

Flowcharting with Excel

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Focus on the Classroom

Abstract:

In this article we present a method for teaching the art of flowcharting to graduate and undergraduate business students using Microsoft Excel. Although the focus is on the academic environment, several aspects of the discussion are relevant for corporate trainers and novice flowcharters. The approach used is to treat flowcharting as a graphical language, complete with its own vocabulary and syntax. A number of practical suggestions and cautions are offered to enhance the legibility and communicative power of the tool. In addition, several extensions are offered to allow customization of individual process maps to the specific needs of a particular application.

Keywords:

Process Mapping, Service Blueprinting, Process Analysis, Process Reengineering

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Introduction:

An old adage holds that “a picture is worth a thousand words.” It should then come as no surprise that one of the most useful tools for analyzing operational processes is the flowchart – a simple picture of the stream of work and information. This graphical tool can easily be customized to support business process reengineering, document processes for training and quality manuals, or illustrate the interaction of cross-functional teams. Perhaps as a consequence of their versatility, flowcharts appear under many names – including process maps, service blueprints, and block diagrams. Yet regardless of the label, the power of this humble tool is its chameleon-like potential to fit the task at hand.

Many excellent texts describe the use of flowcharts in process analysis. Both Galloway (1994) and Damelio (1996) provide a relatively straightforward treatment of the subject, while Harrington (1991) and Roberts (1994) provide a more extensive discussion. Our intention here is not to replicate this analysis, but to focus on the creative process itself – the art of flowcharting. This note outlines the process used in our classrooms to teach both graduate and undergraduate business students how to create and capture process maps on a digital canvas with Microsoft Excel.

The Initial Draft:

Although software is required to generate a professional-caliber graphic, we highly recommend manufacturing the initial draft by hand. We make this

recommendation because most processes worthy of flowcharting are sufficiently complex to require input from a team of analysts or process experts. Indeed, a common goal of flowcharting is to develop a common understanding among affected personnel of the flow of work and information related to a particular process. When multiple participants attempt to generate a flowchart directly on the computer, the result is a team huddle around the terminal. In addition to the highly questionable ergonomics, the keyboard operator serves as both a filter and a bottleneck to the free flow of information – inhibiting the desired team dynamic and exchange of perspectives. Even when a map author is working alone, the limitations of even the largest computer display make it difficult to step back and consider the big picture. In a flowchart of even modest complexity, only a small portion of the graphic will be visible on the screen at any given time in normal view – and in a full-page view, legibility is sacrificed.

The necessary spirit of inquiry is also hindered if the process moves too quickly to a formal document. The flowcharting process is inherently messy. Forgotten tasks need to be inserted, side paths explored, and logical dead-ends tied back into the main flow of work. Our experience indicates that good initial drafts emerge from chaotic environments. Although we don't claim to understand the psychology, novice operators appear intolerant of multiple revisions to their computer-generated charts. As a result, we recommend capturing the chart digitally only in its final, or near final, version to formally document the current state of knowledge and facilitate sharing the chart through written reports, presentations, or intranets.

Paper & Post-It Notes[®]:

The material of choice for initial drafts include either a wide roll of brown wrapping paper or flip chart pads and square Post-It Notes[®] (or the generic equivalent). The large paper serves as the working surface and can be rolled up at the end of the session to facilitate storage or transport. The Post-It Notes[®] are used to represent the individual steps in the process. Their weak adhesive allows them to be readily moved and reoriented as the process map develops. While the notes are generally secure when the map is rolled up, caution should be used to avoid dislodging the notes when unrolling the map to begin work anew. In the later stages of development, it may become advisable to secure the notes to the paper with a stronger adhesive tape.

Beginning Vocabulary:

Flowcharting is perhaps best approached as a graphical language. It is designed to illustrate complex relationships through simple visual cues. Thus, an appropriate starting point is to learn the pictorial alphabet of flowcharting symbols. However, this task is complicated by the fact that industrial engineers, software programmers and many business disciplines have independently developed their own unique symbolic vocabularies. To add to the confusion, there are literally thousands of proprietary symbols in flowcharting software packages available on the market today. As a consequence, we recommend a very limited vocabulary in the initial stages of development. This enables us to share our flowcharts across multiple disciplines and with non-team members without the need for lengthy explanations or glossary of symbols.

In the beginning, we recommend limiting the vocabulary to two symbols – a square, representing a process step and a diamond, representing a decision point. As Figure 1 illustrates, these two symbols are readily achieved using our Post-It Notes[®]. In the case of a process step, a short description of the operation is written horizontally within the note. In the case of a decision, a brief description of the assessment to be made is written at a forty-five degree angle within the note.

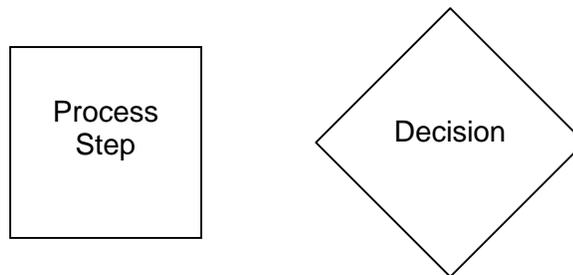


Figure 1

Two comments are worth mention in the use of these two symbols. First, the narrative description should be kept to a bare minimum. Flowcharting is intended to be a visual language – not a method of formatting paragraphs. The audience should be able to glance at each symbol and capture its meaning. Second, decision diamonds are reserved for steps that create a divergence or branch in the flow of work or information through the process. The rationale for this reservation is that we are using the flowchart to analyze the process, not the design of individual tasks. As a consequence, each diamond should have a minimum of two exiting flows. In our experience, the most common mistake made by novice flowcharters is to represent a process step that does not impact the process flow as a decision. While the job design of that particular task may require an exercise of judgment, the underlying nature of the task should be ignored unless it gives rise to a divergence in the flow of work.

Syntax:

As with every other language, flowcharting requires a syntax – rules for ordering its linguistic elements to create logical phrases and clauses that communicate meaning to the intended audience. In flowcharting, this syntax relies on directional arrows connecting the individual symbols to illustrate the relationship between each step. In general, solid arrows are used to indicate physical work flows and dotted line arrows represent the transfer of information.

In the special case of the arrows exiting decision diamonds, each flow should be clearly labeled. In general, each diamond should be labeled with a simple question, with each exiting arrow representing one of the alternative answers to the question posed. In many cases, arrows might simply be labeled “yes” and “no” or “pass” and “fail.” However, whenever possible we encourage the use of more descriptive – yet still brief – labels. For example, in a manufacturing process, the production flow might diverge into three separate streams as the product enters a packaging area. In this case, the flow might be modeled to enter a decision diamond labeled “package type?” The three exiting arrows might then be labeled “single serving,” “six-pack,” and “carton” (Figure 2). By labeling each arrow as an answer to the question at hand the audience is provided more informative signposts to orient their travel through the map.

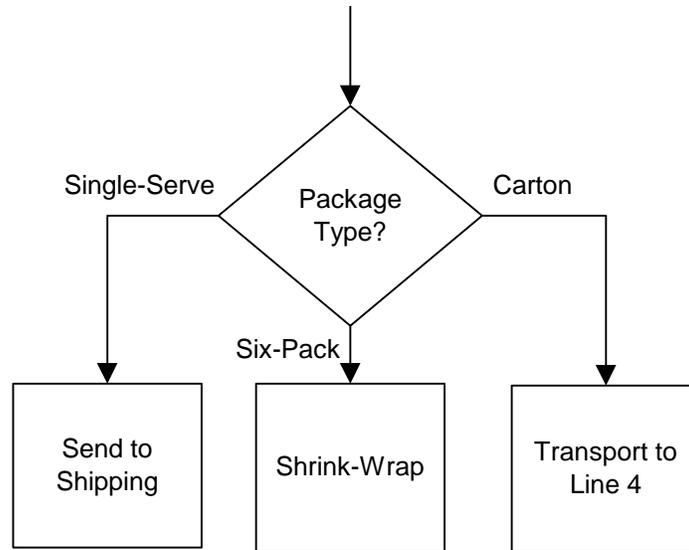


Figure 2

The map author should also attempt to avoid both “spontaneous generation” and logical “cul-de-sacs.” Spontaneous generation occurs when a new flow unexpectedly intersects with the primary flow – requiring the audience to backtrack up the intersecting flow to determine its origin. Similarly, a cul-de-sac often occurs after the primary flow has branched into multiple paths and the author has lost interest in what happens to a secondary flow – abandoning it midstream. Both of these situations disrupt the logical flow under investigation and disorient the audience.

To avoid spontaneous generation it is useful to define an initial input or event of interest – perhaps “order received” or “web site hit.” This initial event may then be defined as a process boundary to signal the audience that whatever came before is of no interest to the current analysis. In a situation with several inputs or initializing events, it may be appropriate to include a fabricated “start” event to provide a common starting point.

To avoid cul-de-sacs, the author should either tie the secondary flow back into the main flow (perhaps at a fictitious “end” task), or if appropriate, define multiple terminal

boundaries. For example, a process might have one flow ending with “purchase declined” and another with “ship UPS.” In any case, secondary flows should be explicitly terminated, not simply abandoned.

In order to visually represent that a step is designated as a boundary, authors may use a unique color or shape of Post-It[®] note or simply draw rounded corners on their existing stock. Later, when the chart is converted to digital form, rectangles with rounded corners (Figure 3) will be used to identify both beginning and ending boundaries.

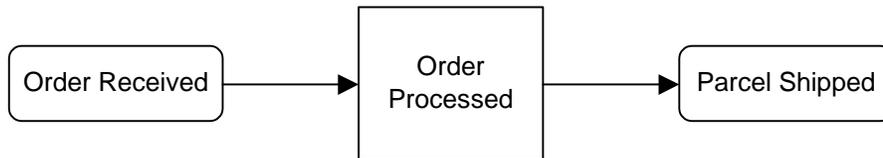


Figure 3

A final grammatical element is the modeling of time. In general, temporal flow should be implicitly represented along either the vertical or horizontal axis. While rework loops are obviously not intended to evoke time travel, maintaining a dominant linear flow throughout the graphic greatly enhances the legibility of the flowchart. In the special case of cycle time analysis it may be beneficial to include an explicit timeline along a chosen axis.

Flowcharting with Excel:

In order to convert our paper chart to digital form, our software of choice is Microsoft Excel. It should be noted that there are a number of relatively inexpensive software packages that are specifically designed for authoring flowcharts. A strong argument can be made that most – if not all – of these software packages outperform

Excel in the fundamental activity of generating flowcharts. However, our choice is not based solely upon the efficiency of the software, but also considers associated transaction costs – particularly those inherent in the academic environment. After spending thousands of dollars on tuition, many students balk at any additional expense for software that receives only limited use in the classroom. Second, by utilizing a general-purpose spreadsheet application, the hassle and expense of securing a site license for in-class demonstration and computer labs is avoided. Further, the widespread availability of spreadsheet software in the post-graduation work environment allows easy application of the new skill. Finally, we've observed a positive side effect – increased familiarity with the drawing functions of Excel boost student confidence and performance with the other capabilities of the software. Although these arguments are directed to academic users, we also believe that corporate trainers and light users of flowcharting software may face comparable incentives.

The Drawing Toolbar:

The primary tools for flowcharting within Excel can be found on the Drawing toolbar. This toolbar is not visible when the spreadsheet application is initially opened with the general default settings. As a result, new users should be shown how to access the toolbar by clicking on View on the main toolbar, then Toolbars, then Drawing, as illustrated in Figure 4.

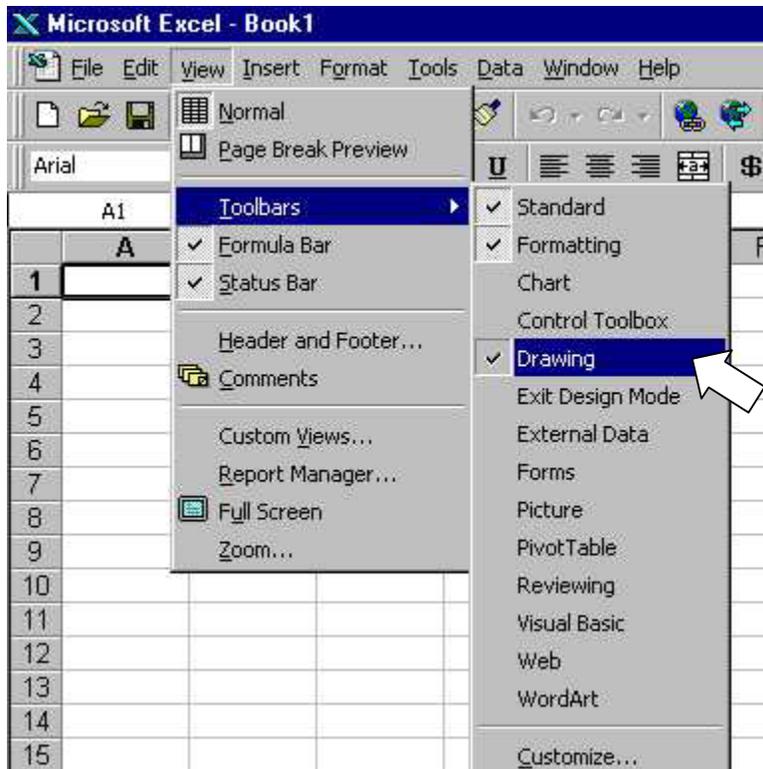


Figure 4

AutoShapes & Connectors:

Access to the basic flowcharting shapes and arrows can be obtained by clicking on the AutoShapes button on the Drawing toolbar as illustrated in Figure 5. Users may note that Excel offers “helpful” hints when the mouse cursor is held over each AutoShape (Figure 5). Novice users should be warned that software engineers programmed these hints and they can be misleading. Many business users will not recognize individual symbols to have the same meaning as that offered by Excel.

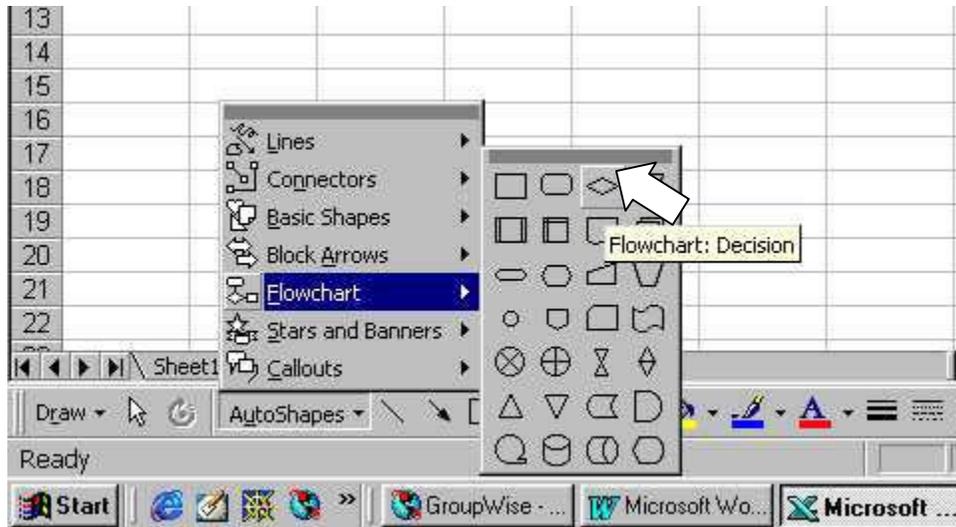


Figure 5

Flowchart authors are strongly encouraged to use the arrowhead Connectors available via the AutoShapes button rather than simple arrows directly available on the Drawing toolbar. By clicking on a Connector and passing the mouse cursor over an AutoShape users will find that small blue squares appear on each side of the AutoShape. By clicking on one of the blue squares, the Connector becomes affixed to the AutoShape. A second click on one of the blue squares of the appropriate downstream AutoShape completes the process. This feature becomes particularly useful when the flowchart is subject to further refinement or amendment. The author only moves one AutoShape and the Connector automatically maintains its connections. Users may also convert a solid arrow Connector to a dotted-line Connector by first using the computer mouse to click on the Connector, and then accessing the line formatting functions of the Drawing toolbar as illustrated in Figure 6.

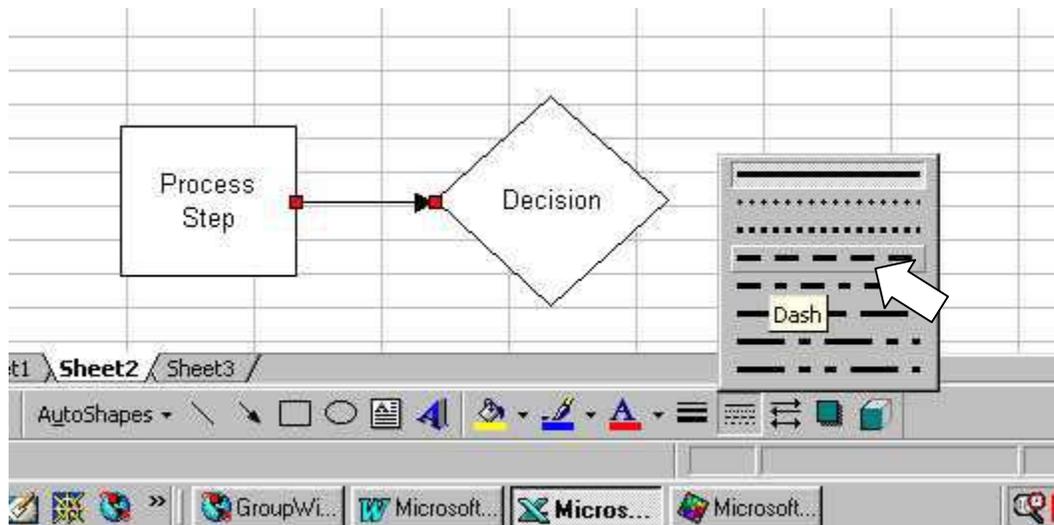


Figure 6

Align & Distribute:

Aligning and distributing individual AutoShapes further enhances the legibility of a flowchart. Related flows should be linearly oriented to each other with the white space between shapes kept relatively consistent throughout the chart. While this may be accomplished manually, the Align and Distribute function available via the Draw button on the Drawing toolbar greatly facilitates the process. The user first right-clicks on one of the AutoShapes to be aligned, then depresses and holds the Shift key down while using the mouse to click on all of the AutoShapes that are to become part of a single linear arrangement. While all of the appropriate AutoShapes remain highlighted, the user then clicks on the Draw button as illustrated in Figure 7. The author may then use the specific alignment and distribution functions as appropriate.

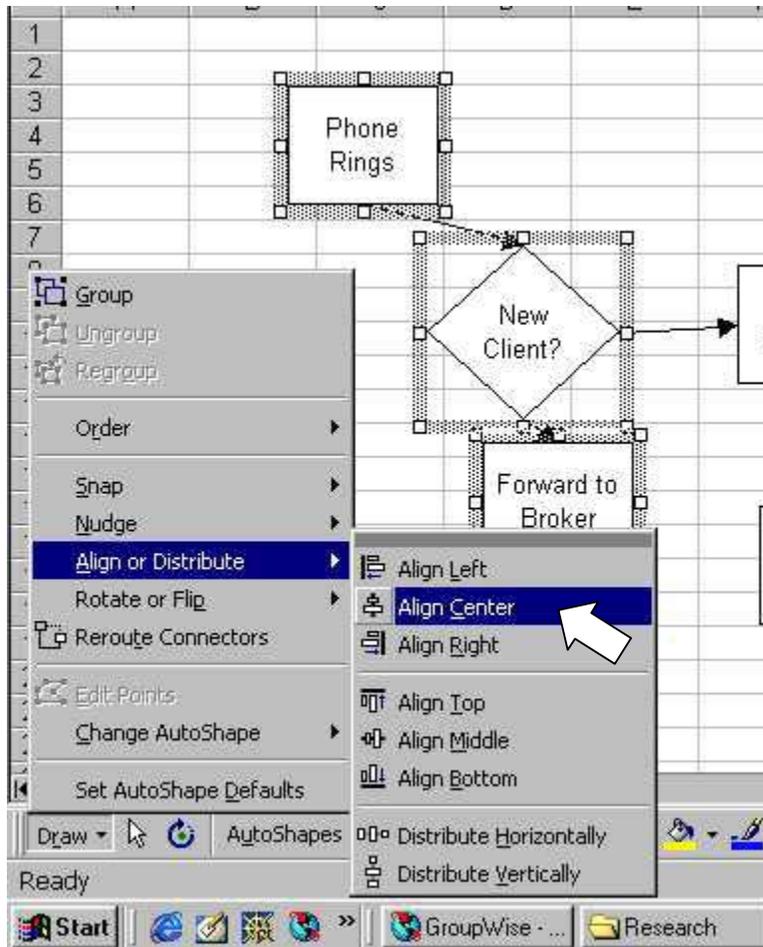


Figure 7

Level of Analysis (Nesting):

Another convention that enhances legibility is to maintain the same level of detail throughout individual charts. Occasionally, it may be appropriate to explore a few steps in greater detail than the remaining items. However, authors should do so cautiously to avoid disorienting the audience. One way to avoid this situation is to provide a consistent level of detail and then signal that a more detailed nested flowchart has also been prepared. This may be accomplished by shadowing the appropriate AutoShape (Damelio, 1996). Shadowing is accomplished by clicking on the appropriate AutoShape, then accessing the Shadow function on the Drawing toolbar as illustrated in Figure 8.

The result is an unobtrusive signal to the audience that there is more information available regarding a particular activity within the larger flowchart.

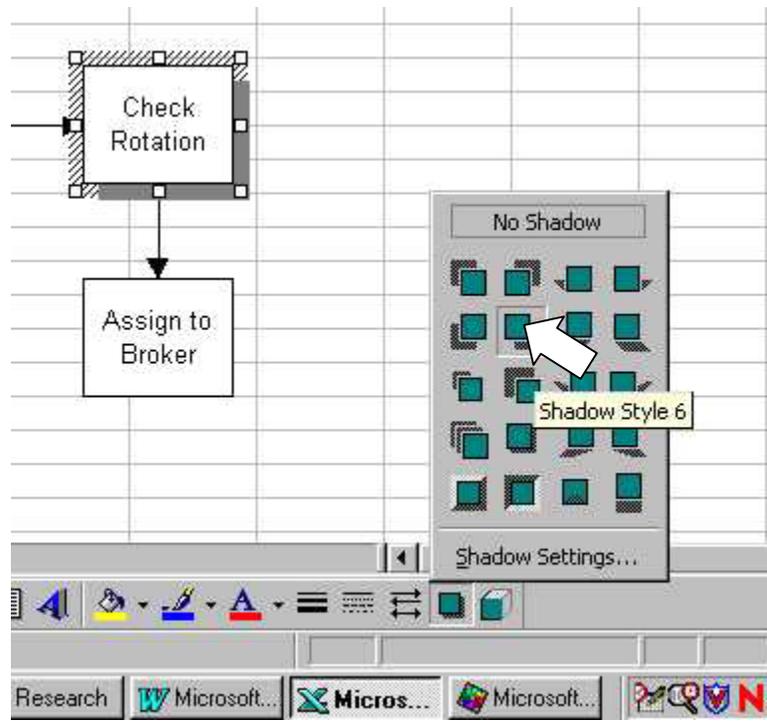


Figure 8

Customization Options:

Depending upon the purpose underlying the creation of the flowchart, it may be appropriate to customize the graphic to distinguish value-added from non-value-added activities, illustrate the shift of responsibility between co-workers, or highlight the visibility of activity to customers. Fortunately, common flowcharting conventions provide the ability to communicate relatively complex abstract concepts, such as these, through simple visual cues.

Value Added versus Non-Value Added Activity:

A focus on eliminating waste in all its forms underlies the just-in-time philosophy of the Toyota Production System developed by Taiichi Ohno and Shigeo Shingo (Hall,

1987). To facilitate analysis, Ohno and Shingo defined seven classes of wastes: overproduction, waiting, transportation, over-engineered designs, inventories, motion, and defective production. Deming (1986) also argued that many inspection activities also constitute unnecessary waste. Four of these classifications are readily transferable to flowcharting – allowing special symbols to be assigned to identify the inherent potential of such tasks to be non-value-added activity. This allows map authors and their audiences to focus special attention on these tasks. Figure 9 illustrates special symbols for transportation, delay, storage, and inspection activities (Harrington, 1991).

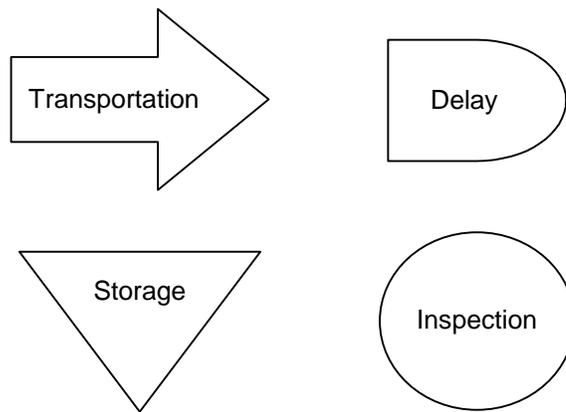


Figure 9

Transportation of goods is generally modeled using a block arrow. In general, this symbol is reserved for significant physical movement or travel. Map authors should keep in mind that the purpose of identifying a task as a transportation activity is to allow the audience to consider alternatives or the possible elimination of the activity. As a consequence, authors should not clutter their chart with block arrows representing minor movements with little potential to enhance the analysis. In any case, authors should recall that the block arrow continues to represent an activity and should not be used to replace connectors, which represent the precedence relationship between activities.

Delays or queues are generally modeled using a blunted rectangle, bullet, or D shaped symbol. This symbol is used when forward movement through the process flow is temporarily delayed. This type of a delay might be due to a busy downstream workstation blocking forward movement – resulting in a queue of work. Alternatively, the delay might be caused by the workstation being starved for a particular input. In either case, the use of the delay symbol emphasizes the temporary nature of the interruption in flow. Once the restricting condition is removed, work is expected to automatically resume.

In contrast, intentional stores and longer-term inventories are modeled as an inverted triangle. Common storage points include raw materials, finished goods, repair parts, or supplies. An inventory or store is distinguished from a delay because an intervening operation is required to call the input out of storage for further processing.

Finally, a large circle is used to signify an inspection or appraisal operation. Examples include using calipers to measure a physical attribute of a product, proofreading a document, or even kicking the tires of a used car. Generally, the input to an inspection activity remains unchanged as it passes through to the next operation. Depending upon the level of detail, the flowchart might simply indicate that an inspection occurs. In more detailed cases, the inspection might be followed by a decision diamond that reveals the divergent paths taken depending upon whether a unit of production passed or failed the inspection. In either case we recommend using the inspection activity to identify the focus of the inspection. In a detailed case, the subsequent decision diamond can be used to define the relevant tolerance limits (Figure 10).

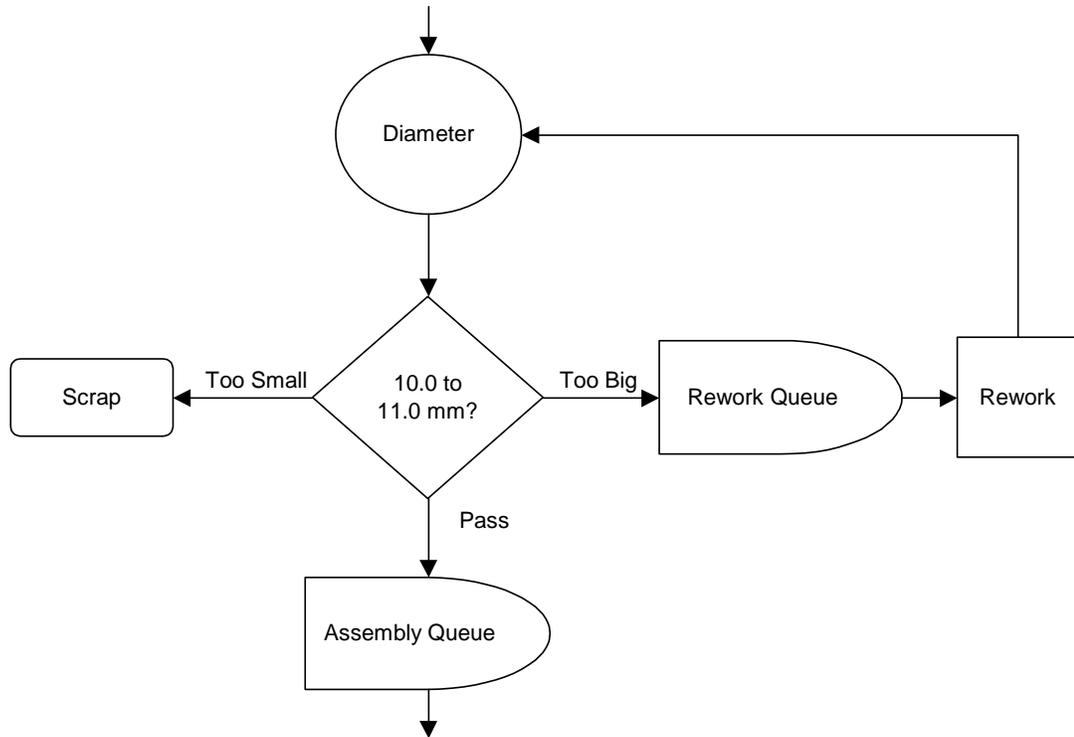


Figure 10

Authors should be cautioned to use the four symbols of Figure 9 carefully. The inherent character of transportation, delay, storage, and inspection merely suggests the potential that the underlying task is non-value-added. Designation of a particular task with one of the above classifications should not be used as a substitute for substantive analysis. In addition, these symbols should only be used if they support the underlying purpose for creating the flowchart. Use of these additional symbols adds visual clutter. As a result, they create the possibility of confusing and distracting the audience. In addition, it cannot be assumed that the audience will automatically understand their meaning. To aid communication, authors must assume the responsibility of either educating the audience or incorporating a glossary of symbols into the report or manual where they plan to publish the flowchart.

Functional Responsibility:

Cross-functional flowcharts are commonly utilized to illustrate the shift in responsibility between co-workers. A functional flowchart utilizes horizontal or vertical bands to represent the scope of responsibility assigned to each worker or department that contributes to the process under analysis. The individual AutoShapes representing tasks assigned to specific workers are then oriented so that they appear within the appropriate band of responsibility. Each time a Connector crosses into a new band, a shift in responsibility occurs. A process analyst may be especially concerned with these cross-functional interfaces because each handoff represents an opportunity for miscommunication or failure to assume accountability. When responsibility for a particular task is assigned to multiple parties, the AutoShape may straddle the relevant bands (this may require some forethought on the way the bands of responsibility are initially laid out). Figure 11 illustrates a simple functional flowchart.

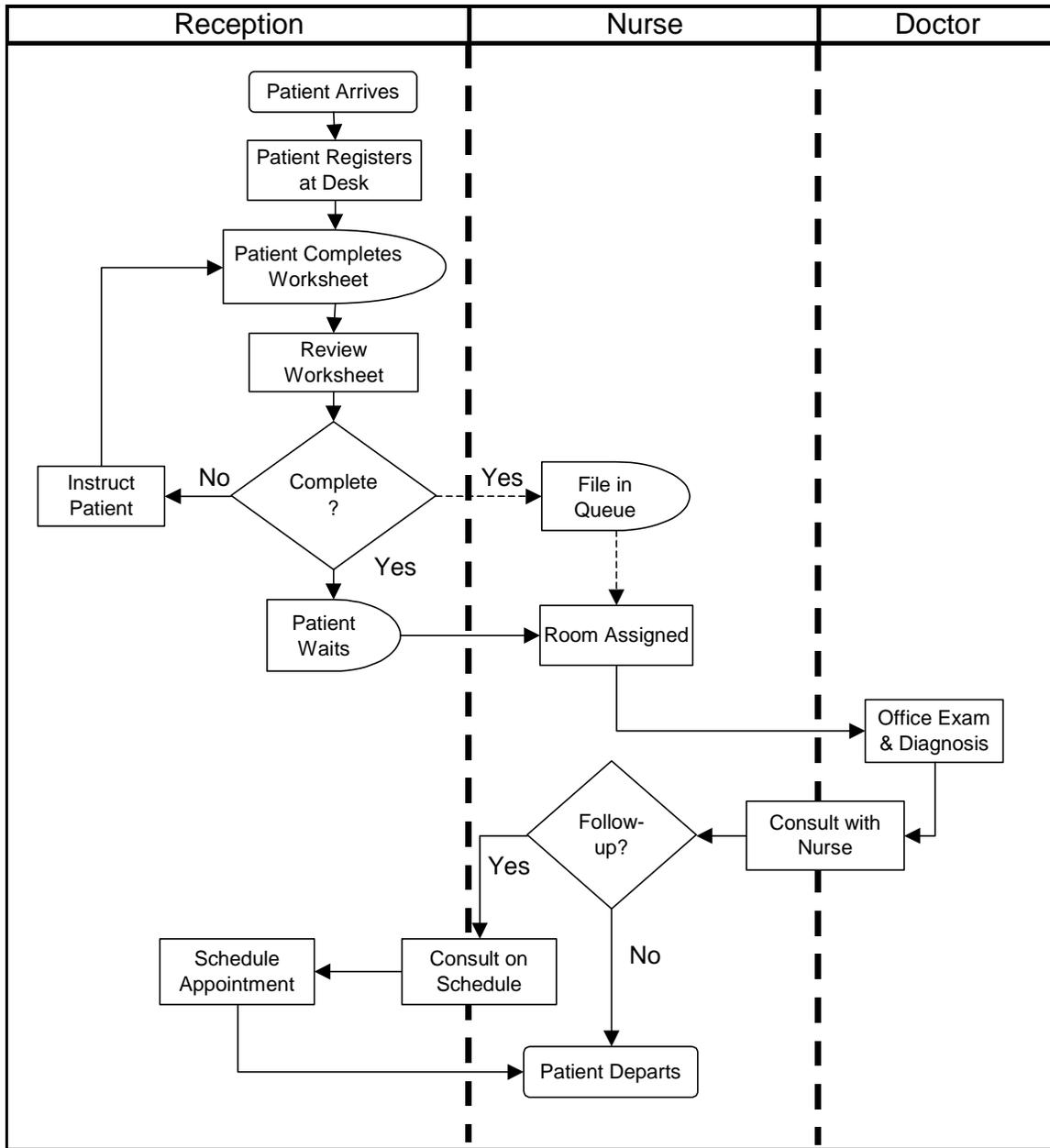


Figure 11

Line of Visibility:

A final customization option is the line of visibility (Anthony & Heskett, 1992). This technique is conceptually similar to a cross-functional flowchart. However, in this case the dotted line represents a division between front and back-office activities. Use of

this technique is particularly appropriate when there are aesthetic concerns and where insurance or health regulations prohibit the physical presence of non-employees. Relevant examples might include processes within an auto repair shop, a butcher shop, or a television studio. Figure 12 illustrates one possible application of the line of visibility.

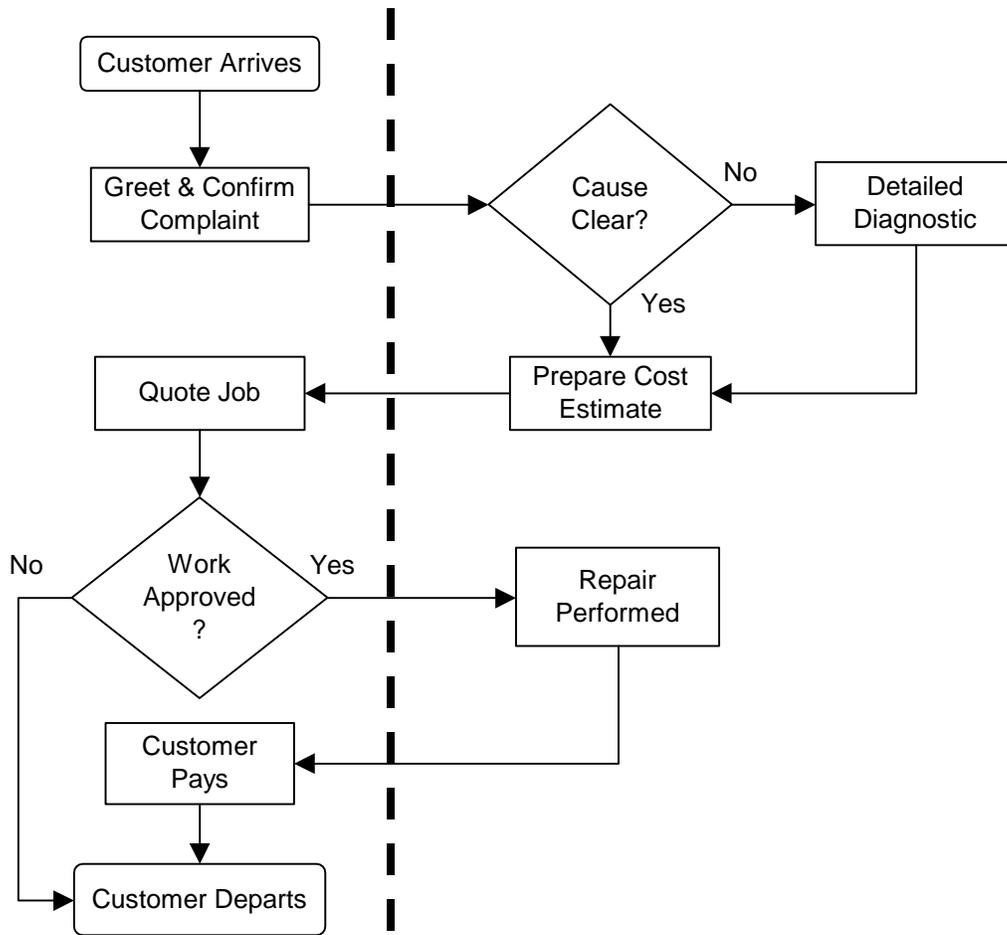


Figure 12

Formatting for Printing:

When the map authors have completed their transfer of the chart to Excel, they should examine their handiwork using the Print Preview icon on the Main toolbar (the icon resembling a sheet of paper and magnifying glass). Frequently, the flowchart will be divided over multiple pages. If printed in this format, the chart may require significant

cutting and pasting to be reunited into a coherent whole. To avoid this, the simplest solution is to go to the Page Setup screen under File on the Main toolbar (Figure 13). Using this screen, the chart can be fitted to one-by-one page or reoriented from portrait to landscape as appropriate.

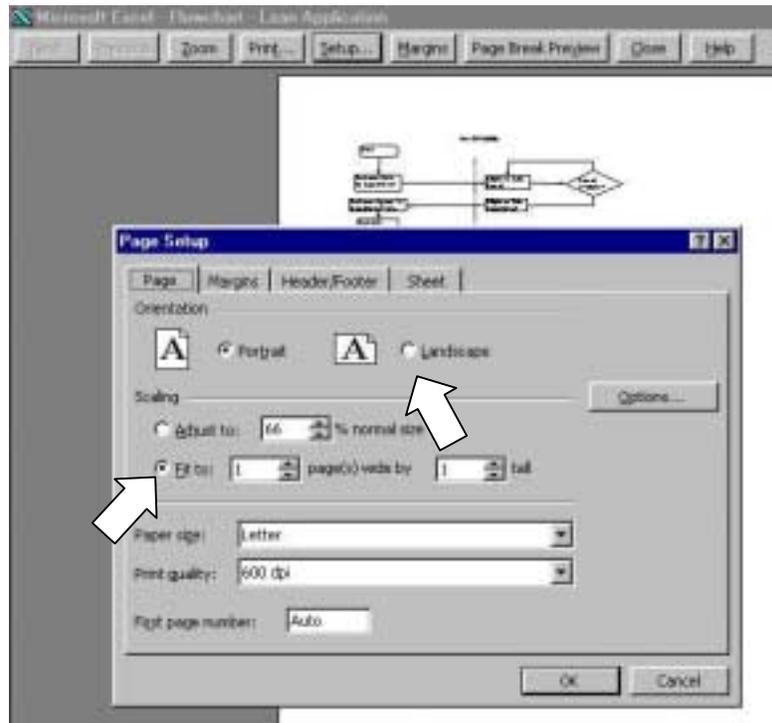


Figure 13

Unfortunately, use of the Page Setup screen to reduce the chart to one-by-one page may result in a font that is too small to be easily legible – reducing the visual impact of the chart. In this case, map authors may wish to use the Page Break Preview under view on the Main toolbar (or the Page Break function under Insert) to manipulate page breaks. However, page breaks should be used sparingly. Authors should make a concerted effort to keep closely related activities on the same page and look for natural divisions within the process under review. In addition, audiences of the chart should not be expected to naturally compensate for the limitations of the tool. The Connectors that

are broken by the page break should be replaced with two connectors running to and from small circles containing the same single capital letter. This cue is intended to communicate to the audience that the flow terminating at point A, resumes on the next page with a duplicated point A (Figure 14). Finally, authors can center their graphics on each page by using the Print Preview function and clicking on the Margins button. This function allows the margins of each page to be directly manipulated using the mouse cursor – allowing the user to nudge the graphic into the center of the page prior to printing a hard copy.

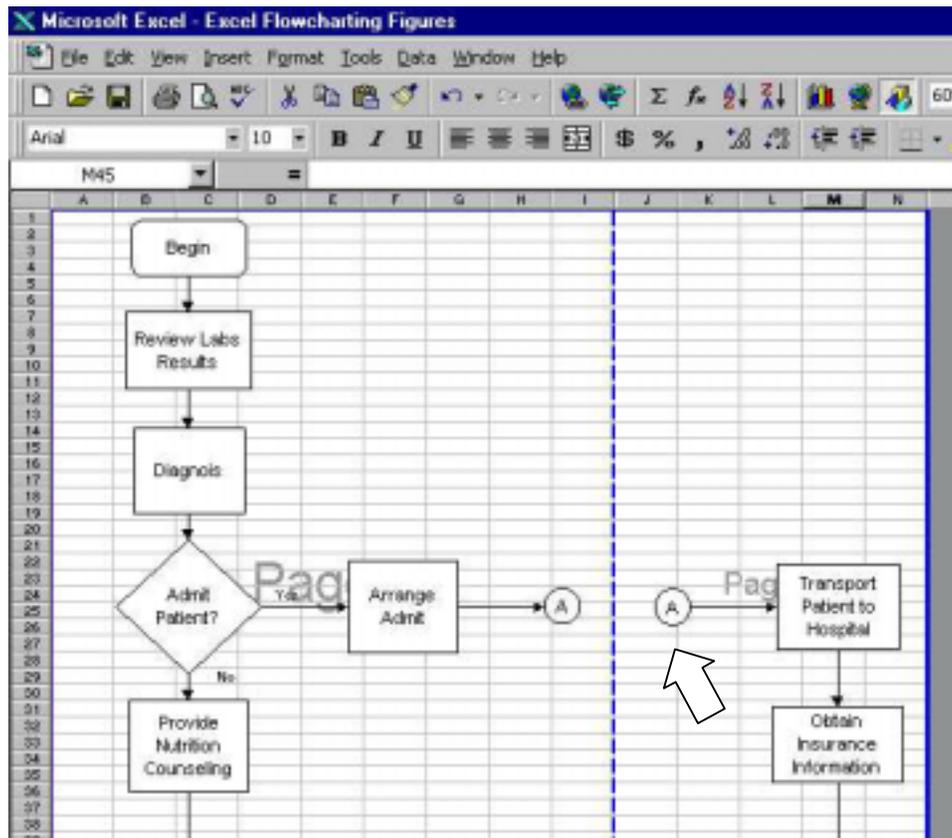


Figure 14

Final Thoughts:

Feedback from our students has been almost universally positive. Their comments suggest that they both enjoy and value the development of their flowcharting talent. As with any skill, immediate application enhances the degree of learning and long-term retention. To facilitate this, we frequently assign the virtual company tours available via www.mhhe.com/pom/ and other web sites to provide practice in developing process maps.

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