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Academic validation of the Innovation Engineering program for use by CIRAS and other MEP centers for increasing innovation in American companies

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Academic validation of the Innovation Engineering program for use by CIRAS and other MEP centers for increasing innovation in American companies

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ABSTRACT

The Innovation Engineering (IE) program, organized by inventor Doug Hall, is an educational workshop that presents methods and strategies to improve innovation. The Hollings Manufacturing Extension Partnership (MEP) program, a division of the National Institute of Standards and Technology (NIST), uses this training for their consultants at MEP-funded centers across the United States. The IE program provides insightful recommendations to encourage the success of innovations with three main categories: Create, Communicate, and Commercialize. The most substantial of these categories is the Create category, which provides tools for generating new ideas. The Communicate category lists techniques for effectively communicating these ideas to others, and the Commercialize category offers advice for ensuring that the innovation is worth the financial investment required to produce it. However, the IE program does not provide peer-reviewed sources to substantiate these suggestions.

This thesis serves as a compiled a collection of experimental treatments in academic literature that investigate the effectiveness of the methods proposed by the IE program. This paper provides a review of the academic literature that supports, and in a few cases refutes, the techniques taught by the IE program. Some additional methods, complementary to the recommendations of IE, are also included.

CHAPTER 1

INTRODUCTION

Innovation is widely accepted as a major force for the growth of any developed economy [1-6], and even the current president of the United States agrees [7]. The production of technological innovations has historically led to economic prosperity, and a new economic theory known as Innovation Economics has become increasingly popular within the last two decades [8].

The commonly accepted definition of innovation is simply the process of introducing something new [9-11]. However, for an innovation to spur economic growth as described above, it must be more than just new – it must also imbue a certain level of importance. Without meaningfulness to the intended audience, an innovation just becomes a change without a cause, and this kind of innovation will be unlikely to obtain a successful response. This is particularly true of innovations in engineering disciplines. New products or technologies require customers to see them as important enough to purchase and adopt, and without this adoption, the product or technology will certainly fail.

Because of the large influence that innovation can have on the economies of developed nations, the United States government has actions to improve the levels of innovation in American businesses. The National Institute of Standards and Technology (NIST) is a non-regulatory organization of the United States Department of Commerce that "Promote[s] U.S. innovation and industrial competitiveness by advancing

measurement science, standards, and technology in ways that enhance economic security and improve our quality of life [12].” NIST has a collection of programs it calls the “Innovation Toolkit [13],” a component of which is The Hollings Manufacturing Extension Partnership (MEP). The MEP “works with small and mid-sized U.S. manufacturers to help them create and retain jobs, increase profits, and save time and money [14]” by acting as a strategic advisor or business consultant at a regional level [15]. With 56 dedicated MEP centers throughout the United States and Puerto Rico and over 1400 technical experts [14], MEP programs have the potential to influence a large number of American Companies. Participation in the Innovation Engineering program is recommended training for all MEP technical experts.

Recently, the MEP has adopted a new system for helping businesses improve their ability to innovate. This system, called Innovation Engineering (IE), was developed by American inventor Doug Hall [16]. Hall is known for his work at Proctor and Gamble, founding the Eureka! Ranch innovation consulting firm [17], his multiple appearances on reality television shows including American Inventor in the United States and Venture in Canada, and authoring a variety of books on innovation, inspiration and marketing [18-23].

Iowa’s Center for Industrial Research and Service (CIRAS), an affiliate of the MEP program, wanted to share evidence of the IE programs’ effectiveness with its clients. Lacking the financial resources to conduct a test vs. control longitudinal study on the effectiveness of the program in an industrial setting (or otherwise), they instead wanted to find existing academic research that supported the IE claims. They contacted

the Interdisciplinary Research In Sustainable (IRIS) Design Lab at Iowa State University to propose a research project which lab owner Erin MacDonald and graduate student Christopher Miller accepted.

This thesis presents a collection of peer-reviewed literature with scientific experimental conditions that either support or refute the effectiveness of methods recommended by IE. The paper proceeds as follows: Chapter 2 provides a background on the Innovation Engineering program, Chapter 3 details the method and organization of the conducted literature review, Chapters 4, 5, and 6 step through each specific topic and the related literature, Chapter 7 offers a discussion and new thoughts, and Chapter 8 provides concluding remarks.

CHAPTER 2

BACKGROUND ON INNOVATION ENGINEERING

The Innovation Engineering program presents a set of methods and principles that can be categorized in a variety of ways, but are best summarized as: Create, Communicate, and Commercialize. Program participants learn methods that generate new ideas intended to grow organizations (typically to increase revenues), communicate those ideas to management and customers, and implement these ideas in commercially-viable products. . The material presented at the program is flexible to business size and goals, and can also be implemented by students, entrepreneurs, and non-governmental organizations. The program began in 2005 [18].

The motivation and structure of the Innovation Engineering program draws inspiration from work by W. Edwards Deming. Deming suggested that the lack of innovation in the market was a failure of the corporate structure rather than the individual workers [24]. This ideology lends itself well to a program like Innovation Engineering that attempts to teach a new system for innovation to business leaders.

Innovation Engineering has tiered levels of certification, much like Six Sigma [25]. At the time of publication, some trainees participate in a three-day workshop called the Innovation Engineering Leadership Institute (IELI). It includes three morning sessions of lectures that introduce the methods and principles, and two afternoons of applied learning. There are two evenings of group homework as well. Attendees also have continued access to associated online resources that guide them through the

processes discussed. As a part of this research, the author attended a three-day IELI workshop conducted directly by Doug Hall.

Advanced “Black Belt” training sessions are longer programs that give participants advanced training in order to teach the principles and methods of Innovation Engineering to others. All MEP technical experts are required to attend this training to become qualified to teach Innovation Engineering to their clients. Additionally, the University of Maine offers both a six course minor program and a three course graduate certificate in Innovation Engineering [26]. There is an online version of the training available that covers similar material.

CHAPTER 3

METHOD

As mentioned previously, the topics of IE can be broken into the categories of Create, Communicate, and Commercialize. Within each topic, there are two types of information shared at the conference: tools and advice. This paper investigates evidence of validity of both types of information.

The evidence of effectiveness presented here comes only from peer-reviewed journal articles and conference proceedings. Further, all evidence presented is from studies that used a scientifically-designed testing procedure and tested results for statistical significance. Other approaches not discussed here might, for example, observe a subject pool and discuss overall effectiveness of a tool in anecdotal terms or draw recommendations from observed behavior of expert designers.

The restriction to test vs. control experiments and closely related formats was placed to ensure that the evidence located would be of useful for CIRAS to prove the validity of the tools when they are presented to manufacturers unfamiliar with the study of design. Outside of the theoretical engineering design community, observational studies are sometimes less well-accepted, as was noticed by the author both at the IE workshop and in conversations with CIRAS employees.

The literature review was conducted using both print and online resources from the Iowa State University Library as well as the Google search engine. The main resource used was the Web of Knowledge, an online database of scholarly literature

from the academic fields of science, social science, arts, and humanities. Other sources include scholarly books and web articles.

The Web of Knowledge literature searches were conducted by identifying up to three keywords from each query. For example, a search for evidence showing the manner in which groups affect creative ability could be performed by selecting the keywords “Groups,” “Creativity,” and “Experiment” and entering them as search components into the database. The abstracts obtained as the result of such queries were classified as relevant or irrelevant. Then, the full document versions of relevant sources were searched for evidence to either support or refute the Innovation Engineering topic in question. Over 1500 abstracts were examined leading to the review of over 300 related studies. Only those including test vs. control experimental evidence are included here.

Table 1 summarizes the methods and advice investigated by this study. It gives a brief summary of the method and lists the references that support and refute the effectiveness of the method.

The next three chapters walk through each main category from the Innovation Engineering program. Each sub-section describes a topic and presents the relevant literature supporting or refuting the effectiveness.

Table 1. A summary of the concepts documentation presented

	Method	Summary	Supporting Literature	Refuting or Mixed Literature
Create	Mind Maps	Tool for graphical organization and sharing of information	[17]c, [18]o,	
	TRIZ	Tool for systematic creativity	[20]c, [21]c, [22]c, [23]w	
	Stimuli	Input from an outside source	[25]o, [26]o, [27]c	[28]o
	Associations	The process of forming mental connections between thoughts	[30]c, [31]u, [32]c, [34]c	
	Groups	Working collaboratively with others	[35]o, [36]o, [37]o, [38]w	[39]c, [40]o
	Dual Brain	Left hemisphere controls analytical thinking while right controls creativity		[41]o, [42]o, [43]o, [44]o
	Humor	The ability to appreciate incongruities and comical situations	[48]o, [49]o, [50]o	
Communicate	Benefit Promise	Why people should care	[51]w	
	Simplicity	Keep the message simple and concise		[54]o, [55]o
	Tell the Truth	Be honest and open with customers	[56]o, [57]c, [58]o, [59]c, [60]o, [61]o, [62]o	[63]o
	Repetition	Repeat your advertising message	[64] o, [65] o	
	Provide Proof	Supply examples of your innovation working	[63]o, [66]o	[67]o
	Tell a Story	The inclusion of a plot entices people	[69]c, [70]o	
Commercialize	Do One Thing Great	Reduce the number of options offered	[71]w, [72]cwo, [73]o	[74]o
	Include a Number	Including objective information improves advertisements	[75]c, [76]w	
	Fourt-Woodlock Equation	Prediction of market success for new products	[77]o	

Letters accompanying the reference numbers in the table refer to the setting in which the experiment was conducted. “c” represents a classroom setting, “w” a workplace, “o” other (such as a lab), and “u” unknown.

CHAPTER 4

CREATE

The Create category of the Innovation Engineering program is designed to help industry professionals generate and refine innovative ideas. These innovations can be products, services, or business practices, but to be effective, the program asserts that they must all share one simple trait: they must be "meaningfully unique." This agrees with the discussion of innovations for economic growth in the introduction: meaningful implies a level of importance to the customer, and unique implies a newness of the idea. The IE program states that this meaningful uniqueness exists when "customers are willing to pay more money for your offering" and offerings that are not meaningfully unique must be cheaper than other options to survive. The basic idea of the Create category is to help businesses develop new ideas that are meaningfully unique. To do this, a variety of methods are proposed and advice is given. The following sub-sections step through the methods and advice of the Create category, offering supporting and/or refuting literature.

Mind Maps

Mind maps are graphical tools that allow people to organize and share information in a way that is simple to understand. An example that organizes the information in the IE Create category is shown in Figure 1. The term was popularized by Tony Buzan in the 1970s [27], though the graphical format has been used throughout

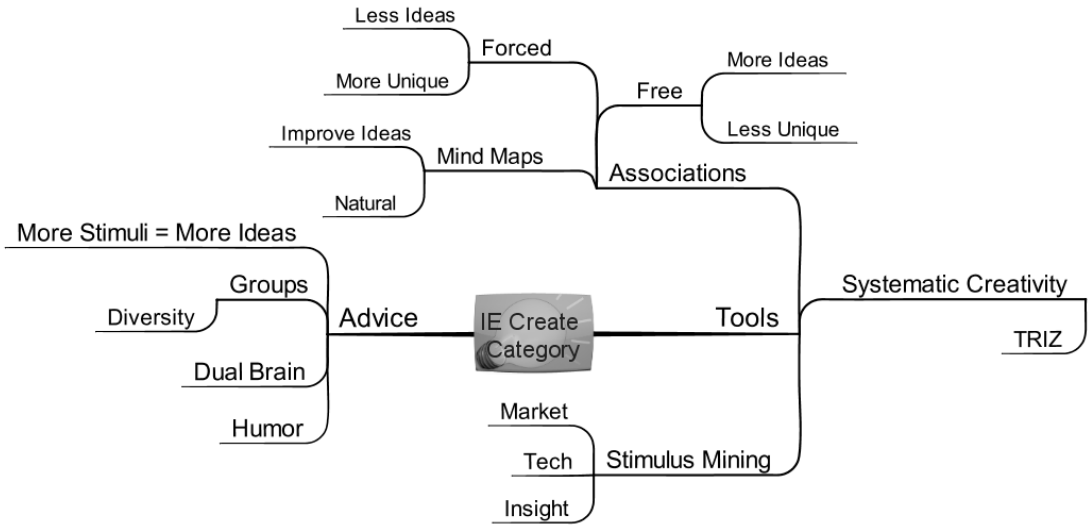

Figure 1. An example of a mind map generated with the concepts from the Create category of the Innovation Engineering program.

history. The mapping begins with a central idea and has ideas or "branches" extend from the central idea. These branches can then spawn branches of their own that continue to extend outward. Linked ideas on different branches can be connected, allowing more ideas to form. This method of organization allows all ideas to be easily accessible and can help to draw connections between thoughts that may seem unrelated at first. IE recommends using mind maps for documenting individual and group association (free and/or forced) exercises.

Kokotovich [28] found that mind maps are useful as design tools through the experimental introduction of mind mapping techniques to industrial design students. In this study, mind mapping techniques were introduced to first year industrial design students in a project based class. The students used mind maps to help them generate individual project proposals, and the creativity of these proposals was reviewed by judges who had not seen the mind maps associated with each proposal. The judges

consistently rated work associated with better mind maps as more creative, and the results show a statistically significant correlation between the quality of the mind maps generated and the students' abilities to develop creative designs. Another study by Unalan [29] examined the ability of graphical organizational tools to convey information. Images of different organizational tools that displayed the same information were created and shown to participants. The participants then judged their clarity and ability to communicate creative content. Mind maps were generally ranked as the best graphical tool by the participants.

TRIZ

The Theory of Inventive Problem Solving, commonly known as TRIZ, is a systematic creativity tool. This tool was developed by Russian engineer Genrich Altshuller and colleagues after they had examined over two million patents to extract commonalities in innovative approaches [30]. TRIZ provides problem solving strategies that are meant to help inventors think creatively and find solutions that they may not have identified without a constructive approach. The component highlighted in IE Create involves identifying contradictory elements (ex. high strength and low weight) in the design of a product. From a list of 39 elements, the designer identifies the two contradictory elements that most closely resemble the problem at hand, and TRIZ uses these indices to provide a variety of suggestions to provoke creative solutions. Beyond the instruction provided by the IE program, an interactive TRIZ-type tool is available

online through the associated website. This tool made using TRIZ simple: the two contradictory elements could be chosen from separate drop down menus, and the software would identify and display which of the principles may be helpful.

While investigating learning styles, Leon-Rovira *et al.* [31] found that freshmen mechanical engineering students who were given an introduction to TRIZ were scored as more creative than those who did not learn about TRIZ. Ogot and Okudan [32] reached a similar conclusion studying final year industrial design and engineering students. The students were given a product design task in which the control groups used traditional creativity methods while the experimental group used TRIZ techniques. The straightforward approach to design that TRIZ employs favored the creative process in these multidisciplinary teams. The effect of using TRIZ in multidisciplinary design teams was also examined by Gonzalez-Cruz *et al.* [33]. Students in certain sections of an undergraduate engineering design class were introduced to TRIZ methods while those in other sections were not. The student groups using TRIZ methods generated 115% more unique design solutions to proposed problems per section than sections that only used traditional brainstorming techniques. A study conducted by Birdi *et al.* [34] helped identify the benefits of TRIZ in the workplace. Power systems engineers from a multinational firm who experienced a one-day TRIZ training workshop reported significantly higher levels of creative problem solving skills, idea generation, and creative motivation than the engineers who did not attend the training. Over a period of three years, 41% of the trainees reported submitting one or more patent applications compared to 28% of the non-trainees. As part of a follow up survey after this three year

period, participants were asked to generate as many original solutions as possible to a posed problem. On average, trainees suggested two ideas each while non-trainees submitted only one.

Stimulus

Stimuli provide information to living organisms and directly influence their behavior by allowing the organism to react accordingly [35]. In the context of creativity, any input obtained from an outside source during the creative process can act to stimulate the mind in new ways, leading to new ideas and possible solutions to current problems. Finding stimuli was one of the most important topics discussed at the IELI under the general heading "stimulus mining." Associated methods included: (1) insight mining, where the designer receives stimuli directly from the customer in the form of observations, conversations, opinions, and surveys; (2) market mining, meaning that ideas can come from current products that are available; (3) technology mining, in which ideas are formed by examining newly available or emerging technology.

Fink *et al.* [36] investigated whether creative cognition could be enhanced through learning the ideas of others. This study found that participants in an alternative uses task were able to generate more unique ideas after they were presented with other participant's ideas than participants that did not see others' ideas. An experiment by Valacich, *et al.* [37] used a computer simulated group to provide participants with different qualities of stimulation during an idea generation exercise. To determine the

quality of stimuli, they first collected responses that groups of five had to a proposed problem. Three domain experts judged the quality of these responses on a seven-point Likert scale. 50 high quality and low quality ideas were randomly entered into a database. During the experiment, a computer program supplied these ideas to participants in a manner that mimicked the way they would have been supplied by an actual group. They found that the highest performance was associated with the highest quality stimulation.

The Design Heuristic Cards created and used in a study by Daly *et al.* [38] work as stimuli for designers and have been shown to improve ideation. The cards explain a design pattern or approach that has been identified from an examination of design techniques and show two examples of the pattern in use. In the experimental study, these cards were given to freshman engineering students along with a design task. The solutions to the design task generated by students who were asked to use the cards were more original and better developed than the solutions generated by students that were not exposed to the cards.

The IE program emphasizes ethnographic studies as a source of customer insight. This approach is widely-accepted in academia as effective, but the authors were unable to find a test-vs.-control experiment to validate its use.

A possible downfall in using stimuli to assist in creative problem solving is the concept of fixation. Design fixation occurs when a designer becomes familiar with an existing solution and aspects of that solution begin to appear in their designs. Linsey *et al.* [39] investigated the topic of fixation with respect to engineering design. In their

study, groups of engineering design faculty members were given a design task. Experimental fixation groups were given material including example designs. These groups produced fewer unique solutions than the groups who were not given the fixation material. Some groups given examples that specifically violated one or more design constraints submitted solutions that violated the same constraints.

Associations

As it relates to mental processes, association is defined as the process of forming mental connections or bonds between sensations, ideas, or memories [40].The ability to make associations between different ideas is a very useful way to generate creative ideas. In making associations, stimuli that may not seem related can be combined to form new ideas. The IE program suggests that new ideas can be combinations of old ideas. It discusses two types of associations: free and forced. Free associations were defined as those made between closely related stimuli, such as apples and grapes. When unrelated stimuli, such as a clock and an elephant, are introduced as brainstorming stimuli, they are referred to as forced associations. The IE program suggests that free association leads to more ideas than forced association, but the ideas generated by forced association are generally more unique.

Association warm-up exercises were found to improve creative thinking ability during a study by Freedman [41]. Participants in the experimental group were given a stimulus word and then asked to generate other associated words, while those in the

control group read stimulus words but did not generate associated words. On a subsequent creative thinking test, male participants who completed the association exercises earned an average score of 18.05 out of 30, which was significantly higher than the average score of 14.15 out of 30 that the control group earned. The difference in female participant scores was not as large as that for male participants, but the facilitation group still performed better than the non-facilitation group.

Participants in a study by Coskun [42] generated more ideas during a brainstorming session after exercising on closely linked word pairs. The participants who exercised on distantly linked word pairs did not generate as many ideas. This finding suggest that "free association" may be more effective at generating larger volumes of ideas than "forced association," but it does not speak to the quality or originality of these ideas. Miller *et al.* [43] found that free association training improved participants' abilities to discover additional links between stimuli on the Remote Associations Test [44]. Participants in the experimental group were given 30 seconds to free associate additional words for each of 10 stimulus words. To ensure that simply being exposed to the words was not enough to significantly affect scores, each participant in the control group read the words generated by a randomly selected participant in the experimental group. Association instruction was shown to directly affect creativity in a study by Cheng *et al.* [45]. After a creative thinking pretest determined that there were no significant differences between fourth grade students, both free and forced association training was given to an experimental group over a five week period. This training consisted of making associations between numbers, images, stories

and music. One example given is the association between the number 14 and a man windsurfing. After the treatment phase, all students wrote poems to be judged on creativity. The poems by students in the experimental group were consistently judged as more creative than those from the control.

Groups

When attempting to generate creative ideas, it is commonly thought that working in groups will positively affect productivity. More people working on a common task means more opinions, experiences, thoughts, and neurons influencing the final product. The usefulness of groups is emphasized by the IE program. Every activity involved group work in-part or in-sum, as it was explained to help clarify and refine ideas.

By comparing the quantities of ideas generated by groups and individuals, Paulus and Yang [46] determined that groups could outperform individuals and nominal groups (pooled individual data) in idea generation. Using a brainwriting paradigm, groups of students sharing their ideas with others in a group lead to the production of more unique ideas than individuals or pooled individuals. Another finding from this study is that ideation performance is inhibited when the group members are asked to memorize the ideas generated by teammates. Different levels of group interaction during brainstorming activities were examined by McGlynn, *et al.* [47]. University students were assigned either high interaction groups or low interaction groups. Groups working with low interaction (working individually but in the same area) generated more ideas than high

interaction groups (working face to face), but when the quality of ideas was considered, the high interaction groups performed the best. The high interaction group consensus solutions were also rated as significantly better than the group members' individual responses. Coskun [48] studied the effect of group size and session length in brainstorming activities. Groups of four, six, eight, ten, and twelve people were given an idea generation task and allowed to work for either fifteen or twenty minutes. The number of unique ideas generated by each group increased proportionally with the size of the group, but the size did not affect the performance of the individuals that comprised the group, suggesting no synergistic or combinatorial effects. Pirola-Merlo and Mann [49] identified that even though a majority of the variance in recent team creativity was accounted for by the average recent team member creativity, a systematic variance still exists in group creativity after controlling for individual creativity. This means that even though the individual group members' creativity accounted for most of the group's creativity, there was evidence of improved creative thinking that occurred due to group interaction.

Taggar [50] found that groups can help to improve creativity if the members engage in behavior that encourages the open sharing of information. However, if group members are inadequately trained or if the group is too large, team processes can stifle creativity. This suggests that ideal creativity-fostering groups are relatively small with members who understand the importance of their behavior. Diehl and Stroebe [51] examined a number of possible ways that group brainstorming could negatively affect the productivity of the members. The data they collected suggests the existence of

blocking, or the inability to share ideas because a different member was sharing, as a possible hindrance to group idea generation. The delay between the generation and sharing of ideas due to blocking may prevent new ideas from being developed.

Dual Brain

A commonly held belief throughout the general population is that creative and impulsive behavior originates in the right hemisphere of the brain while logical and analytical behavior stems from the left hemisphere. Although this hemispheric distinction does not exist, the terms “right brain” and “left brain” have become figures of speech pertaining to creative and analytical personality types, respectively. The IE program refers to right brain and left brain as descriptions of personality with remarks such as “Logical Left Brain” and “Radical Right Brain.” There was also a personality quiz to identify whether the attendees were left brain, right brain, or whole brain thinkers. The left brain thinkers were praised for their work ethic and their ability to make ideas real while the right brain thinkers were praised for their risk taking and for being the engine for change. Whole brain thinking was also discussed, with the ability to combine the strengths of both thinking types and obtain the best results.

Kowatari *et al.* [52] conducted fMRI scans on both expert and novice designers during a design task to find that expert designers showed a bias toward right hemisphere activation while the novices experienced a more bilateral response. Many experts showed a negative change in blood oxygenated level-dependent signals in the left

hemisphere. Both fMRI and EEG measurement methods were used by Fink *et al.* [53] to record brain activity during creative thinking tasks. Participants working on tasks such as generating alternative uses, describing object characteristics, inventing names, and completing words experienced whole brain activation rather than a bias to one side. Abraham *et al.* [54] examined brain activity associated with conceptual expansion and found that the regions involved were those responsible for the retention, retrieval, and integration of conceptual knowledge, which are strongly lateralized to the left hemisphere. Howard-Jones *et al.* [55] identified the brain area involved in approaching a creative story generation task as the right prefrontal cortex.

This literature suggests that the notion of separated brain hemispheres is not entirely accurate. While some creative processes showed lateralized brain responses, others caused whole brain activation. These responses can be affected by the level of experience the participants have with the creative activity being completed. Also, while certain specific creative processes may elicit the activation of a particular area of the brain, other areas of the brain are necessary utilize these processes.

Humor

Humor is one of the many ways that people can interact with one another, and it is important in maintaining healthy interpersonal relationships [56, 57]. Humor is defined as the mental faculty of discovering, expressing, or appreciating the ludicrous or absurdly incongruous [58]. The IE program uses humor and included satirical anecdotes

to demonstrate points. Beyond applying to creativity and innovative idea generation, it was noted that humor at work will increase the productivity and mood of employees because it leads to a more enjoyable experience.

To identify the relationship between humor and creativity, Humke and Schaefer [59] had participants complete humor and creative thinking measures. They found a Pearson correlation coefficient of 0.77 between scores on the Multidimensional Sense of Humor Scale and the Franck Drawing Completion Test. Rouff [60] also found a positive correlation between subject's abilities to identify humorous incongruities and Remote Associates Test scores. Ziv [61] investigated the relationship between laughter and creative thinking. A humorous recording, selected due to its ability to produce high amplitude and long duration laughter in subjects listening to it, was played for participants in an experimental group taking a Torrance Test of Creative Thinking. The participants who listened to the recording performed significantly better on the test than the control group that did not.

Conclusion

Each tool in the IE Create category has been tailored to improve the quality and/or quantity of ideas that can be generated by designers. Since none of the tools contradict any others, it can be assumed that combining the tools will result in compounding improvements in both quality and quantity. To obtain the best results,

however, it is necessary to understand how to best use each of the tools. A detailed discussion of this can be found in Chapter 7.

CHAPTER 5

COMMUNICATE

It is commonly thought that professionals in technical disciplines, such as science and engineering, are poor communicators. According to a summary of recent Graduate Record Examinations scores, students intending to obtain engineering graduate degrees had some of the lowest average verbal reasoning and analytical writing scores of all intended majors [62]. Furthermore, the information that technical professionals must communicate is often quite complex and difficult to understand, so even skilled communicators may have trouble effectively presenting it. For these reasons, it is necessary to ensure that once a good innovation has been developed, it can be communicated to the intended audience. This chapter explains the methods and advice of the Communicate category and walks through the relevant literature.

Benefit Promise

The major point in this category is to communicate what the Innovation Engineering program calls a “benefit promise.” Benefit promise is the term the program uses to explain the specific benefit that an innovation will provide to the audience. The IE program stresses that it is important to tell people why they should care as opposed to simply listing features of a product or service.

Although no studies could be found that directly related to the importance of a benefit promise (likely because the term was created by the IE program), a study by Cooper and Kleinschmidt [63] showed the relative importance of product benefits to product success. After examining 109 different products from chemical companies, the authors identified the traits that lead to successful products. The top three traits identified involved the products' relative quality and price as compared to the competition, and the fourth trait was the featuring of a specific benefit of importance to the customer. This shows that while products still need to be competitive, including the promise of a benefit also increases the likelihood of marketplace success.

Simplicity

In communication, simplicity refers to limiting the amount of information being exchanged. More information being communicated by one party means more information for the other party to remember. Therefore, it is suggested by the IE program that all communications be made as simple as possible to allow the most important aspects of the message to be received and remembered.

While this suggestion of simplicity is widely available in many forms [64, 65] there was a surprising dearth of academic research available from the literature search methods used for this thesis. Both the benefit of using simple communication and the difficulties caused by complex messages were investigated, but no relevant results were located. One reason for this could be that simplicity in communication is assumed to be

common sense. Therefore, it is possible that research funding and effort is directed away from this subject.

Perhaps this scarcity in research is misguided, however, as sources were located that refute the idea of making communications as simple as possible. Shedler and Manis [66] tested the effect additional but unrelated details have on the credibility of arguments. Participants heard equal numbers of opposing arguments about the fitness of a mother and were asked whether they thought the mother should retain custody of her child. One group of participants heard additional details for the positive arguments while the other group heard additional details about the negative arguments. Interestingly, even though the details were unrelated to the fitness of the parent, the additional information significantly affected the subjects' judgments in both cases. Another study by Macklin *et al.* [67] examined how the readability of a print advertisement affected a reader's ability to retain important information. Different versions of a printed advertisement that were statistically verified to contain the same information and vividness were shown to different groups of participants who were later tested for information recall. The experiment revealed that the readability did not affect the ability to recall ad claims, attitude toward the brand or ad, or purchase intent.

Tell the Truth

Honesty is commonly known as a vital component in any relationship. Being honest proves trustworthiness, which is also important in relationships. The IE program

contests that the relationship between a company and its customers is no exception, and the literature found for this thesis agrees completely.

The Edelman Trust Barometer [68] is a public survey that attempts to gauge why people trust companies. Information from 26000 public respondents in 26 countries was used to identify attributes that encourage trust in companies. Honest communication from the companies was identified as one of the most important attributes to build trust. Trifts and Haubl [69], Corbitt *et al.* [70] and Jarvenpaa *et al.* [71] all showed that the perceived trustworthiness of an internet vendor is positively correlated with the probability that consumers choose to purchase from those vendors. A mail survey conducted by Lau and Lee [72] identified that brand performance and is a strong predictor of trust in a brand, and that trust in a brand contributes to brand loyalty. Participants in a study by Settle and Golden [73] were shown advertisements where a new product was compared to the current best-selling alternative. One group was shown a version that claimed the new product was superior in five of five areas while another group was shown a version that only claimed superiority in three of five areas. The group shown ads accepting inferiority in two areas reported a higher confidence in believing the advertisements. A study by Anderson [74] investigated the relationship between expectations and actual performance of a product. When subjects were given realistic expectations of a pen's performance, they rated its performance higher than participants who were given overly positive expectations.

Although it does not directly refute the idea of being honest, one study offers some insight into how much honest information should be supplied. Liberali et al. [75]

found that brands supplying information that made them vulnerable to criticism did not increase participant trust in the brand. This is important to note: honesty is important in communication, but it is not advised to supply extra information that may negatively affect an innovation if the only reason for doing so is to appear more trustworthy.

Repetition

The Innovation Engineering program claims that repeating a message increases the likelihood that it will be remembered. This notion is widely accepted, the literature found agrees. D'Souza and Rao [76] tested the effect of repeating a specific advertisement relative to competitors. They found that higher repetition resulted in significant increases in top of mind awareness, brand preference, and brand choice. Ray and Sawyer [77] reached a similar conclusion after examining the effect of advertisement repetition. Female shoppers were exposed to slides featuring ads with varying amounts of repetition and then took a survey. Repetition of the ads had the most significant effect on recall, with an almost 40% increase in recall when comparing a single exposure to four exposures. Purchase intention for the products shown also increased significantly, but the improvement was not as substantial as in recall.

Provide Proof

Providing proof presents potential customers with concrete evidence to support a marketing claim. The examples of proof used in the Innovation Engineering program include test results, company pedigree, testimonials, and guarantees. The program also indicated that as long as the proof is meaningful, more of it is better.

Liberali *et al.* [75] tested whether access to additional information would alter consumer brand preferences. Subjects were exposed to direct product experience, print and online resources, word of mouth, or recommendations from trusted advisors. The study found that providing direct product experience and testimonials significantly improved brand consideration and trust in a brand. East *et al.* [78] used surveys mailed to homes to measure the change in purchase intent after exposure to positive and negative word of mouth. The results showed that positive word of mouth improved the subjects' probability of purchase by an average of around 50% while the negative word of mouth decreased the average purchase probability by 25%. Multiple references from the Tell the Truth section [69-71] explain that consumer trust improves brand consideration; this trust can be affected by a company's reputation and pedigree.

Fu and Chen [79] offer a slightly mixed review of offering guarantees. In a study examining online auctions, the authors identified that while offering a refund guarantee did increase the price premium of the items up for bid, it did not affect the time until the first bid, number of bidders, or number of bids. This means that the customers were

willing to pay more knowing they were guaranteed a refund, but the guarantee did not attract more interest or additional customers.

Include a Number

The Innovation Engineering program suggests that including numbers in advertisements makes them concrete and understandable. For example, the program would encourage replacing the message "this toothbrush design removes more plaque than the leading brand" with "this toothbrush design removes three times as much plaque as the leading brand." The number three in this example gives the audience a value to place on the product; using one of these new toothbrushes is like using three of the old ones.

The literature found here supports the Innovation Engineering program's claim. Holbrook [80] had participants read and rate advertisements that were either objective or subjective in nature. Objective ads included statements such as "27 miles per gallon" while subjective ads would instead read "truly excellent gas mileage." Subjects who saw the objective advertisements consistently reported higher brand attitude and belief in the claims than those who read the subjective ads. The same result was obtained by Rossiter and Percy [81] when they had consumer participants rate a product after seeing its advertisement. Subjects who saw ads that included concrete information such as "Bavaria's number one selling beer for the last ten years" responded more favorably to

the product and the brand than those who saw less concrete statements like “Bavaria’s finest beer.”

Tell a Story

A good story, such as a novel or a movie, can captivate large audiences and involve them both intellectually and emotionally. A particularly good story, such as *Star Wars* or *Harry Potter*, can even land the creator on the Forbes 400 list by drawing in enough people [82]. The power that stories have to excite and intrigue leads the Innovation Engineering program to suggest their use in communicating marketing messages.

Green and Brock [83] investigated the believability of a story. Participants were given a short story to read and told that it was either fictitious or real. A survey conducted after the reading identified that subjects who reported higher transportation by the story (deeper mental processing/emotional involvement) rated the situation described as more realistic regardless of whether they were told the story was true or false. These participants also reported more positive feelings toward the characters in the story. The effect of arranging facts into a story was examined by Pennington and Hastie [84]. Participants acted as jury members for a mock trial, and after being presented evidence, were asked to determine if the defendant was innocent or guilty. The study found that when evidence supporting one verdict was presented in a story-like order, the subjects were significantly more likely to pass that verdict. After choosing a verdict, the

participants also reported significantly higher confidence in their decisions if they heard the evidence in the story-like order. This shows that stories not only influence judgments and perceptions, but they also improve the persuasiveness of an argument or claim.

Conclusion

The tools listed here are meant to assist in the effective communication of ideas. Most may seem relatively simple, but can often be overlooked even though implementing them may not be difficult. A more in depth discussion of how and when to implement these tools can be found in Chapter 7.

Keeping these tools in mind can help to strengthen communication when crafting any message, not just advertisements. Educational effectiveness is almost entirely dependent on the students' ability to understand and appreciate the material being taught. Most, if not all, of these tools have been investigated as ways to improve learning as well. Although no studies related to education were identified here, it remains a prominent area for future investigation.

CHPATER 6

COMMERCIALIZE

In a developed consumer market, readily-available and easily measurable determinants of a successful product, process, or service innovation are financial numbers, such as revenues and profits. There are multiple variables that influence economic success, and many of these are outside of the designer's control. Examples of such variables include governmental policy, organizational changes, and product distribution. The customer base also plays a vital role in profitability, and shifts in public opinion can also strongly impact the profitability of an innovation. If designers are privy to these variables, they can attempt to influence or incorporate them through clever design, but there will always be a level of uncertainty associated with innovation. Because of this, the Innovation Engineering program offers advice for mitigating the risk that accompanies innovation processes.

Do One Thing Great

By focusing on a single task or project, all effort and attention can be devoted to that particular thing. Stretching resources thin can allow for multiple tasks and processes to be completed simultaneously, but the quality of the outcomes will likely suffer. Limiting focus to a single topic can reduce distractions, improve output, and even increase decision making rates as discussed by the following studies.

Aside from the common sense implications, some research identified also supports this limiting of the available options. Boatwright and Nunes [85] investigated the outcome of removing lower selling products from grocery stores. When the lower selling items were discontinued, the average category sales significantly increased. Although the reduction in options caused some customers to leave the retailer, the majority of customers whose preferred brand was cut adopted a different brand. A similar conclusion was reached when Iyengar and Lepper [86] examined the effect of limiting the number of choices available. Participants from the public were offered a large selection set with 24 to 30 options or a reduced selection set with only 6 options of jam flavors in a grocery market setting, extra credit essay questions in a classroom, or gourmet chocolates in a lab. Although the large selection set attracted more participants to investigate the offer, more participants followed through with the desired activity (ex. purchasing the jam) when they were offered the limited set. These results may be clarified by a study conducted by Redelmeier and Shafir [87] that investigated how decisions are altered by the addition of new options. When presented a hypothetical situation in which participants had plans to complete one activity but were then offered a single more attractive alternative, only 21% chose the original activity. Interestingly, when participants were offered two better alternatives, 40% chose to follow through with the original activity. This appears to show that when given multiple options, a significant number of subjects chose to avoid making a decision.

One study located does refute the idea of limiting offerings. Oppewal and Koelemeijer [88] mailed surveys to consumer participants that asked for opinions about

a variety of flower assortments. When subjects were given more assortment options, the average evaluation of the assortment significantly improved. The authors found that the average assortment evaluation was linearly correlated with the number of options provided to participants. However, it should be noted that this study did not investigate how many subjects might follow through with purchasing one of the assortments.

Fourt-Woodlock Equation

The IE program recommends the use of the Fourt-Woodlock equation to compare the likely successful commercialization of generated ideas. As the name suggests, this equation was created by Fourt and Woodlock [89] in an attempt to predict the market success of new products. During their investigation, Fourt and Woodlock determined that the unit sales of a product could be related to factors like the number of potential customers, the rate at which the potential customers will try the product, the rate at which those who tried the product will buy it again, and the number of units each customer will buy each time they buy. The equation, as it is presented by the Innovation Engineering program, is

$$AS = FDM \times TR \times FPR + FDM \times TR \times RR \times RPR \times NRP$$

where AS is the annual sales forecast, FDM is the number of final decision makers, TR is the trial rate, FPR is the first purchase revenue, RR is the repeat rate, RPR is the repeat purchase revenue, and NPR is the number of repeat purchases. It should be noted that

these variables are not the same in all representations of the equation, but the meaning of the variables used does not change markedly from one version to another.

To generate this method, Fourt and Woodlock used trial rate and repeat ratios based on observed test markets and real purchase data, and made a number of assumptions about the consistency of environment in which the products would be sold. These assumptions were that the distribution, promotional expenditures, prices, competitive activity, product, and packaging would not change substantially during the time of the estimate. In situations where these assumptions held and the rates could be determined by an initial test sample, this method predicted volume changes within 5% of the actual values. This means that for a given length of time, the sales of specific items can be accurately forecasted, allowing businesses to determine how their innovations will sell in the future. By knowing the revenue that would generated by sales of an innovation, companies can determine if the innovation is worth taking to market. If the prediction shows that a product will bring in a substantial profit, businesses can justify spending the money to mass produce and market it. Conversely, if the forecast implies a poor return, the company can edit the offering in an attempt to improve the prediction or scrap the offering altogether.

It is important to note that, as presented by the Innovation Engineering program, this method did not include rates determined by an initial test market or stress on any of the stated assumptions. In situations observed by Fourt and Woodlock where one or more of the assumptions was violated, the estimate became much less accurate. The

program also suggested estimating the trial and repeat rates, which will likely lead to further loss of accuracy.

To ensure accuracy, the Fourt-Woodlock equation requires values generated from a test market. Such test markets have been used for many years, and multiple forecasting models have been generated to predict new product performance [90]. Other models have been developed by Baum and Dennis, Parfitt and Collins, Eskin, and Nakanishi [90-92]. These models, however, involve much more complicated values than the simple integers and percentages used by the Fourt-Woodlock equation. No literature found suggested that these other methods were any less useful, so the Innovation Engineering program likely selected the Fourt-Woodlock model due to its relative simplicity to the other options.

Methods for predicting innovation adoption also exist. One of the most popular tools for modeling adoption rates is the Bass diffusion model [93], developed by Frank M. Bass in 1969. This model predicts the total number of adopters of an innovation throughout time, assuming that a small portion of society is innovators and a larger portion is imitators. This model has been studied substantially and has even been modified to accurately predict specific adoption rates for specific markets [94-98]. However, this model assumes that the innovation in question will eventually be widely accepted, ending with complete adoption across a population. Examples of innovations that fit this case are personal computers or televisions. Unsuccessful or superfluous innovations will likely never see this widespread adoption throughout a consumer population. For this reason, the Bass diffusion model cannot be used to accurately

predict innovation success rates, but only offer insight into the adoption rate of a breakthrough innovation as a function of time.

Conclusion

Although the Commercialize category of the IE program includes the least distinct tools, the tools discussed can still have a profound impact on the success rates of innovations. Having the ability to influence customer decisions and being able to predict the success or failure of a new product before it launches can save companies time and money. As with both Chapters 4 and 5, a detailed discussion of how to effectively use these tools can also be found in Chapter 7.

CHAPTER 7

DISCUSSION

Although this project is by and large a literature review, it is also important to understand how this information affects the Innovation Engineering program and those who use the techniques. The overall goal of this research is to determine whether or not the IE program techniques should be used, and while ensuring that they work is a large part of this, the subtleties of the program must also be understood to validate it as a whole. What follows in this chapter is an analysis by the author of the IE tools. The assertions presented are not tested or proven by any of the studies found; instead they build upon the findings from the reviewed studies to make more general claims about using the techniques reviewed above. Dual brain and simplicity were left out of the following discussion because, as used by the IE program, they were not supported by the located literature.

Concept Difficulty

It is obvious from the number of concepts presented here that some will be more difficult to understand or implement than others. Figure 2 below shows the author's interpretation of which tools and techniques are more difficult to master.

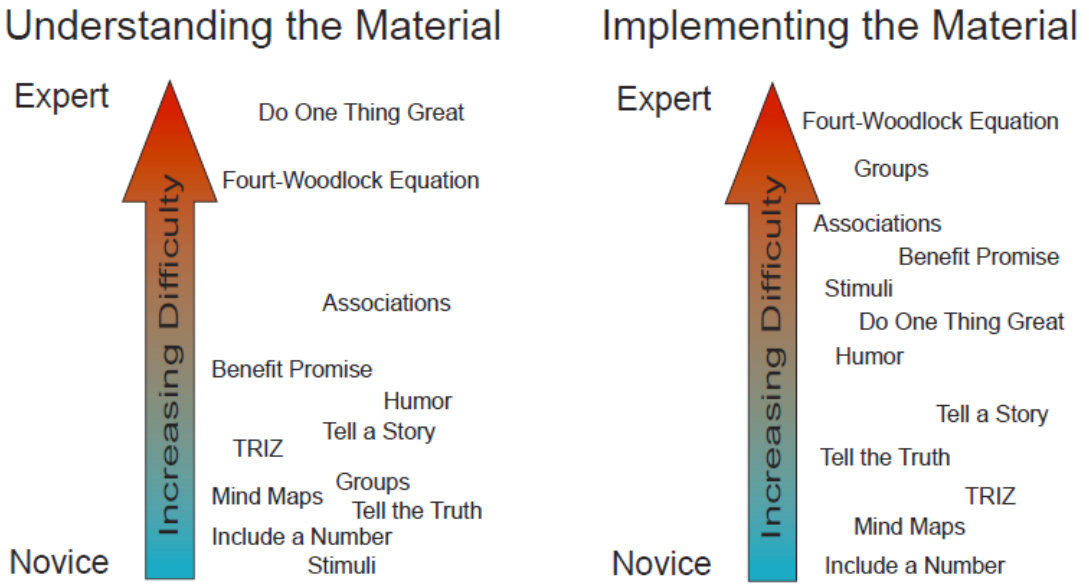

Figure 2. The proposed difficulty of understanding the concepts and correctly implementing them. It can be seen that most concepts are more difficult to implement than to understand, but a few are simpler to implement than to understand.

Most of the concepts move up in difficulty when attempting to implement them as opposed to understanding them. This is plausible since many of the concepts seem simple enough, but in order to correctly use the concept, its subtleties must be understood. For example, the notion that working in groups improves creativity is quite easy to understand. However, it is more difficult to see results from group work if the group is unaware of the nuances involved, such as the potential for blocking or the decrease in effectiveness while trying to memorize other members' ideas. A few of the techniques are easier to implement than to understand. An example of a concept that fits this description is TRIZ. It is quite complicated to understand just how TRIZ works and how the tool is able to provide generic suggestions that can offer new ideas on multiple

very different problems. It is also somewhat difficult to understand how Altschuller and colleagues came up with the 40 principles by looking at patents. However, this knowledge is not necessary to correctly use the technique. All that is required to make TRIZ work is the list of contradictions, the list of solutions, and the knowledge of which contradiction the current design fits.

Although the Fourt-Woodlock equation seems simple at first glance, there are many factors that influence its accuracy that are not obvious, especially when the technique is explained as it is in the IE program. This equation is the sole method taught by the IE program to determine if an innovation is profitable or not. The outcome of this forecast can determine the life or death of a new innovation, and actions taken based on the outcome can significantly impact a company's finances. Because of this, it is imperative that the technique is completely understood and implemented correctly. Therefore, it is the author's recommendation that this topic receives the most attention when teaching the Innovation Engineering techniques.

Humor was somewhat difficult to place on the implementation scale. This is because the difficulty of including humor is incredibly dependent on both the people interacting and the situation. Some people find it very easy to make others laugh, while other people can make similar jokes and not receive a response. The personalities of the comedian and the audience and the delivery style are all important when implementing humor. Some situations are also much more accepting of humor than others. It is simple to accept that designers working on a new children's toy may have a much easier time joking around than business executives developing ideas and terms for a merger. In

reality, humor could span the entire difficulty spectrum shown in Figure 2. For clarity, however, it was just placed near the middle.

Figure 2 shows that some concepts require more effort during training than others. It is suggested that when the Innovation Engineering tools are taught to novice designers, more time is spent on learning how to implement the concepts that are higher on the implementation difficulty scale. Although it is not necessary to fully understand how all of the concepts work to use them to an advantage, it is suggested that a baseline understanding of how each technique works be provided to anyone learning the IE program. During training, more effort should go into explaining the topics toward the top of the understanding difficulty scale.

Individual Concepts

Although not explicitly identified by any of the studies, certain conclusions can be drawn about the individual topics covered by the Innovation Engineering program based on the results of the studies located. Because mind maps were identified as a good graphical representation of information, it follows that using mind maps will likely increase the participation and attentiveness of people the mind map is shared with. This can lead to improved communication that can also improve the quality of stimuli provided by others. Since these new stimuli can lead to better associations to add to the mind map, the quality of the mind map can be improved, which was shown to be correlated with a higher quality final product. TRIZ is relatively simple to use, and was

shown to improve creative thinking skills in people who learn how to use it. It was also shown to increase the motivation to be creative, which can influence the overall creative output as a number of studies noted. It was shown by a few studies that the mental process of making associations improved creative thinking scores when simply being exposed to the associations did not. This implies that each individual needs to make his or her own associations to improve their creativity, and taking a back seat while others in a design group will not help the individual. The use of stimuli was proven to increase the number and originality of generated design solutions, but it was also shown that some stimuli can cause fixation and hinder the creative process. This requires that the designer is informed about the possibility of fixation so they can regulate how much influence each stimuli has on their new design. Groups were shown to improve idea generation, and more interactions in groups led to higher quality ideas. However, all group members must be aware that problems such as blocking can arise, and groups need to be kept small enough that each member can contribute effectively. It was also shown that attempting to memorize other members' ideas decreases group effectiveness. This implies the need for an effective means of recording the group's ideas. A digital recording device or an assigned note taker who does not participate in idea generation can help to mitigate this loss in group effectiveness. Sense of humor was shown to be positively related to creativity, and the act of laughing improved creativity test scores. From this it could be concluded that mood can affect designer performance, and designer effectiveness can be improved by having fun and keeping a lighthearted tone.

Marketing messages explaining the direct benefit customers receive from a product or service was linked to the success of the products, showing that customers do not just care about what an offering does; they also care about how it will affect them and if they will be better off by purchasing it. Telling customers what benefits they will receive allows them to envision themselves receiving the benefits and makes a more concrete argument for purchasing the product. Because truthful statements are correlated with increased trust in companies and increased purchase probability, it can be inferred that being caught in a lie would do the opposite. It was also shown that setting unrealistically high expectations for an innovation's performance negatively impacted customer's opinions, there is no reason to provide false claims. Repeating messages means that the audience will have more exposures to them and be more likely to remember details, and this is obvious from everyday life. More exposures to information due to studying for a test generally improve performance. However, when relating to advertisements, there may be a cap on useful repetition. Although the studies located show increasing recall and brand preference with increasing exposure, they did not test for obnoxiously large numbers of exposures. Ads that are repeated too many times may start to dissuade customers from purchasing a specific product or service because they become frustrated with the intrusiveness of the ad. Since proof like direct product experience and testimonials affected brand consideration and purchase probability, it can be concluded that customers appreciate being shown that an innovation is worth purchasing from more sources than just the company's marketing department. Advertisements that display objective information are better received by customers

because they want to see concrete information before committing to a purchase. The concept of including a number can be used in other areas than just advertisements, however. Associating numerical values with internal goals and benchmarks is suggested by other engineering techniques such as Six Sigma [25] and House of Quality [99]. Future investigation could attempt to validate the use of numbers in more areas than just advertisements. Because stories were shown to increase the believability of information shared, using them as part of a marketing message can increase the believability of claims. Crafting quality stories can improve the audience's emotional involvement and can further increase the believability of the information. Stories can also help designers during the development process – thinking about the story an innovation will tell or be a part of can identify necessary traits and focus design efforts. When people are offered too many options, they may have a tendency to refrain from making decisions. Simplifying these decisions and providing easily distinguishable choices can improve the participation rate. Reducing the number of options also allows the company to focus more and put their effort into fewer projects instead of stretching their resources thin. The idea of limiting offerings can be a bit disappointing to some people who have multiple goals and aspirations, however. A further investigation into methods for successful expansion could be conducted to include in the IE program, even if it isn't necessarily suggested. There are many factors and assumptions that go into the Fourt-Woodlock equation, but if used correctly, the tool can forecast an accurate sales volume change for new products.

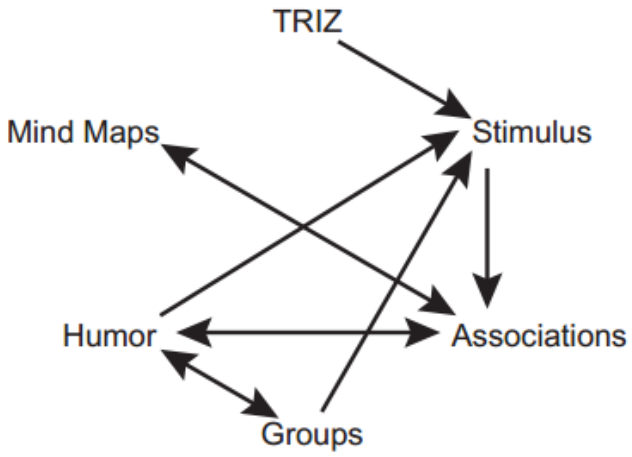

Figure 3. The relationships between techniques in the Create category of the Innovation Engineering Program. Arrows indicate the flow of creative thoughts; implementing the technique at the tail of the arrow can lead to new ideas related to topics at the head.

Linking Concepts

Most of the literature found agrees that the techniques work at a fundamental level, but none mentions how the techniques are interrelated and can influence each other. Throughout the course of this research, it has become clear that the effectiveness many of the techniques described by the IE program can be affected by other topics discussed. Figure 3 shows the connections between the topics of the Create category, and Figure 4 shows the connections between the topics of the Communicate and Commercialize categories.

Some of the relationships identified by Figure 3 may be unclear, so it is important to explain the reasoning that led to their generation. TRIZ is a technique that focuses on removing or overcoming design barriers. The approach provides new stimuli that can aid in the production of new ideas. Sometimes when new stimuli are introduced,

new associations can be made between them, leading to new ideas. The introduction of new stimuli can also spawn associations with previous ideas. Mind maps are good tools for improving creativity since they work by provoking the designer to make new associations, and the mental process of making associations was shown to increase creativity. Working in groups greatly increases the number of stimuli that are available, allowing members to draw upon each other's ideas. This increase in available stimuli increases the possibilities for associations to be made. Introducing humor into a group can lighten the mood and improve performance, and an individual with a good sense of humor is likely to be a well-liked member of any group. Humor can also lead to new associations; although ideas may start out being facetious, they can spark new stimuli or associations that can lead to new useful ideas.

Figure 3 also suggests that the Create category really focuses on a single central theme: making associations. Techniques like TRIZ, group processes, and stimulus mining are used to locate new stimuli, which are used to make associations. Aside from keeping everyone in a good mood, humor can also generate new associations, although they may not always be useful. Mind maps focus on helping new associations form. All of the associations made not only provide new ideas, but also improve creativity in general. As shown in the figure, associations can lead back to mind maps and humor, but using either of these two topics eventually leads back to forming more associations.

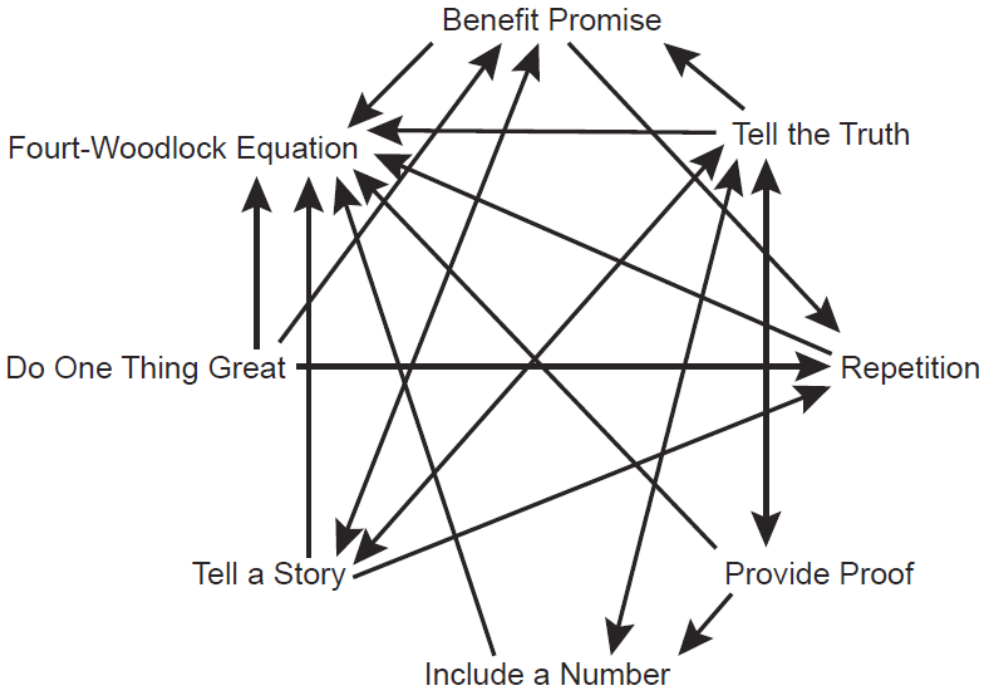

Figure 4. The relationships between techniques in the Communicate and Commercialize categories of the Innovation Engineering Program. Arrows indicate the flow of creative thoughts; implementing the technique at the tail of the arrow can lead to new ideas related to topics at the head.

Because the Communicate and Commercialize categories both focus on marketing and business concepts, they can be combined when looking for relations between their topics. Reducing the number of offerings a company provides can lead to repetition in marketing messages since there will be fewer products or services that the company needs to advertise. In this case, advertising budgets can go toward more ads for each offering. Although simplicity is not included in Figure 4, it is obvious that reducing offerings can be tied to simplifying as well. Focusing on one thing can also lead to better benefit promises. If a company focuses on one specific product or service, they can focus research and development budgets, efforts, and resources, which could lead to superior benefits when compared to competitors' products. A benefit promise is a good

thing to repeat, since it provides customers with knowledge about an innovation's existence and tells them what the innovation will do for them. This is likely more effective than simply repeating an advertisement slogan. Stories can be used to enhance benefit promises by making them more memorable and realistic, allowing the customer to connect with the innovation being offered and see why they should purchase it. This effect can be compounded if the company has a reputation for being honest, since more customers will believe what they have to say. There is no reason to set unrealistic expectations for a produce since this was shown to decrease customer satisfaction with the product. These disappointed customers will likely then tell their friends or family about the lackluster performance, spreading negative word of mouth, and decreasing other potential customers' willingness to purchase. If instead realistic expectations are set because the marketing message is honest, the customers will think that the performance is better and spread positive word of mouth, improving purchase probability in others. Having a reputation for being honest will also improve the chances that customers believe any numbers that are included in objective marketing messages. Providing proof like test results or testimonials will further improve the believability of any numbers included in marketing messages, since these numbers are basically testimonials coming from the company. Every one of the other concepts will affect the Fourt-Woodlock estimate since correctly implementing them will increase the number of customers that will try a product or service.

It is understandable that the topics in the Create category will not individually influence topics from the Communicate and Commercialize categories, and vice versa,

but the outcome of the entire Create category will undoubtedly affect the other two categories. This is obvious since the tools in the Communicate and Commercialize categories are designed to help sell the innovation developed by the Create techniques. It is unlikely that any generic marketing messages or financial forecasts could be useful; these must be tailored to the innovation being sold. A perfect example of this is the alteration of values used in the Fourt-Woodlock equation, as described in Chapter 6. To change a number in the equation, a corresponding change must also be made to the innovation. Altering an aspect of the innovation in the Create stage can change the benefit promise, proof provided to customers, objective marketing numbers, and truth about the product. However, the tools in the Communicate and Commercialize categories do not have a direct effect on the techniques in the Create category, since the innovation will not change depending on how it is marketed.

CHAPTER 8

CONCLUSION

In general, the evidence compiled here supports the assertion that the methods of the Innovation Engineering training program can be used to improve creativity and marketing success. It should be noted that none of the studies tested innovation per se, but rather creativity and marketing, as is probably appropriate for a set of tools defined by the headings “Create,” “Communicate,” and “Commercialize.” Creative ideas are defined as being both novel and useful [100], while innovation is an extension of creativity; a more nebulous concept of effectively implementing a creative idea. This is why the Communicate and Commercialize components of the IE program are also important.

Some references do challenge the suggestions of the IE program. These sources include the work by Linsey *et al.* [39] showing that the use of some stimuli can in fact decrease creative output and even cause violations in design criteria. Taggar [50] and Diehl and Stroebe [51] identified reasons why group-based processes can inhibit creativity. Compiling the literature found for hemispheric brain activation [52-55] leads to the conclusion that the entire brain is necessary for the generation and implementation of creative ideas. Shedler and Manis [66] and Mackin [67] showed that it can be beneficial to increase complexity by including extra and possibly even irrelevant details, thus refuting the idea that simplicity always improves communication. Fu and Chen [79] suggested that some forms of proof suggested by the IE program are not as helpful as

one might think. Oppewal and Koelmeijer [88] proved that increasing the number of offerings can lead to more positive reactions from customers. Although the majority of literature found supports the IE tools, it should be noted that evidence refuting or disproving effectiveness may be more difficult to find. This could be because the methods are highly effective, or it could be that publishing a paper on an unsuccessful experiment is much more difficult than publishing a paper on a successful one.

In the studies summarized in this paper, creativity is judged in numerous ways, for example by volume of ideas generated, quality of ideas as judged by experts, and results of tests such as the Torrance Test of Creative Thinking. The translation of effective improvement in creativity in a study judged by an arbitrary metric to effectiveness in the workplace as judged by financial growth of the company is a complex undertaking. Table 1 notes the studies that occurred in workplace scenarios, and this evidence is perhaps the most effective in supporting the recommendations of the IE program, as it is geared toward workplace settings.

Many references included in Chapter 4 incorporate idea generation tasks, but only a few involve product design tasks. Because CIRAS is an MEP whose duty is not only to help improve idea generation but also product, process, service, market, and message innovation, more sources evaluating the effect of these techniques on innovation in these areas could be identified.

Although it was not explicitly searched for, a few references also mentioned the importance of motivation in creativity. When participants in these studies were asked to be creative or knew that their creativity would be judged, it prompted them to respond

more creatively. This was explicitly documented by Miller *et al.* [27] and Howard-Jones *et al.* [44]. The prosperity of the Innovation Engineering program also depends on this motivation. The program is only successful as long as companies want to improve their innovation skills. Many of the topics discussed by the IE program specifically include a deliberate attempt to improve creativity or profitability. While most companies already want to be financially successful, this motivational aspect provides evidence for implementing widespread organizational support for creativity and innovation.

As detailed in Chapter 7, all topics discussed in this paper are related to other topics in some way. Because of this, the overall Innovation Engineering program has not been academically validated, but the majority of the concepts it teaches has. An ideal test of the Innovation Engineering program would be a study that incorporates all principles in a test vs. control environment. One possibility for this experiment is to give the open ended design task of "generate a new innovation that will make money for your company" to a control group and an experimental group. Participants in the control group would simply begin working on the task while participants in the experimental group would first be introduced to the Innovation Engineering concepts by either the Eureka! Ranch or a local MEP center. Other sub-experiments could be conducted by including individuals and groups in both conditions, measuring creative test scores before and after the IE experience, and testing the effects of the training on both novice and expert designers. It is possible that metrics such as trial markets or Kickstarter [101] donations could be used to test potential for financial gain and avoid the immense financial investment to actually develop and market test the developed innovations.

The Innovation Engineering program continues to evolve, and even throughout the course of this year long research project, the program has changed notably. The program is only a few years old, and will likely continue to evolve as new creativity, marketing, and business techniques are developed. However, based on this research, it is the author's opinion that the leaders of the Innovation Engineering have the right intentions and have enough knowledge to produce worthwhile concepts for improving innovation.

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