Author: **Vizer, Rodney J.**

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STUDENT:

NAME: Rodney Vizer **DATE: 4/24/2018**

ADVISOR: (Committee Chair if MS Plan A or EdS Thesis or Field Project/Problem):

NAME: James Keyes, Ph.D. **DATE: 4/24/2018**

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1. **CMTE MEMBER'S NAME:** **DATE:**
2. **CMTE MEMBER'S NAME:** **DATE:**
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Vizer, Rodney J. ***Operational Integration of CAD Data and the Impact on Organizational Development in a Small Business***

Abstract

The influence that large companies have over small businesses is quickly apparent with the struggle to remain aligned in terms of internal capabilities and allocation of resources. Unfortunately, small businesses are often at the mercy of their larger counterparts with regard to the extent of technological integration with what were once manual and laborious work processes. The cost of such improvements impacts the ability of many small organizations to remain competitive in a market that continually moves forward. One particular method of keeping current with larger competitors is to leverage existing assets to create value added services in other areas of the company. The development of advanced CAD packages, such as SolidWorks, has allowed small businesses to expand in-house resources in a manner that not only supports design and engineering but also operational pieces such as procurement, inventory, and accounting and finance. This is only a small facet of the true power that CAD has within a company, as the software reaches and extends deeper into several aspects of organizational development and improvement in the way it positively impacts various departments.

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Chapter I: Introduction

Company XYZ, name has been changed to protect confidential information, a local systems integrator, is a small operation with nine employees and is located in Burnsville, Minnesota. The company designs, manufactures, and supports environmental remediation equipment and industrial control systems for treatment of soil, ground water, and air contamination. Company XYZ creates products tailored to particular client specifications, including some custom applications such as mobile decontamination units.

Since entering the environmental remediation market in 1988, Company XYZ grew steadily as they established clients throughout the United States. Along with normal challenges growing companies face, Company XYZ also experienced increasing customer requirements related to the discovery of new remediation methods and technology, more stringent government and industry-wide standards, and the need for increased turnaround on short notice. However, a lack of sufficient software applications would not readily accommodate such demand. To make matters worse, dated processes and procedures complicated issues to the extent production was delayed significantly.

While business opportunities increased over time, access to modern computing solutions did not follow suit. Rework increased, inventory went grossly under controlled, quality concerns were not closely monitored, costs spiked, and operational efficiency suffered. A growing need for cohesiveness became obvious as many employees failed to establish and maintain common work practices and documentation.

With the advent of complex computer-aided design (CAD) programs, such as SolidWorks, small businesses have had the opportunity to invest time and money in one software package that is able to fulfill many interdepartmental needs. Without access to capital and cash flow that many larger corporations have at their disposal, small businesses such as Company XYZ must be selective with where to invest economic resources. SolidWorks provides a single solution to address many organizational demands including cost analysis, production planning, inventory control, quality control, standardization, document management, materials management, process management, and the support of a quality management system.

As an integrator, Company XYZ selects particular equipment to meet client specifications, and those components are ultimately expressed in a bill of materials (BOM). The bill of materials historically served as a guideline to help determine costs, necessary materials, work processes, and time required to complete and deliver a system for installation in the field at the time of client quotation. Engineering was responsible for creation of the bill of materials and, consequently, for much of the operational planning that occurred. Without software to assist with enterprise resource planning (ERP), material requirements planning (MRP), or a formal quality management system (QMS), the bill of materials was an essential tool at several levels. Company XYZ determined the best course of action was to seek a single solution to address the most immediate business needs, and this was accomplished by purchasing SolidWorks. Since a significant relationship exists between a bill of materials and SolidWorks, and this relationship can be further expanded due to compatibility with other common software and the use of tags within the bill of materials, SolidWorks was considered an ideal choice to invest in and develop a new system for driving the company.

SolidWorks is a three-dimensional computer-aided design program that is used to create solid geometry and assemblies to solve design and engineering challenges. However, the software is also an effective tool for analysis (SolidWorks Simulation), automation (DriveWorks), and data management (PDM Professional). The package has other capabilities such as graphical support via Photoview 360 and Animator, which can be used for marketing purposes or to provide additional documentation to further support internal or external stakeholders. There are file converters to add increased compatibility with other platforms, in addition to Toolbox and 3D Content Central which allow access to supplier-manufactured products. This improves accuracy of designs, increases time to market, and provides a direct link to several vendors.

Probably the most underutilized and unnoticed aspect of SolidWorks is the use of macros to automate rudimentary processes. This is where the software truly excels and benefits a business. Macros are essentially sets of instructions that automate common tasks, and since SolidWorks is compatible with Microsoft Office products this added element can be leveraged to benefit several departments at any given time.

Company XYZ struggled to incorporate modern software tools and applications over the course of time, to remain competitive in their industry, and it is easy to understand the impact of SolidWorks within the organization and how quickly it affected the bottom line. Although only in its infancy, this advanced computer-aided design application has already changed the way Company XYZ does business.

Statement of the Problem

A lack of modern software applications at Company XYZ increased costs and waste and decreased consistency, quality, and on-time deliveries. The lack of cash flow had a negative impact on supplier relationships, employees were frustrated by a lack of work instructions, and clients threatened to take their business elsewhere.

Purpose of the Study

This study analyzed existing software applications that were being used for data management, procurement of materials, and production planning. SolidWorks was added to the business to assist with streamlining workflow to provide greater support to most internal and external stakeholders. Company XYZ wanted to increase overall collaboration and be able to share data throughout the organization using a single platform while avoiding costs associated with purchasing several different applications to perform the same function.

Company XYZ believed decreasing costs rested upon the successful integration of a single piece of software with various other software applications already being used to manage data, materials, and production. Combining old and new technology curbed some of the financial impact until the business was able to absorb additional expenses at a later date. SolidWorks was selected primarily because of its close relationship with Microsoft-based products, such as Excel, as this ensured compatibility with those resources.

Company XYZ wanted to improve upon current processes by focusing on successful bill of materials management and using lessons learned to improve their creation. Beginning with the heart of the organization, SolidWorks provided an immediate upgrade to the engineering department. SolidWorks was able to assist with bill of materials management, and Company XYZ quickly noticed how the data captured within that computer-aided design application could be used in several ways to speed up various internal processes.

Company XYZ understood that the study intended to result in improved organizational effectiveness, customer satisfaction, lead-time, and profitability while also decreasing costs and waste. However, nearly a decade of stagnancy, with regard to lack of improvements, would require additional time for effects of the study to significantly impact company goals.

Assumptions of the Study

There were several assumptions for this study, but probably the most significant was whether or not Company XYZ gained buy-in from all stakeholders involved. Not all employees were cooperative because they had become set in their ways. Change was a difficult obligation for some due to the uncomfortable nature of performing tasks in a different manner than they were accustomed. While most were happy to try a new way of doing things, others were not quite so flexible. In order to properly assess effectiveness of a new system, it was crucial that employees adhered to common work processes and procedures and followed work instructions associated with their tasks.

The second assumption was that data would be properly captured and reported using guidelines that were established for the study. The work environment did not previously require the type of structure necessary to ensure workers followed guidelines, as most did what they felt was required to complete their tasks. The study meant employees had to properly document information that was critical to assess effectiveness, and sometimes information was not recorded.

The next assumption required other changes not be made during the time period the study was conducted. Since the company had not made significant changes in prior years leading up to the study, this was not initially a concern. However, employees were still notified that they were not to make adjustments or changes without first asking for management approval before doing so. Ultimately, the study relied on workers fully complying with this requirement.

Another assumption was that all employees had the same resources available for use, and this includes computer software. Only a single seat of SolidWorks was purchased, and only one employee had formal training. Furthermore, most employees used different software on their computers, as they each performed tasks relevant to their role in the organization. There was simply no way to ensure everyone had access to the same software without incurring a large expense to Company XYZ. However, the purpose of this study was to utilize SolidWorks in a manner that eliminated this division of resources, so it was understood that there would be obstacles along the way.

Finally, executive leadership needed to be actively involved in the study. This was necessary to gain buy-in and compliance from employees and also to remove road blocks that occurred. It was the responsibility of leaders to drive change in the organization, and they needed to help steer the direction of the business for goals to be successful.

Definition of Terms

Several terms were used frequently or deemed significant to this study. The following definitions are provided for clarification:

Bill of materials. A list of all parts required in a finished product. It is represented by a tree structure depicting necessary components or materials (Vegetti, Henning, & Leone, 2002).

Computer-aided design. Use of computers to create, modify, analyze, or optimize a design (Groover & Zimmers, 1984).

Enterprise resource planning. Information system used to integrate and optimize processes and transactions (Moon, 2007).

Macro. Programming that automates common tasks (Etheridge, 2010).

Material requirements planning. Planning logic for purchasing materials only as required for work to be completed (Ptak, 1991).

Quality management system. The integration of processes involving people, technology, equipment, materials, and work environment (Hoyle, Thompson, & Ebrary Inc., 2002).

Limitations of the Study

There were several limitations for this study, the first of which involved compliance. Employees did not always fully comply with the requirements of the study, but this was not addressed as it was outside of my work scope to assess consequences for not doing so. This function was the responsibility of executive leadership, as this commitment was made prior to starting the study.

A second limitation was the lack of access to employees, documents, or sensitive data. The company had sole discretion as to whether or not to grant use of staff or documentation to assist with the study and decided the some things were not required to assess effectiveness.

The study focused on SolidWorks and did not assess other software and the impact that alternative applications may have had on employees or Company XYZ. Leadership felt the key was to focus on one application to address gaps in several departments. Therefore, study examined the benefits of computer-aided design implementation relative to its impact on other software applications and interdepartmental needs.

Next, the study focused only on Company XYZ. While other businesses may have experienced varying results or benefits from similar studies, Company XYZ was only concerned with its own experience and the impact with the organization itself.

Finally, data collected was limited to dates within January and April, 2017. This time constraint had an impact on the amount of data collected and ability for a complete investigation into root causes of systemic problems throughout Company XYZ. Furthermore, not all potential benefits of SolidWorks could be examined, so the primary focus for this study was the use of a tagging system within the software to improve documentation, planning, and quality control.

Methodology

A literature review was used to examine the principles of organizational development and determine opportunities to positively impact cost savings, procedure and process creation, consistency, quality, and on-time deliveries.

SolidWorks was used to add procedures and work instructions to drawings and documentation, and employees assisted with revisions. The bill of materials for projects were updated to include tag numbers, and these tag numbers were used in drawings and purchase orders to link information such as the supplier, manufacturer part number, material, and quantity to the location used within a given assembly or system. Data related to rework, scrap, order accuracy, late deliveries, customer satisfaction, and supplier payment performance was collected throughout the study and compared to historical figures to gauge effectiveness of the plan and how it affected changes necessary for growth.

Finally, standardization was put in place during the course of the study through notes on drawings and within other engineering documentation. This was significant to ensure greater consistency over time and control the work environment in ways that encouraged collaboration and common work techniques.

Summary

In a world focused on continual change and improvement, small businesses often suffer from an inability to maintain new software applications and systems that facilitate growth necessary to remain competitive in their market. However, a little planning and creativity can go a long way in utilizing limited resources to their fullest advantage.

SolidWorks is an industry leader in design and engineering software applications, more specifically those computer-aided design based platforms that offer compatibility with software targeting operational aspects of a business. This seamless integration between SolidWorks and other pieces of software establishes a cost-effective solution for organizations with little funding available for annual upgrades larger corporations may perform.

Company XYZ was able to initiate change and growth through implementation of SolidWorks and a tagging system which increased efficiency and productivity, established processes and procedures, improved on-time deliveries, and decreased operational costs associated with rework, scrap, and ineffective use of time.

Chapter II of this paper presents a literature review that focused on concepts of successful SolidWorks integration and the impact on consistency, quality, customer satisfaction, and profitability. The ability of SolidWorks to act as a single solution without the need for complex enterprise resource planning, material requirements planning, or quality-focused software, in addition to bill of materials management outlining specific client requirements, was also examined. Finally, the significance that macros play in developing solutions that increase productivity and efficiency, especially those related to SolidWorks, was reviewed.

Chapter II: Literature Review

Company XYZ experienced increased costs and waste and decreased consistency, quality, and on-time deliveries that resulted primarily from a lack of advanced software applications. The organization wanted to mend supplier relationships through improved cost and financial management, provide increased support to employees via enhanced documentation, and prevent the loss of clients by prioritizing tasks and decreasing steps in workflow. This literature review analyzed SolidWorks and the reasons it was effective in solving several key issues that hampered efforts to improve materials management, productivity, and efficiency. In addition, literature related to quality management systems was reviewed to provide insight into organizational development practices and how they were used to assist with integration of software and new work practices in a manufacturing environment.

Computer-Aided Design

Computer-Aided Design is an engineering technique that utilizes a computer system in the design process. This technique has two main components: computer graphics that assist with visual layout and representation in the form of drawings and application programs to support engineering functions such as stress-strain analysis, dynamic response between mechanisms, and heat-transfer calculations (Groover & Zimmers, 1984). In recent years, Computer-Aided Design software has been developed as a single package to perform operations that once required separate application programs. This equates into time and cost reduction and further eliminates duplication of efforts and human error while also avoiding data exchange incompatibility (Pan, Wang, Teng, & Cao, 2016). Design activities may be completed, and process plans for manufacture of products created, through the use of Computer-Aided Design software by specifying a sequence of production operations required (Groover & Zimmers, 1984).

SolidWorks. The accessibility of Computer-Aided Design data throughout an organization is critical, and the ability of different pieces of software to communicate with one another is part of the solution. The relationship between SolidWorks and Microsoft is one that allows for increased productivity and accessibility without compromising performance (Stackpole & Lynch, 2007). Additionally, SolidWorks employs its own application, eDrawings, which enables users to share compact files containing Computer-Aided Design information without the need for entire software packages (Lang, 2004). Workflow is important, and since companies often outsource or operate from several global locations SolidWorks provides the ability to share information and ensure up-to-date files throughout the company via Product Data Management (Allen, 2007).

Bill of materials. SolidWorks PDMWorks Enterprise is a Product Data Management add-on which also enhances Bill of Material capabilities, and this is due to the software's "ability to create, manage, and share Bill-of-Material information throughout the organization" (Allen, 2007, p. 1). A Bill of Material can be made to display different data sets to various organizational departments and reduce manual data entry and errors. At the same time, any changes that occur are reflected in PDF versions of engineering drawings throughout the company network (Koliha, 2006). Even greater tools have been created to track files using a check-in, check-out system that controls revision history and only allows one user at a time to edit the same document (Ames, 2001). This is important in maintaining the integrity of a Bill of Material for any given product or system. As product customization continues to grow, the need for a complex Bill of Material to solve production management issues such as material requirement planning, enterprise requirements planning, and manufacturing resource planning is critical to compete in a market now driven by technology (Vegetti, Henning, & Leone, 2012).

Macros. Macros are used to automate routine tasks and reduce the number of steps in any given operation within software (Etheridge, 2010). This is true of operations within Computer-Aided Design software, including SolidWorks. Often created using programming language such as Visual Basic for Applications, macros reduce product development time and interconnect common office software with engineering tools to assist with creation of mechanical drawings, Bill of Materials, and three-dimensional models (Tzotzis, Garcia-Hernandez, Huertas-Talon, Tzetzis, & Kyratsis, 2017). The commonality of Visual Basic for Applications, and the relationship of Visual Basic for Applications between Microsoft Excel and SolidWorks, makes it easy to find programmers that can create macros which in turn help manage complexity and reduce programming time from hours to minutes (Danford, 2012).

Computer-Aided Design, Operations, and Organizational Development

Many of the products, assemblies, and systems today are made-to-order, and several changes that occur throughout the manufacturing process begin with computer-aided design and affect technical documents, bill of materials, and assembly instructions (Brown, 2004). Computer-Aided Design is important as a communication tool within organizations, and this sometimes occurs in the form of piping and instrumentation diagrams, process flow diagrams, and block flow diagrams which relay information between engineering, production, management personnel, and the client (Nasby, 2012). Computer-Aided Design applications may also contain workflow tools that manage repetitive tasks and automate internal processes such as engineering change orders, document revision, and document review that control who gets what and when (Brown, 2004).

Advantages and Disadvantages of Technology

Technological investments, though often necessary for improvement, can be accepted or rejected by employees due to perceived usefulness and ease of use in addition to other factors such as user involvement in the process, software type, implementation uncertainty, and worker beliefs and attitudes (Davis, Bagozzi, & Warshaw, 1989). According to Kemp et al. (2014), technology is valuable to increase accessibility and availability of information, but over-reliance can result in the loss of skills in other areas. Proper management of technological resources, namely computers and software, is necessary to prevent negative consequences (Kempt et al., 2014). Quality of technology given to employees is related to the customer experience a business can provide and also to a collaborative work environment; those who keep up with trends will be more competitive (Medforth, 2016). Computer-Aided Design technology improves communication and storage of ideas and design intent for manufacturing and office personnel but removes the user from machines and manufacturing processes on the shop floor, and success or failure depends upon the skill set of the designer (Adler & Winograd, 1992).

Compatibility Issues

Many companies continue to use two-dimensional Computer-Aided Design software, as there remains an apprehensiveness to migrate from the familiar to the unfamiliar, and this creates a divide between businesses with regard to use of two-dimensional and three-dimensional programs (Goode, 2002). The matter is further complicated through the sheer number of applications available to engineers. Interoperability is increasingly challenging as the tools employees use vary from one organization to another or one industry to another (Costlow, 2007). While universal file formats are available, many designers prefer native files to prevent loss of inherent data (Costlow, 2007). The integration of Computer-Aided Design and Enterprise

Resource Planning can be difficult, since sometimes a part created via Computer-Aided Design software is interpreted by Enterprise Resource Planning software as both a part and a Bill of Material (Gould, 2012). According to Green (2005), the wide range of file and data types, in addition to platforms available for use, require careful planning that mandates specific procedures for managing all systems in use.

Planning for the Future

Computer-Aided Process Planning allows process planners the ability to integrate Computer-Aided Design and Computer-Aided Manufacturing to interpret design data, sequence manufacturing operations, select machines or equipment, determine parameters, choose fixtures, and calculate machine operating times and associated costs (Yusof & Latif, 2014). Experimental Computer-Aided Process Planning, referred to as Agent-Based CAM, has evolved and is a combination of Computer-Aided Design and Computer-Aided Manufacturing, Agent-based technology, and the machine data standard STEP-NC (Allen, Harding, & Newman, 2005). These advanced manufacturing systems are important to satisfy customer requirements and compliment Computer-Aided Design techniques by shortening lead time, reducing production costs, and integrating information and manufacturing technology (Narita et al., 2004). The introduction of four-dimensional Computer-Aided Design has allowed improved graphical representation, data exchange standards, simulation and analysis, automation techniques, and features new tools used in Geographical Information Systems, cost estimation, and health and safety matters (Heesom & Mahdjoubi, 2004). Computer-Aided Design also features new technology focusing on model based assembly simulation that allows for early evaluation of the assembly process, creation of assembly operation sequences, and virtual assembly design, all of which are useful in reducing manpower requirements and simplifying planning activities (Leu et al., 2013).

Enterprise resource planning. Enterprise Resource Planning systems act as a connected database to Computer-Aided Design software and provide reductions in both communication and acquisition costs. Access to information is greatly improved by production employees and managers through the use of a combination of Computer-Aided Design and Enterprise Resource Planning software (Bloom, Garicano, Sadun, & Van Reenen, 2014). Files created by engineering using Computer-Aided Design systems are used to generate a Bill of Materials that is stored in a central database and later transferred to an Enterprise Resource Planning system. The database includes relevant materials, tools, and manufacturing operations that are useful in planning or work and materials procurement (Zahharov, Shevtshenko, & Karaulova, 2009). Data obtained from these systems is being further integrated into web-based systems linked with suppliers and customers that helps create an easily accessible network to improve overall product development aimed at reducing costs, increasing productivity, and ensuring compliance and traceability (Davis, 2002). There is additional research that supports a direct and positive correlation between Computer-Aided Design, Enterprise Resource Planning, and the impact they have on quality performance. The combination of people, business and technology with quality management yields a competitive position (Sanchez-Rodriguez & Martinez-Lorente, 2011). Enterprise Resource Planning software can also be expanded to include service-oriented architecture and other customized features to assist engineer, manufacturing, and management employees (Moon, 2007). The integration of Computer-Aided Design and Enterprise Resource Planning can experience occasional obstacles during data exchange, but proper planning by management to continually measure performance lessens negative impact on operations (Soliman, Clegg, & Tantoush, 2001).

Material requirements planning. Material Requirements Planning can be traced back nearly a century. What began as manual handling and processing of information has since been superseded by computers and software capable of determining capacity, managing inventory, and coordinating the flow of materials in the workplace (Wilson, 2016). Computer-Aided Design of today can include both product and production data in a single three-dimensional data model, and this data can be used in Material Requirements Planning to create documents, business applications, and processes that improve equipment effectiveness and reduce downtime, changeover, scrap, and rework (Parker, 2007). Material Requirements Planning and Computer-Aided Design also help engineering and management to arrange efficient workflow and production methods by optimizing manufacturing methods, assembly lines, and the flow of people and materials within a manufacturing setting (Timm & Blecken, 2011). The relationship of Material Requirements Planning, a Bill of Materials, and Computer-Aided Design make it sensible to use a combination of these tools to allocate materials and resources as required by production in manufacturing (Ptak, 1991).

Strategic development and deployment. Flexibility is viewed as a competency necessary for a business to maintain a competitive advantage and establish greater performance (Zhang, 2006). SolidWorks helps provide such flexibility as it is able to assist with several organizational operations. Manufacturing technologies allow increased throughput at a lower cost and also the ability to share information efficiently (Zhang, 2006). The transition from two-dimensional to three-dimensional software has grown the ability of engineering to capture part and product information and also nongeometric data useful in production and completion of customer orders (Shultz, 2006). The use of three-dimensional technology is disruptive as an innovation because it has changed the way information is represented, changed, and shared, and this allows companies to be innovative in efforts to create greater detail of designs and subsequent workflow (Boland, Lyytinen, & Youngjin, 2007). The future will be more focused on presentation, sale, production, and support versus the actual design data, so the ability to acquire information as a system is in use will be significant in automation and data sharing (Shultz, 2006).

Workplace culture. The use of software to facilitate collaboration in the workplace is significant in creating growth and discovery of innovations that drive and improve workplace culture (Lamont, 2012). Innovation allows for adoption of new ideas and behaviors and implementation of advanced manufacturing technologies (Hage, 1999). New business models and value chains are now possible, and employees are able to access company data and work remotely enhancing business competitiveness (Gupta, 2010).

Summary

This chapter covered the ability of SolidWorks to streamline various software applications and positively impact consistency, cost, process improvements, quality initiatives, and ultimately on-time deliveries. SolidWorks is often employed as a tool by successful companies throughout the world to increase efficiency while enhancing effectiveness of workers at their role within the organization. Provided the challenge faced by Company XYZ, the research performed was intended to help the business better utilize its limited resources in a way that made growth possible.

Chapter III of this research paper examines methodology used to integrate SolidWorks into the workplace and how the application impacted the business. The scheme used to standardize workplace practices, drawings, and documentation is also introduced. Finally, the data collection and analysis methods related to rework, scrap, order accuracy, late deliveries, customer satisfaction, and supplier payment performance are discussed.

Chapter III: Methodology

This study reviewed existing software applications that were being used for data management, procurement of materials, and production planning. SolidWorks was then introduced to the business to improve workflow and production support. Efficiency, output, and time-to-market increased, while costs associated with rework, scrap, and lost time decreased.

The objective of the study was to implement and evaluate a modern software application used to streamline tasks, create improved work practices, and positively impact internal operations and supplier and customer relationships.

The following chapter describes the methods used to achieve the objective of this study and the significance software applications, such as SolidWorks, had on an organization when leveraged properly.

Existing Production and Assembly Process

Opportunities to improve production and assembly processes and techniques were investigated. The existing work practices were evaluated and found to no longer be effective, as workload had increased while number of employees to perform tasks did not. Therefore, improvements to communication through improved notes, Bill of Materials, and standardization were initiated to decrease opportunity for errors to occur and allow for increased productivity by reducing idle time and rework. The amount of scrap had also reached unacceptable levels, and specific work instructions noted on drawings were used to improve performance. Prior deliveries were documented along with those that occurred during the study to assess impact of changes in the organization, and an example of the results is shown in Figure 1.

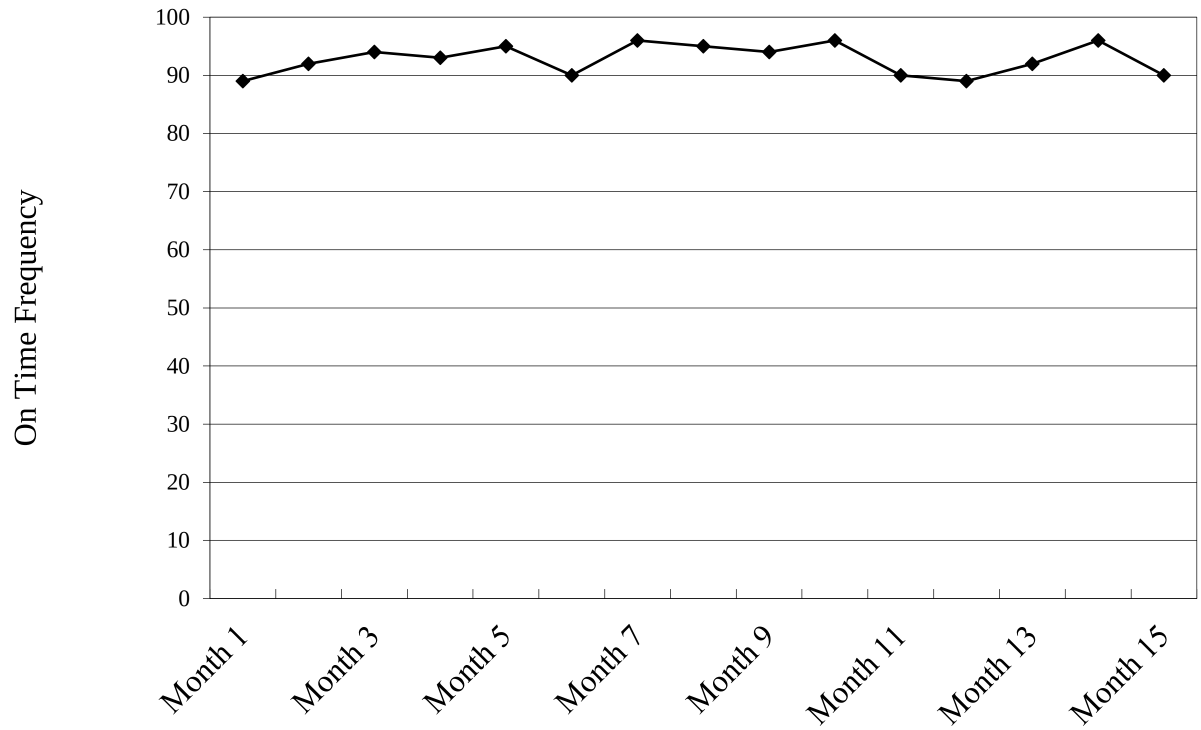

Figure 1. Example of frequency of on time deliveries.

Instrumentation

This study required use of a column chart that depicted how design information was communicated prior to any organizational changes that occurred. Each collaborative tool was categorized. Then the percentage of use was calculated by counting number of occurrences within individual project folders for a period of one year prior to the study. The same process was repeated after SolidWorks integration into the workplace. New data was captured over the study duration of three months. Figure 2 shows an example column chart representing use of communication methods during two periods at Company XYZ.

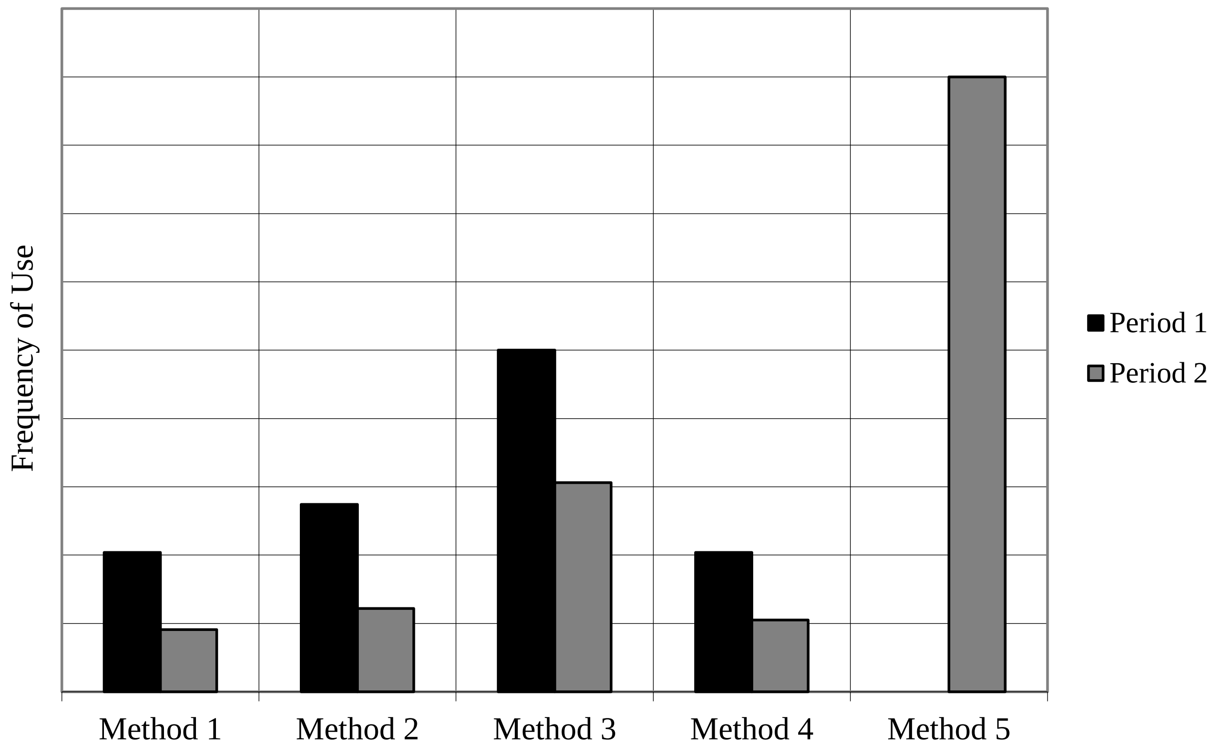

Figure 2. Example of communication methods during two periods.

SolidWorks included the use of notes to better express design intent and communicate additional requirements for production employees. The notes were found to be an excellent resource to enhance production drawings and assist with concerns during the review or validation process and increased collaboration between engineering and production. An example is shown in Figure 3.

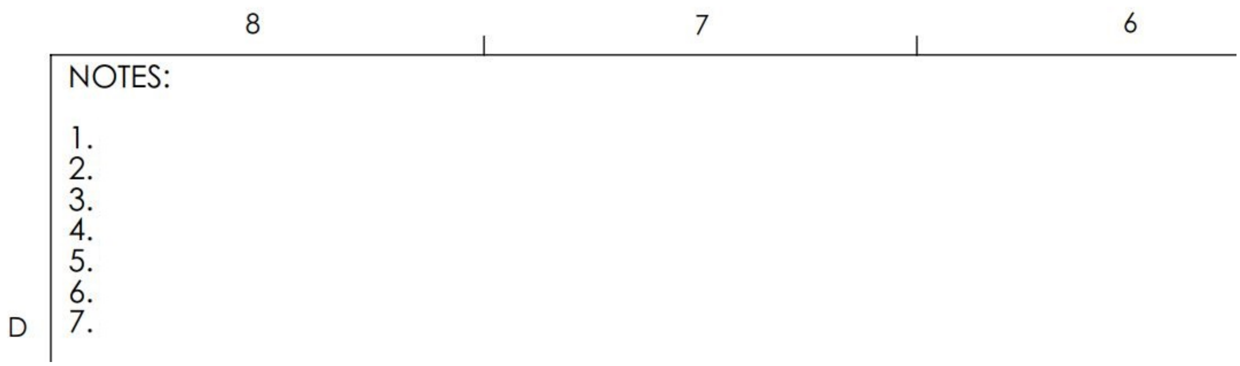

Figure 3. Example of notes showing additional work requirements.

Additionally, work instructions were added to drawings generated by SolidWorks to assist workers with specific steps related to assembly and fabrication or to add clarification to an image. Figure 4 represents a work instruction similar to one used in the study.

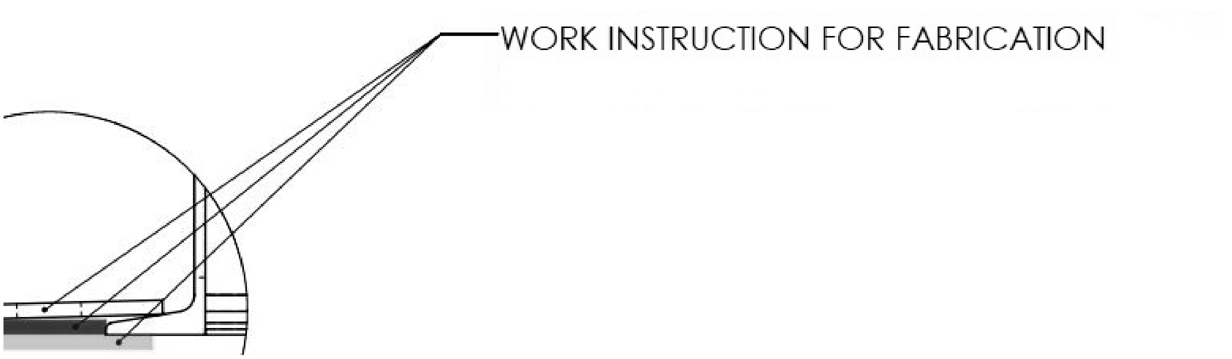

Figure 4. Example of a work instruction for a specific procedure.

A Bill of Materials was used in SolidWorks drawings to provide a list of all components included in a system design. These components were identified by item numbers that matched a specific column in the Bill of Materials. A related column included a tag number, and this tag number matched equipment received by vendors. The tag number was assigned during the design phase, included during all stages of procurement, and then physically noted on items as they were received at the loading dock. This was a significant step in improving errors being made during production. An example Bill of Materials is represented in Table 1.

Table 1

Example of a Bill of Materials

Item No.	Tag No.	Qty.	Description	Part No.	Supplier	PO No.
-	-	0	-	-	-	-
-	-	0	-	-	-	-
-	-	0	-	-	-	-
-	-	0	-	-	-	-
-	-	0	-	-	-	-
Total		0				

SolidWorks also assisted with scrap and cost reduction, and this translated to improved on-time deliveries and overall customer satisfaction. In order to identify and manage the level of scrap and rework that occurred, a cost analysis chart was created to input data. There were several purposes of creating the chart: root cause identification, determination of appropriate course of action, evaluation of scrap versus rework occurrences and related costs, and assessment of effectiveness of SolidWorks in achieving lower costs that occurred from rework, scrap, and late deliveries to clients. Figure 5 is an example of the chart used to document this information.

ID No.	Defect	Rework Process or Scrap	Related Cost
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-
-	-	-	-

Figure 5. Example of a cost analysis.

Finally, the study instigated company-wide standardization and the practice of improved file and data storage and identification techniques. This also led to better traceability, quality initiatives, and knowledge management. The use of standard title blocks on all drawings started and immediately proved useful to production employees, as it allowed for quick identification of a job or project. Lost time that was previously spent searching for relevant documentation quickly decreased. Drawing numbers that used a date and numerical sequence were incorporated into the title block of production drawings, as well as the client name, job number, file location, and other information such as acceptable tolerances and approvals. The improvement of file and data storage techniques, and overall traceability, allowed managers to gain quick access to important information related to specific project and production details and maintain work instructions or procedures for future production purposes or review and improvement. This further provided a clear path to find and identify information to remove non-value practices or procedures and fine-tune new work instructions specific to individual departments or roles that target increased efficiency and overall effectiveness. Figure 6 shows a standard title block that contains information related to the file and data storage and overall traceability.

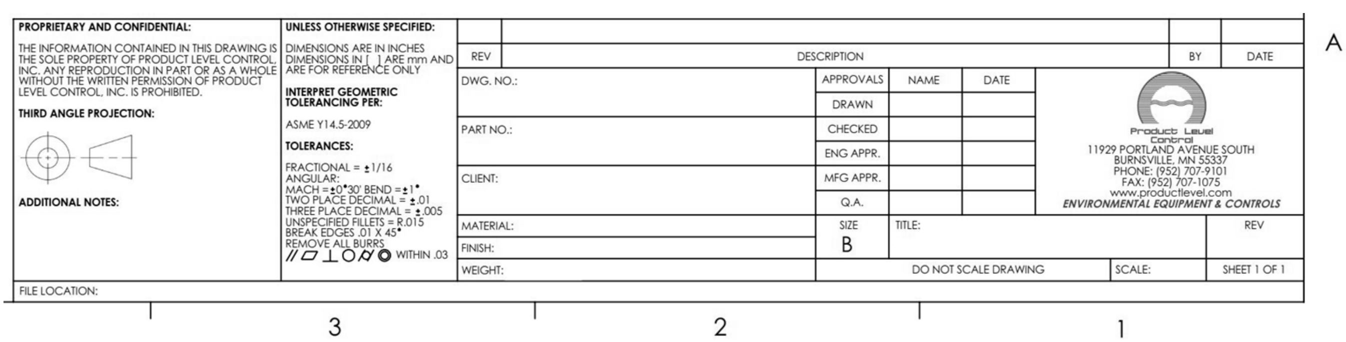

Figure 6. Example of a title block.

Data Collection Procedures

The data collection in this study began with documenting frequency of on time deliveries for the year prior to the study as well as during the study itself. Next, information related to design communication tools being used in the organization was entered to create bar charts. Lastly, cost analysis charts were created using information documented by production and engineering personnel at time of occurrence.

Data Analysis

Data collected for this study was used in evaluating the need to implement updated software and modern technological tools, such as SolidWorks, to improve work practices. The use of SolidWorks allowed the team at Company XYZ to make changes that improved individual levels of effectiveness and overall organizational efficiency. Comparison of the data collected after implementation of SolidWorks with historic figures allowed management to make appropriate changes that converted into significant time and cost savings.

Assessment of software applications that were being used for communication of design information throughout the company occurred as a first step in changing the way the business created documentation. Project folders on the Company XYZ server were examined for a one year period preceding the study for those computer programs used to create, view, and share drawings, notes, work instructions, procedures, and Bill of Material records. The same process was repeated after SolidWorks was installed and used for the three month study period to obtain the impact SolidWorks had on the way the company communicated design information.

Next, the root cause of rework and scrap were studied through the use of cost analysis charts. The cost analysis charts identified several problems during the production phase that were impacting quality and project deadlines. These charts also provided an effective guide towards appropriate disposition of each occurrence and further analyzed deficiencies in several areas. Problems during production were assigned an identification number by the shop manager, and the defect type was described. A decision was made whether to perform rework or create scrap, and details were noted. Attempts were made to salvage scrap and reduce rework to avoid significant impact to time or budget. Finally, cost was assessed in terms of the type and extent of resource impacted. This initiated open discussion between employees that allowed creation of new work instructions or procedures to avoid future lost time or waste and promote feedback and recommendations from management.

Dated inspection methods did not properly address deficiencies impacting production and customer satisfaction prior to this study. To effectively address this matter and impact rework and scrap issues, engineering practices were modified. At the time production and layout drawings were created, notes were added to improve understanding of production requirements. Specific work instructions were added directly to fabrication drawings that explained steps to yield a desired outcome. To ensure this knowledge was maintained for future use and always available to employees as needed, a drawing title block template was created to capture important pieces of information including client name, project number, drawing number, revision level and any changes made, title, and other relevant items such as material used, total weight, and specific tolerances. Finally, all drawings utilized item numbers in balloons that linked parts and equipment in a drawing with particular rows in a Bill of Materials. The Bill of Materials correctly identified those parts to be consumed in the system during production by including details such as a tag number placed on parts and equipment during the receiving process, quantity used, physical description, manufacturer part number, supplier, and purchase order number. Engineering was responsible for ensuring information was entered into SolidWorks during the design phase and correctly displayed in the Bill of Materials at time of release to production.

Summary

This chapter examined the methods used by Company XYZ to collect data used in evaluation of organizational improvements by incorporating SolidWorks into operations. Historical cost of rework, scrap, and lost time were compared to those after SolidWorks was implemented to measure effect on efficiency, output, and time-to-market. The resulting data of this study is captured and presented in Chapter IV.

Chapter IV: Results

This study reviewed existing software applications that were being used for data management, procurement of materials, and production planning. SolidWorks was then introduced to the business to improve workflow and production support. Efficiency, output, and time-to-market increased, while costs associated with rework, scrap, and lost time decreased.

To achieve the objective of the study, changes were made to the way engineering created drawings and documentation. Records of communication methods were reviewed and frequency of use noted. Modification of engineering practices occurred. Notes, work instructions, and a Bill of Materials were added to shop drawings to improve workflow from the design phase to system delivery. Rework and scrap were assessed. Finally, efforts to preserve documentation were addressed through drawing templates and detailed drawing title blocks.

The following chapter reviews the results of the software assessment, how SolidWorks improved the flow of information and work practices in Company XYZ, and the cost of poor quality and workmanship.

Existing Production and Assembly Process

The goal of the business was to integrate a modern software application that was compatible with existing programs and technology to impact production. SolidWorks was added to the business and used almost 36% more throughout the study than any other engineering tool available in the past. The program was used to automate manual processes that were previously costing workers time, including automatic translation of model based definition directly into notes, work instructions, Bill of Materials, and title blocks via templates created in engineering. The time saving features moved designs to production ahead of schedule, and this impacted on time deliveries by allowing shop personnel more time to complete work requirements.

Figure 7 shows the frequency of on time deliveries for all of 2016 and the three month study period during 2017. Company XYZ failed to consistently deliver systems within the timeframe allowed throughout 2016. Rounded to the nearest whole percent, on time deliveries failed to meet the company goal of 98%: January – 76%, February – 69%, March – 73%, April – 86%, May – 76%, June – 69%, July – 77%, August – 72%, September – 87%, October – 89%, November – 76%, and December – 75%. While still falling below the company goal, 2017 proved to be more consistent and had figures moving in a linear and upward trend: January – 92%, February – 93%, and March – 96%. This was encouraging news regarding the positive impact of SolidWorks on production and meant an increased level of customer satisfaction by deliveries that were received on time, and as promised.

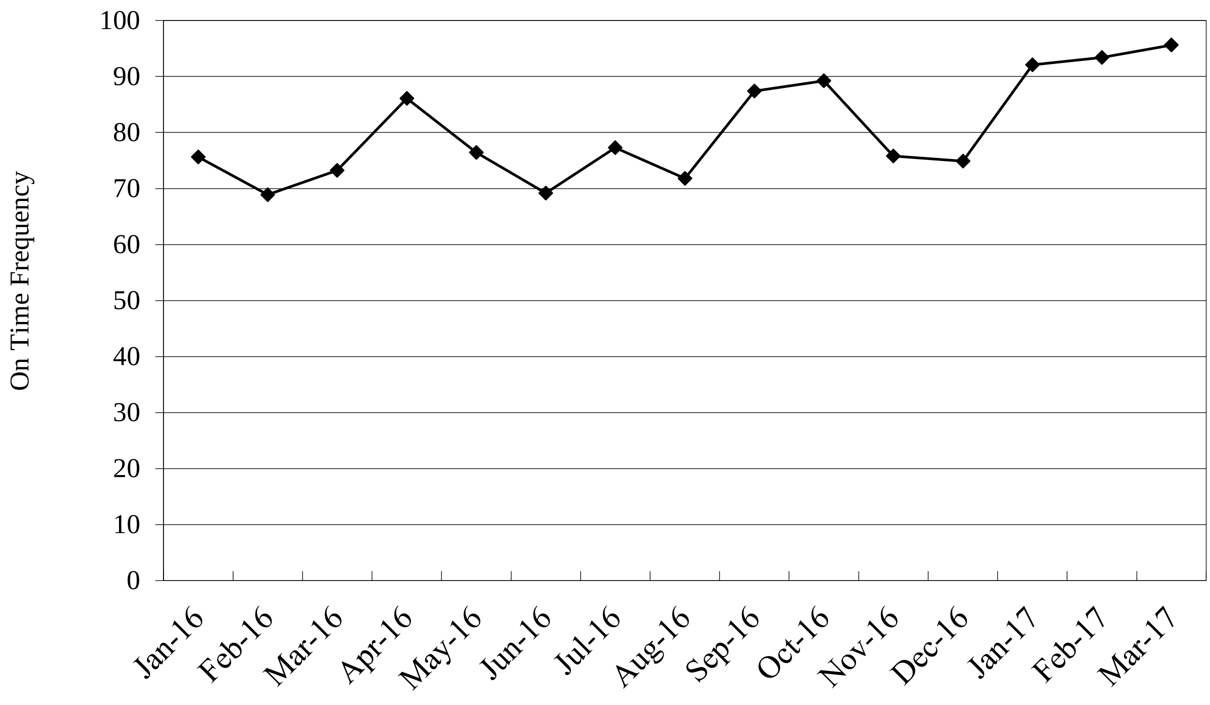

Figure 7. Frequency of on time deliveries.

Instrumentation

A total of 42 projects were examined for year 2016, prior to SolidWorks integration at Company XZY. At that time, four different communication methods were being used to share design-related information and data: two-dimensional Computer-Aided Design, information technology tools other than Computer-Aided Design, handwritten sketches, and verbal communication. As shown in Figure 8, two-dimensional Computer-Aided Design was used in 61% of all communication, including creation of process and instrumentation diagrams, Bill of Material lists, structural construction drawings, and system assembly drawings. Information tools other than Computer-Aided Design, such as Adobe Photoshop and Microsoft Excel, were used in 12% of communications and primarily for sales-related drafts, preliminary layouts, and Bill of Materials used in customer quotes and proposals. Hand sketches were created 17% of the time and used to communicate design intent or as built changes. This generally occurred when and where computers were not available and if shop personnel on the floor needed to exchange information regarding changes during fabrication. Hand sketches were also used to quickly communicate basic ideas to later be refined in AutoCAD, the software application Company XYZ used for two-dimensional Computer-Aided Design. Finally, verbal communication was used in 10% of communication that occurred between engineering and shop personnel. Verbal communication was used to reinforce and clarify information included in drawings as documented in employee notes found in project folders on the company server.

The integration of SolidWorks in 2017 added a fifth communication method to those already in use during 2016. A total of 12 additional projects were examined during the course of the study that started in January of 2017 and lasted for a three month period. Again referencing Figure 8, an immediate shift occurred as many of the tasks previously managed by two-dimensional Computer-Aided Design software were completed with the new three-dimensional Computer-Aided Design application. A total of 59% of all communication occurred via SolidWorks during the first quarter of 2017. Two-dimensional Computer-Aided Design was used 21% of the time and mainly for process and instrumentation diagrams or rework of two-dimensional drawings produced by SolidWorks. Use of information technology tools other than Computer-Aided Design remained nearly identical at 11% and continued to be used to support sales and preliminary design documents. A significant decrease occurred in the number of hand drawings created, as they were only used 3% of the time as opposed to the previous amount of 17%. This was due to the ability to quickly create and modify assemblies and layouts while management or shop personnel remained with engineering employees to observe changes and provide feedback. The practice reduced opportunity for communication errors and kept staff engaged in work performed. Finally, verbal communication decreased to 6% as model based definition was captured in the three-dimensional parts and assemblies and subsequently provided in documentation to shop employees. Some level of verbal communication remained necessary to explain changes requested from clients or provide detailed instruction at time of fabrication.

The data collected for communication methods displayed the ease and quickness of SolidWorks integration and also its ability to drive all other forms of communication between different departments. This is significant, because Company XYZ wanted the software to improve collaboration while reducing miscommunication, production errors, and delivery time.

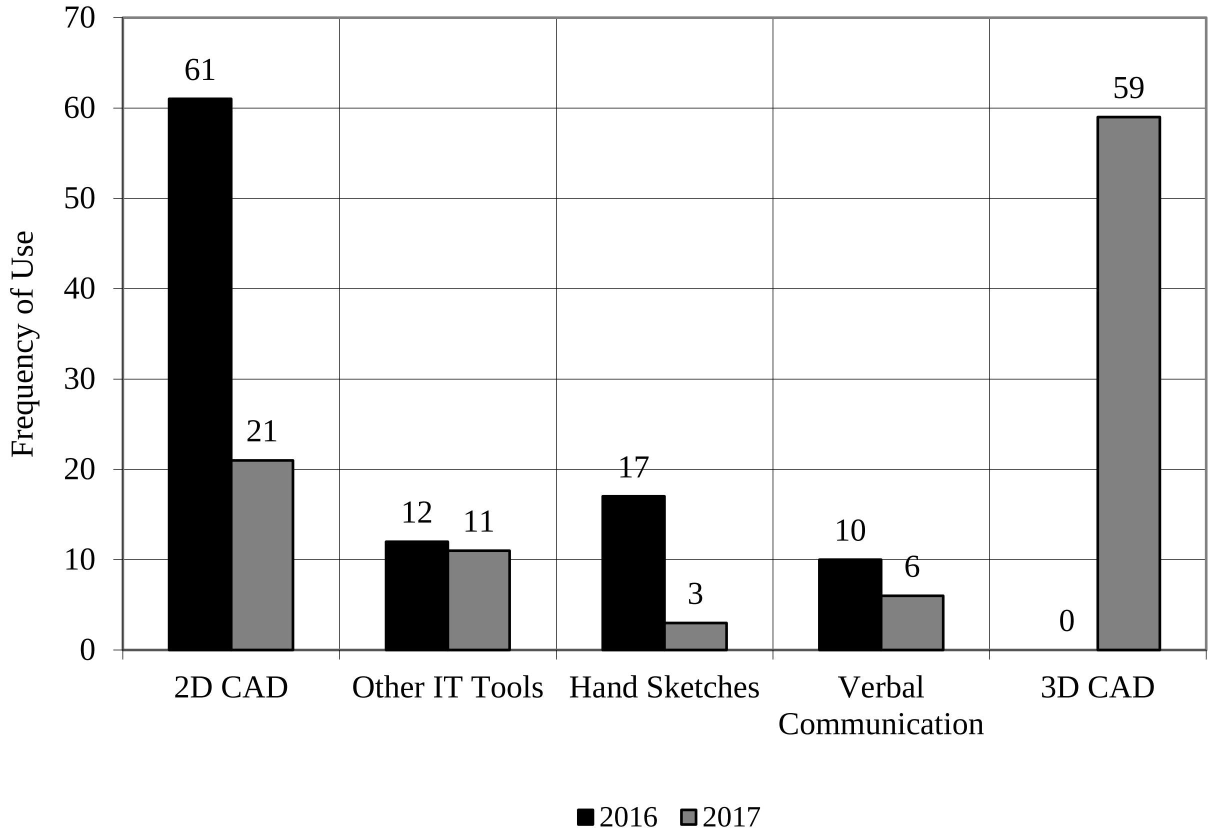

Figure 8. Communication methods during two periods.

SolidWorks included the use of notes to better express design intent and communicate additional requirements for production employees. The notes were found to be an excellent resource to enhance production drawings and assist with concerns during the review or validation process and increased collaboration between engineering and production. Figure 9 shows seven notes used for fabricating a steel floor commonly found in buildings produced at Company XYZ.

Examining Figure 9, Note 1 was created to inform a welder that anchor plates added to a steel floor must be welded per Detail A and B on that particular fabrication drawing. Next, Note 2 was added to let the welder know that the type of weld to be used for all joints in the steel floor was a fillet weld. Note 3 informed the welder that the thickness of the fillet weld was to be the same as the material being welded. Note 4 informed the welder that the next step was to weld the job number on the face of the steel floor frame to help identify the project as it was staged in the shop. Note 5 informed a production employee that fork lift pockets were to be cut to allow the final structure to be moved and that the holes, or pockets, were required to be eight inches long and three inches high so forks could fit through the frame. Note 6 was included to let employees know that the steel frame required priming and painted for the purpose of rust prevention. Finally, Note 7 was added to let fabricators know that their work needed to be within one eighth of one inch of any dimension included in the production drawing.

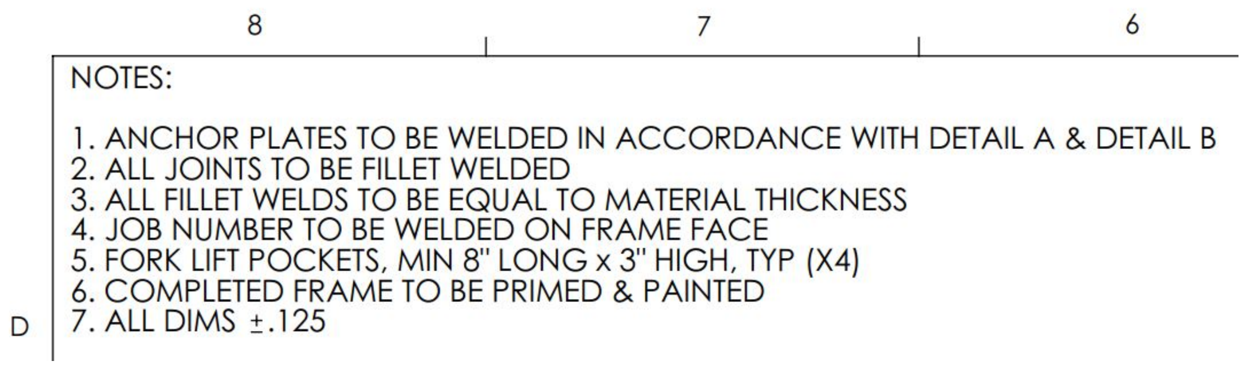

Figure 9. Notes showing additional work requirements.

The use of notes decreased production time by nearly 10%, as much of the information required by fabricators was clearly displayed in the upper-left corner of all production drawings. This simple step lowered the number of trips that production personnel had to take to obtain work details from engineering and saved nearly 25 minutes per day in lost time due to work stoppage. Employees focused on the task at hand without interruption to workflow.

In addition to notes, work instructions were added to drawings generated by SolidWorks to assist workers with specific steps related to assembly and fabrication or to add clarification to an image. Figure 10 shows a work instruction added to the same steel floor fabrication drawing referenced in Figure 9.

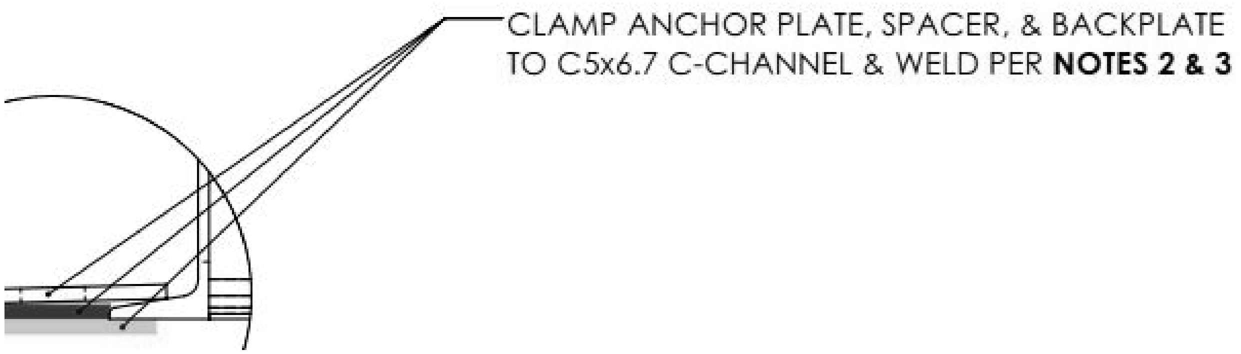

Figure 10. Work instruction for a specific procedure.

The work instruction in Figure 10 was added to specify the parts involved and the process required to fasten them to the steel frame. In this instance, the fabricator was required to clamp one anchor plate, one spacer, and one backplate to the steel frame. The next step involved welding the anchor plate while following Note 2 and Note 3 from Figure 9. These notes specified using a fillet weld equal to material thickness. Material thickness in the case of Figure 10 was the thickness of the anchor plate.

Work instructions like this reduced rework approximately 25% by guiding fabricators from the beginning to completion of a task, as displayed on production drawings. Projected savings due to the reduction of rework were estimated to be $26,000 annually through both labor and replacement part costs.

A Bill of Materials was used in SolidWorks drawings to provide a list of all components included in an assembly or system design. Table 2 shows the components in a Bill of Materials for a standard level sensor assembly at Company XYZ. The level sensor was assigned item numbers one through six, indicating six items on the SolidWorks drawing they're associated with. Tag numbers LSL-1 through LSL-6 were used to indentify location on a related process and instrumentation diagram that was created prior to the SolidWorks drawing and during the preliminary stages of the project. There are six parts total in this particular assembly: a pipe nipple, shroud, insulator, switch, spacer, and cable. Each of these six parts has a manufacturer part number which are 4568K211, SDS1-SFI7, SDS1-SFI8, 10-782-AC, SDS1-SFI9, PLTC3-18-1S-1000. Four suppliers were used during the procurement process, including McMaster-Carr, Fabtech Plastics, Wales Instruments, and Automation Direct and assigned purchase orders 43737, 43709, 43704, and 43711 respectively.

Table 2

Bill of Materials

Item No.	Tag No.	Qty.	Description	Part No.	Supplier	PO No.
1	LSL-1	1	Pipe Nipple, 3/4" MNPT, Sch40 Brass	4568K211	McMaster-Carr	43737
2	LSL-2	1	Shroud, Nylon 101	SDS1-SFI7	Fabtech Plastics	43709
3	LSL-3	1	Insulator, Acetal	SDS1-SFI8	Fabtech Plastics	43709
4	LSL-4	1	Switch, Acetal	10-782-AC	Wales Instruments	43704
5	LSL-5	1	Spacer, Acetal	SDS1-SFI9	Fabtech Plastics	43709
6	LSL-6	1	Cable, PVC	PLTC3-18-1S-1000	Automation Direct	43711
Total		6				

This was a significant step in eliminating errors made during production, because it properly identified parts and their locations. The result was $15,000 of annual projected savings from reduced return fees, shipping charges, and scrap stemming from improper installation. Furthermore, it was estimated nearly 250 man hours per year were saved with this organized method of traceability. The Bill of Materials also supported customers, because it provided information required for future part replacement or to order spares.

In order to identify and manage the level of scrap and rework that occurred, a cost analysis chart was created to input data and is shown in Figure 11.

ID No.	Defect	Rework Process or Scrap	Related Cost
20170130-001	Design	Customer design incorrect; moved relief valve	1. No cost; change order issued
20170202-001	Design	Improper placement of check valves; redesigned manifold and repositioned	1. Manpower
20170215-001	Fabrication	Manual bleed valve assembly not built to print specification; replaced process piping	1. Manpower 2. Materials 3. Profit
20170227-001	Part	Temperature sensor did not operate properly; vendor replaced free of charge	1. No cost; warranty
20170308-001	Installation	Flow meter not calibrated correctly; recalibrated using settings provided by manufacturer	1. Manpower
20170314-001	Damage	Weatherhood damaged during shipment; carrier insured	1. No cost; billed carrier
20170323-001	Leak	Fluid leak around fitting; torque adjusted to manufacturer recommended setting	1. Manpower

Figure 11. Cost analysis.

The results show one instance over the three month study period where production employees failed to follow drawings provided and scrap occurred, as seen by examining identification number 20170215-001. There were two instances, 20170130-001 and 20170202-001, where engineering identified problems prior to work being released to production. Identification number 20170227-001 was a warranty replacement for a defective part, and 20170314-001 was an item damaged in transit to Company XYZ which was later paid for through the carrier’s insurance company. Finally, 20170308-001 and 20170323-001 were instances where an employee failed to follow installation instructions provided by the manufacturer. Ultimately, the analysis revealed the amount of rework and scrap occurrences dropped substantially, approximately 25%, from the same period just one year earlier.

Finally, templates with model based definition in title blocks were used to standardize information captured in drawings. Figure 12 shows a title block from a template used to capture additional information about the same level sensor detailed in Table 3.

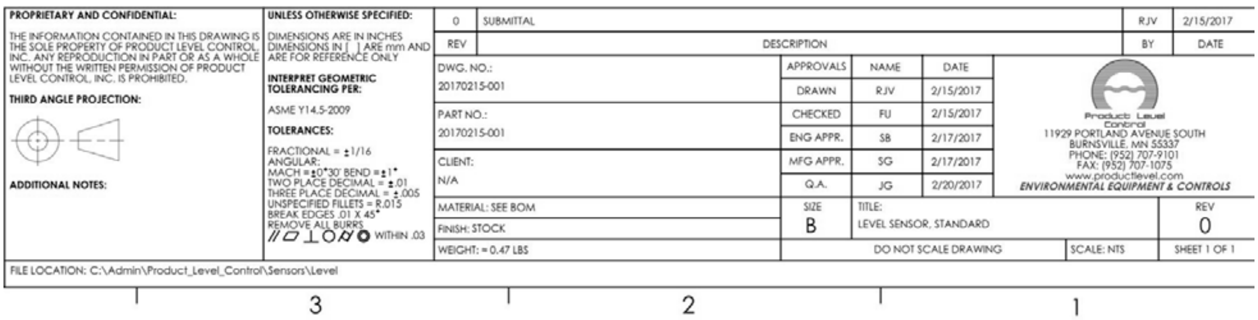

Figure 12. Title block.

The title block shown includes a proprietary statement explaining ownership details and leaves room for additional notes. Also included is a third angle projection symbol, the United States preferred method of orthographic projection or view. Another area includes information about the type of standards applied to the drawing and associated tolerances, or amount of variation, allowed for different variables. In this case, the standard is ASME Y14.5-2009. The actual tolerances depend on the dimensional value applied to different parts of a drawing and the number of decimals used. The drawing is at revision level 0, which was created on February 15, 2017 using drawing number and part number 20170215-001. The actual part and drawing number may differ depending on their date and sequence of creation. No client is listed, as this is for an in house application. The title block directs the viewer to the Bill of Materials regarding specific material information. In this case, that information was referenced in Table 2. All parts are a stock finish, and the final assembly weight of the level sensor is 0.47 pounds. The title block shows that no scale is applied to the drawing, and there are approvals from the designer, checker, engineering, manufacturing, and quality assurance as the drawing made its way to the production floor. The last items shown are the size of paper the drawing is to be printed on, which is B, the title of the document, the contact information for the company that created the drawing, and its physical location on the company server.

The title block improved traceability, quality initiatives, and knowledge management. Lost time decreased nearly 20% in the front office due to use of title blocks, because it was easier to locate documents quickly and access important information they contain. Production personnel benefitted as well, since the title block stored values that drove the level of variance allowed in an assembly or system layout.

Data Collection Procedures

In order to establish frequency of on time deliveries, project shipping dates were reviewed for 2016 and the three month study period of 2017. Actual shipping dates were compared to the customer’s expected delivery dates each month. Results were entered into the line chart in Figure 7. Another procedure was used for collection of data regarding communication methods employed at Company XYZ during that same timeframe. Project folders were reviewed to conclude which communication methods were being used when, and this information was then separated into two periods of time: 2016 and 2017. However, data for 2017 was limited to the study period itself. The results were entered into the column chart in Figure 8. Finally, a procedure was used to gather data to be used for a cost analysis. Production and engineering personnel would manually enter records of rework or scrap at time of occurrence during the study to identify root cause, course of action, and evaluation of scrap versus rework. These incidents were assigned an identification number using a date and sequential format, as shown in Figure 11, and a cost was determined and documented.

Data Analysis

Quantitative analysis was used throughout the study to determine the impact of SolidWorks integration on Company XYZ. Data was used to evaluate progressed work practices through the use of three-dimensional software in comparison to prior methods of communication. In order to assess improvements in the organization, column charts, figures, and tables were used to express and measure changes that were made. The analysis included percentage of communication methods, increased notes and work instructions, increased detail to Bill of Materials, decreased rework and scrap, and enhanced title blocks.

Summary

Communication methods employed at Company XYZ showed a shift in use after SolidWorks integration, where the three-dimensional Computer Aided-Design application accounted for 59% of all design documents. The impact of notes, work instructions, and improved Bill of Materials was described as reducing production time by 10%, reducing rework by 25%, and saving nearly $15,000 respectively. Cost analysis was performed to show the effects of rework and scrap on the business, and improved traceability was explained and found to decrease time lost hunting for documents by as much as 20%. The next chapter, Chapter V, reviews the entire study and discusses conclusions and future opportunity for improvements.

Chapter V: Discussion

A lack of modern software applications at Company XYZ increased costs and waste and decreased consistency, quality, and on-time deliveries. The lack of cash flow had a negative impact on supplier relationships, employees were frustrated by a lack of work instructions, and clients threatened to take their business elsewhere.

This study analyzed existing software applications that were being used for data management, procurement of materials, and production planning. SolidWorks was added to the business to assist with streamlining workflow to provide greater support to most internal and external stakeholders. Company XYZ wanted to increase overall collaboration and be able to share data throughout the organization using a single platform while avoiding costs associated with purchasing several different applications to perform the same function.

Chapter I discussed the background and history of Company XYZ, including the type of systems they design and fabricate, the market they support, and their current processes and procedures. Deficiencies were discussed in the way the company failed to support production efforts. The lack of collaborative tools was hindering efforts to improve throughput between engineering and production and ultimately on time deliveries to clients. In order to meet growing demand and higher levels of customer requirements, it was necessary to review new software applications that could be integrated into the current scheme. Also included in Chapter I was the problem statement, the purpose of the study, assumptions, definition of terminology used, limitations, and methodology.

Chapter II included a literature review that analyzed SolidWorks and the reasons it was effective in solving several key issues that hampered efforts to improve materials management, productivity, and efficiency. In addition, literature related to quality management systems was reviewed to provide insight into organizational development practices and how they were used to assist with integration of software and new work practices in a manufacturing environment. Other items in the literature review included basic elements of Computer-Aided Design, the importance of a Bill of Materials in a production environment, the use of macros to automate tasks, advantages and disadvantages of technology in the workplace, problems due to compatibility between programs, future planning, enterprise resource planning, materials resource planning, strategic development, and workplace culture.

Chapter III explained the various methodologies and steps used in the study to obtain the results desired. The existing production and assembly process was examined to determine a baseline for opportunities to improve techniques. Work practices were evaluated and found to no longer be effective, so a plan to change the current system was developed. Also discussed in Chapter III were the data collection procedures such as the bar chart used to show communication methods or the cost analysis chart for expressing rework and scrap. Finally, data analysis was explained which included how the data in the study was used to evaluate the need to implement updated software applications to improve work practices.

Chapter IV discussed the results of SolidWorks integration into the organization, including modification of engineering and production practices, improved notes and work instructions, rework and scrap assessment, and improved documentation techniques. The existing production and assembly process was revisited and found to have improved delivery times to from levels previously near 70% to levels all above 90%. SolidWorks became the primary communication method at a frequency of 59%. Production time decreased 10% via improved notes, and improved work instructions decreased rework and scrap by approximately 25%. Detailed Bill of Material lists created a projected decline in costs of nearly $15,000 annually.

Cost analysis validated improvements in production processes and helped create transparency regarding root causes of rework and scrap.

Limitations

There were several limitations for this study, the first of which involved compliance. Employees did not always fully comply with the requirements of the study, but this was not addressed as it was outside of my work scope to assess consequences for not doing so. This function was the responsibility of executive leadership, as this commitment was made prior to starting the study.

A second limitation was the lack of access to employees, documents, or sensitive data. The company had sole discretion as to whether or not to grant use of staff or documentation to assist with the study and decided the some things were not required to assess effectiveness.

The study focused on SolidWorks and did not assess other software and the impact that alternative applications may have had on employees or Company XYZ. Leadership felt the key was to focus on one application to address gaps in several departments. Therefore, study examined the benefits of Computer-Aided Design implementation relative to its impact on other software applications and interdepartmental needs.

Next, the study focused only on Company XYZ. While other businesses may have experienced varying results or benefits from similar studies, Company XYZ was only concerned with its own experience and the impact with the organization itself.

Finally, data collected was limited to dates within January and April, 2017. This time constraint had an impact on the amount of data collected and ability for a complete investigation into root causes of systemic problems throughout Company XYZ. Furthermore, not all potential benefits of SolidWorks could be examined, so the primary focus for this study was the use of a tagging system within the software to improve documentation, planning, and quality control.

Conclusions

Company XYZ experienced several problems that impacted their ability to operate effectively. There were issues communicating designs and customer requirements to production, and this created significant levels of rework and scrap. Also affected was the ability to deliver completed systems within the timeline promised to customers during the sales process. The inability to share information quickly was a contributing factor. Company XYZ investigated the benefits of SolidWorks implementation with regard to the fast and direct impact it could have on the company.

SolidWorks integration was successful and met expectations to address several matters affecting operations, production, and customer satisfaction. SolidWorks now accounts for 59% of the communication methods being used and is compatible with most all design applications that exist today. This translates into improved communication between Company XZY and their customers. Positive feedback was already received from clients about the benefit of having access to three-dimensional models, as it helped them to better assess integration into the worksite or larger systems in the field. On time deliveries advanced to levels above 90% for the first time in several years. Build time has decreased in the shop by almost 10% from improved notes on drawings, and this has saved employees in upwards of 25 minutes per day which was previously lost from work stoppage. Rework and scrap are down nearly 25% from improved work procedures drafted in SolidWorks and applied to drawings and documentation, and this resulted in estimated annual savings of $26,000. Improved Bill of Material management has led to an additional projected annual savings near $15,000 due to decreased return fees, shipping charges, and scrap related to improper installation. Finally, lost time decreased nearly 20% as SolidWorks was used to create improved document storage and retrieval features.

Recommendations

Executive leadership at Company XYZ must become more involved in properly assessing operational needs throughout the organization. This involvement includes putting controls in place to gain compliance from all employees when initiating change. Today's market demands the ability to adapt quickly to changing conditions in order to remain competitive with other businesses, and cooperation from everyone is required for success. In addition, a large degree of transparency is necessary to better understand and define root causes related to deficiencies noted in the study. Failure to address internal dysfunction will result in a broken system of managing costs, personnel, and quality.

Inability to access employees, document, and data was a struggle due to poor knowledge management practices. Company XYZ should continue to discuss ways to capture and maintain information crucial for supporting employees and documenting practices, procedures, and product information. There are several cost effective solutions, such as cloud applications, where company data may be securely stored and have little impact on the work environment in terms of access or space.

Additional software or add-on applications should be considered to compliment the foundation that SolidWorks has created. Creating a work environment where people can quickly share information and create necessary work documents is significant in the goals of effectiveness and efficiency being achieved. The production area should be assessed for computer installation to create an access point to data on the server, such as drawings, work instructions, procedures, maintenance documents, and supplier contact information. The same computer could be used to manage shipping and receiving. UPS is the primary carrier utilized, and they have software to make streamline steps for managing shipments.

Company XYZ should consider additional research for improving communication methods between work departments targeting improved efficiency, reduced cost, and advanced timelines. Examining other businesses within the environmental remediation industry may prove beneficial to address internal concerns and better understand customer requirements.

References

Adler, P. S., & Winograd, T. A. (1992). *Usability: Turning technologies into tools*. New York, NY: Oxford University Press, Inc.

Allen, R. (2007). Enhancing PDM capabilities. *Design News, 62*(16), 12.

Allen, R. D., Harding, J. A., & Newman, S. T. (2005). The application of STEP-NC using agent-based process planning. *International Journal Of Production Research*, *43*(4), 655-670. doi:10.1080/00207540412331314406

Ames, B. B. (2001). The race to data management: CAD providers scramble to make BOMs and track model versions. *Design News*, *56*(24), 23.

Bloom, N., Garicano, L., Sadun, R., & Van Reenen, J. (2014) The distinct effects of information technology and communication technology on firm organization. *Management Science 60*(12), 2859–2885.

Boland, R. J., Lyytinen, K., & Youngjin, Y. (2007). Wakes of innovation in project networks: The case of digital 3-D representations in architecture, engineering, and construction. *Organization Science*, *18*(4), 631-647. doi:10.1287/orsc.1070.0304

Brown, A. S. (2004). Simplifying complexity--again: No matter how many hands are on the job, technology aims to keep the work flowing. *Mechanical Engineering*, *126*(3), 43-45.

Costlow, T. (2007). Design software's search for compatibility. *Design News*, *62*(2), 43-44.

Danford, M. (2012). VBA macros ease program creation. *Modern Machine Shop, 85*(6), 108-114.

Davis, B. (2002). Cradle to grave. *Professional Engineering, 15*(10), 29.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science*, *35*(8), 982.

Etheridge, D. (2010). Excel data analysis: Your visual blueprint for creating and analyzing data, charts and pivottables. *Visual Blueprint*, *42*(3), 280. doi:10.1002/9781118983935

Goode, B. G. (2002). Ooching toward 3D. *CADalyst*, *19*(11), 8.

Gould, L. S. (2012). Turnkey integration for ERP. *Automotive Design & Production*, *124*(7), 38-39.

Green, R. (2005). Managing multiple CAD systems: Training, data management top the list of challenges. *CADalyst*, *22*(4), 39-41.

Groover, M. P., & Zimmers, E. W. (1984). *CAD/CAM: Computer-aided design and manufacturing.* Upper Saddle River, NJ: Prentice Hall.

Gupta, M. (2010). The enabling role of e-business technologies in strategic operations management. *Journal of International Technology and Information Management*, *19*(2), 109-IV.

Hage, J. T. (1999). Organizational innovation and organizational change. *Annual Review of Sociology*, *25*, 597-622.

Heesom, D., & Mahdjoubi, L. (2004). Trends of 4D CAD applications for construction planning. *Construction Management & Economics*, *22*(2), 171-182. doi:10.1080/0144619042000201376

Kemp, A. T., Preston, J., Page, C. S., Harper, R., Dillard, B., Flynn, J., & Yamaguchi, M. (2014). Technology and teaching: A conversation among faculty regarding the pros and cons of technology. *The Qualitative Report*, *19*(3), 1-23.

Koliha, M. W. (2006). CAD and BOM data get connected: At Water Pik, engineers can drill down to any drawing that is related to a part number on the BOM. Heres how. *Design News*, *61*(8), 75-80.

Lamont, J. (2012). Collaborate, innovate, adapt! *KM World, 21*(10), 10, 26.

Lang, M. M. (2004). Software aims for efficient workflow: Users give feedback to Autodesk on need for multi-user access to smooth organization and collaboration tools. *Design News, 59*(3), 48-51.

Leu, M. C., Elmaraghy, H. A., Nee, A. Y. C., Ong, S. K., Lanzetta, M., Putz, M., Zhu, W., & Bernard, A. (2013). CAD model based virtual assembly simulation, planning and training. *CIRP Annals - Manufacturing Technology, 62*(2), 799-822. doi:10.1016/j.cirp.2013.05.005

Medforth, T. (2016). How to take advantage of technology to improve your company culture. *Strategic HR Review, 15*(1), 43-44.

Moon, Y. B. (2007). Enterprise resource planning (ERP): A review of the literature. *International Journal of Management and Enterprise Development, 4*(3), 235.

Narita, H., Shirase, K., Arai, E., Nakamoto, K., Chen, L. Y., & Fujimoto, H. (2004). Proposal of a concept of future oriented machine tools for advanced manufacturing systems. *International Journal of Production Research, 42*(17), 3657-3673. doi:10.1080/00207540410001703989

Nasby, G. (2012). Using process flowsheets as communication tools. *Chemical Engineering Progress, 108*(10). 36-44.

Pan, Z., Wang, X., Teng, R., & Cao, X. (2016). Computer-aided design-while-engineering technology in top-down modeling of mechanical product. *Computers in Industry, 75*, 151-161. doi:10.1016/j.compind.2015.05.004

Parker, K. (2007). Recognizing innovation in the global manufacturing enterprise. *Manufacturing Business Technology, 25*(10), 18.

Ptak, C. A. (1991). MRP, MRPII, OPT, JIT, and CIM: Succession, evolution, or necessary combination. *Production and Inventory Management Journal, 32*(2), 7.

Sánchez-Rodríguez, C., & Martínez-Lorente, A. R. (2011). Effect of IT and quality management on performance. *Industrial Management & Data Systems, 111*(6), 830-848. doi:10.1108/02635571111144937

Shultz, D. (2006). Software's next step. *Wood Digest, 37,* 36-37.

Soliman, F., Clegg, S., & Tantoush, T. (2001). Critical success factors for integration of CAD/CAM systems with ERP systems. *International Journal of Operations & Production Management, 21*(5), 609-629.

Stackpole, B., & Lynch, R. (2007). And CAD data for all. *Design News, 62*(4), 72-74.

Timm, T., & Blecken, A. (2011). A method for the hierarchical planning of the structure, dimension and material requirements of manufacturing systems. *International Journal of Production Research*, *49*(12), 3431-3453. doi:10.1080/00207543.2010.495735

Tzotzis, A., Garcia-Hernandez, C., Huertas-Talon, J. L., Tzetzis, D., & Kyratsis, P. (2017). Engineering applications using CAD based application programming interface. *MATEC Web of Conferences, 94*(01011), 1-7. doi:10.1051/matecconf/20179401011

Vegetti, M., Henning, G. P., & Leone, H. P. (2002). An object-oriented model for complex bills of materials in process industries. *Brazilian Journal of Chemical Engineering, 19*(4), 492. doi:10.1590/S0104-66322002000400019

Wilson, J. M. (2016). The origin of material requirements planning in Frederick W. Taylor's planning office. *International Journal of Production Research, 54*(5), 1535-1553. doi:10.1080/00207543.2015.1092616

Yusof, Y., & Latif, K. (2014). Survey on computer-aided process planning. *The International Journal of Advanced Manufacturing Technology*, *75*(1), 77-89. doi:10.1007/s00170-014-6073-3

Zahharov, R., Shevtshenko, E., & Karaulova, T. (2009). Integrated CAD/ERP framework for modular construction industrialization through lean manufacturing concepts. *Annals of DAAAM & Proceedings of DAAAM International Symposium*, *20*(1), 591.

Zhang, M. J. (2006). IS support for strategic flexibility, environmental dynamism, and firm performance. *Journal of Managerial Issues*, *18*(1), 84-103.