The High-Tech, Global Design and Manufacturing Enterprise of 2035

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Abstract

Many global manufacturing enterprises develop a long-term vision for their company. These enterprises set goals and make plans to achieve that vision. This paper considers a hypothetical, high-tech, global manufacturing enterprise that has hired me as a consultant. My goal is to help this company become a leading high-tech, global design and manufacturing enterprise by the year 2035. In the text below, there is an opening dialogue section between the CEO of this company and me, the consultant. Although a fictional conversation, the data that the consultant shares with the CEO comes from actual research done in the literature as well as a 2.5 week global product development course I participated in. The course included visits to 20 companies and 1 university across 5 countries, namely, the U.S.A., Panama, Brazil, Chile, and Argentina. After the dialogue, a report is given about the scientific foundations of the product realization process, the principles academia will need to address over the next 17 years, and the engineering and business applications pertaining to the high-tech, global design and manufacturing enterprise of 2035.

The High-Tech, Global Design and Manufacturing Enterprise of 2035

"Jake! You're back! How did the trip go?" exclaimed Dan, my current employer and CEO of Rogue Candle Industries.

Dan had hired me as a consultant a couple of months ago to help his company become a successful high-tech global design and manufacturing enterprise. We set a goal to achieve this status by the year 2035, however, we needed more information so I took a business trip.

"It was incredible. You won't believe all the information I have for you and the company. I am excited to get to work on it."

Before departing on my three week escalade across South America, Dan and I had reviewed his hopes for the company. Currently, Dan's enterprise focuses on manufacturing and is spread across the globe. Since Dan wants to shift towards a global design *and* manufacturing company, I suggested he read a useful article, "Restoring American Competitiveness," from the Harvard Business Review while I was away.

"So what did you find?" pressed Dan.

"Well as we agreed upon before I left, I focused on understanding the product realization process. However, before we talk about that, did you read 'Restoring American Competitiveness'?"

"I did" said Dan.

"And…" I probed.

"And it explained our situation exactly! As you know Jake, we only have corporate offices here in the U.S. All of the manufacturing is done in other countries. I've wanted to design our own products and produce them, but we've continually struggled in moving past the concept development stage.

"I bet! The reality is that many companies are struggling to design and innovate because more and more manufacturing is being outsourced."

"Exactly! The authors, Pisano and Shih, explain 'product and process innovation are intertwined.' Even though our profits increase when we outsource, our company cannot innovate as well. Our engineers don't even know how our products are being made anymore!" Dan practically yelled.

"I know, this is one of the many obstacles to creating a successful global enterprise."

"Alright, now tell me, what did you find out?" said Dan.

"Ok, I've broken down the information into three categories for you: Scientific Foundations, Principles Academia will need to Address, and Engineering and Business Applications.

They are arranged in a pyramid tree (see fig. 1) to show the relative sizes of each category and how they stem from each other. There are relatively few scientific foundations, containing many principles to be studied by academia, which will create and improve numerous engineering and business applications.

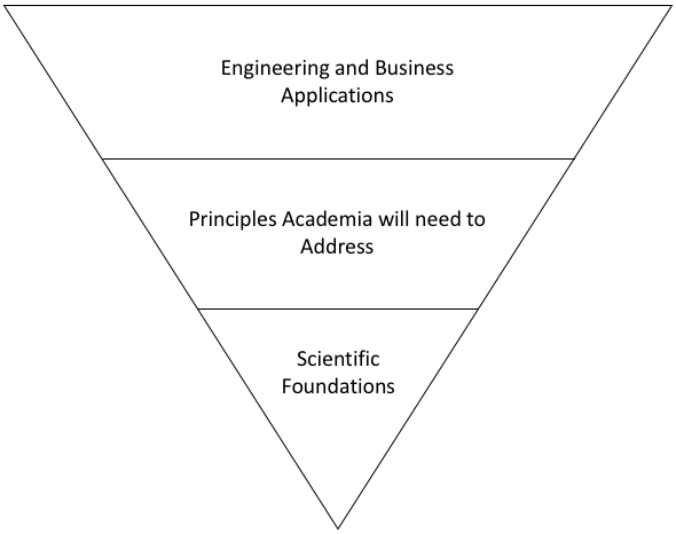

Figure 1: Academic Principles stem from Scientific Foundations. Engineering and Business Applications stem from Academic Principles.

Specifically, I am going to introduce to you the scientific foundations for understanding the product realization process which are suitable for a global manufacturing enterprise. I will then discuss the associated principles academia will need to address in the following 17 years. Finally, I will define the resulting engineering and business applications necessary to the success of Rogue Candle Industries in the year 2035, including the research challenges, the company's mode of operation, the essential partnerships, and the vital technology."

"Remember, I didn't want a report more than 10 pages long. This sounds like it could take all day!" exclaimed Dan.

"Not to worry Dan, I've consolidated my thoughts for you, it will be concise. Enough of our dialogue, enjoy the report."

Scientific Foundations

The scientific foundations for understanding the product realization process are simple. Through extensive research and observation, the three most encompassing foundations are: communication, collaboration, and sustainability.

Communication

A leading high-tech, global enterprise of 2035 will need to be a leader in communication at the company and individual levels. Since the enterprise is focused on design and manufacturing, it can be assumed that a significant number of employees will fulfill technical and engineering positions. Chapter 5 of *Sustainability in Engineering Design*, by Johnson and Gibson (2014), discusses the requirement design engineers have to communicate necessary and applicable information to other professionals. Already, society is long past hiring engineers solely for their technical abilities, and will be even less inclined to do so in the year 2035. The employees of Rogue Candle Industries must be well-versed and able to communicate information quickly and accurately across the globe. Most importantly, Rogue Candle Industries will need to be adept at communicating within the company, with other companies, and with consumers.

Collaboration

Collaboration is a fundamental scientific foundation which allows two or more people to create more than they could on their own. Collaboration is vital to all stages of the product realization process. From the opportunity development stage, or market research, all the way to post-release refinement, engineers need to coordinate interdependent activities (Mattson & Sorensen, 2013). Academia will improve the product realization process by researching how to develop globally competent engineers and how to increase the effectiveness of interdisciplinary teams. Engineers will then be prepared to collaborate with those of other cultures and expertise.

Sustainability

The Industrial Revolution was the turning point which has led us to the prosperity we enjoy today. However, with an industrialized economy, many negative effects have impacted planet earth. As this knowledge becomes increasingly known, people value companies that take measures to protect the environment. Likewise, manufacturing companies have begun to save money through reducing waste and to earn money by bolstering their company image through "green" measures (Guo, Duflou, Deng, & Lauwers, 2018).

Sustainability can also refer to the upkeep of products and processes. As a leading, high-tech enterprise of 2035, Rogue Candle Industries will need to not only sustain its products and processes, but continually improve them.

Principles Academia will need to Address

In the realm of communication, there are three principal areas to excel within: internal communication, external communication, and customer feedback. Academia's research in these three areas will be vital to the competitiveness of the company.

Internal Communication

How well employees can communicate and work with one another is an indicator of success. In order to achieve the status of a high-tech, global design and manufacturing enterprise, a high level of trust and openness in communication must be obtained.

Software platforms will be highly valuable to the aspiring global enterprise. Globant is a software development company, headquartered in Buenos Aires, Argentina. A personal visit to their headquarters was eye-opening. Although they develop software for their clients, they also produce software used in-house. One of their platforms is titled: "StarMeUp." This is an employee engagement platform that allows co-workers to thank and praise each other for what they do. There is a palpable feeling of unity at the Globant Headquarters in Argentina, partially due to this technology.

Academic experts should develop models and use existing software platforms to measure unity amongst engineering teams. Although a majority of the data to be collected is qualitative, using a Likert scale, quantitative data can be extracted and synthesized.

External Communication

External communication includes everything from speaking with other companies and universities to speaking with the press.

Throughout the product realization process, there are many occasions to speak and coordinate with other companies. It is necessary to coordinate shipments, materials, equipment, packaging,

delivery, and so on. Clear communication with other companies is vital to receiving what you need, when you need it. ATL Technology, located in Springville, Utah, focuses on providing solutions through their engineers to their clients' engineers. As this practice becomes more and more common over the next 17 years, Rogue Candle Industries will need to hire engineers who can communicate. Already, there is a trend amongst employers seeking graduates with soft skills over hard skills; working in groups is an effective environment for these graduates to learn to communicate, to be honest, and to take initiative (Zhang, 2012). Further research should be conducted in designing models to evaluate soft skills in engineers and in redesigning engineering education curriculum.

Engineers also receive attention from the press and need to know how to appropriately respond. Engineers need to be accurate, official, and simplify or omit most details to avoid overwhelming their audience and representing their company professionally (Johnson & Gibson, 2014). Again, redesigning engineering curriculum to prepare engineers to communicate professionally will be of great value to the enterprise of 2035.

Customer Feedback

Academia will need to study how to collect customer feedback as well as how the company should incorporate customer feedback into their product realization process.

The Panama Canal is an example of a business, in this case a government, who responded positively to consumer needs. In 2016, the construction of a new Panama Canal was completed. This third waterway was constructed to meet the demands of a changing economy. Transportation vessels were becoming bigger and the old canal was becoming obsolete.

The goal for Rogue Candle Industries is to design and manufacture with customer feedback in mind. By doing so, the enterprise will be able to revise products in brief periods of time. Granted, the new Panama Canal was a huge undertaking, but a new canal would have been beneficial before 2016. Academia should investigate how to timely collect customer feedback, model it, and apply it to products already modularly designed.

In the realm of collaboration, there are two principal areas in need of further research: the development of globally competent engineers and interdisciplinary teams. As academia studies these sectors of research, graduating and graduated engineers will be better equipped to contribute to various stages of the product realization process rather than just their expertise.

Development of Globally Competent Engineers

With the ever-increasing phenomena of globalization, "there is a growing need for students to enter the workforce with global, cross-cultural skills and experiences" (Ball et al., 2012, p. 156). To have the brightest, globally-minded engineers by 2035 requires immediate research to be performed. Ball et al. (2012) highlight future areas of exploration to prepare globally competent engineers. They suggest determining which activities and the order in which they are practiced truly do develop global competence. Also, they are interested in the development of methods or models that can effectively measure global competence.

The University of Michigan has already implemented undergraduate and graduate courses focused on preparing engineers to obtain global competencies and "to work with international suppliers, co-workers, and clients" (Eljamal, Pang, Edington, 2005, p. 1). As academia improves the implementation of core global competencies in study abroad programs, foreign internships, and other global educational experiences, the global, high-tech design and manufacturing enterprise will thrive in working with people of all different cultures.

Interdisciplinary Teamwork in Product Development

Globant, the software development company mentioned previously, deploys an agile methodology and works in multi-disciplinary teams, known as "pods." The agile methodology, primarily used in software development, allows for flexibility in responding to changing consumer needs. However, Maruping, Venkatesh and Agarwal (2009) claim that "flexibility is not without cost, as it is fundamentally inimical to the degree of structure embedded in a development process" (p. 378).

Over the next several years, academia faces the challenge to conceive, test, and validate product realization processes which incorporate "small company speed and customer responsiveness with the cost effectiveness and technical excellence of a big company" ("HOS Gold," 2018). The only way to accomplish this feat is to involve design engineers and process engineers or manufacturers simultaneously. At Akaer, an aerospace company in Brazil, they follow this methodology. Through collaborating and designing the process at the same time as the product, the company saves time and energy. The global design and manufacturing enterprise of 2035 must do this and more to become the market leader. Academic experts in the engineering field need to conduct more interdisciplinary research, such research should include: pilot courses where an engineering student is part of an interdisciplinary team (non-engineering majors) to measure professional growth and studies that show the effect of taking business classes in an engineer's success in product development.

Expanding one's own knowledge as well as working with other disciplines is critical to reducing the TTM (time to market) and still producing a quality product.

Finally, in the realm of sustainability, there are two principal areas of research to be pursued: reducing effects on the environment and continuous improvement.

Environment

Decisions made during the design phase have more of an impact in saving materials and energy than in later manufacturing process optimizations (Guo et al., 2018). This signifies the importance of design and process engineers collaborating from the beginning. Not only will they make wise design decisions, but they will preserve resources and the environment. Academia should further investigate the work of Guo et al. (2018) in applying energy efficient models and comparing near-net shape strategy vs. conventional shape strategy in manufacturing with common materials.

Continuous Improvement

Kaizen means continuous improvement. Technology changes quickly and many people in today's workforce went to school without personal computers. These same people use computers and other advanced technology that did not exist 20 or even 10 years ago. Employees at companies in North and South America (namely IM Flash, Akaer, Latécoère and Mobi) gave advice such as "keep learning every day," "learn to love learning," and "continue to learn, stuff is changing too fast." In order to have a competitive design and manufacturing company in 2035, the engineers working there must have a love of learning and be able to do so on their own. The book, "Educating the engineer of 2020: Adapting engineering education to the new century," states that institutions must take responsibility for the learning habits of their students (National Academy of Engineering). There is potential in studying the underlying factors of engineering students' desires to be lifelong learners.

Products need to continually improve as well as people. Tying in closely with customer feedback, once a product has entered into the hands of consumers, how well it functions should be

monitored closely. “Field service and maintenance costs should be monitored as part of a continuous cost/performance improvement methodology.” Then this data can be processed and the company can make subtle, yet significant, design changes to improve the product in a relatively short amount of time (Committee on Analysis of Research, 1991, p. 112). Academia will need to design indicators that can be used to measure product effectiveness versus product failure in field service and maintenance costs. They also will need to design and validate business management models that incorporate these indicators. The company will be able to implement this model and these indicators, becoming a leader in reconfiguring products to meet consumers’ needs.

Engineering and Business Applications

Research Challenges

Apart from the research challenges mentioned above, Rogue Candle Industries faces the challenge of hiring the most prominent engineers. This challenge arises from the fluctuation of engineers moving to other sectors. We see many engineers going into business, finance, and other fields. For example, in the Goldman Sachs’ 2016 Letter to Shareholders, Blankfein states that “roughly one-quarter of the firm work[s] in various engineering-related roles.” Rogue Candle Industries must determine a strategy to recruit top-engineering students.

Other research challenges will include implementing new product realization processes to facilitate the collaboration between product engineers, process engineers, and marketing specialists.

Mode of Operation

The mode of operation of this company is crucial to its success in a competitive and ever-changing market. The company needs to move from the traditional product development cycle to a product realization process which integrates many of the product development steps into one; effectively, the steps will be layered, see figure 2 (Committee on Analysis of Research, 1991).

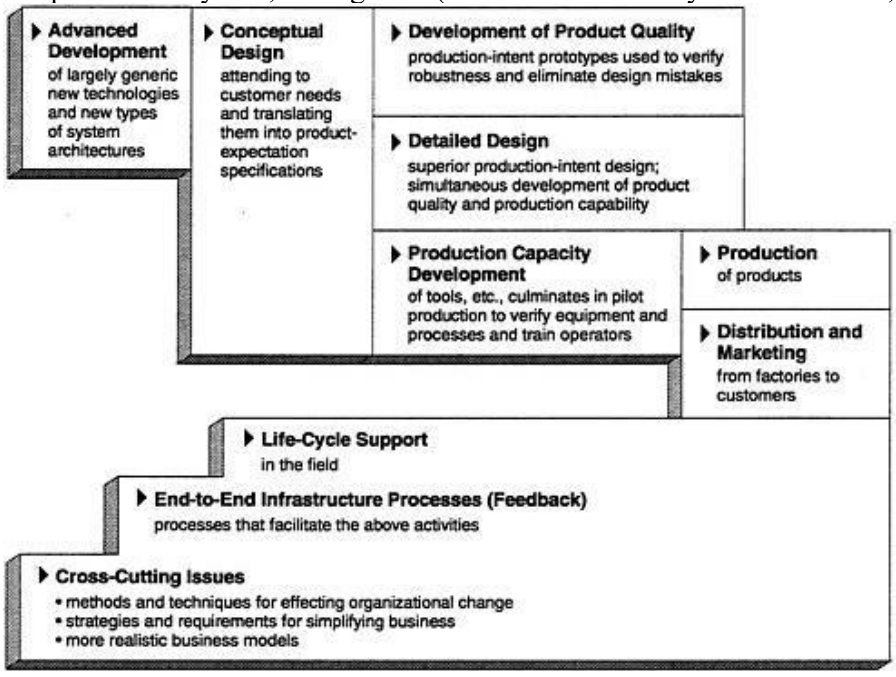

Figure 2: Product Realization Process – Current Process vs. Future Process

Partnerships

There are various opportunities for industry to partner with highly-accredited universities in the United States. Partnering options available to corporations include on and off-campus opportunities. On-campus, companies can sponsor senior-level capstone projects or provide funding to specific research labs. Off-campus, companies can provide internships and fund co-ops. These partnerships are opportunities for the company to hand-train young, globally competent engineers.

Sponsoring on-campus research will be a great benefit to the enterprise. "One of the intended outcomes of academic research is for industry to use the research outcomes" (Rajaeian, Cater-Steel & Lane, 2017, p. 37). Students are eager to work on "real" projects and will be assets to the company.

Rogue Candle Industries should also consider partnering with leading software firms, such as Globant, to create platforms. Software platforms will help the global enterprise to manage its massive amounts of data and logistics in one digital area.

Technology

Virtual reality (VR) hardware has recently been introduced into the consumer market. However, there are many implications of this advancement which apply to engineers who collaborate together, locally and remotely. Coburn, Salmon, and Freeman (2018) discuss the effectiveness of using virtual reality hardware as a communication tool for engineers. Their study shows the advantages of collaborating in virtual reality rather than by video conferencing. Improving the current virtual reality audio and the ability to design in VR should be of great interest to academics. The global, high-tech design and manufacturing enterprise of 2035 will undoubtedly need this advanced technology in order to collaborate from remote locations across the world. As virtual reality capabilities increase, it may no longer be as important to have R&D facilities close to manufacturing facilities as Pisano and Shih (2009) suggested. The collaboration possibilities are endless due to the increasing advancements in technology.

Conclusion

"Excellent, simply excellent. However, all this information is going to take some time to process" Dan breathed.

"Definitely, my trip to South America and the literature I studied opened my eyes to global product realization processes. They all had those common foundations: communication, collaboration, and sustainability. I gave you lots of principles to reflect upon in hope that you will find more specific applications to the company."

"What you did was great, Jake. Thank you for your work" said Dan.

"And I gave you a few applications to start implementing, but most will be up to you."

"That is just fine. I think my first step is to commence R&D where my manufacturing plants are currently operating. Whether I send engineers over…I'll decide…at least until new technology is available…let's see, product and process engineers need to be united…and university partnerships…" Dan trailed off, leaning back in his chair, absorbed in his own thoughts.

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