

THE PRODUCT-DEVELOPMENT NEEDS OF SMALLER MANUFACTURING FIRMS

Larry A. Stauffer, Ph.D., P.E. and Alfred D. Kirby

Abstract

A study was conducted to better understand the product-development needs of smaller U.S. manufacturers. We discovered how firms believe they rank relative to their competition in five stages of product development: product investigation, product design, product test and validation, market launch, and production. We learned that companies generally perceive themselves to be better than their competition except when launching a product into the marketplace. They also believe they could become more competitive by improving their business related activities in product development. The factors that contribute to their performance are also presented. Finally, implications of these findings for engineering design research and education are discussed.

1. Introduction

There are nearly 400,000 smaller manufacturing firms (less than 500 employees) in the U.S. today [10]. They contribute as much value as the larger firms yet are not experiencing the same productivity gains. To a large extent, they lack the resources of larger firms to constantly improve their design and manufacturing practices and keep up-to-date with technology. While every manufacturer contends with limited resources, small firms do not have the financial backing and cash flow that is available to larger firms or to a small group in a large company. Their product development processes are often ill defined (if they exist at all). These firms tend to focus on getting product shipped rather than on the design of the product. To survive over time, as with larger firms, they must successfully develop products.

1.1 Background

Product development is a necessary yet difficult endeavor for any company, large or small. New products typically account for half of a company's sales and profits [8]. While some firms may be successful at doing the same thing year after year, their type "is a dying breed". Even companies with successful existing products must continuously advance those products to maintain market share. Yet given all of this importance that product development has to a firm, the process usually fails. The numbers vary but most experts report that only about ten percent of new products fail to be launched successfully into the market place. Most product ideas fail during the initial investigation at the company. More fail during development as technical challenges prove too difficult or expense to overcome. The rest fail during launch due to poor market response.

Those products that do survive to the point of successful launch to the market must be continuously attended to. During the years or months of production, the company will

constantly reengineer the product and revamp production methods to drive down cost. Much of a company's financial resources can be committed to this process. Because of its importance, we conducted a study, under the sponsorship of the National Institute of Standards and Technology (NIST), to help small manufacturers improve their product-development practices.

1.2 Objectives

This study has one main objective, to gain a better understanding of the product-development needs of smaller manufacturers. In this project we are seeking to answer three main questions. First, how well do smaller manufacturers believe they execute the five stages of product-development activities? Second, in activities that they do not execute better than their competition could improvement in any of the associated activities make them execute better? Third, what are the issues that prevent them from developing products as well as desired? The product-development practices in use at today's most successful large companies are well documented [4]. In smaller firms with fewer personnel and resources, they have a more difficult time implementing world-class practices if they implement any type of process at all [5]. We believe that discovering the answers to these questions will help us pursue the research that small manufacturers need most.

2. Research Methodology

In order to gain insight into our research objectives regarding U.S. manufacturers, we administered a survey instrument to a sampling of companies. As this project was sponsored by NIST, we had to obtain permission and follow guidelines established by the Federal Office of Management and Budget (OMB). The survey instrument was based on a model of the activities of product development. This model arranges product-development activities into groups of five stages and multiple activities, Table 1.

This particular organization and description of product-development activities is a synthesis of several product-development models [3], [11]. This table is meant to be a logical collection of activities, not a sequential model of how to design.

We did not include activities related to the retirement or disposal of the product. We omitted this group of activities, realizing that very few small manufacturers have any involvement with their products after they leave the company. For the most part, these companies supply their products to OEMs or the end user discards their products.

2.1 Survey Instrument

The survey instrument included a series of questions to gain insight into the needs of small manufacturers regarding product development as listed in the objective above. The first set of questions describes the five main stages of product development from Table 1 and asks them if their company executes these stages *worse*, *the same*, or *better* than its competition.

In the second set of questions, the activities from Table 1 were listed for each stage and defined sequentially and the respondent was asked if improving these activities would make them more competitive. The purpose of this set of questions was to identify more specifically those product-development activities that needed the most improvement.

The final set of questions focused on the cause of difficulties. Specifically, we wanted to know what was holding them back. That is, what were the factors that were keeping them from executing product-development activities as well as they desired.

Product Development Activities		
Stages		Activities
1	Product Investigation	Idea Generation
		Market Assessment
		Technical Assessment
		Manufacturing Assessment
		Product Definition
		Financial Analysis and Risk Assessment
		Project Management
2	Product Design	Conceptual Product Design
		Detailed Product Design
		Production Design
		Marketing Planning
3	Test and Validation	Product Refinement
		Marketing Preparation
		Production Deployment
		Administrative
4	Market Launch	Product Change
		Marketing Implementation
		Production Implementation
		Customer Support
5	Production	Marketing Maintenance
		Product Cost Reductions
		Production Cost Reductions
		Customer Support

Table 1. Stages of Product-Development Activities

In summary, the first and second set of questions was directed towards discovering the product-development activities that made them less competitive and the third set of questions were directed towards learning why.

2.2 Survey Process

A total of 61 individuals from smaller U.S. manufacturers in 10 states across the U.S. were surveyed. This was the number of companies authorized by OMB for 95% confidence. These individuals and companies were not selected by total randomness. We were looking for companies that had a desire to improve and typically employ 20 to 200 employees. We were seeking manufacturers that develop their own products that were typically mechanical or electro-mechanical in nature. Therefore we bypassed the very small firms, the process industry of chemical manufacturers, or those that do contract manufacturing, and so forth. The firms we spoke to, make a wide variety of products such as vacuum cleaners, speakers,

brake components, etc. We talked to the NIST manufacturing extension organization in ten states that volunteered to assist us with the study. They identified 8-10 companies in their state that fit our profile. The company individuals we spoke to were typically heads of engineering, design departments, or company owners. Basically, they were the individuals most cognizant of the company's product-development efforts. To begin the survey process, these individuals were contacted by telephone and after a brief explanation of the project and process they were queried the questions from the survey instrument. All 61 respondents stated their assessments for all five stages according to the first set of questions. From this point, the survey administrator identified two or three of the stages where the respondent stated their company was worse and administered the next set of questions for those stages. If a company had less than two stages listed as *worse* from the first set of questions, we would query them on a stage listed as *the same*. We had a goal to keep the telephone call under ten minutes. We found that asking questions about too many stages made the survey process too long. The positive effects of this decision is that the time for the survey response was typically less than ten minutes and therefore, most of the firms we contacted agreed to participate. The negative effect of this decision is that the number of respondents for each stage in the second set of questions was less than 61 decreasing the confidence in the results for those sections. The number of responses for the five stages was: product investigation, 26; product design, 14; test and validation, 14; market launch, 30; production, 14.

3. Findings and Discussion

3.1 Competitiveness of the Firms

The first part of the survey process was to query firms on their perception of their product-development competitiveness. The five stages of product-development activities were described to each respondent one at a time. They were asked the question, "From your own perspective, would you say your company executes this stage worse, the same, or better than your competition?" The results of the 61 respondents surveyed are listed in Figure 1. The bottom bars indicate *worse*, the middle bars are *the same*, and the tops of the bars indicate *better* than the competition.

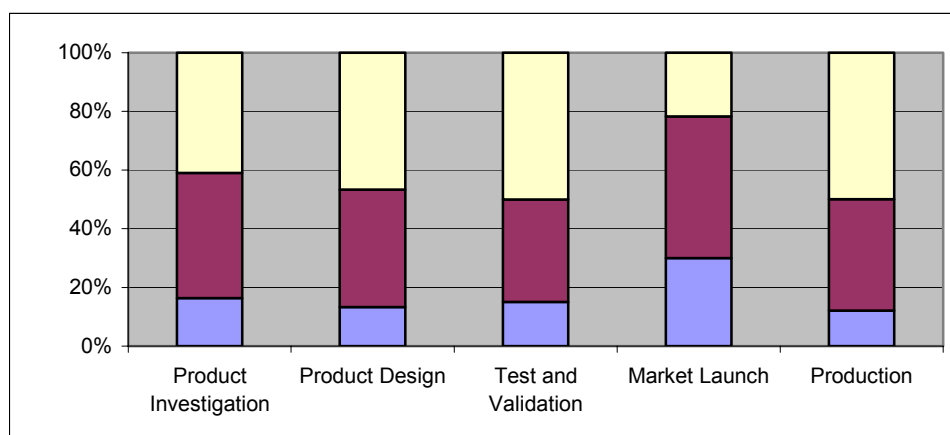


Figure 1. How Well Smaller Manufacturers Perceive They Execute Stages of Product Development

Between 40% and 50% of the respondents thought their company executed product-development activities better than their competition, except in the stage of market launch where only 20% believed they were better. Market launch is the stage where a company

ramps up production, processes final product change orders, advertises, begins to take orders, distributes product through established channels, and so forth. In some sense, this stage is the most critical for a company. This is the first time customers are buying product and revenue is coming in. This is also the time when the financial deficit is highest for the product. How well a company does in this stage can make or break the production stage.

3.2 Improving Product Development

In this section we describe the survey results where product-development activities associated with each of the five stages were described to the respondents. This is the second set of questions. They were queried whether improving any or all of these would help them be better than their competition in this stage.

3.2.1 Product Investigation

This stage of product development describes the activities that are conducted to define the product and initiate the project. This stage was described as having the following activities:

1. Idea generation – *creating a new product idea, etc.*
2. Market assessment – *identifying demand, interviewing lead customers, etc.*
3. Technical assessment – *define technology gaps, patent search, codes and standards, etc.*
4. Manufacturing assessment – *supply chain issues, production capabilities, etc.*
5. Product definition – *customer requirements, performance requirements, etc.*
6. Financial analysis and risk assessment – *ROI calculations, pricing strategy, etc.*
7. Project management – *define tasks, schedule, and resources, etc.*

Over half of the respondents indicated that they would like to improve their efforts in Market assessment, Financial analysis and risk assessment, and Project management (Figure 2). By far the number one area was Market assessment. This result indicates that companies struggle with activities such as understanding customer requirements and setting prices. They also struggle to set adequate financial goals, understand demand, and manage the project. It is also interesting to note that improving all activities were deemed important by many of the respondents. The one exception is that only a fourth thought they could become more competitive by improving activities related to Idea generation. There did not seem to be shortcomings in identifying product ideas. Rather, the shortcomings were bringing these ideas to market successfully. It is also noteworthy that the assessment activities of the product and process were not seen to be very valuable for enhancing competitiveness.

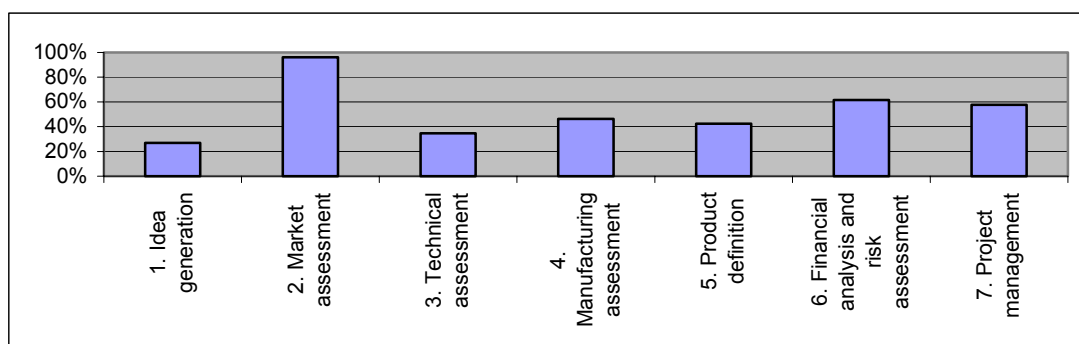


Figure 2. Areas Needing Help During Product Investigation Stage

3.2.2 Product Design

This stage of product development describes the various activities that are conducted to design the product, produce it, and plan the marketing effort. This stage was described as having the following activities:

1. Conceptual product design – *generate concepts, product architecture, etc.*
2. Detailed product design – *define shape, materials, and other life-cycle issues, etc.*
3. Production design – *define process, make/buy decisions, quality control process, etc.*
4. Marketing planning – *promotional plans, distribution channels, etc.*

Roughly half of the respondents indicated that they would like to improve their efforts in all activity areas (Figure 3). The one exception, again, was in the marketing area where nearly 80% thought improvement here could help them. Primarily companies struggle to have a sound strategy to promote their products and develop proper distribution channels for selling them. Half the respondents thought improving their product-design activities would make them more competitive. Even fewer saw the value in improving the design of their production processes.

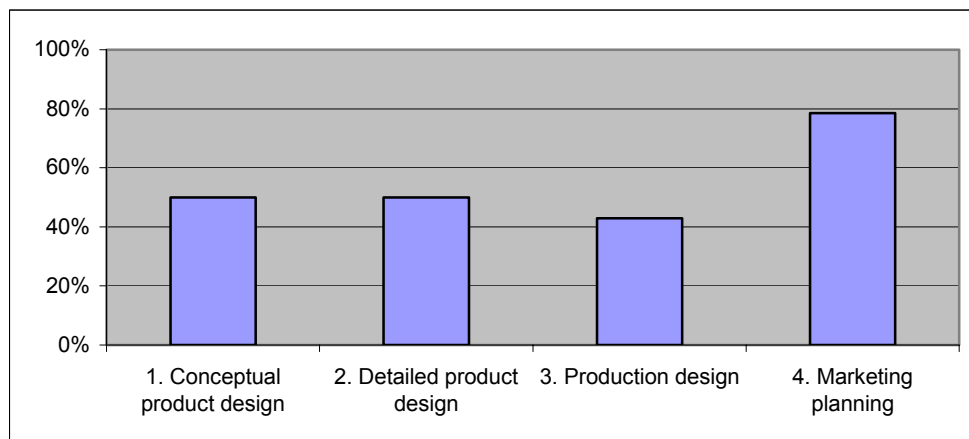


Figure 3. Areas Needing Help During Product Design Stage

3.2.3 Product Test and Validation

This stage of product development describes the various activities that are conducted to test and validate the product design and prepare the production and marketing functions. This stage was described as having the following activities:

1. Product refinement – *prototypes and life and reliability testing, etc.*
2. Marketing preparation – *promotional materials, evaluate with lead customers, etc.*
3. Production deployment – *refine production process, install facilities, etc.*
4. Administrative activities – *educate sales force, establish customer-support, etc.*

Respondents felt they could beat their competition by improving all of the product-development activities in this stage (Figure 4). This stage of product development is described as a mix of design refinements through prototypes and life cycle testing and preparing the company to produce and sell the product. In this stage the company's financial investment in the product-development project begins to accelerate. In some sense, this is when the project comes out of engineering and obtains active involvement by all functions of the company. The concurrent development paradigm calls for up-front, continual involvement of all functional groups to make this stage successful [9].

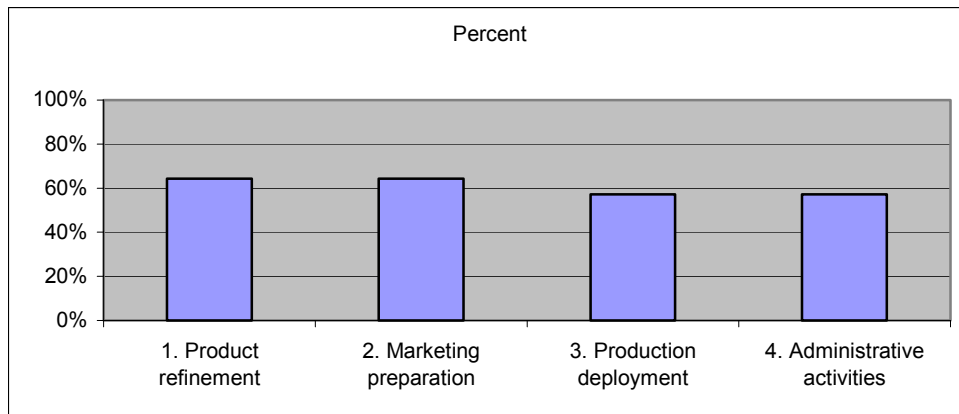


Figure 4. Areas Needing Help During Test and Validation Stage

3.2.4 Market Launch

This stage of product development describes the various activities that are conducted to launch the product into the marketplace. This stage was described as having the following activities:

1. Product changes – *implement new features, change orders, etc.*
2. Marketing implementation – *implement marketing plans, etc.*
3. Production implementation – *ramp up, production changes, etc.*
4. Customer support – *implement customer support and distribution channels, etc.*

Marketing implementation activities were deemed to have the greatest potential to improve competitiveness by 80% of the respondents, followed by production implementation by half (Figure 5). One should recall that this stage was perceived to be a bigger weakness than any of the other stages. The challenges are enormous: keeping the product design stable, ramping up production, informing and convincing customers to purchase the product, and supporting its transition into the market place. This process of “giving birth” can cause tremendous financial loss if it fails. It is critical that this risk is managed throughout the product-development process. Some thoughts on this finding are discussed in more detail in section 4.

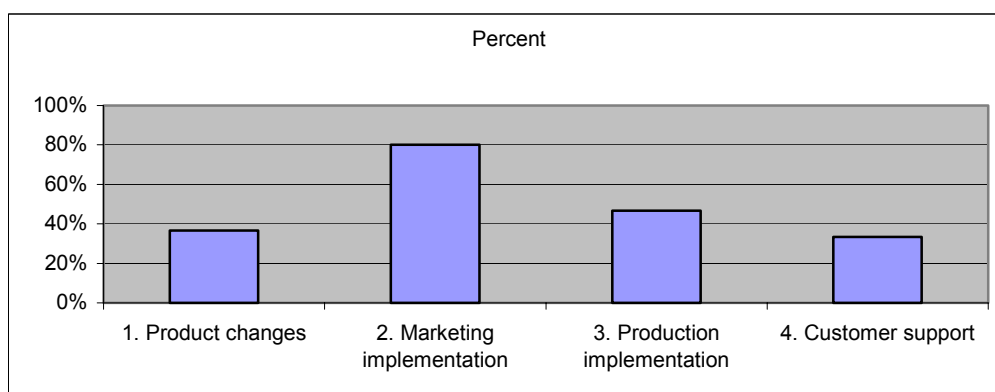


Figure 5. Areas Needing Help During the Market Launch Stage

3.2.5 Production

This stage describes the activities that are conducted to produce and support the product over time. It also covers the on-going redesign effort to keep the product relevant to the customer and reduce costs. This stage was described as the following activities:

1. Marketing maintenance – *monitor sales goals, explore new markets, etc.*
2. Product cost reductions – *value engineering, update technology, etc.*
3. Manufacturing cost reductions – *update technology, optimize supply chain, etc.*
4. Customer support – *provide maintenance, product updates, etc.*

Improving activities of cost reduction are seen to provide the most benefits for competitiveness (Figure 6). To compete, a firm must reduce cost while maintaining performance and quality. Cost reductions happen in both the product and processing.

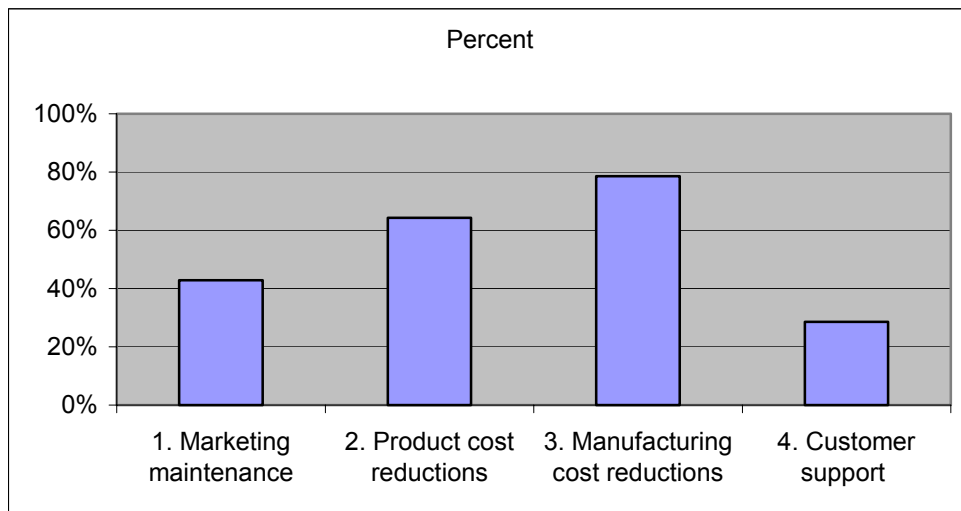


Figure 6. Areas Needing Help During Production Stage

3.3 Contributing Factors

In this final section of the survey we were looking to identify some contributing factors that keep these companies from executing product-development activities as well as desired. We provided five factors that seemed to be important during the previous, informal discussions with smaller manufacturers. The results of this question are shown in Figure 7.

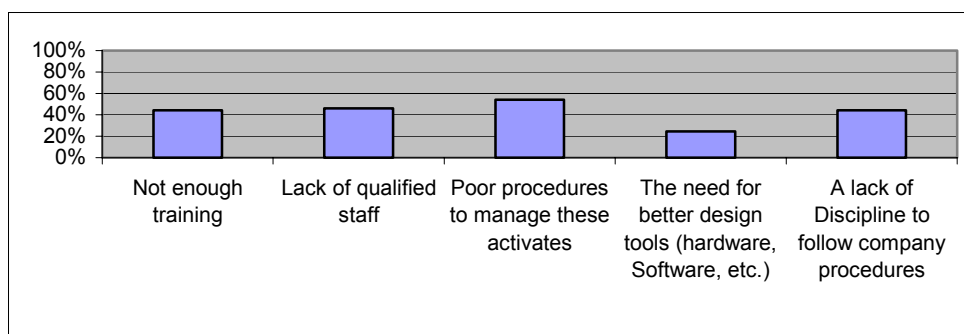


Figure 7. Factors Contributing To Poor Performance

4. Implications on Design Research and Education

There were no findings in this project to suggest that current design research or education is focusing on unimportant topics. There are some areas, however, where increased emphasis in research and education could prove to be of great benefit. The Table 3 lists the activities that rated around 60% or higher as to whether improvement in these areas would help firms become better than their competition.

Top Activities	Example Activities
Market assessment	identifying demand, interviewing lead customers, etc.
Financial analysis & risk assessment	ROI calculations, pricing strategy, etc.
Project management	define tasks, schedule, and resources, etc.
Marketing planning	promotional plans, distribution channels, etc.
Product refinement	prototypes and life and reliability testing, etc.
Marketing preparation	promotional materials, evaluate with lead customers, etc.
Marketing implementation	implement marketing plans, etc.
Product cost reductions	value engineering, update technology, etc.
Manufacturing cost reductions	update production technology, optimize supply chain, etc.

Table 3. Product-Development Activities Where Manufacturers See Biggest Potential for Improvement

These activities are focused on business issues of product development, mainly in the areas of marketing and finance. An interesting comparison comes from a study by Cooper [2] who made an investigation into product failures of 114 firms. He tracked the success of the firm as to whether they did twelve product-development activities well. The poorest executed activities were: detailed market study; test marketing; detailed financial analysis; prototype testing with customers; and preliminary assessment of the market. These are areas where engineers typically have little involvement. There should be a broader focus as to what the engineering design research community studies and what is taught. In the area of design research, there appears to be the need for increased effort in the connection between market information and design information. Early in the process, while assessing the market, firms would do well to organize multifunctional teams that interact with customers. Insights into expected market demand, market segments, lead customer interviews, and so forth could help smaller firms become as successful as large firms. We could develop new theories and methodologies of how this interaction should take place and how to incorporate this information into the design process. Informally, there was much frustration expressed by the respondents of feature creep. That is new or enhanced features added to the project during product development by management or marketing. This results in extra cost and time delays. Are there new methods or paradigms that could better manage this phenomenon? In the area of cost, can there be new techniques for minimizing design iterations and reducing costs early in the process? One successful technique is design for manufacture and assembly [1]. Are there others? Can we investigate improved ways in which engineering can support marketing in launching products?

There could also be opportunities for more research on the process of product development. Typically we have left this area of inquiry to business researchers. But engineering design researchers have a responsibility to bring an engineering viewpoint and look at product-

development practices applicable to manufacturers. In the area of design education, there also needs to be an increased effort in incorporating more business issues. Many of these issues are currently being addressed in engineering programs, but the effort should continue. How many engineering programs have students talk with real customers and then design products with the understanding of how to promote and distribute them? If small manufacturers deem these issues important then they should be a part of engineering design education.

5. Summary

We present the results of a study to better understand the product-development needs of small manufacturers. We learned that nearly half of them perceive themselves as executing product development better than their competition. The one exception is that only 20% feel the same concerning launching their products into the market place. Overall, the most improvement was deemed to lie in the business related activities in product development. Improving marketing, project management, and product refinements along with reducing the cost of the product and processing were seen as the greatest potentials for increased competitiveness. Over half of the respondents indicated that they could not execute the product-development activities as well as desired because of poor procedures to manage these activities.

6. References

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For more information please contact:

Larry Stauffer University of Idaho 800 Park Blvd., Suite 200 Boise Idaho 83712
Tel: 208-364-4084 Fax: 208-387-1246 E-mail: stauffer@uidaho.edu
URL: <http://www.boise.uidaho.edu/>