The Innovation Canvas: An Instructor's Guide

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Traditional approaches to design education have stressed technical aspects of solution development, but have not integrated other critical components that are essential for creating the value that will bring success. As engineering education recognizes that emphasizing entrepreneurial skills are vital to innovation, there is a clear need for tools that help students integrate opportunity exploration and ideation, marketing, financial considerations, and operations issues with technical knowledge to develop and implement effective new products and services.

The Innovation Canvas (IC)[3] is a solution-development framework that guides teams through the design process. While technical solution development is a key component of the IC, it also incorporates the concept of the value proposition, along with an understanding of feature space and marketing. As engineering educators, we are interested in developing educational experiences that build both technical and entrepreneurship skills. To examine how the IC could be used in in undergraduate engineering education, a working group was convened during the summer of 2013 to learn about and develop teaching tools that incorporate the IC. Some members of the group were also able to utilize these teaching tools in classes during the Fall of the 2013 academic year and their experiences are summarized in this paper.

Members of the working group had varying levels of experience with the IC prior to the summer development opportunity, but spending time as a team learning and interacting with the tool resulted in a greater appreciation of the richness of the tool and how it could be used to enhance the ways students think about innovation and the design process. It became clear that there is a learning curve associated with the IC, and it was determined that set of best practices and an instructor's guide would be helpful to instructors striving to successfully implement the IC in their curricula.

While the IC provides a useful framework for the design process and its context, it is intended to be used in conjunction with many of the technical analysis tools that are already taught in engineering curricula. Some of these tools include; voice of the customer, interactions, features and minimum viable product, main parameter of value, modularity, and product architecture. These tools and how they might react with the IC are further described in reference 3.

An Introduction to the Innovation Canvas

The Innovation Canvas (see Figure 1) consists of a poster on which the design team can post ideas, lists, and analyses. It consists of five sections, each denoting a component of the product development process. These sections are; **Value**, **Explore**, **Ideate**, **Market**, and **Design**.

> The **Value** section is the space in which the team is asked to describe the need that the proposed solution is going to meet and the value of meeting it. Developing a compelling value proposition statement is a key skill for entrepreneurs and a clear statement of the value proposition is a key landmark for students as they work through the development of their product. It was found that requiring focus on the value proposition and keeping it front and center during the design process is a good way to ensure that design teams keep

track of the original motivation for the projects. Students can be guided to develop value propositions via various templates such as the one described by Geoff Moore[4].

In the **Explore** section, students elaborate on the basic approach of the design. Students provide a more detailed description of the project goals, collect stakeholder and voice of the customer input, clarify the benefits and values of a product, and provide context for the project.

Before developing technical designs, students are asked to think about the features and functions of their system in the **Ideate** section of the canvas. This is also the region where they begin to construct a high-level design that describes “what” the product will do (as opposed to “how” the product will do it). Students also consider external systems that the device interacts with and features that define the value that the device provides.

The **Design** section of the IC is the place where the group will do a formal requirements analysis, translate the functions identified into key components or modules and will perform the technical design development. Critical design objectives, constraints, or risks are identified and integrated into this section.

Student groups should think about the business context for their product in the **Market** section of the canvas. This section of the canvas, which was derived from Business Model Generation[5], identifies many areas of marketing that will impinge on the design. Subregions in this section ask the students to think about financial and economic issues, as well as customers and other stakeholders.

In using the canvas, student groups are challenged with the interconnectedness of the different regions and the iterative nature of design. As changes, new information, or analyses alter one region of the canvas, it often necessitates changes to other regions that students may have thought finished. While development of the value proposition must be done early in the process, and the technical design should come late in the process, there is no prescribed sequence as to how student groups address the components of the canvas. Furthermore, the areas within the subregions are meant to be suggestions, it is not necessary to fill in all boxes or to limit the content to the boxes shown on the original canvas.

The Development of the Innovation Canvas

The Innovation Canvas has been developed to more fully integrate product design themes with the business model themes of the Business Model Canvas[3,5]. The Business Model Canvas has emerged recently as a popular tool in entrepreneurship education to develop and refine business models for ventures. The Innovation Canvas incorporates all the themes of the Business Model Canvas in the **Market** quadrant. The **Explore**, **Ideate**, and **Design** quadrants have been added to include the key themes of a metamodel for a system[7]. It is important to recognize that the themes included on the canvas include key themes from ‘metamodels’ for system design or a business model and not process steps or categories of information. In addition, the process steps for design and business model development are not encoded in the canvas but are realized through the use of the canvas.

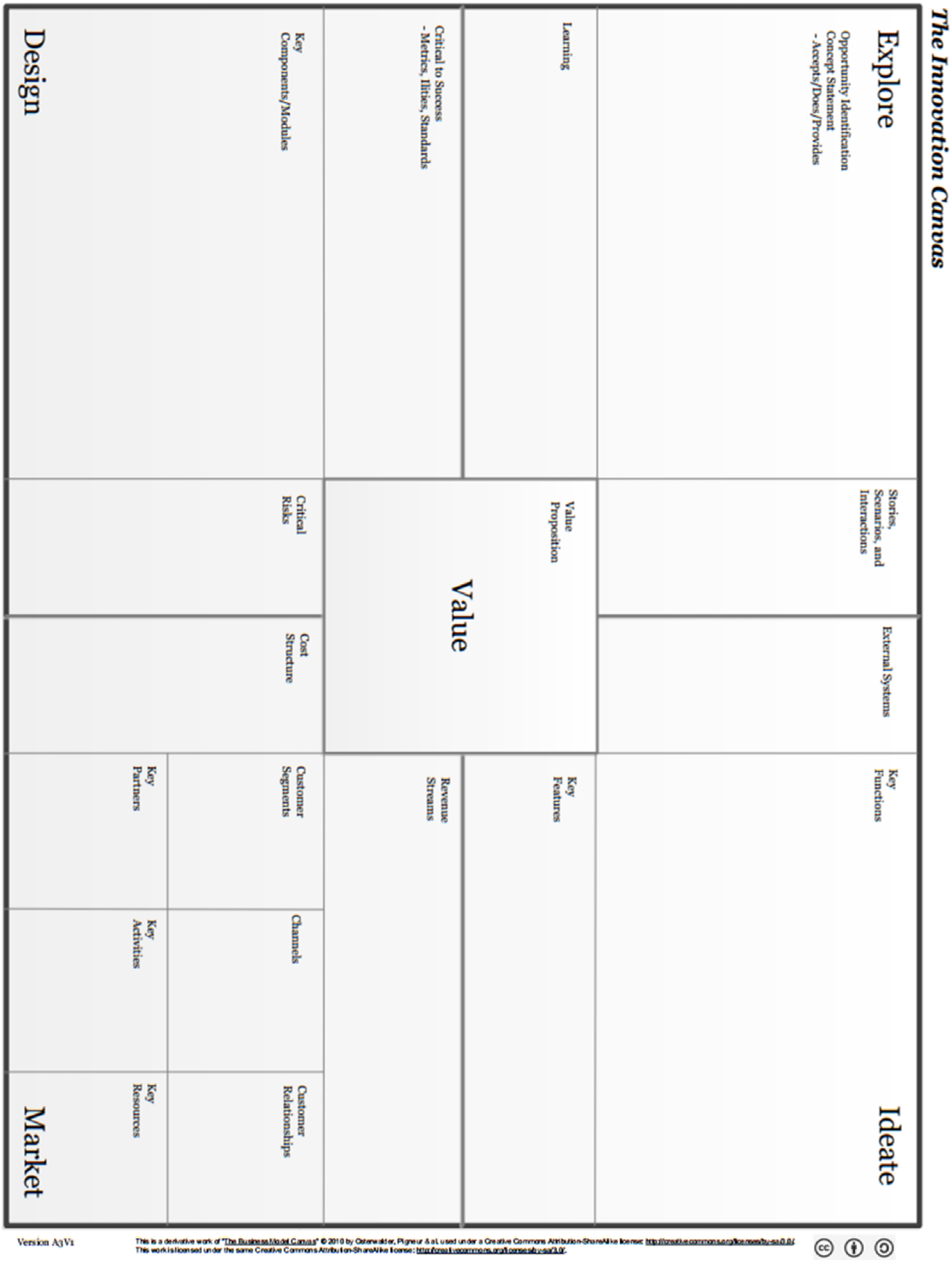

Figure 1: The Innovation Canvas with a central **Value** theme surrounded by four sections associated with successful product development.

A number of design and business model concepts can be illustrated through comparisons and associations among canvas blocks. For example, the concept of modularity can be illustrated though the mapping of functions in Ideate to components in the Design quadrant. The minimum viable product (MVP) concept can be illustrated by identifying the critical few features of a larger set in the Ideate quadrant. The cost/benefit value of each feature can be explored through examining the revenue and cost contributions of each one in the Market quadrant. Numerous other illustrations can be made with the canvas. The Innovation Canvas is available for use through a Creative Commons (CC) license[3]. Blank canvasses and other resources are available at http://www.rose-hulman.edu/offices-and-services/office-of-innovation-engagement/innovation-canvas.aspx.

A Sample Innovation Canvas Activity

As an illustration of how the Innovation Canvas can be used to introduce design concepts, the authors examined a product that is already on the market, the ORAL-B® CrossAction® Power Whitening Toothbrush (illustrated in Figure 2), and analyzed the design of this device using the IC as a framework.

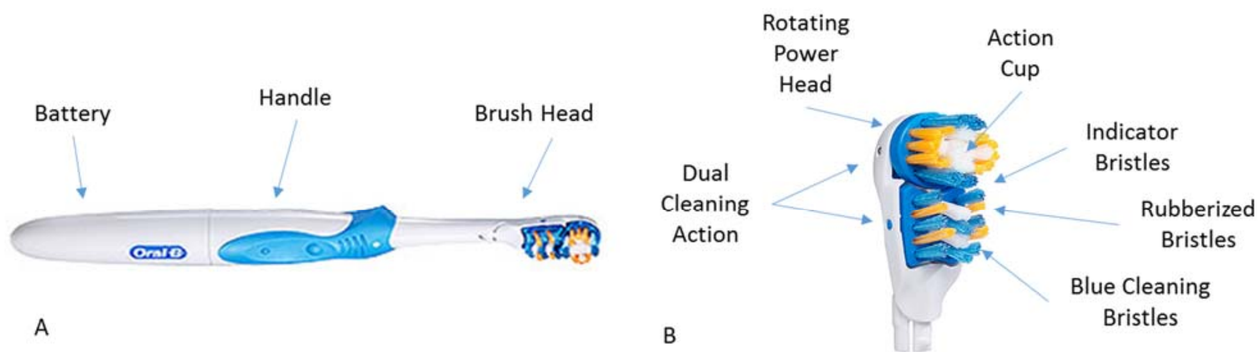

Figure 2: The ORAL-B® CrossAction® Power Whitening Toothbrush A) Whole view of the toothbrush. B) Closeup showing specializations of the brush head.

This toothbrush has a replaceable brush head and is commonly sold though discount stores. A sample canvas for the toothbrush developed by instructors is shown in Figure 3. In some cases, it is difficult to know the exact details of an area of the canvas but this encourages healthy speculation. The canvas serves as a high level framework to collect information and in several cases, there may be underlying analysis performed. For example, the key functions identified come from a functional decomposition of the toothbrush, and the key features come from researching marketing literature for the toothbrush.

Many informative illustrations and discussions can be facilitated with the canvas. Examples of a few include:

- All the features identified must be implemented with functionality in the **Ideate** quadrant and should be valuable to the customer segments identified in the **Market** quadrant. Do we need all these features and do they really provide value?

- We envision generating revenue from sales of complete units and brush heads. What are the costs and prices associated with each?
- All of the functions in the **Ideate** quadrant must be mapped to components in the **Design** quadrant.
- Have we missed any external systems with which the toothbrush might interact?
- We have identified four main customer segments and three channels for reaching them – do these make sense?
- Do all of the entries on the canvas align with and support the value proposition at the center? Do we think this device might be successful in the target markets selected?

The toothbrush example was implemented in a Senior Design class with students, the results from this implementation are discussed briefly later in this paper and in more depth in reference 6. While student work was not as complete and comprehensive as this instructor sample, the canvas provided a framework for students to collect observations as they disassembled the toothbrush.

Introducing the Innovation Canvas to Students

As the working group learned more about the canvas and the opportunities that it provides for design education, the significant learning curve in understanding the components of the IC suggested that students would have an even greater challenge. Ideally, the IC would be used throughout an undergraduate engineering curriculum as a standardized framework for thinking about design. Early on, students could be asked to interact with the IC using current designs that are on the market (like the toothbrush example discussed earlier) or by watching as others work through the design process. Later on, students could explore the individual sections of the IC as components of different classes through the curriculum. With appropriate preparation, the IC could then be used as a framework for senior design projects. The next paragraphs describe some approaches investigated by the working group.

<u>The IDEO video:</u> In 2009, ABC's Nightline program did a profile of the design group IDEO[8]. The profile discussed the "Deep Dive" approach that IDEO uses in developing new products and presents a case study of how the IDEO team approached the design for a novel shopping cart. This video, which lasts roughly eight minutes, shows an interesting example of a design process that stresses understanding user needs. This design study affords an excellent chance to introduce students to the design process and to the IC. The working group watched the video (which was new to many in the group) and then reviewed the project by filling in the sections of the IC based on the video content. There was an excellent mapping to the functional analysis in the **Ideate** section of the paper as well as to the more defined design section. The "Deep Dive" approach is a very clear illustration of the **Explore** component of the IC. While not directly discussed in the video, the accessible subject matter of the shopping cart allowed participants to give knowledgeable input about the **Market** section of the IC.

<u>Case Studies:</u> The working group examined solutions that are successful in the market today via the lens of the IC. Here are brief descriptions of three examples developed to introduce students to the IC.

Reverse Shoulder Arthroplasty: The natural shoulder is a ball-and-socket joint with the ball on the top of the humerus (upper arm) bone and the socket on the glenoid process of the scapula (the shoulder blade). Early shoulder prostheses mimic this architecture, but did not have good outcomes for many patients with rotator cuff muscle damage. To remedy this limitation, a design was developed that reverses the traditional architecture and places the ball on the scapula and the socket on the top of the humerus. This approach limits the importance of the rotator cuff and restores much greater range of motion to the recipients of these new prostheses. This case study would make an excellent addition to a Biomechanics class that would allow some of the mechanical analysis of the shoulder joint to be brought into a design context. It is an excellent example of allowing functional analysis to drive design as opposed to simply developing analogs to natural anatomy. That is, it develops a solution that more effectively addresses the value proposition of restoring the quality of patient's lives

A novel bicycle wheel: In racing bicycles, weight-saving is critical. This case study proposes the incorporation of a novel light-weight (and somewhat costly) material in the design of a bicycle wheel. This will require a detailed mechanical analysis of the wheel design. It will also require a detailed cost/benefit analysis. In many applications, the increased cost would be prohibitive to the success of the product. In other areas, such as racing bicycles, there is more tolerance of cost in the pursuit of limiting weight. This type of discussion is a great way to introduce students to the marketing aspects of design via the IC. Given that this is an area where engineering graduates are quite limited in their knowledge, this would be an important addition to the curriculum. This case study would be an excellent addition to a mechanics of materials course.

Point of care blood gas analyzers: At the turn of the century, blood gas analyzers were confined to the hospital laboratory and were large, temperamental machines that required significant upkeep and training to use. A health care professional who wanted a blood gas reading would take a blood sample via an artery and send it to the laboratory for analysis. The lab would run the sample through the desktop analyzer and send the results back to the practitioner to help them make decisions about patient care. The main deficiencies of this system were the fact that taking blood gas readings in the field or in the doctor's office were not possible, and that the turnaround time was too long for optimal decision making on the part of health care professionals. The relatively recent development of point-of-care analyzers (which can be used in the field, at the bedside, or at the Doctor's office) has addressed these deficiencies at a higher cost per measurement. This case study is an interesting example of a novel design that would actually have the same functional description as a traditional blood gas analyzer, but with a very different embodiment due to differences in available technology and marketing constraints. This would be an interesting addition to an instrumentation course as it explicitly focuses on the value of information and the importance of timing and contexts in instrumentation design

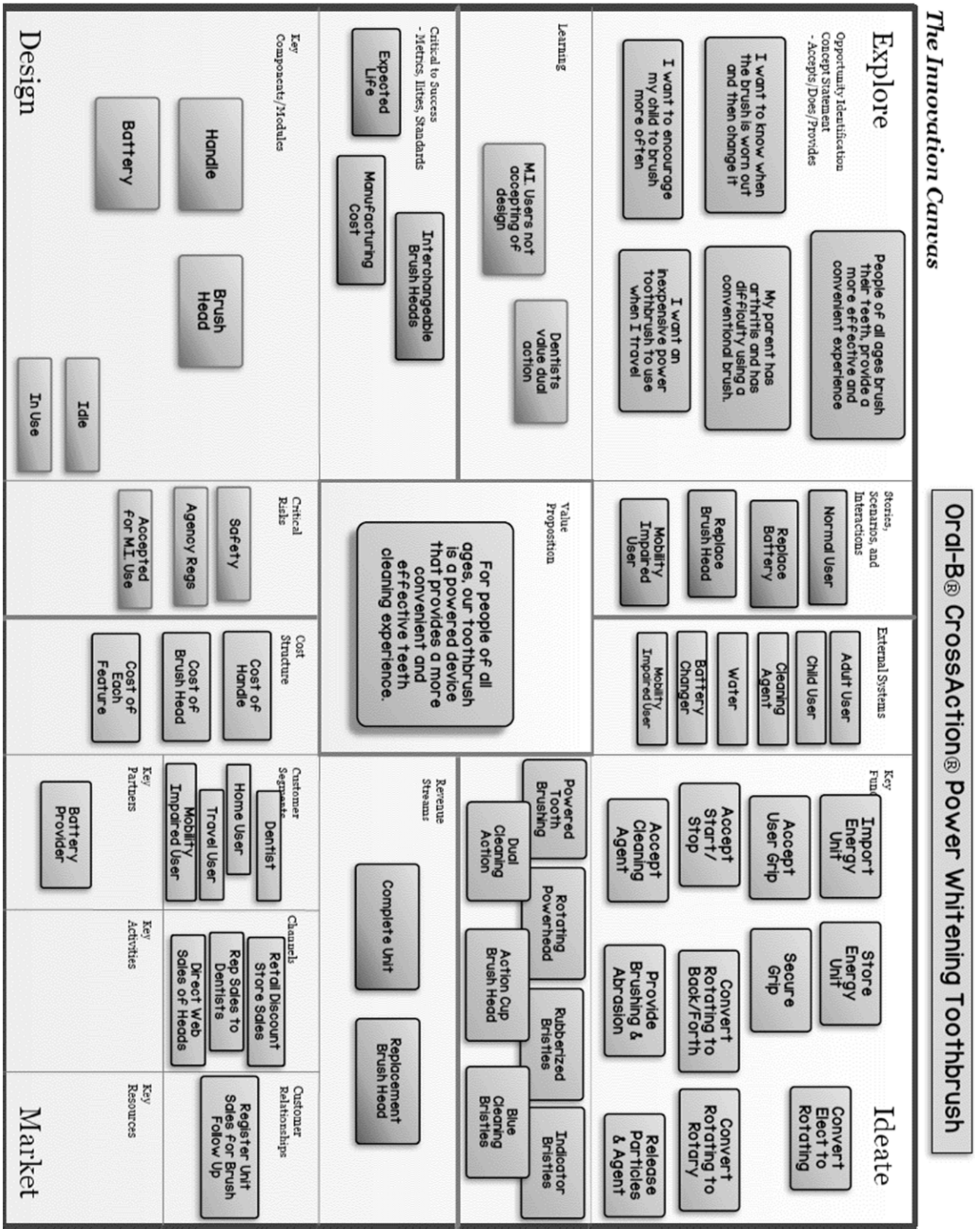

Figure 3: An Innovation Canvas for the toothbrush example as executed by the authors.

Reverse Engineering: Reverse engineering or Disassemble-Analyze-Assemble (DAA) activities have been shown to motivate students and improve the students' ability to apply their knowledge in design[2]. Studying a product that has been engineered for a specific task provides insight on how the product functions. A well-designed activity of this sort not only asks the students to disassemble the product, but it also requires that they document the disassembly process, analyze functional elements, investigate design decisions, and understand the relationship between features and functions. Since many of these issues are explicit to the Innovation Canvas we postulated that the canvas would be a good tool for students to use in conjunction with a reverse engineering activity. Furthermore, once an item has been analyzed, the students can be asked to develop novel solutions when subject to new constraints, thus interacting with the IC in a novel way.

In most reverse engineering activities for students, market issues and the value proposition for the product are not considered. An added benefit of the canvas is that these issues are also explicitly shown and can be considered by the student team. Note that there is also literature about the way technologies have evolved serendipitously, reverse engineering activities with an IC context might even point out opportunities for innovation[1].

Some examples of items that can be reverse engineered include the following; disposable film cameras (which are becoming quite hard to find), old cell phones, small hand-held sanders, and disposable toothbrushes. Some notes from the implementation of two of these will be shared in a later section of this paper.

Notes from the field: Implementing the Innovation Canvas

Technical Entrepreneurship classes: These notes are from two courses that are both introductions to entrepreneurship for engineers and scientists that have been taught for many years. The mantra for these courses is that everyone should "think like an entrepreneur." That is, they should learn to identify opportunities and to consider all the necessary aspects of effective execution to take advantage of those opportunities. The IC is introduced a few weeks after they have learned about the traditional business plan and the business model canvas. The IC is a tool for showing how all of its themes must be considered in dynamic, iterative ways to turn a good idea into a sustainable entrepreneurial venture. In particular, it illustrates the equivalency of understanding the market and customers and resource requirements to getting the technology right. This can be enormously helpful to technical people who think they get the great idea, build it and wait for the world to "beat a path to their door". The canvas is also owned by the entire team involved in the venture which is counter to the typical student view that each person can do their part and then just fasten individual contributions together in a successful plan. Thirdly, the canvas is used to emphasize the system nature of implementing so that a change in one area (e.g., target customers) will necessitate adjustments in other areas (e.g., design, operations, distribution and so forth).

The focal point of these courses is to have one to four students experience business plan preparation for their own innovation. This experience uses what they have learned about innovation and business principles that apply to independent ventures, launches of new products or services in existing organizations and implementing new approaches to solving societal problems in non-profit, as well as profit seeking ways. Some advocates of the business model canvas suggest that it makes business plans obsolete. These courses have shown that the IC and the business plan are complementary. The business plan becomes the scenario that illustrates how the themes of the canvas fit together at any point in time. Scenarios are powerful ways to pull knowledge together and identify holes and problems. In the past, the business plans that were done by student teams evidenced sequential thinking – technology to product to market to operations and then financing. Presentation of the plans also showed evidence of individual efforts that were then fastened together for the assignment, rather than integrated stories reflecting team conclusions. Since students have been using the IC there is more evidence of team work such as less inconsistencies in the plans. Moreover, there is more evidence that uncovering customer needs and desires and identifying the appropriate target markets has informed the development of the product. These conclusions are based on anecdotes and impressions so far, and there has been no determination of how the canvas has aided system approaches to the incorporation of new knowledge. Application of rubrics to documents and increased student self-reporting on processes they have used may yield some more quantitative evidence in the future.

<u>Senior Design in Optical Engineering and Engineering Physics</u>**:** During the fall quarter 2013, the Innovation Canvas was tested during a reverse engineering activity in the senior capstone design class for optical engineering and engineering physics majors. All students had completed an introductory design course covering the product development process and were already familiar with topics such as identifying customer needs, product specifications, concept generation, concept development, functional decomposition, and target costing. Thus, students had the appropriate background and knowledge needed to understand most of the concepts and some of the tools associated with each of the canvas quadrants.

The specific product used for this activity was a small hand-held sander. Four student teams of 3-4 students each performed the activity. All of the teams identified key functions and most of the key features at the beginning of the activity and began filling in the **Ideate** quadrant. As the disassembly proceeded all teams listed key components and modules in the design quadrant. Several issues were identified and opportunities for improvement were noted including alternative materials that might be considered for the housing and certain parts. One team redesigned the sandpaper pad to account for sanding in corners. The most pleasant surprise was the thoughtful consideration of the market. Each team correctly identified a potential revenue stream that could be generated by sales of sandpaper and pads. Each team also listed numerous sales channels and customer segments. However, the most disappointing outcome of the activity was the student's perception of the value proposition. They seemed to confuse value with use case statement, i.e. how would the product be used. One team simply wrote down a sales cost as the value, confusing value with cost. Obviously, more instruction on value propositions is needed.

<u>Senior Design in Biomedical Engineering</u>: Forty Biomedical Engineering Senior Design students participated in a guided reverse engineering activity in which they disassembled an electric

toothbrush. During this activity, they were introduced to and interacted with the IC.   A "post-activity" survey was conducted with these students in which the students were asked about their interactions with the IC.

The survey revealed some interesting findings regarding the most "helpful/insightful" aspects of the Canvas. *Each* aspect (**Explore**, **Value**, **Ideate**, **Design**, **Market**) was mentioned as being the most helpful/insightful by at least one student; there was not a clear, single aspect of the Canvas that was identified as *most* helpful. This is encouraging to the instructors because the Innovation Canvas was able to engage all the students during the reverse engineering activity and the survey results support the importance of implementing the Canvas in a team environment as each member brings a unique and important set of concerns and issues to the Canvas. Eleven students commented on the structure of the Canvas as being helpful for providing an overall perspective and making them think about the different aspects of design and all of the areas that need to be taken into account for product development. Several students commented on the freedom that the Canvas provides, i.e. they can start anywhere without a forced direction of implementation.

Twenty-five of the forty students identified "Marketing" as the most confusing aspect of the Canvas. The students commented that they did not understand most of the marketing terms (revenue streams, cost structure, customer segments, channels, etc.) and did not feel as though they were well-informed on these topics and how they related to the design process (unlike the Explore, Ideate, and Design aspects). Many of the students commented that while they appreciated the importance of marketing in the engineering design process, marketing was "not interesting" to them. Despite their discomfort with the marketing terminology and lack of expertise in this area, design students were able to identify the critical role that marketing plays in product development. The Innovation Canvas was an effective tool for introducing marketing concepts and provided a foundation for future development of these concepts. A more in-depth discussion of this activity and the results can be found in reference 6.

Summary

The workgroup found that the Innovation Canvas provides an excellent framework to assist students in engaging with the multifaceted components and iterative nature of the design process. While it has some efficacy when introduced in a capstone design experience, we found that optimal implementation of the IC calls for introduction to the framework early in the curriculum and continued exposure throughout the college experience so that they are comfortable with many of the terms and analyses inherent in use of the canvas before they use this tool in a complete design cycle. In this paper we have attempted to suggest many different ways in which this exposure could be done, including the use of case studies, reverse engineering experiences and design videos. While our experience with the canvas has shown that there is a significant learning curve for both instructors and students, we feel that the advantages of the IC in managing the many aspects of design, including the value proposition and other key entrepreneurial aspects of the design process, make the IC worth the investment.

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