems by copying the answers directly from the key. Is this legal? Is this ethical? Does the President know of and approve of this behavior? This behavior can elicit an interesting dialogue on ethics and the use of privileged information, especially if there are multiple organizations where some did not explore this opportunity.

Computer-based information systems: To this point in the exercise and debriefing the focus has primarily been on what was done and how it was measured in the paper-based environment of Solutions Diversified. At some point it is useful to spring the question of whether or not a computer-based information system would have improved monitoring of the operations of the organization. What is necessary for a computer system to be put in place? Should it represent current operations, or should the currently flawed flow of products and information be refined prior to the installation of an information system? This turn in the discussion provides the opportunity to introduce systems analysis and design, workflow, and business process redesign into the conversation. In addition,

consideration of enterprise resource planning (ERP) systems can be added.

Realism: One concern with simple, quick exercises is whether or not they are realistic enough to provide an opportunity to learn. While Solutions Diversified is an artificial organization, through discussion it is often possible to get the participants to favorably compare their experience with Solutions Diversified with their own experiences in terms of its representation of the real world. Many people have had jobs where they received no job description or little instruction, let alone a half-page description. Many have found themselves with little or no knowledge of how their work fit with the work of others and how it contributed to the organization's success. Many have found themselves in positions where they felt they were not qualified, where they found themselves bored and disinterested, and where they found they really had little to do. All can be encountered with this experience.

The debriefing process is an attempt to openly discuss and process the participants' experience in this exercise. The richness of the exercise provides a broad range of topics that can be explored and an opportunity for deeper inquiry on specific issues that can then be linked to common topics within the information systems domain.

4. DISCUSSION

As with any exercise, activity, or case, its verisimilitude is important. If it is not realistic, the participants may go though the motions of completing the activity, but the opportunity for real learning will often be missed. Real organizations provide a wealth of examples, both current and historical, that can be used to enrich and reinforce the lessons from the Solutions Diversified exercise. It is impossible to do anything approaching an exhaustive list in the limited space of this manuscript. However, several are briefly explored below as illustrations of how they can be linked to the exercise. These examples have been selected because they are generally well known, although perhaps not in this context, they authenticate some of the events experienced by the participants in the exercise, it is easy to acquire additional information on the specific events from a wide variety of sources, and they can be easily used to integrate with other information- and information systems-related topics. Depending on the larger goals of the exercise, additional or other examples can be developed.[4]

4.1 Historical Illustrations

IBM: According to Watson (1990), even IBM encountered a critical situation where they discovered they had inadequate systems in place for capturing useful data to provide an accurate portrayal of the organization's financial position. On April 7, 1964, IBM announced an ambitious project to develop the first family of upward-compatible mainframe computers, the System/360. While considered an immediate marketing success, competitors quickly identified gaps in the computer family and deficiencies in the software systems that allowed them to continue to capture valuable potential customers. IBM responded by adding corresponding new machines to the System/360 family, requiring the "diversion" of additional "engineering talent" to the already massive project. The software, both operating systems and application programs, for the System/360 computers was also more complex than anticipated and delivery fell behind schedule. Yet, even with the addition of more programmers, software development continued to be late. (This aspect of software development has come to be know as "Brooks Law," and, along with a number of other concepts, is developed and explained in *The Mythical Man-Month*, Brooks 1999). Machines were being delivered, but the promised software was not ready, requiring many organizations to work with temporary more rudimentary software system patches until the software could be completed, tested, and delivered.

As it came time to close the books on IBM's finances for 1965, it was realized that they could not account for at least $150 million of work-in-process inventory. (Note: This would be equivalent to 'misplacing' or losing track of over $ 650 million of inventory in 2002 dollars.[5]) After a more thorough inventory assessment, the total turned out to be closer to $600 million. The accounting system was out-of-date and was unable to adequately track the "millions of parts and thousands of machines" at various stages of production moving between factories throughout the IBM manufacturing system. Watson (1990, pp. 357-358) described the accounting system as an "anachronism" from when IBM's manufacturing consisted of only a few plants that were largely responsible for their own products. The System 360 program had led to increasing interdependence between factories leading to incomplete inventory data and, ultimately, a shortage of cash.

This cash crunch ultimately led to IBM unexpectedly issue $370 million of stock to provide the financial resources necessary for the hardware and software systems to be completed and delivered to the customers and begin to generate a revenue stream. (For a more detailed discussion of the System 360 project and the related financial challenges, see Watson 1990, pp. 346-360). In summary, a corporation with (at that time) over 50 years of history as one of the premier manufacturers of data processing equipment and the leading manufacturer of multi-million dollar computer systems had, due to outdated and insufficient reporting systems, lost track of its financial operations.

IBM was a massive organization, even in the mid-1960s (Sobel 1981). It had become so large and complex, however, that its once reliable financial reporting

processes had become antiquated. This meant that information on operations was flawed and incomplete. Management did not realize the problem until they reached a critical point in a routine process – closing the books on operations for 1965. Consider, there was an immense amount of information about IBM's operations, i.e., there was a large quantity of information, but it was of poor quality. This is similar to the events in Solutions Diversified. The financial information was being received in a routine fashion, but, due to its poor quality, its relevance was questionable. Only a quick infusion of cash through an unplanned stock issue and the on-going heroic efforts of engineers and software developers allowed IBM to emerge from this financial crisis and gave it time to restructure and improve its reporting systems. This example provides tangible evidence that poorly designed accounting information systems provide inaccurate and flawed information even at a corporation like IBM. After completing an exercise like Solutions Diversified, it is useful to link the students' experiences back to real examples.

The Space Shuttle *Challenger*: On January 28, 1986, the Space Shuttle *Challenger* exploded 73 seconds after liftoff, killing all seven astronauts aboard and destroying the $2 billion spacecraft (Boisjoly 1987). No American astronaut had ever been lost in space flight until that day. A leak in an o-ring gasket that was meant to seal the joint between two sections of the solid rocket booster developed into a tongue of flame that ruptured the liquid propellant tanks and caused them to explode. A Presidential Commission was quickly organized to try to understand what had gone wrong. The results of the Commission investigation were astonishing.

The morning of the launch was exceptionally cold for Florida, and was easily the coldest temperature in which an attempt was to be made to launch the shuttle or any other manned spacecraft by NASA. Under these cold conditions, the rubber-like material in the o-ring became inflexible and, therefore, was incapable of sealing the joint as the booster flexed during launch and the subsequent flight operations. In spite of the cold, the decision was made to proceed with the launch.

A variety of factors contributed to the decision to proceed with the launch, including commercial, financial, political, and public relations pressures. When originally proposed to Congress, the Space Shuttle system was promised as a cheap and reliable way to get satellites, scientific experiments, and other commercial payloads into orbit. Yet other organizations were competing with NASA for these paying customers by offering lower prices for the payloads and were providing more timely launch opportunities. NASA operations were well over budget and behind in achieving operational goals and objectives (i.e., the annual number of launches) for the Space Shuttle system and the U.S. Congress was considering NASA's future budgets. Then President Reagan was scheduled to have a conversation with the crew during the annual State of the Union Address before Congress. Additionally, one of the crewmembers was Christa McAuliffe, the "Teacher in Space" and first civilian passenger on the Space Shuttle. Finally, the launch had already been delayed several times due to technical and weather-related issues.

The launch decision stirred even more controversy when it was learned that several engineers at Morton Thiokol, the manufacturer of the solid rocket boosters, had expressed a strong concern about launching in the cold weather conditions. It should be noted, however, that the majority of engineers did not express concern. Although the o-rings had experienced damage on several previous flights, these events were characterized in post-mission analyses as "normal deviations" and an "acceptable risk" allowing for certification of flights subsequent to those in which some damage occurred (Vaughan 1997). In addition, no specific data existed for o-ring performance at that low temperature, although some evidence existed that any temperature below 53° F, the lowest temperature for any previous launch, was of significant risk. Therefore, when asked to support their argument with data, the Thiokol engineers were unable to support their concerns with "conclusive" quantitative data (Jensen 1996; Tufte 1997).

For *Challenger*, the information was essentially not available, i.e., information quantity was low. The information that did exist was inconclusive (i.e., there was data on both undamaged and damaged o-rings from launches under apparently similar temperatures and circumstances) and was therefore deemed weak or ambiguous. However, a decision still had to be reached. An appropriate conclusion could be reached through extrapolation, but it was not conclusive and was poorly presented, i.e., low quality. Many of the concerns that were expressed were not communicated to the higher-level decision makers. Finally, the concerns that were issued were largely discounted as being irrelevant since a complete failure had never occurred before. And, even after damage was noted on other flights, the required certifications continued to be made; i.e., the organization had rationalized and made routine substandard performance. It is impossible to know if a different decision would have been made if the data had been better presented, if the concerns had been better communicated and more widely disseminated, or if the pressures to launch had been mitigated. This example makes the point that the failure to collect and report the relevant information can lead to deadly consequences. While the simulation does not lead to deadly consequences, it does lead to indecision, confusion, and uncertainty about how the organization is doing.

4.2 Contemporary Illustrations

Cisco Systems: Cisco Systems is an organization that specializes in designing and creating the hardware

infrastructures for data and telecommunication companies. It does not build most of what it sells; instead, it outsources most of its manufacturing. Cisco was one of the Cinderella stories of Internet boom and the so-called New Economy (Mehta 2001; Nee 2001). Its revenues grew by a compound annual rate of 49 percent between 1998 and 2000 (Lakenan, Boyd, & Frey 2001). During this same period gross profit increased 48 percent and net income rose 42 percent. As a stock by mid-2000 it had increased in value 100,000% since its initial public offering in 1990 (Serwer 2000). Yet, in the fourth quarter of 2000, Cisco had to write-down $2.25 billion in excess inventory.

The cause was a flaw in the ordering and fulfillment process, a significant defect in the supply chain that was supposed to be "visible" and "live" (Stewart 2000). In 1998 Cisco installed an ERP (enterprise resource planning) system to better integrate the flow of information throughout the organization. Using the Internet, Cisco also integrated their inventory system, including inventory forecasts, order backlogs, and 3 months of daily data on subassemblies and parts, with its manufacturing partners information on in-process inventory, cycle times, and order lot sizes to make real-time decisions on what needs to be built on a day-by-day basis. Cisco also connected with its customers in a similar fashion through the Internet (Stewart 2000).

In hindsight, it turns out that customers were often ordering substantially more equipment than they would actually need. This was because Cisco was so inundated with orders that most of its product offerings were backordered, meaning that it was typically able to only partially fill orders. Recognizing this, many organizations ordered more than they needed, expecting to receive only a percentage of the order and to be able to postpone or cancel the remaining part of the order at a later date. Unfortunately for Cisco, they used these oversized orders to project future growth in demand and to target manufacturing orders and contracts. By the time Cisco recognized the precarious situation with their inventory, the surge from Y2K was past, the broader economy had already dramatically slowed, and orders were being substantially reduced or even cancelled as companies reassessed their IT needs.

The integrated information systems Cisco had in place provided substantial quantities of what was thought to be high quality, real-time information. Decisions on manufacturing schedules and quantities were adjusted daily based on orders and supplier inputs. Unfortunately, the systems were not tuned to differentiate between the inflated order quantities and the real needs of the customers. Therefore, the decision makers were unable to use the information they received to anticipate and react to an economic downturn in a timely fashion. This example provides evidence that even the best information systems are only as good as the data they are capturing, the information they are producing, and the use to which decision makers put the information they receive. In Solutions Diversified, the President is receiving a lot of information, but much of it is flawed, as in the completed connect-the-dot drawings available in Inventory Control, inappropriate, as in the number of incorrect math problems communicated to the President by Quality Control, or difficult to construct, as in the work-in-process information across the organization. Good decisions are difficult to make without good information.

Airline industry: The transportation industry has long been an early adopter of technology that could assist in better coordinating and managing dispersed operations. In fact, the advent of "standard time" zones in the United States and the development and dissemination of the telegraph can be largely attributed to the requirements of the railroad companies of the late 19th century to standardize and coordinate operations across the vast expanse of their growing operations.

More recently, the airline industry has also relied heavily on advances in technology to better manage their operations. Scheduling and positioning aircraft, scheduling flight crews, coordinating flights into and out of the hub-and-spoke terminals, etc. are just some of the typical activities. Computer-based reservation systems, such as Sabre, are another way the airlines are trying to improve their flow of information. Moving the reservation systems onto the Internet, with websites such as www.aa.com (American), www.continental.com (Continental), www.delta.com (Delta), and www.southwest.com (Southwest) is another approach the airlines are using to better control their information. Removing travel agents from the ticketing process also saves the airlines a significant amount of money in terms of transaction fees and commissions. Yet, with tight competition, rising fuel costs, and shrinking operating margins, there is ample room for additional efficiencies (i.e., cost savings) and new opportunities for revenue generation to be identified (Flint 1998; Henderson 1992).

One approach is to better manage (i.e., fill) the inventory of seats that are available (Flint 1998). When a commercial aircraft takes off, an empty seat is revenue that is forever lost. Yield management systems are a type of software system that assists the airlines in maximizing revenue from operations. They allow an airline to examine the profitability of their operations using a variety of factors. One approach is to manage the price charged for each seat. The airlines can vary the price of remaining seats on a flight on an almost minute-by-minute basis, i.e., using economic models and historical data to adjust the pricing scheme for the available seats to charge the highest amount possible while still filling the aircraft to 100 percent capacity by departure. Using historical data, the airline can also predict with a high level of accuracy the number of people that are likely to not show up for a flight,

allowing the airline to overbook by a predictable percentage that will rarely lead to an inconvenienced passenger or to extra costs for the airline to reschedule the passenger. This data also can allow an airline to consider changing the type and size of aircraft used on specific routes at different times. According to McCartney (2000), with the paper tickets and tracking of actual passenger use, it typically took several weeks before an analysis could be completed. The airlines "are now squeezing more dollars out of each airline seat" by using the newer yield management systems that allow for almost-real-time analysis using potentially several hundred variables (McCartney 2000, p. A1). An increase of just a fraction of a percent in revenue can yield millions of additional dollars in profits. High quality, large quantity, quickly analyzed and delivered, and relevant information are important to the continuing success and profitability of the airline industry. Again Solutions Diversified allows the participants to experience first hand the difficulty of not being able to have timely and relevant information to make decisions. This can lead to a discussion of what Solutions Diversified needs to do to make the information system they currently have, even one that is not computer-based, provide information that is both timely and relevant to the decision makers.

4.3 Some Variations on the Exercise

A wide variety of real world issues can provide a great deal of variation for the exercise. It can be useful for these illustrations to be particularly relevant to the participants. However, additional variations to the exercise itself can also add richness to the experience.

The typical initial inventory provides more than enough math problems for the duration of the exercise. However, the supply of connect-the-dot line drawings is often exhausted prior to the end of the exercise. This provides the challenge of what to do with the idle workers from both SolGraph and SolArt. Should they be switched to SolTech, or allowed to remain idle?

As reproductions of the inventory supplies for the organizations prior to the start of the exercise, some degradation in the quality of the supplies may occur. In fact, when copies are made of copies some distortion will emerge in the supplies over time. This can include background flaws, such as phantom marks and faded images, as shown in the sample connect-the-dot line drawings in Appendix 2B. It can also mean that the images may no longer be square or centered on the page, and even that the image creeps toward the edge of the page leading to the loss of dots or wording in the math problems. Some of this inventory may even be impossible to use. This flawed input inventory can be useful in creating additional ambiguities in operations. There is no formal provision for inspecting input inventories at the start of the exercise. Therefore, it is impossible to know how much bad inventory actually exists, adding to the uncertainty during the debriefing.

When multiple organizations are running in parallel, it can be interesting for one organization to have an inventory shortfall while another organization has a surplus. Are agreements reached between the two organizations? Do the organizations merge? Are divisions traded, such as one organization becoming solely SolTech, while another becomes solely SolGraph and SolArt? What are the impacts on inventory and productivity information when these types of transaction occur?

Each of the variations mentioned above provide the opportunity to explore additional facets of the characteristics of information and the management of information as a resource within an organization and for different levels of decision makers. Many additional variations can be included and adapted as the facilitator's experience with the exercise grows.

5. CONCLUSION

Managers and decision makers claim to be inundated with data, yet contend they are starved for useful information. Increasingly, the challenge in the early 21st century is to manage the tsunami of data and information that is available from the multitude of inexpensive, easily accessible sources. Therefore, treating information as a resource is ever more important. Yet, many people have never encountered or consciously considered the characteristics and features of good information, and the different information requirements for disparate roles within the organization. The Solutions Diversified exercise was presented as a rich and robust activity to expose people to these issues. The exercise was described, including how the organization works and variations on the activity. The debriefing process was presented and connected to the characteristics of information. Several historical and recent real world examples, for which there are ample additional sources of information, were provided to add depth to the discussion. Upon completion of the exercise and debriefing, participants should have a deeper understanding of the multiple issues related to good information.

According to Tom (1987), the second half of the 20th century has been a rapid evolution of organizations toward an "information age," where information is "recognized as an important business resource" (p. 4). Organizations have moved from "discovery" in the 1960s to "surprise" in the 1970s to "disillusionment" in the 1980s to "motivation" in the 1990s to "knowledge or dependency" on information and information systems in 2000 and beyond (Tom, 1987, p. 6). Further, information is projected to become an even more important competitive weapon. For an organization to be successful it will need to continually explore and learn how to manage information as a corporate resource (Tom, 1987). During the first four decades management spent most of its time focused on faster

technology, new software tools, and methods for doing rapid development and implementation of information systems. In more recent years, management has turned its focus to information as a resource. The Solutions Diversified Simulation directs future information systems professionals' and future managers' attention to the issue of thinking about information as an organization resource. For example during one of the debriefing session, the second author asked the question, What if we automated the current information system? Would that help?" After a brief moment of silence, the president responded, "No! I would just get the wrong information faster. We would first need to decide what information each unit needed and what information I need. Only then should we automate the system." And so, Solutions Diversified had made its point. It is the information that we, as organizational members, must focus on first.

Drucker (1990, p. 76) stated: "We will have to learn, before understanding any task, to first ask the question, 'What information do I need, and in what form, and when.'" We should begin thinking about the delivery system for the information only when this is clear.

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7. ENDNOTES

[1] This exercise works best in locations with moveable work areas and desks, but it has been successfully used in locations with fixed desks and in tiered classrooms. These constraints can be used to stimulate discussion during the debriefing.

[2] The first author prefers the random approach, where the participants select their seats, meaning their roles for the exercise, upon arrival to the exercise session. This means that the participants have little advance knowledge of the exercise. The work spaces have already been arranged and the organization and position descriptions have been placed at the appropriate locations. The second author has used both approaches but has found that in an undergraduate Introductory Management class when discussing the significance of information that the assigned role method works best. By assigning the roles, the participants can't use the excuse that they didn't understand their responsibilities as the reason the data and information gets confounded.

[3] All materials described in the exercise are available from the authors upon request. Suggestions and information on how to construct your own materials are also available.

[4] You can contact either of the authors for additional examples and references.

[5] This was calculated using the GDP Price Deflator index found at www.economagic.com. A First Quarter, 1966, value of 24.13 would be 110.13 in First Quarter, 2002. This yields a 4.559 multiplication factor. In other words, it costs 4.559 times as much in 2002 dollars and it did for an equivalent valuation in 1966 dollars. Therefore, $150 million * 4.559 = $ 683.85 million, or more than $650 million in 2002 dollars.

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APPENDIX 1
Role Descriptions

President: You are the President of Solutions Diversified, Inc., a company in the problem solving business. The company's profit depends on the efficiency of generating accurate solutions, so you should be concerned about productivity as measured by correct solutions generated per hour. Your company is formally structured as shown in the organization chart.

Inventory Control: Your job is to maintain inventories of raw material (math problems and connect-the-dot line puzzles) and finished goods. The math problems come in packs of 12, which you should issue on request from SolTech. Connect-the-dot puzzles come in packs of 10, which you should issue on request from SolGraphics. Quality Control and SolArt will turn in completed math problems and completed connect-the-dot puzzles respectively for finished goods inventory. Lo all inventory transaction on the attached form. Forward the form to the President after every 20 minutes.

Quality Control: Your job is to check the accuracy of math problem solutions completed by SolTech. Since it is more economical in to test in batches, the facilitators will provide you with the correct solutions only after you have collected a set of 10 completed problems from SolTech. Forward only those problems with correct solutions to Inventory Control for shipping. Retain problems with incorrect solutions in your file for future reference. Report the number of rejects (incorrect solutions) to the President every 20 minutes using the attached report forms.

SolTech: Your job is to correctly solve as man math problems as possible. You may draw problems from Inventory Control in packages of 12. Forward completed problems to Quality Control. Every 10 minutes, report to the President on how many completed problems you have sent to Quality Control. Use the attached report forms for these reports.

SolGraph: Your job is to complete as many line drawings as possible. You may obtain projects from inventory control in packages of 10. You complete drawings by connecting the dots in numerical sequence. (On approximately one project in five you should expect to make an error by skipping a dot or otherwise connecting dots out of sequence. Do not reveal this error rate unless the President or Quality Control asks for it. Do not change the error rate unless the facilitator tells you to.) Forward line drawings to SolArt as you complete them.

SolArt: Your job is to finish any line drawings you receive from SolGraphics by applying three colors to each drawing. The choice of specific colors is up to you. (Approximately one drawing in five that you receive from SolGraphics will be incorrectly drawn in that the dots will be connected out of sequence. Color these drawings anyway. In addition, on approximately one of five drawings (not necessarily the one received in error), you should use two or four colors instead of the correct three. Do not reveal either of these error rates unless the President or Quality Control asks for it. Do not change your error rate unless the facilitator tells you to.) Forward completed projects to Inventory Control.

APPENDIX 2

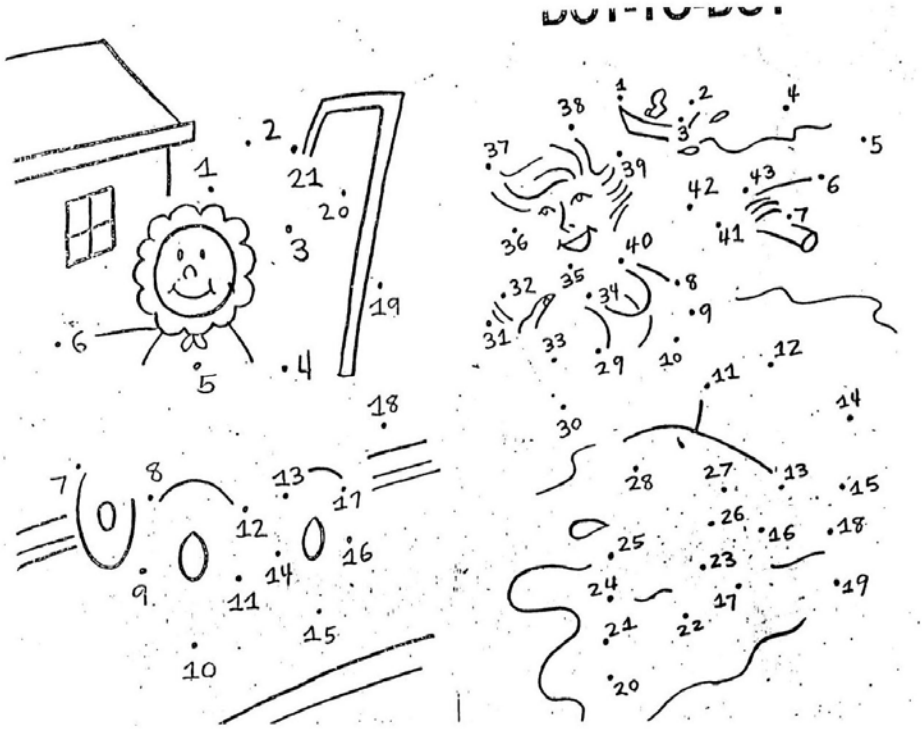
APPENDIX 2A – Sample Problems from SolTech

How many positive integers greater than 1 and less than 105 are factors of 105?

A carpenter worked alone for 1 day on a job that would take him 6 more days to finish. He and another carpenter completed the job in 4 more days. How many days would it have taken the second carpenter to do the complete job working alone?

When $x^3 - 2x^2 + Cx + 9$ is divided by x - 2, the remainder is 3. Find the value of C.

APPENDIX 2B – Sample Dot-to-Dot Line Drawings



The two connect-the-dot line drawings have been shrunk to fit within the Exhibit space. When running the exercise, Exhibit 2B would be in landscape orientation on a standard 8.5" * 11" piece of paper.

Note the background clutter or noise (i.e., the extra dots, smudges, and phantom lines) that has appeared in this reproduction of a connect-the-dot line drawing. Also note at the top of the right side drawing the chopped words. These are examples of the degradation that can occur as copies are made of copies, and can be a useful bit of realism added to the exercise.

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