A History of Vehicle Design Development: Educational & Training Implications

A Report of an Employer-Educator Breakfast Discussion

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The American Society of Body Engineers (ASBE) and the Design and Manufacturing Alliance (DMA) hosted a breakfast forum on April 11, 2003 at Oakland Community College. Fourteen representatives of the vehicle design industry and 20 educators attended the event. The industry representatives included an OEM representative, tier one suppliers, contract supply companies and professional societies. Educators included representatives of Universities, Community Colleges, High Schools and an E-learning supplier.

The group was divided into tables with industry and education equally represented. Each table discussed the future for entry level jobs within the vehicle design and manufacturing industry for people with an associate degree from a community college. The specific questions included: What entry roles might associate degree graduates perform? What skills would these roles demand? What implications do these findings have for academic programming?

Initially, this discussion was to be limited to the thinking, needs and practices of second and third tier suppliers. However, the composition of the employer group, (nine of the fourteen industry participants were OEM, first tier and first tier contract suppliers), immediately broadened the discussion to the automotive industry as a whole. It may be true that the requirements of the OEM's and the tier suppliers are, in fact, the same. In any case there was a consensus within the group that the community college design programs that were available today did not meet the design industry’s expectations for today's entry level hires.

A History of the Development of the Design Industry:

To be able to understand what is happening in the design industry today, It is good to have some sense of history.

The product design industry for vehicles developed in the 1940's from the need to design vehicle parts that could be made by multiple sources rather than by one company. Before that time body companies were often commissioned to develop an entire body for an automotive chassis. These companies would hire modelers who, with little or no documentation of the design or its evolution, crafted the body. The automotive “motor” companies needed to document the design to be able to share part drawings with potential suppliers. They hired draftsmen who replaced the modeler to carry out this documentation. These draftsmen produced the drawings and were support people for engineers who had earned university degrees. The draftsmen were generally high school trained people or others who learned much of their craft through on the job training. The craft itself was highly developed, as it needed to describe parts that had complicated shapes and proportional surfaces.

In the 1950's private schools emerged teaching the automotive product design craft that now required knowledge of descriptive geometry and surface development. Still, a large amount of training was done in the "detailing" department of each company. Details were individual part drawings that were separated from the large assembly drawings developed by the more senior draftsman.

In the 1970's the computer was introduced to this industry. No longer was there a need for a “detailer” to separate parts from assemblies. The entry-level job of detailer was gradually eliminated. The community colleges became the training ground for the new entry-level people. They began to provide an intensive program for imparting the technical and computer skills that were needed to function in a design world where much of the work was done on graphic consuls with sophisticated software.

That system that provided entry product vehicle designers for the automotive industry remained in place until 2000. At that time Ford and GM declared that they would no longer hire associate degreed people for this profession. The needs of industry were changing again and the technology of the craft was being improved with software now capable of developing surfaces and solving descriptive geometric problems with ease. Though captured knowledge bases and parametric designs that can "morph" from an existing part to a future part are not yet common, they are in place and will be widely used within the next five years. This spawned the notion that, with the computer doing more of the design work, the work of the product release engineer, the structural analysis engineer and the product vehicle designer could be integrated into one job, that of the “designing engineer”. It was felt that this position required mechanical engineering knowledge as a base skill. Still, the training of a mechanical engineer today does not include many of the specific design skills essential for the role this new “designing engineer” would be expected to play.

Community College Confusion:

Each time change has occurred as either a result of change in design methods or advancements in technology, the way designers are trained has changed. Generally, this has led to additional academic requirements and skill competencies for entry level hires.

Most recently, the decision by Ford and GM to rely heavily on the Designing Engineer for product development has caused educators, particularly community college presidents and deans, to re-access their colleges role in the training of product designers. Their questions include. Is there a role for the associate degree product designer, if not at the OEM level, at least within the supplier community? Should community colleges just prepare students for transfer into an engineering program? What opportunity exists in design for the student who may not be able to complete an engineering degree? What implications does this have for high school drafting programs? Are the Bachelor of Science in Engineering Technology programs or the Bachelor of Science in Design acceptable degrees that community college graduates in design should be encouraged to pursue?

Because this is a critical issue for nearly all of the community colleges in Southeastern Michigan, as mentioned previously ASBE and DMA agreed to co-host a breakfast. At that breakfast representatives from the design industry met with high school, community college and university administrators and instructors to discuss whether there was a "role" for the associate degree graduate in design, what "skills" that person would need to possess and what "implications" this might have for current curriculum.

The Role of Associate Degree Graduates:

It seemed clear from the comments of the industry representatives that the design industry from top to bottom is becoming more dependent upon the designing engineer. Advances in technology provide the tools that simplify the design process and at the same time provide the opportunity for people with design and engineering understandings to design with engineering parameters in place. Just as the advent of CAD required a more highly trained entry person, the further sophistication of software requires an even more highly trained individual. At the same time, the nature of a computerized workplace and the erosion of prior entry assignments make it more difficult to provide training on the job. This places more responsibility on the college and university to prepare employees for the more demanding entry assignments.

While what has been said is certainly true with the OEMs, there are more opportunities for persons without an engineering degree within the supplier community. Still, the nature of the tools available points out the need for a more skilled workforce throughout.

The industry participants were generally agreed that fewer opportunities existed for the person graduating from a community college design program today. However, they seemed to assume that the only way to develop the skills needed for today and tomorrow's design industry is to earn a degree in mechanical engineering. It would

seem also legitimate to ask whether the current associate degree design curriculum might be modified to enable students to develop the skills necessary to handle the opportunity that today's technology presents. Are we dealing with a whole new level of learning or can, like CAD, these more sophisticated design and engineering competencies be integrated into the community college degree.

The Skills of Associate Degree Graduates:

In general it is clear that associate degree graduates will need to possess both broader and higher level skills. In addition to current conceptual design capability and the ability to use at least one computer assisted design tool, they will need to be familiar with simulation and possess at least basic engineering and manufacturing understandings. These understandings will likely include background in fluid mechanics, hydraulics, electronics and the use of instrumentation in testing and certification. This will require additional background courses in math and science completed at either the high school or community college level.

In addition, employers will likely expect entry employees to possess certain "foundation skills" including a knowledge of their career opportunities and career ladders. Creativity and problem solving capability, the ability to work in teams, cultural awareness, knowledge of a second language and the ability to function effectively in a global environment will be important. Strong written and oral presentation skills will be essential while knowledge of technical writing will be helpful. Basic computer skills and internet user capability will be a prerequisite for employment. Many of these skills need not be the content for specific courses but often will be the result of how courses are instructed. Certainly, they can be the result of related industrial experiences made possible through job shadowing and cooperative education. The development of such capability begins at the high school and even earlier and demands collaboration and curriculum integration between the high school and the community college.

It is important to note that the skills and understandings described do not appear to necessarily require an engineering degree but do go beyond the skills that an associate degree graduate currently possesses.

This presents an interesting challenge to community college educators and administrators. To what extent are they able to work with their high school colleagues and industry partners in packaging a design engineering curriculum that meets the needs of the industry within the traditional parameters of an associate degree. Not too long ago community colleges felt that it was unrealistic to think that computer assisted design could be incorporated into the associate degree in design without a significant increase in credit requirements and yet this has been generally accomplished. Perhaps this involves a similar challenge.

Academic Implications:

Changing Technology:

Once again technology (*i.e.* parametrics, spreadsheet engineering, captured knowledge, *etc.*) has enabled industry to rethink the design process. More powerful computers and more sophisticated software programs have changed the skills needed by the workforce and have dramatically reduced the number of jobs for those with only an associate's degree. Tasks that were once performed in three technical areas will become the domain of one degreed engineer armed with ever so sophisticated software. However, the current Mechanical Engineering graduate also lacks the design skills needed for this new responsibility. This presents an opportunity for the academic community to equip entry level candidates with the new skills required and for industry to fashion entry-level jobs and work experiences for those same candidates. If those tasks cannot be accomplished, the design industry will be forced to provide expensive training for all of their entry-level design engineers before placing them in the workforce. If the academic community is unable to respond and industry can't afford retraining programs, the result would likely be exportation of many design jobs from Southeast Michigan to other design centers throughout the world.

An Academic Response:

High schools need to identify students with engineering potential and then provide career paths through modified vocational programs. Such programs should contain a capstone experience in the vehicle design environment (*e.g.* The General Motors Technical Academy). At the same time these programs need to provide the opportunity for able students to develop the foundation skills in math and science prerequisite for an engineering program. Often high school students who want to pursue engineering in college have to choose between math and science sequences and the drafting program because of scheduling constraints. As a result, students are unable to develop the combination of technical and foundation skills that are the basis for design engineering.

Community Colleges need to structure their design programs to enable a student to take the math and science sequences required for transfer into engineering and the design sequence that will provide the necessary technical background for design engineering. It is important that this program is well articulated so that courses transfer with ease. At the same time, community colleges need to integrate practical experience into academic programs to enable students to appreciate and understand design and engineering theory. Finally, community colleges need to develop and deliver training to keep industry employees abreast of ongoing changes in technology. Web based training for this population will be the preferred delivery mode.

Universities must change their curriculum to provide more design applications for their engineering students, perhaps even establishing a college or discipline of vehicle design. The purpose of the GM sponsored PACE Program is to encourage the integration of design into mechanical engineering. To date, few universities have developed this capability, even within the PACE partnership. At the same time

Universities might encourage prospective students to take drafting and pre-engineering courses while in high school. Though these courses may never come to be required sequences for university admission, their encouragement may cause high schools to sequence offerings to enable students to conveniently take both foundation skills and technical courses.

Industry Responsibility:

Industry must work with academia to supply the latest technology to the schools so students will experience a 'real world' environment. It must also provide real projects to further the experiences of students at every level. It should participate in the development of instructors for the new curriculum. Also, in order to attract candidates to this field, there must be an even flow of entry jobs available to graduating students.

Combined responsibilities:

Cooperative education remains an effective strategy to equip the graduating student with the skills and knowledge to enter the workforce. This is a relatively inexpensive way for industry to ensure the product, a graduating student, has all of the technical and personal skills to succeed within their company. This allows the company to observe and train students and provides the student with a modest income. That income allows students to focus on their chosen profession rather than taking summer jobs in an unrelated area.

Professional Organizations:

Organizations like the American Society of Body Engineers (ASBE) and the Society of Automotive Engineers (SAE) need to continue to help in the early identification and encouragement of students with engineering potential (*e.g.* "The World of Motion Program" from S.A.E., and the “ASBE High School Drafting Contest"). Professional organizations need to keep their members and interested others abreast of changes in technology and provide their membership with career enrichment and professional certification.

Continuing Professional Development:

The nature of this industry will not only encourage but also demand continuous learning. Individuals will have to be students of their profession since much of their learning will be the result of reflection upon what they do each day. At the same time, there will be new technology and software to be learned and certifications to be achieved.

Because the design industry is just a component of the broader manufacturing industry, an understanding of developments in the broader field will be critical. As design and engineering become more integrated, engineering understandings and even an engineering degree may be necessary. It is not only important that students understand this but also that they be equipped for and personally motivated to pursue their continued development.

Appendix One:

The following contains a summary of comments about roles, skill requirements and academic implications taken directly from the table discussions. While these observations were made with the Automotive Industry in mind, they may certainly have application to related industries.

Roles:

- Roles will vary from level to level. Even though the companies lower in the supply chain may not require more than an associate degree, clearly mechanical engineers with design capability will be well received at all levels.

- Entry level requirements will vary from the associate degree to the master's depending upon whether an individual is working for a tier supplier or an OEM and depending upon the type of work being done.

- Across the industry designers will also be expected to provide engineering support and will therefore need to have at least engineering understandings, if not engineering credentials. Associate degree designers may become obsolete because of hiring requirements, not necessarily because of the skills they possess.

- Individuals possessing basic design capability will serve as test certification, build and work processing technicians in the design, prototype, build and manufacturing processes. Consequently, they will need to possess the basic skills necessary to be able to operate sophisticated equipment and to be re-certified as the equipment and work processes become increasingly complex.

- In addition to design technicians with mechanical understandings there appears to be a developing role for engineering technicians. These individuals will need to possess basic mechanical understandings and be able to utilize the sophisticated testing technology that is being currently used in the industry and will be used in the future. While the role that associate degree designers will play is the focus of this paper, this role for the engineering technician in both the design and manufacturing process merits further conversation.

- Employment will often be transitional. As technicians earn advanced degrees and develop more sophisticated engineering skills, they will be able to move up through the supplier chain to the OEM.

- There is a need for students at all levels to understand how developments in the design industry are shaping both entry opportunities and career ladders. In addition to technical skill requirements, students need to understand what kind of personal and social expectation employers have for all of their employees.

Skills:

This discussion identified two types of skills needed in the industry: foundation skills and technical skills.

In general, entry employees will need to possess higher and broader skills and certainly be capable of multi-tasking.

Foundation skills include:

- Advanced math and science capability necessary for both design and mechanical skill development.
- Creativity and problem solving capability.
- The ability to work effectively in teams.
- Cultural openness, the knowledge of additional languages and the ability to work effectively in a diverse and global environment.
- Written and oral communication and presentation skills.
- General Computer software and internet user capability.

Technical skills include:

- Mechanical aptitude with background in fluid mechanics, hydraulics, electronics and instrumentation.
- Modeling and simulation capability both in design and manufacturing.
- The ability to use advanced computer assisted design and simulation tools as well as certification in certain skill sets.
- Not only the ability to use advanced tools but also the capability of moving projects from design to deliverables.
- Background in tooling and manufacturing processes.
- Technical writing skills.
- Knowledge of and the ability to use professional affiliations for ongoing professional development.

Academic implications:

- There will be fewer technician positions in design and many of the technicians that are there will move into design engineering through a combination of academic and work experience.
- Students need to develop basic design understandings. Software manipulation capability without such understanding is of little value.
  - Team building skills need to be integrated into the academic experience.
  - It is important that students understand the importance of taking a personal pride in the development of a product.
- More emphasis needs to be given to the development of engineering related understandings and skills in the process of design education. This requires the development of underlying math and science skills.

- It is important that continuous learning capability be developed and encouraged. Many technicians will move from current roles into engineering. There will be a need for continued certification and both technology and software will constantly change. Individual initiative in learning will be critical to success.
- Because of the sophisticated and broad understandings which need to be developed, collaboration at all levels of education and with industry must occur. In the future partnerships will need to be the rule rather than the exception.
- There is a need for industry to develop opportunities for related experience.