Value Engineering in the Developing World

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Abstract

This paper examines the ways in which Value Engineering could be effective in resource constrained settings in the Developing World. These settings have certain similarities to the context in which Larry Miles pioneered the discipline. Many of the professionals that work in these areas are used to developing creative solutions to challenges and could potentially be excellent VE team members. The author uses an example of a project they managed while working in Tanzania to usher the reader through a potential application of the Value Methodologies Job Plan.

Introduction

Before taking a position at Value Management Strategies, Inc. (VMS) my work was, at first glance, very different from conducting Value Management consulting services. I served in the Peace Corps as a Community Health Extension Officer in Tanzania and lived in a rural Sub-Saharan African village of about 4,000 people. My job was to provide health related education, run health-related programs, and connect people in the community to services. The primary health issues in the community where I lived were HIV, Malaria, and malnutrition.

Environments like the Southern Tanzania Village in which I lived are extremely resource constrained. In contexts such as these, people are forced to be inventive in their approach to solving problems. During my time in Tanzania I would frequently see imaginative and ingenious solutions to everyday challenges. For example, I witnessed excess cardboard become oven-mitts for taking hot pots off open flames, and newspapers, tightly wound into cones, used to hold small bulk items such as nails or dried beans.

These resource constraints forced me to be creative in my work as well. Solutions were never as simple as they might initially appear because, inevitably, some key piece of the puzzle was not available. The practice of Value Methodology (VM) emerged from a similarly constrained scenario during WWII. Larry Miles recognized that he could continue to deliver effective projects at General Electric by focusing on functions, rather than components or by using other traditional methods. Now, in my role at VMS, I've come to realize that a practice like VM, born out of scarcity, could be tremendously beneficial to projects, programs, and processes in the developing world. Many of the people that I met in Tanzania were remarkably creative and were consistently able to find clever and inventive ways to work around the resource limitations that they faced, however no formalized methodology like Value Engineering could help yield better results.

One of my main projects as a Community Health Extension Officer was the construction of an apiary (collection of beehives) for a group of people infected with HIV. From here forward this essay will discuss the apiary project as an example of how various creative solutions proposed by the apiary project team mirrored the Value Engineering Process, and also how Value Engineering could have been applied to improve project outcomes.

Value Methodology Job Plan Background

First, it's important to give a brief description of the Value Methodology (VM) Job Plan. This paper will use the six-step job plan to walk through the example project. The first step in the VM Job Plan is the Information Phase. The purpose of the Information Phase is to gain a thorough understanding of the project under consideration. This is accomplished through a team study and review of available information.

The second step of the VM Job Plan is the Function Analysis Phase. Function Analysis is the activity that sets VE apart from other approaches. Function Analysis breaks down a project or process into the functions it seeks to provide (as well as unintended functions) by focusing on what things do rather than what they are. Teams can divine more creative solutions when they can think about what a project or product does, rather than what it is.

The third step of the VM Job Plan is the Creative Phase. During this phase team members seek to develop as many create ways to accomplish the required project or product functions as possible. At this juncture, all ideas are recorded so that they may be evaluated in the next phase, volume is more important than quality in this phase.

The fourth step of the VM Job Plan is the Evaluation Phase. During the Evaluation Phase the team meets and discusses the brainstormed solutions from the Creative Phase. The goal is to reduce the number of potential solutions. Often, this phase is conducted with stakeholder input to eliminate ideas that are not feasible. Typically, the team will also compare potential alternatives against the baseline concept to determine cost, schedule, and performance implications for proposed solutions.

The fifth phase of the VM Job Plan is the Development Phase. During this phase team members will 'technically validate,' selected alternatives to ensure they have been quantified as fully and accurately as possible. The development phase gives VE team members the opportunity to prepare to present their findings to relevant stakeholders. These presentations must be developed in a way that ensures decision makers understand proposed alternatives and can make informed decisions moving forward.

The sixth and final phase of the VM Job Plan is the Presentation Phase. During the Presentation Phase the VE team prepares a report of the developed alternatives. The goal of the presentation phase is to inform the owner, project team, customer, and any other relevant stakeholders of the VE team's findings. This phase is not intended to serve as a 'decision-making' phase, that happens later in project development, but rather the phase that gives stakeholders the information that they need to make decisions and advance their project.

Information Phase

We understood that the scope of our project was to build an apiary for a People Living with HIV (PLHIV) group to generate income for their community (the highest order function). Our apiary project was scoped to build 26 large bee-hives. Beekeeping is a common agricultural practice throughout many parts of East Africa and there were people in the community where I lived that kept bees. Beekeeping was a new skill to members of the PLHIV group, but we were able to engage community beekeepers to provide guidance on our project. That said, the traditional style beehives that other members of the community used were very different than what we designed and built for our apiary project. The traditional beehives that are common in Tanzania are made from hollowed out logs hung parallel to the ground from sturdy trees. It is extremely challenging to harvest honey from these hives and they often rot out from the inside, hence our decision to find an alternative design.

One of the main challenges with beekeeping is ensuring that the hives remain populated. Bee colonies can leave for many reasons, but one challenge is that hives can be seriously disrupted by the honey harvesting process. Honey can be harvested in several different ways; the most common way to harvest honey from beehives is to cut all the areas that contain honey out of the hive. Honey is contained in wax combs that occasionally will house bee larvae as well. To separate out the honey from the wax and other solids, beekeepers generally heat the entire mass, causing the wax and other solids rise to the top, and allowing for easy removal after they cool and re-form into a solid.

Cutting out the entire area of the hive that contains honey can be problematic for a few reasons. First, it requires a high level of knowledge to be able to look at a hive and determine which areas contain honey and which areas are mostly used by the colony for breeding. These areas mostly contain bee larvae but can also contain the colony's queen bee (there is only one per hive and she is incredibly important to the hive's continued existence). Second, removing the areas that contain honey when combs are not properly separated removes larvae that are critical to the hive's future population growth and overall success. The larvae turn into young bees who will work to feed and defend the hive in the future. Third, bee colonies use the honey as food for their young and removing all the colony's food at once creates challenges for hive survival.

Removing the wax combs from the hive creates a far more nuanced problem. Combs take a tremendous amount of time and energy for bees to create. As a simple concept, bees will not produce honey, at least in quantities large enough for human use, unless they have combs in which it can be stored. A bee colony typically spends about sixty days creating the wax combs that they will fill with honey, but only an additional thirty days producing the honey itself. This means two-thirds of honey production is actually comb production. Honey combs, if you will, are a long lead item in a bee-hive's critical path. Destroying combs slows honey production considerably and increases the likelihood that a bee colony will simply look elsewhere for a home.

In many developed countries the solution to these challenges is for beekeepers to use the Langstroth Hive. This style of hive has two compartments—one for breeding and one for honey production—with an excluder to ensure that the queen cannot pass into the honey production area. This excluder ensures that the combs where honey are stored will not contain larvae as well. It also has removable frames in which bees build the combs of their hives. These removable frames can be taken out of the hive and honey can then be removed without destroying the combs.

Our project intended to build more modern-style hives with similar functionality to the Langstroth Hives. We learned a great deal about the design and performance requirements for several components of the Langstroth Hive. The frames that bees would use to construct their combs should not be wider than 22 inches or taller than 9 inches, otherwise the combs could become too heavy and therefore unstable. We wanted our hives to be constructed from a material that was durable, as opposed to the traditional cut-out logs. We also wanted our apiary to have a honey extractor; the extractor and frames in combination would allow us to harvest honey without destroying combs. Honey extractors work similarly to a centrifuge by spinning the frames that contain combs to help honey flow more quickly from the combs. For a honey extractor to be effective it must spin at 60 revolutions per minute or greater. Any metal components of the honey extractor that would contact honey must be coated with something like paint to avoid oxidation that could contaminate honey. These requirements, along with many others guided our thinking throughout the entire process.

Function Analysis Phase

While we did not perform formal function analysis, the project's success hinged on its ability to provide a few key functions and these functions did ultimately inform many of the decisions made during project delivery. The basic function of the project was to 'Produce Commodity.' Some of the other requirements that we learned during our informal information phase made a few other functions clear as well. For the purpose of this example, I will carry those functions forward in my discussion of the remaining VM job plan phases as well.

'Produce Commodity,' was obviously the basic function with the objective being to produce honey, but what were the supporting secondary functions that would make this project efficient enough to be successful? How was our team going to effectively 'Produce Commodity'? We were going to create an environment and system in which bees would thrive in the new Apiary, the function for which could be 'Enclose Animals'' wherein the target animals are the bees. 'Enclose Animals' was accomplished by creating a space in which the bees were comfortable and undisturbed. In order for the bees to be disturbed as little as possible we knew it was important to 'Remove Container.' The ability to 'Remove Container' in our case meant having combs separated from the areas of the hive where breeding occurred were far less likely to be disturbed by harvesting honey. It also meant that individual combs could be removed one at a time for harvest, which ensured a constant food source for the colony.

‘Preserve Container’ was a secondary function as well. More efficient beekeepers have a good way to extract honey without destroying the wax combs, or for our purposes, while preserving the ‘container.’ Combs that are built inside of man-made frames can be ‘opened’ or ‘unsealed’ by melting the wax cap on the face of the comb with a hot knife, which allows for honey to flow freely from the comb. This flow can be aided by using tools like a honey extractor. Then frames with intact wax combs can be placed back into the hives after honey extraction. This process speeds up the honey production process considerably, because bees are then free to refill the existing combs without building new ones. ‘Remove Container’ and ‘Preserve Container’ work together as a value adding risk mitigation strategy to increase honey production and reduce the associated uncertainty and risk that the colony will leave because of disturbances to the hive. Unfortunately, hives with frames and honey extractors are not commercially available in Tanzania.

Creative Phase

This was the phase in which the team that I worked with naturally performed well. They were able to find clever ways to work around the lack of certain machines, materials, and other resources. While my team naturally thrived at thinking creatively, examining the situation from a functional lens would have helped to inspire even better out-of-the-box ideas.

The majority of our creative ideas to deliver an effective project that met project requirements came from two functions: ‘Preserve Container,’ and ‘Remove Container.’ ‘Preserve Container’ was a function that dealt with the ability to extract honey from the hives without destroying combs. Combs could be ‘opened’ and harvested and then replaced into the hives. For our purposes, ‘Remove Container’ was the function for easily extracting combs for harvesting without disrupting the whole colony and for separating the areas of the colony that were used for honey production from those used for breeding more bees.

After talking to a local beekeeping subject matter expert, we discovered that there were cheap and affordable ways to accomplish most of these functions we had identified with locally available goods and materials. First, he explained that while beekeepers in East Africa largely have not adopted the Langstroth Hive, there is a similar style called the Top Bar Hive that was widely used in the region and offered similar functionality. These hives utilize ‘Top Bars’ similarly to the Langstroth’s frames. In these systems, bees build combs on the underside of the top bars. Top bars are oversized just enough that they create a natural separation between the combs where bees can pass in-between, which also allows beekeepers to pull out individual combs for inspection and harvesting. These top bars could easily be modified to be vertically oriented frames like Langstroth Hives. Introducing the frames was new to local beekeepers and the carpenters who built beehives, but the change was easy to explain and incorporate into apiary designs. We also considered building mud-brick cement-coated hives modeled on our Top Bar – Langstroth hybrid, because bricks were the most readily available and durable material in the community.

Figure 1: A local builder named Ima constructs the inside of the mud-brick hives

Second, we were informed that in a top bar hive a makeshift excluder could easily be made from a common type of plastic-coated wire mesh fencing that is often used for chicken coops. The first third of the top bars would be reserved for breeding and the back two thirds would be used for honey production. Queen bees are considerably larger than all other types of honeybees in the hives, and the size of the holes in the wire mesh was large enough that all other types of bees would be able to pass into the back of the hive, but small enough that the queen would be sequestered in the first third of the hive. Between the modified top bars and the wire mesh extractor we were finally able to accomplish our 'Remove Container' function.

Figure 2: After the cement exterior has been added a green plastic-coated wire mesh barrier is added to exclude the queen bee

Unfortunately, the expert did not have any suggestions for an extractor. Some people who owned larger operations had imported extractors from Europe, but that was too expensive for our small project; we needed to find another way. We understood from reading about honey extractors that if frames rotate more than sixty revolutions per minute, honey would flow freely from the ‘opened’ combs. We realized that while we could not purchase a honey extractor, we could make a centrifuge with similar dimensions that could serve the same ‘Preserve Container’ function.

I took a bus into the nearest city with a friend to look at our options for supplies. We found that we could buy 5/8-inch steel rods that could be easily welded together to make the interior portion of the centrifuge (essentially a stand on which a metal box with compartments for the bee-hive frames) could rotate) and there were large plastic tubs that could contain the whole apparatus. I worked with a local welder to construct the interior portions and to paint them so that frame would not oxidize and contaminate the honey. With a little bit of creative thinking we were able to construct a honey extractor which met all our performance requirements at a very low price.

Figure 3: The local welders construct the improvised interior of the honey extractor

Figure 4: The interior of the honey extractor sits inside its plastic drum housing

Evaluation Phase

The Evaluation Phase of this project was modified considerably because there was not a ‘baseline project’ or formally proposed set of alternatives. Instead, the evaluation phase for this project involved brief discussions with stakeholders on the feasibility of whether some of the creative solutions we proposed were realistic and desirable to the end user (the PLHIV group). Similar to the VM Job plan, the Creative and Evaluation Phases can be quite iterative and circular to arrive at the best value solution. That being said, a formal process to evaluate all the creative ideas would have been helpful to ensure that all the ideas we explored in detail were realistic and desirable prior to spending time on collecting more information. For the purposes of this exercise, it is fair to say that a modified and limited Evaluation Phase was conducted.

Development Phase

During the development phase the team conducted an analysis of some of the new ‘alternative’ design concepts including a queen excluder, top bars, and a honey extractor. This included a breakeven point calculation to determine how many years of more efficient honey production it would take to make back the initial capital cost of the honey extractor and a Life Cycle Cost Analysis of Brick Hives versus Traditional Hives. The use of these modern technologies is an example of a set of fully developed ‘VE Alternatives’ that were accepted and implemented into the final project. The development of other ‘alternative’ design concepts the was more ad hoc and did not involve any mathematical or engineering analysis.

Presentation Phase

We were able to use some ‘Presentation Phase’ strategies to show stakeholders the benefits of the more modern hives. Unfortunately, many of the local leaders who became involved with the project initially pushed to use the more traditional methods with which they were familiar. These were influential men in the community, so it was important to be able to thoroughly explain the benefits of the proposed modern design. While these traditional hives were easier to construct and more affordable, they had very short life spans and often lasted fewer than four years and were less efficient. The hives that the team proposed had a brick and concrete exterior; they had a high initial capital cost, but also a much higher return on investment based on their twenty-year service life. In the end, the project team decided to incorporate all the 'alternative' design concepts, or new technologies into the project, which led to a more efficient apiary.

Conclusions

During my time in Peace Corps I was entirely unaware of the VM process, but today I can see that using the VM Job Plan on any of the projects that I managed during my time in Tanzania would have increased their value tremendously. VM is centered around finding different and often more efficient ways to deliver the same function in a project, product, or process, there is no doubt that VE can be leveraged to generate the creative solutions that projects in resource constrained global health and development settings like the projects I worked on in Tanzania required.

VM emerged during a time of intense resource constraints which makes the practice uniquely well suited for application in the developing world. Function Analysis would be an effective tool for identifying alternative ways to provide required functions when the typical resources are unavailable. There is tremendous growth in infrastructure and access to health care throughout the developing world, and Value Engineering could be applied to infrastructure projects from hydroelectric dams to roads, bridges, and railways, or used to improve processes like supply chains for lifesaving medical supplies to ensure that projects are delivered effectively. Applying Value Engineering in the developing world would be a way for VE practitioners to continue the legacy that Larry Miles pioneered decades ago when he created the Value Methodology to solve challenging problems in heavily constrained contexts.

Figure 3: Members of the Furaha (Happy) Beekeeping Group Pose in their bee suits