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Managing the Industry-Academic Interface

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Abstract

The microelectronics technology program at ASU has been totally restructured over the past three years with substantial industry input. As a result, we have been able to execute a strategy that aligns the capabilities of graduates with the workplace skills required by our supporting companies. Using that benchmark, a modular program has been defined to cover the key features of integrated circuit fabrication technology as well as the organizational and solution management skills needed by any effective practitioner in the industry.

Industrial participation has included a very active Advisory Board, senior staff assignment, seminars on specialist topics and company visits. Although this activity has a specialist microelectronics focus, there are many general features that are applicable to all branches of technology.

1. Refocus the goals

The interface between industry and academia is never comfortable. Nor should it be if we are to meet changing market needs with independence and measured forethought. All academic technology programs profess a close interaction with industry with the goal of producing graduates who are "work ready". That goal is sharpened by the need to enhance the competitive capabilities of the workforce at a time when deskilling and outsourcing are the two less-palatable by-products of our technology success.

In the case of microelectronics at ASU, there were also several local drivers for change. The Technology College has relocated on a new campus and with an influx of new faculty, it was a good time to take stock and restructure the program. The centerpiece is a shared set of values between industry and academia that is beginning to establish a new "brand identity" for Technology. The policy to achieve this goal is based on two operational features:

1. Establish a much higher level of interaction with industry than has been the norm.

2. Use the well-established procedures of Systems Engineering [1] and the Balanced Scorecard [2] to shape strategy and identify targets for change.

The industry dialog was relatively easy to enhance. The Phoenix area has a major concentration of semiconductor companies and by a process of personal contacts and references, we assembled an Industry Advisory Board (IAB) with representation from 12 key companies. We sought out people at a sufficiently senior level to be able to speak for their organization but not so senior that they had little contact with day-to-day business issues. These technical managers are invariably instinctive problem solvers so we made them part of our solution. For 18 months, the IAB met monthly and since then it has operated as a network of specialist working groups. The outcomes have been much sage advice and a stream of resources to support fast implementation of the new program. In the latter category, the most important was Motorola's assignment of Jon Weihmeir to ASU for a period of 18 months as a full-time visiting professor.

An important (and easily overlooked) asset is that about half of the students in the program are already employed in the semiconductor industry. Many are following a qualification upgrade path either to convert an AAS to BS or BS to MS qualification. Together, they bring a wealth of practical experience that is a vital component of all class discussion and team working activities.

2. Strategy

As in all systems design activities, an accurate statement of requirements is the essential starting point (and guaranteed source of endless trouble if it turns out to be wrong). Since our goal is to provide a seamless transition from the university to the work place, we selected the university-industry interface as the starting point as represented in figure 1. If the requirements and everything that follows to implement them are to be valid, it is essential to understand and manage this interface.

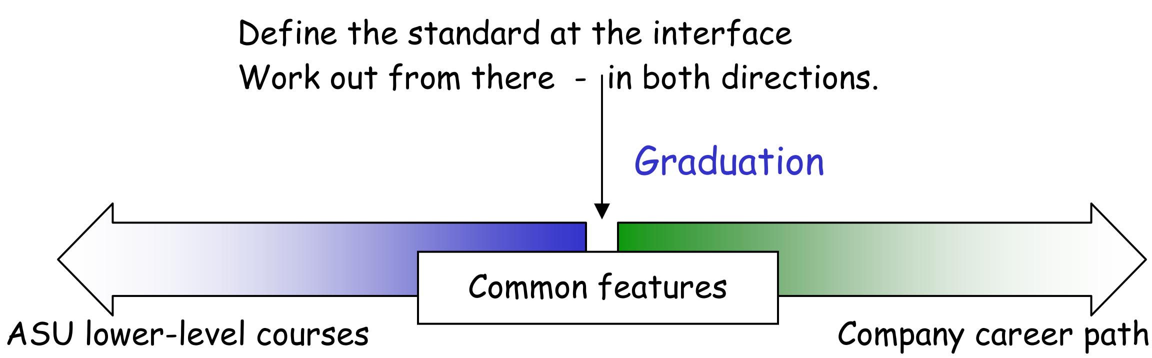

Figure 1: Emphasis to manage the industry-academic interface

For this simple concept to work, we need to start with a clear understanding of the whole range of skills expected of new graduates. This covers business and inter-personal skills as well as technical capabilities. It is significant that all the IAB members were able to reach consensus very quickly on the requirements. Interestingly, the outcomes were remarkably similar to those defined by Wisler [3] for the aerospace industry.

The requirements for graduate skills and capabilities fall into three categories:

- Technical understanding and competency
- Soft skills such as communication, team-working and business methods
- How all skills are used and improved

We set no priorities because the skills in all three categories must be used in concert if an individual is to be effective. That doesn't mean that each category is allocated the same amount of course time but it does mean that they were all considered in the definition of every course. Thereafter, we followed the typical systems development path [1] shown in figure 2. Expansion of each of the requirements categories was relatively easy with a large team of experts contributing.

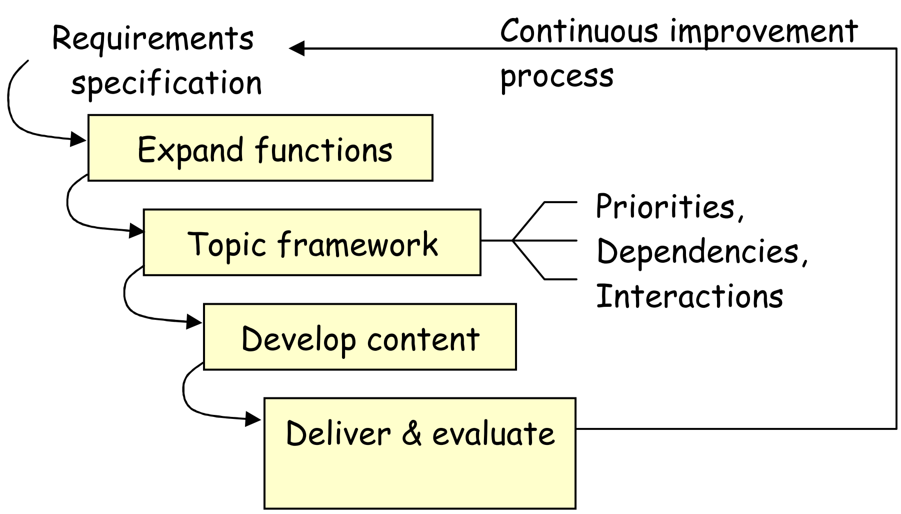

Figure 2: Procedure to expand requirements

Derivation of a work-plan from a set of high level specifications is a familiar methodology so the industrial contributors were able to join in and quickly drive progress. However, the approach does make an important contribution to our wider mission to "Reinvent Technology". The top-down identification of requirements leads to the complex interaction of skills implied by the framework component of figure 2. We can then "pull" the necessary components of science, math and engineering to do the job. This process can be considered as an application of the just-in-time production concept to education. The disadvantage (as in all lean systems) is that the statement of requirements has to be accurate since changes later in the process are expensive and wasteful. Given the broad base of expertise we have used, we are satisfied that we have appropriate coverage to meet the semiconductor technology education needs of the next decade.

By defining the requirements specification from the business side of the academic-industry interface, we have created:

- A well-developed methodology for curriculum development
- A format for technology course design as a top-down activity
- A program strategy that is closely tied to the stakeholders' perspective.

The combination of these steps leads directly to the program mission: "To be the preferred educational site in microelectronics for both students and employers".

3. Implementation paths

Translation of the grand plan into a lean, efficient educational experience (for all participants) is a protracted challenge. The principles are represented in figure 3 where the characteristic features of the new-graduate workplace are used to determine the format of the upper division courses.

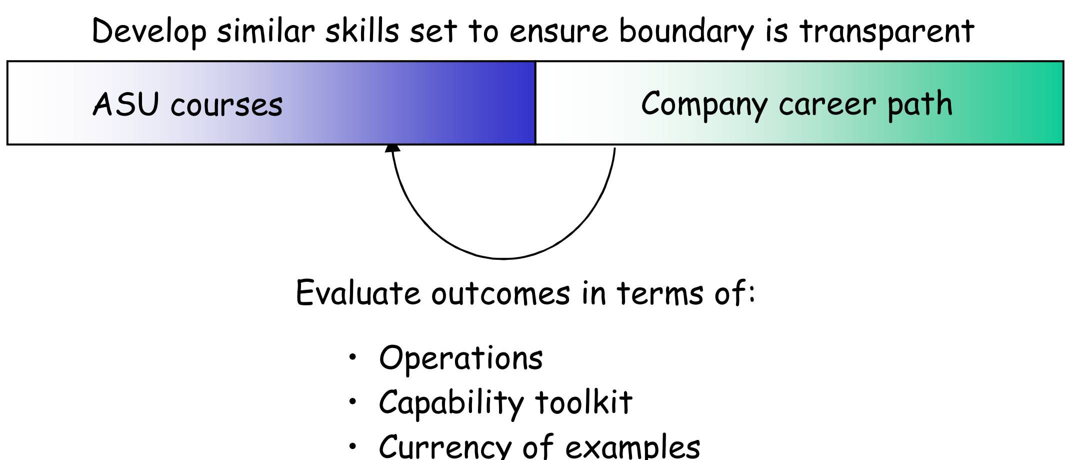

Figure 3: Schematic of implementation process

In order to track the effectiveness of the process and have good outcomes metrics, we have focused on three aspects: operations – how courses are delivered; the essential capabilities we expect all graduates to have in their personal toolkit and finally, the currency and relevance of the course topics and examples to the development of the industry.

Operations

One of the first decisions was to provide courses on a compressed schedule [4]. This arrangement devotes a whole day (six hours) to a topic and the whole course is completed in 5 or 6 days spread evenly throughout the semester. The arrangement has been especially welcome to the part-time (working) students but surveys show that it has been equally well received by full-time students. To relieve everyone of the pain of a six hour lecture, the time is split up into explanation of new concepts, dialog on problems, lab demonstrations and seminars from industry experts. In turn, these activities lead into

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discussion of workplace experiences, personal learning maps (as a preparation to manage life-long learning) and external lab projects.

One essential complement to concentrated classes is adequate preparation. Two weeks before each class, students are given access to a web site with the class material. This typically has 100 slides, several current papers, a textbook section (for background) and a number of assignments. The assignments have to be submitted the day before class so they provide individual feedback on progress and also an indication of the problems areas for the whole class. The heavy preparation component effectively makes each course a hybrid of conventional and distance learning so the requirements for three semester credits are fully satisfied.

In a typical semiconductor company, the participants in a work-area will have the wide range of qualifications and backgrounds and be expected to contribute in different ways to the common technology issues. We have tried to replicate that condition by co-delivery of some 4xx and 5xx classes. Both groups study the same technology but the emphasis is slightly different. The MSTech students taking the 5xx classes have to examine a wider applications context and do additional work to consider process optimization – in line with their likely job scope.

The essential student toolkit

Every course in the program has a goal to demonstrate some features of the toolkit of skills needed in the workplace. However, it has to go further and demonstrate that effective use of the toolkit adds to the competitive capabilities of the individual and the organization – an important issue when the business operates on a global scale.

The technology features are the easiest to deliver. The modular course structure, up-to-date examples and demonstrations and interactions with the local industry make this a time-consuming but well-received segment of each course. The soft skills and cultural values present a greater challenge. Some bad habits have to be unlearned and personal disciplines are severely tested. The inevitable pushback is buffered by our strategy to use the workplace as the benchmark. To the bleat, "Do we really have to do all this?", the working students provide a uniform chorus, "Yes, that's just the way it is at work".

The first item in the toolkit – and a likely showstopper if lacking – is the capability to manage personal time. The two-week preparation cycle before each class seems to be about right to allow reasonable individual flexibility but still meet a hard deadline. Everyone quickly gets the message that it is foolish to pass up the marks for assignment submissions so they learn to deliver on time. Good preparation is quickly seen to pay off in terms of more active class discussions and team contributions.

The practical activities undertaken in the program reinforce the priorities of the class-based courses. We have an extensive clean room with many industry-donated process tools. The primary goal is not to show students how to operate the machines – companies do that much more effectively with more modern tools in their proper context. What we can do uniquely is show how all the facets of science and engineering blend to determine performance and how every technology solution is a blend of many interacting trends and trade-offs. We have developed a process for reverse engineering [5] to demonstrate many complex concepts that could not be covered in any other way.

Soft skills are largely developed by two procedures: to define problems so they have solutions and to present these solutions to others. Many academic programs only present problems that are well defined, have just enough information, have only one method of solution and relate directly to a small recently covered section of the course. The reality of the workplace is that it is often much more difficult to define the problem than to solve it. The inputs range from fuzzy impressions to contradictory data so it is often far from clear whether we are dealing with a simple or a difficult problem. The penalties for a false diagnosis, however, can be severe. A representation that is overly simplistic is likely to fail. Conversely, an over-elaborate statement will consume excessive resources for a solution. The practical examples reinforce the message that a clear problem statement is essential and in addition, cost and time are parameters of every solution.

The complement to problem definition is presentation of the solution. In a company, one person's solution is another's starting point. When a problem is seen for the first time, it is interesting and gets constructive attention. If it seen repeatedly, the interest is less positive so everyone has an incentive to learn from each experience. That means good documentation using text, statistics, diagrams, math and references. There is no correct formula – only that it be appropriate and convey the scope and depth of the outcomes. Every class offers opportunities for individuals, small groups and the whole class to communicate outcomes. However, for all, the mantra is the same, "Treat every communication as a selling job".

Up-to-date topics

This is perhaps the easiest facet to present – though there is a lot of information to manage. There are many good web newsletters available and we have access to monthly industry statistics through links to analysts and marketing departments. The personal perspective comes from seminars given by industry experts, occasional visits from IAB members and for 18 months, we had direct support from our visiting industrial professor. There have been occasions when a class had 3 industry contributors as well as the professor present. Add students with hands-on experience to that mix and we have a recipe for a lively session.

4. Outcomes and conclusions

For 3 years, we have followed a curriculum development path that is derived from the capabilities that new graduates are typically expected to have in the semiconductor industry. By using a wide range of interactions with the local companies, we have defined the key program requirements in terms of technology know-how, soft skills and how the mix can best be applied.

The result has been a modular set of courses that cover the principal facets of semiconductor technology. Students have been eased into a self-sufficient mode where they can manage their time and resources, use their acquired knowledge to formulate viable solutions and deliver the results to their customers. For some, this is a hard transition.

Experience in a more general course development context (to be reported elsewhere) indicates that this approach has general applicability since the soft skills and their appropriate application can be used in almost any technology application.

5. Acknowledgements

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References

1. The International Council on Systems Engineering (INCOSE) provides a full and helpful outline of systems engineering principles at: http://www.incose.org/practice/fellowsconsensus.aspx

2. Kaplan R S & Norton D P, "The balanced scorecard: measures that drive performance", Harvard Business Review, Jan-Feb 1992, pages 71-79.

3. Wisler D C, "Engineering – what you don't necessarily learn in school", Proc ASME/IGTI Turbo Expo 2003, June 16-19, 2003, Atlanta, GA.

4. Robertson J, Munukutla L and Newman R, "Delivery of a common microelectronics technology curriculum at several degree levels",
Proc ASEE Annual Conference, Montreal, June 2002.

5. Robertson J, Wales B and Weihmeir J,
"Reverse engineering as a means to understand complex tool design"
Proc ASEE Annual Conference, Salt Lake City, June 2004.

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