

The “Market Pull” versus “Technology Push” Continuum of Engineering Education

Jon C. Dixon
University of St. Thomas
BFGoodrich Aerospace

Abstract

Technologists, engineers, marketing agents and business managers are well acquainted with the “technology push” versus “market pull” continuum of product development. The “market pull” approach attempts to provide products the market demands. The “technology push” approach attempts to interest the market in new products based on new solutions.

Asking industry what it is thinking about its future needs for life-long learning, and what academia should do about it represents intention by academia to emphasize a “market pull” course of action with industry as customer. The academic institution desires to be of great help to local and regional industry by teaching students skills of immediate and tangible use by industry. Industry prospers, economies are fortified, academia has fulfilled its role, and America is strengthened. The antithetical method is often negatively viewed as too “theoretical” or ivory tower in approach.

While useful to some degree, the “market pull” approach is necessarily reactionary, shortsighted, and works not to strengthen America’s economy but to weaken it. An academic “market pull” approach shortchanges academia’s more important customers...its students, and America at large. It subjugates imaginative, creative leadership skills to “in the box” thinking. The approach satisfies short-term industry needs while defocusing the leadership crisis in American industry.

Consideration of an advance along the continuum from “market pull” dominance more towards “technology push” thinking is proposed. The question is rephrased as “What should tomorrow’s industrial leaders be learning today?”

I. Introduction

The future of American industry depends on the directions set by today’s engineering students. Whether these students become followers or leaders is largely up to them. But that outcome is strongly dependent upon how their academic institutions influence them today. I submit most urgently that academia’s collective charter is to make certain these

students do not look back and understand their academies decided how to educate them by consulting micro-managed, closed system companies whose sole interests were profit.

Too heavy a reliance on industry input into engineering curricula can not improve engineering education. Such input will not encourage academia to nurture open systems leaders with critical thinking skills. Today's industry does not provide fertile soil for such creative individuals. Overemphasis on industry input will instead assure the production of interchangeable cogs called engineers whose lot in life will be working on poor products for micro-managers intent on profit at all costs.

I submit American industry today is in crisis. Everywhere we turn we witness claptrap products, a worsening of the American standard of living, reductions in employee benefits, corporate imperialism and ravenous thirst for profit above all else. This misguided and dangerous focus of American industry will, in the next two decades, be either affirmed or rejected by today's engineering students. There is too much at stake to ask the managers of today's industry what tomorrow's leaders should be learning.

If we are to wonder what and whom to ask about our engineering curricula, we should ask the question "What should tomorrow's industrial leaders be learning today?" We must ask this question of ourselves as educators.

II. Defining the "Market Pull" versus "Technology Push" Continuum

One of industry's (and academia's) greatest challenges is to develop products customers want and will purchase. There exists a fine balance between providing just what the customer is known to want and what the producer believes is a far superior solution set. This balance represents a continuum, with development approaches known as "market pull" versus "technology push" respectively.

"Market pull" is a scenario in which the market demands a product (or service) type, or defines a problem, and producers respond by producing and delivering that product. Market desire is well calculated. The producer is in the business of delivering products intended to fill a market-defined niche. In short, market pull product development is based on a perception of what products or services the customer wants, with the customer having a large say in the direction of product development. The customer defines the solution and educates the producer.

"Technology push", in juxtaposition, is the scenario in which the producer, seeing an advantage to the consumer that the consumer does not see, creates a product type and also the demand for that product type. The producer is in the business of fulfilling functions for the consumer, and uses unique methods, technology or approaches to better fulfill the function in ways even the consumer may not initially recognize. The producer carefully learns and understands about customers' problems. In short, technology push product development is based on the belief that the supplier recognizes a market need even before the market does. (By technology push I do not mean proffering products simply because

the technology or method are capable of it. I do mean fulfilling functions better than do any other current methods.) The producer ultimately educates the customer.

To further our definition, it should be noted that there exists a difference between “product” and “function”. A product is a specific physical embodiment or service that fulfills some function. The function is defined as that set of work requirements the product or service must perform for the customer. An automobile tire is a *product*. Its *function* is to transmit forces between the automobile and the pavement. Often more than one product may fulfill the same function. Bias ply and radial ply tires both serve this function, albeit the latter better than the former. The function of removing the cork from a wine bottle may be achieved by nearly countless methods and designs, ranging from the traditional corkscrew to air injection devices. Each represents a different product fulfilling a single function. What is critical to customers is *function*.

Products and services are developed most often somewhere between the extreme cases of pure market pull or pure technology push. Figure 1 illustrates the continuum.

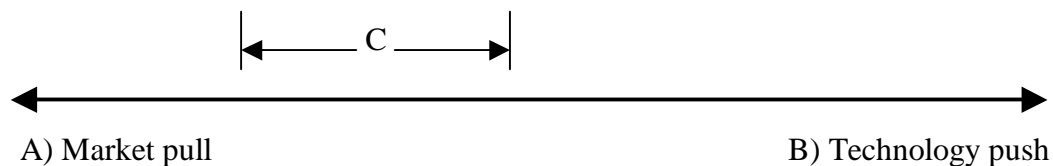


Figure 1. The “market pull” versus “technology push” continuum.

In Figure 1, A) represents an extreme market pull approach to satisfying customers. B) represents the extreme technology push approach. Products assume a location on the continuum depending upon the market approach methodology used to create the product. Regions A) and B) represent extreme positions. The region denoted C) illustrates a bandwidth approach. This bandwidth may move left or right, be tighter or narrow for any given producer. Product offerings may be generally placed along the bandwidth, some representing more market pull emphasis, others more technology push. The center of region C) represents an average of the producer’s offerings, and reflects its general philosophy towards new product development. The width of the band represents the producer’s ability, willingness, or more likely culture, to approach new product development from different perspectives along the continuum. The width of the band also represents a certain inherent tension between the appeal of the two approaches. In this illustration, the more commonly held approach favoring the market pull end of the product development spectrum is illustrated.

Both ends of this spectrum are represented by characteristic ways of thinking and approaches to the market. These may be illustrated as in Chart 1.

Chart 1.	Market Pull	Technology Push
Business decisions	Safe	Risky
Risk	Low to moderate	Moderate to high
R&D costs	Low to moderate	Moderate to high
Return on investment	Assured	Unknown, unsure
Ready market	Yes	Believed but uncertain
Marketing	Easy	Reshaping the market
Chance of wrong product	Little chance	Big chance
Comfort zone	Dead center	Nowhere in sight
Core competencies	Yes	Develop new competencies
Effort	Low to moderate	Moderate to high
Investment	Low to moderate	Moderate to high
Education	Producer educated by cust.	Customer educated by prod.
Market belief	Belief in the current market	Belief in market change
Types of products produced	Phenotypes	Genotypes
Product evolution scenario	Current S-curve products	Next S-curve products
Vision	Making what exists better	What <i>could be</i>
Asking the customer....	Business answers dominate	Customer may not know
Focus	Products	Solutions for functions
Innovation	Mild	Incredible
Typical mgmt. mindset	Managerial	Leadership

Chart 1. Characteristic differences between market pull and technology push product development.

A final point of definition from Morello¹ serves to illustrate the difference between a “user” and a “consumer”. The user of a product (or service) is that person who actually uses the product or service for his or her immediate purpose. When I use a photocopier at my place of employment, I am the “user” of the product. With regard to products or services, users have a refined interface with the product. They utilize it on numerous specific occasions. The user might or might not utilize all of the capabilities of the product. The use of the product becomes a “microproject” for the user.

A “consumer” may be defined as the person (or group of persons) who puts the product (or service) into place for users. The purchasing group that decided what copiers to purchase or lease for a company, based on expected, collective, intended usage, and after comparing offerings, is the “consumer”. Consumers place the product into condition for proper use by users, and must consider every possible occasion of use. The consumer interface with this item becomes a “macroproject”.

It is critical to keep in mind that the generalist term “customer” often contains both users and consumers. Neglecting to differentiate between these classes of customer is to court

market failure. Both market pull and technology push products or services must be tailored appropriately to users and consumers.

Referring again to Chart 1, it seems clear from the characteristics that typically management is far more comfortable with a market pull approach. Risks, effort and costs are relatively low, markets are ready, core competencies may be readily applied to things customers desire and there seems little chance for failure. The producer is in a comfort zone.

At the other end of the spectrum, technology push is uncomfortable. Risks, effort and costs are high, markets require education and justification, new competencies need development, customers may not ultimately desire your product and there is significant chance for failure. This is the realm of the unknown, of adventure. There is no comfort zone.

III. Education Along the Continuum

Increasingly academia is striving to move its market approach along the continuum towards market pull. Asking industry what it is thinking about future needs for life-long learning, and what academia should do about it represents intention by academia to emphasize a “market pull” course of action with industry as customer. Specifically with respect to engineering education, academia is seeking to understand from industry what attributes are desired in engineering graduates, both at the bachelor’s and master’s levels. Academia would then modify its curricula to more closely serve industry’s needs. The academic institution desires to be of great help to local and regional industry by teaching students skills of immediate and tangible use by industry. Industry prospers, economies are fortified, academia has fulfilled its role, and America is strengthened.

Consideration of increased motion along the continuum towards market pull represents recognition of the continuum, and a perception that market pull is favorable for a variety of reasons. It is assumed that an extreme market pull position is not being sought or proposed, but rather a general, mild movement along the continuum in that direction. The antithetical approach of technology push is often negatively viewed as too “theoretical” or ivory tower for academia. Movements towards market pull in some ways signal intent to retreat from the “ivory tower” perception of universities as theory-bound, cloistered walls insulated from the “real world”.

There exist educational analogies to industrial product development. Academia, like industry, has products, customers (users and consumers), and markets.

The “product” universities sell is not invariant, and is tailorable for its customer. The university enables and encourages the student to motivate him or herself to learn fundamental sets of information and develop key skills. This information is represented by engineering principles. The university teaches skills such that the student may apply this information in meaningful ways to solve problems. This is called engineering knowledge. The skill of the university in providing knowledge (information applied to

solve a problem) and an environment that fosters the thirst to uncover, understand and apply that knowledge is its product development approach. The actual product, it may be argued, is a certificate that assures third parties that the purchaser, by virtue of acquired knowledge, has demonstrated certain competencies. Another way to look at the product is the assurance to both the student and interested third parties that the student is well poised to translate from potential to kinetic energy these skills in engineering. The product is the certification, or the potential energy part of the balance. The function, however, is precisely this skill or ability to translate knowledge into wisdom by solving problems with expertise and experience gained over a lifetime. The function is the kinetic energy part of the balance. One might consider the product as the functional ability to think critically.

The primary customer of any educational institution is the student. Whether the student pays tuition, is awarded partial or complete scholarships or is supported in his educational endeavor by parents or employment tuition reimbursement programs, it is the student that is customer. The student, as customer, is a “user”.

Companies that hire engineers are secondary customers in the “consumer” role. Human resource departments and hiring supervisors put the graduate “into place for use”.

Students desiring particular types of education represent the primary market. Companies desirous of hiring such graduates because of their perceived (and certified) skill sets (very) secondarily represent the market. The market is of the market pull type, based on the definition of the product offerings.

IV. Drawbacks of Market Pull in General

It is clear after reviewing Chart 1 that market pull is a safer, less costly, risk averse approach towards pleasing customers. However, there exist dangers in this approach that are often overlooked or unseen.

Customers often do not know what they want. Customers (users and consumers) are immersed in the realm of the present. They compare, acquire and use the products of today, but are neither in the mindset or business of looking towards future developments. When customers are asked what they want, business answers dominate over truly substantive answers. Customers want basically the same product as they have had in the past. But they want it cheaper, faster, or with greater reliability. They recognize what they do not like. They have no real ability to critique technology or methodology, they are hard pressed to imagine “what could be...”, and so resort to asking for modifications to what they understand. Only producers really are in the position, through intimate knowledge of their products and markets, to know “what could be...”. (An excellent example is served by the transition from bias ply to radial ply tires. Michelin’s invention was not something either purchasers or manufacturers of automobiles demanded. They simply did not know what to ask for other than cheaper bias ply tires that lasted longer.

Michelin's breakthrough radial tire that not only lasted longer but tracked straighter and offered dramatically improved cornering and braking capabilities was a technology push product that, once accepted, became the absolute in market pull. Automobile buyers then demanded automobile manufacturers equip new cars with the remarkable new product.) Customers are not experts in the producer's field of endeavor and can only compare among current market offerings, selecting those which intuitively or through reasonable research they consider "better". They are left to select among the common offerings.

Morello¹ discusses the market pull phenomenon from an interesting perspective that relates design of products to societal perspectives. Morello cites a series of further drawbacks associated with powerful market pull scenarios that I desire to paraphrase.

Competition and market sharing are assured in any market pull system. Producers acknowledge implicitly, if not explicitly, they are willing to share markets because no one is offering truly new and unique market-creating products. The competitive drive is to achieve more of a given market, not creating new markets or making dramatic advances in an existing market.

Competition between enterprises predominates rather than service to users. Competitors are concerned with producing the same things at lower costs. The focus on competition dominates over taking care of the customer. Differentiation of similar products becomes the only means of competition. The focus on existing products aims to wring out the last penny of advantage from them. The customer as user is forgotten.

This situation produces what Morello¹ calls *a high phenotype/genotype ratio*. (Phenotypes may be defined as variations of performances. Genotypes, on the contrary, are different kinds of products.) Really new products are few and far between. There exists a lack of authentic innovation. Because the focus is on existing products, producers try desperately to make the base model better and better in subtle ways. Unfortunately, this leads to what Morello calls "overcomplication of performances" and "overdecoration of products". The base model is tweaked, fiddled with and gilded to look and seem new. It is made into something it was never intended to be. Underneath it all lies the same old product. Because the same product is being offered long past its natural "S-curve" maturation, the only possible means of competition is to find ways to make the same product at a cheaper cost. Process innovation prevails over product innovation. Product cost becomes main focus of producers. Competitors focus on each other, oblivious to the customer, and move entire categories of products to an undifferentiated, "commoditized" condition in which they can ONLY compete on price.

The focus is on products not functions. What still remains elusive is the focus on function, on true customer needs, on introducing products based on real innovation. Consider automobile engines. A carburetor and a fuel injection system are completely different products that fulfill the same function...delivering fuel to the engine in the right amount at the right time. The focus on products, in this example, creates better and better carburetors. The focus on function, however, replaced the carburetor with the cheaper and far more efficient and effective fuel injection system. Focus on product suffocates the

“what could be...” creative solution and excitement. Asking customers to define product needs leads to line proliferation and extensions rather than truly new products. Customers are about function.

Management infuses the company with a market pull culture. Companies become so enmeshed in market pull product development that the method becomes endemic within the organization. The comfort zone becomes the culture, making real innovation seem much riskier yet not only because it is risky, but is also beyond the culture of the organization. The energy barrier to innovation becomes higher and higher.

The “attacker’s advantage”, as we learn from Foster², is the complacency associated with market pull comfort zones. An “attacker” is any company or organization that takes markets away from stalled, market pull competitors. The attacker pays strict attention to functions, not products. The attacker, armed with technology push methods and a thirst for fulfilling customers’ functions with exciting, advantageous new products, offers the market dramatically new and innovative products that take the market by storm, denying the market pull producers their markets.

V. Perspective of Modern American Industry

At first blush it seems natural, inevitable, to ask industry what it desires from academia. Inquiring as to how a university might produce students more suited to their ultimate industrial careers seems a valid source of feedback, akin to Japanese QFD (quality function deployment) principles. Let us review the current state of affairs in industry before we set out to ask industry what it wants from academia.

I have discussed companies infused by management with the market pull, comfort zone mentality. Management talks innovation, yet fears and opposes risk. These systems are what Havener³ describes as “closed systems”. Closed systems are those that simply do not recognize or acknowledge their interdependence with their environment. Closed system institutions forget their original passion for being or “originating purpose”, and become irrevocably focused on the internal forms and structures that drive it, rather than remaining connected, involved, passionate about the environment within which they operate. Do not confuse much of industry’s focus on profit and desire to find new ways to profit as open system thinking. The relentless drive for profit at the expense of employees and America’s standard of living is the worst of closed systems. Such industries attempt to control that which they cannot control...money in the hands of potential customers. They forsake true focus on customers. Closed systems ultimately create sufficient internal entropy to cause their own demise. Witness so many companies whose employees are literally downtrodden, resentful, unhappy, unchallenged and unappreciated.

I submit Chart 2 to clarify the concepts of Havener’s open and closed systems (to which I shall again refer).

Chart 2.	Open System	Closed System
Primary Driving Force	The system's originating purpose, its intended result, its passion.	Disregards original purpose. Concerned with refining its forms and processes. Corporate imperialism.
Relationship with Environment	Connected, integrated with environment, customers and employees.	Disconnected, isolated from environment, customers and employees.
Nature or State of Balance	Dynamic – constantly reinvents itself to sustain its purpose. Minimized entropy.	Static – constantly strives for control, and “rigidification” of processes. High entropy.
Perspective	Synthesizing. Sees wholes, their interdependent parts, and understands the relationship between them.	Linear and dissective – Analytical. Sees parts in isolation, disconnected from one another.
Mindset	Integrative – about the customer's needs. Qualitative – about meeting functions. Outcome focused	Normative - about the company, not customer needs. Quantitative – about volume and money. Sustaining – how we have always done it.

Chart 2. Havener's summary of the critical differences between open and closed systems.

Current industry trends include massive imperialism. Companies are aggressively acquiring others as fast as they possibly can in the name of economies of scope and scale. The acquired entity is mined for profit. Byproducts of corporate imperialism include decimation of local culture and traditions. Hegemony of profit becomes the new culture. Passion for a particular business is replaced by the business of merger and managing conglomerates. Language changes from pride in product to corporate financial lingo. Metrics change from product quality to bottom line. Draconian cost reduction efforts and massive layoffs are common. Seniority becomes associated with high wage costs and retirement benefits, not an attribute associated with dedication and knowledge of products, markets and customers. Universal claims, rarely achieved, include price reductions, cost reductions, better customer service, greater efficiency, healthier competition and a financially healthier investment for stakeholders.

Americans are now working more hours than ever. Two full-time jobs in one family are common. Despite maturation of capitalism and the increasingly caustic quest for profit, American standards of living continue to decrease compared to other capitalist nations. The political promises we recall from the 1950's that suggested future generations would work less than the standard 40-hour workweek have not come true. Corporate America does not concern itself with employees as Americans, but simply as cumulative payroll

costs. American industry simply does not concern itself with America or Americans, but only with its own aggrandizement.

The proposed question to industry, in the market pull scenario, includes "...what it is thinking about its future needs for life-long learning...". American industry has developed a dramatically short-term focus, myopia largely due to pressures by investors for immediate profit and investment returns. Corporate executives literally navigate their businesses by looking at the monthly, weekly, indeed daily "bottom line". This short-term focus becomes endemic within organizations, particularly technical organizations that cannot afford short-term focus. Capital equipment expenditures, research and development projects, staffing issues and product development are all under increased pressure to perform anachronistically in the short-term. Even the professional development of technical staffs takes a back seat to short-term focus. It is not likely that significant answers to "future needs for life-long learning" will come from this focus.

Our graduate engineers are poised to jump into these companies. They are excited about being offered jobs and beginning careers. They desire to demonstrate ability to translate from potential to kinetic their energies. The "real world" is, however, not a warm and fuzzy place. It is into this world, nonetheless, that we place our graduates. It is the leaders of this world whom we contemplate asking our curriculum questions. Can we, in all good conscience, ask such questions of such persons?

VI. Drawbacks of Market Pull for Academia

I submit there are serious dangers in relying on too heavy a market pull focus when addressing engineering curricula.

As for academia, these concerns are exacerbated by a review of the industrial (secondary) customer. We see in industry a non-paying, near-sighted, secondary consumer harshly focused on closed systems profit at the expense of employees, and increasingly engaged in market pull product development. To ask industry what it expects from engineering education is to place industry into the role of primary customer. Perhaps it should be stated that such a course permits industry to assume the role of primary customer. Industry certainly will assume such a role, since it is the role of a non-paying recipient of the university's products. But assumption of this role usurps the student's role as primary customer.

Moreover, it is highly questionable whether industry desires critical thinkers desirous of shaping the future or interchangeable workers with fundamental engineering skills to routinely perform processes. I submit real desires between students and industry are different. Therefore, the functions and products must be different.

To place previously discussed concerns into academic context:

- *Customers often do not know what they want.* Academia cannot expect its students will understand industry and their place in it. (This is less true for

working adult students seeking master's degrees.) Academia cannot expect managers of closed systems to either desire change or recommend curriculum changes that support significant change. Neither students nor industry will be able to contribute dramatically to a new way of educating students, largely because they do not know academia's capabilities and lack true long-range views for American industry in service to all America.

- *Competition and market sharing are assured.* If each university begins to alter its curricula according to local industry requests, there will ultimately be little to differentiate between universities. Market share will be assured since every institution will be trying to provide the same things to the same customers.
- *Mild evolution dominates over real innovation or creativity.* Market pull approaches to curricula changes will result in mild, evolutionary curriculum changes. The result will be curricula that foster modified status quo solutions for maintenance of closed systems approaches in industry.
- *Focus is on product, not function.* A high phenotype/genotype ratio will obfuscate academia's raison d'être. Our universities will churn out engineers with a "degree in X", unable to see beyond today's industrial management crisis, and certainly unable to creatively influence and pursue change from closed to open systems thinking. There will be no room for critical reasoning.
- *A culture of mild evolution becomes intrinsic for the producer.* Relying on market pull will create within academia a culture of hoping to produce what local industry wants. Universities, which should be centers for learning and advanced thinking, relegate themselves to regurgitating learning that is expected by closed systems in which advanced thinking is not only undesirable, but disdained. Status quo becomes modus operandi.
- *Competition between producers dominates over service to the customer.* It is considered that in asking industry what it wants, universities are serving the customer by helping create ready job markets. All of this is false. The short-term, closed system world revolves around this argument. Universities working the market pull approach will become so focused on providing what industry asks, that the focus on the primary customer will disappear. Universities will challenge one another to satisfy industry's perceived needs, while the focus on the student's future will disappear. The primary customer is duped and cheated.
- *Producer is open to the attacker's advantage.* Academic institutions that decide to give in to the market pull approach must expect to be attacked at some time by more forward thinking institutions whose curricula do focus on future leadership, not the evolved regurgitation of what closed system managers want today.

VII. Summary and Recommendations

Summary

I do not believe those proposing a tendency towards more market pull approaches would claim the subject is at the apex of engineering educational topics. I submit, however, that trending towards market pull curriculum content obfuscates precisely what those more important issues are. Among those issues is the strengthening of America.

While useful to some degree, the market pull approach is necessarily reactionary, shortsighted, and works not to strengthen America's economy but to weaken it. An academic market pull approach shortchanges academia's most important customers...its students, and America at large. It subjugates imaginative, creative leadership skills to "in the box" thinking. The approach satisfies short-term industry needs while defocusing a leadership crisis in American industry.

What is required today is an evolution of engineering (and other) education aimed at transforming American industry into a place where true creativity, innovation, and employee enthusiasm can flourish. America is not about those few who milk organizations for profit or for the organizations themselves. America is about all citizens. Engineering education should be about how engineers can grow into leadership roles and translate the real potential of employees into an ever-stronger America.

The antithetical technology push method by academia is often negatively viewed as too "theoretical" or ivory tower in approach. Movements towards a market pull approach in some ways signal intent to retreat from the "ivory tower" perception of universities as theory-bound, cloistered walls insulated from the "real world". I submit that what advanced education should do is open horizons, challenge the status quo, encourage creativity and foster leaders. It is precisely these leaders who will break the cycle of closed systems, eliminate reaching for ever-higher profits while handing Americans an ever-decreasing standard of living.

Certainly there are perils associated with technology push. Perhaps the greatest is the potential to produce a product that the market does not want. Risk is higher, costs are higher, there is less certainty in the ability to produce the product, let alone in its market acceptance. However, the rewards are potentially enormous. The rewards in education are not solely for the academic institution. The truest rewards are for America via enlightened industrial leadership. These rewards will come from alumni of enlightened academic institutions who become leaders of industry. These rewards are the ultimate function for academic institutions.

Things that don't adapt don't survive. Industry is constantly in a fit over change. Employees are taught, admonished, nearly threatened about how change will come faster and faster, and that employees must adapt or perish. The mantra creates fear more often than not. But there are corollaries for every phrase. For every "the only thing that remains the same is change" phrase exists a contradictory "the more things change, the more they

stay the same". Hopefully our academic institutions do not teach by phraseology. Industrial management universally perceives its employees as having difficulty changing. (It never seems to be the reverse case.) Resistance to change, I submit, is not due to fear of change, but represents reaction to too frequent redirection of meaningless change (resulting from the myopia of focus on today's bottom line rather than the future health of the industry). It is curious that what does not change is today's industry. Managers run amok looking for the latest trends, reading the latest management books, trying to get to market faster. But they waste so much time running from wall to wall of their bottom line maze, and getting the same tired products to market, that there is no time for the real, substantive change, for real adaptation that must take place. Today's industry is in a highly excited state akin to Brownian motion, scalar not vector motion, lacking direction. The agitation is over profit. Havener³ illustrates so clearly that profit is not and can not be the main focus of industry, because it is not within the control of industry. (Industry only controls its offerings not the money in the hand of potential customers.) It is unlikely these managers are the ones to help redirect engineering (or other) curricula in such a way as to create significant redirection of American industry.

Recommendations

I propose academia move its product development bandwidth ("C" in Figure 1) towards the technology push end of the spectrum. I do not propose an extreme translation, but I do suggest a significant shift. This translation requires significant and real academic introspection. It requires courage. Technology push offers the potential of gaining an entire new product of advanced engineering and engineering management methods, while leaving less adaptive universities holding onto old, obsolete curricula. The attacker's advantage is realized. Technology push becomes powerful market pull once the customer is educated, recognizes the new offering as something beyond the market pull solutions, and begins to demand the new vision being offered. At this point, the university has succeeded in not only creating a new market that will attract ever more students, but in becoming leaders in American education.

I do not propose ignoring industry requests for tailoring curricula. Academia must surely listen to these requests. But potential changes must be considered in the context of the larger picture I suggest in this paper. Academia must also understand the reality of industry today and its often-negative impacts. Academia must ask questions everywhere, of everyone who has perspective on the institutions into which their students will find jobs. Only then can academia hope to understand what needs to be taught in order to effect real and substantive change. In this way academic institutions can refrain from usurping the primary customer's functional needs.

I propose continuation of "the basics" of engineering education. To be an industry leader in the engineering world requires the fundamental understanding of engineering principles. I do suggest, however, that the remaining coursework be less tailored to random electives and more towards coursework on leadership, ethics, philosophy, technology forecasting and history of American industry.

I propose a long-term focus for students. We must make sure both the academic institution and the student understand that the bachelor's work is a foundation for a life's work. We must make the student aware from our earliest contact that we expect them to be leaders of American industry. We must, in response to this expectation, provide better tools for helping the student achieve that goal. It is no longer acceptable to offer "a degree in X".

I propose that education remain an arena of open thought. Academic institutions must not constrain students to conformity, but must expand the horizons of students by teaching and encouraging open system thinking. Academia cannot be a place that teaches the status quo. It must provide the environment that encourages freethinking, worldviews, big scale, future focus and the "*what could be...*" that is so critical for leadership in any venture.

I propose academia define education not as the transference of a set of current knowledge, nor even as a mild evolution of current ways of thinking. Education should be about new ways of thinking, unquenchable thirst for better ways, a global perspective of leadership and learning to view the infinite. Academia must go beyond economic reproduction or correspondence theory, beyond cultural reproduction theory, and indeed beyond the language of critique to the language of possibilities. We must consider that the "degree in X" is the student's first formal benchmark. That first benchmark, however, should represent a powerful foundation for future leadership. The market pull approach asks only what we might do to make "X" more useful to a closed system. We must insist that "X" is a fundamental structure for building open systems. In order to do that, we must expect leadership of ourselves first. We cannot ask others how to do that; we must ask ourselves.

I propose academia focus on functions, not product. Academia should not want to churn out automatons that learn engineering management, leadership and business ethics on the job in closed systems. Academia must focus on the function of the primary customer as user, the student. The student's function is not just to attain a job in engineering, but to be a future leader of American industry. This is an enormous charge, potentially affecting hundreds of thousands of lives. It is a charge that encourages changing industry from closed to open systems, and creating environments of creative thought that are secure, hopeful, indeed wondrous places to spend creative time. The leaders I speak of are not managers. I do not speak of persons who work in the microscale of industry, making sure employees are doing things right. I speak of leaders, of visionary persons who work on the macroscale of industrial change, who make sure the right environments are in place for motivated human beings to do the right things, to occasionally fail, and to occasionally excel beyond their wildest imagination.

I propose every university create a lifelong, closed-loop (open system, but closed-loop) mentoring system for its graduated students. I do not propose charging students for this service, but rather making it a lifelong commitment to the student as part and parcel of the university's responsibility. Graduated students must always be able to call upon their alma mater for assistance, guidance, counseling, and should, in return, help provide

current, accurate pictures of American industry's methods, pressures and directions. Both the academic institution and industry can remain open systems, and will be united by the leaders in both realms of endeavor through such a feedback loop.

I propose that the students' transition point from potential to kinetic energy cannot take place solely within industry after the attainment of "a degree in X". The above-mentioned mentorship program must originate preferably with industry-sponsored intern or co-op programs for students.

I discussed that one significant problem with a technology push approach to markets is the danger of providing something the customer does not want. I submit that turning out young, energetic, educated leaders armed with forward-thinking skills and open systems approaches is not a "product" that can remain unwanted for long.

Conclusion

The future of engineering within corporate America, indeed of corporate America, will stem from the directions set by today's engineering students. Whether these students become followers or leaders is largely up to them. But that outcome is strongly dependent upon how their academic institutions influence them today. I submit most urgently that academia's collective charter is to assure America these students do not look back and understand their academies decided how to educate them by consulting micro-managed, closed system companies whose sole interests were profit.

Certainly industry must not be permitted to influence academia into becoming yet another closed system.

If we are to wonder what and whom to ask about our engineering curricula, we should ask the question "What should tomorrow's industrial leaders be learning today?" We must ask this question of ourselves as educators.

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JON C. DIXON

Jon Dixon is an adjunct faculty in the Graduate Programs in Manufacturing Systems and Engineering at the University of St. Thomas in St. Paul, Minnesota. He received his Bachelor of Aerospace Engineering and Mechanics degree at the University of Minnesota, and his Master of Manufacturing Systems Engineering degree at the University of St. Thomas. Mr. Dixon is a doctoral student in Educational Leadership at the University of St. Thomas. Mr. Dixon has 18 years experience in industry as an engineering manager with BFGoodrich Aerospace.