Maintaining Industry Partnerships in Integrated Product and Process Design Education

Norman Fitz-Coy, David W. Mikolaitis, R. Keith Stanfill, Loc Vu-Quoc

University of Florida Department of Aerospace, Engineering Mechanics and Engineering Science / Department of Aerospace, Engineering Mechanics and Engineering Science/ Department of Industrial and Systems Engineering / Department of Aerospace, Engineering Mechanics and Engineering Science

Abstract

The University of Florida Integrated Product and Process Design (IPPD) faculty have become expert at teaching multidisciplinary design (9 fields of expertise) and cultivating industry partnerships. With an annual 25+ project activity, 150+ student and 20+ faculty, many lessons have been learned and codified in the areas of project recruitment, project scope definition and project management. Industry praises the program as an outstanding experiential education, with benefits for students, faculty and industry. Between 1995 and 2001, 133 projects and $2 million in support were provided by industrial sponsors. Two thirds of the projects each program year come from repeat sponsors. Since 1996, Boeing, Lockheed-Martin, Pratt & Whitney and the USAF have sponsored 25 aerospace-related projects. Lessons learned in design project management and funding are explored in the context of representative aerospace-oriented projects.

Introduction

Integrated Product and Process Design (IPPD) is a two-semester education program for seniors at the University of Florida's College of Engineering and Warrington School of Business. In this course, qualified students from various disciplines are assigned to 5- or 6-person teams. With an experienced engineering faculty member as coach and a liaison engineer from an industrial company, each team designs, builds, and tests real-life industrial projects. Over an 8-month period, the student engineers are taught a structured design process. The students put the process into practice solving the customer company's design problem. IPPD is institutionalized at the University of Florida; 133 industry-sponsored projects have been completed, and nearly 800 students have graduated through the program in its first 6 years of success.

IPPD program overview

Course structure

The IPPD course is supported by four key principles: 1) multidisciplinary teams of 5 to 7 students working on industry-sponsored design projects, mentored by a faculty coach and supported by an industry liaison engineer, 2) a structured development process based upon industry best practices and tailored to fit an 8-month development cycle, 3) use of industry-standard design tools (such as Pro/ENGINEER and Mentor Graphics), and 4) adherence to proven project management methods. The structured development process for hardware and software projects is illustrated in Figure 1. The design process initiates with the formation of project teams.

The remainder of the structured development process encompasses two consecutive semesters of extensive work commitment by each team of students. The process can be subdivided into 5 phases: conceptual design, system level design, detailed product/process design, verification, and production[1]; similar to that presented in reference Ulrich and Eppinger [2000] Each phase is realized via completion of various deliverables and meeting major milestones at the end of the first, second and fourth phase; ending the structured development process with delivery of a working prototype to the industry sponsor. The embodiment of the process into the curriculum takes on the multi-faceted format of lectures, workshops and team teaching. The lectures, given twice a week by engineering faculty and/or guest lecturers from industry and the business school, are used to formally introduce each aspect of the design process via theory, examples, case studies and in-class activities. The lectures are presented in a just-in-time fashion such that upcoming deliverables are explained one or two weeks in advance. The workshops focus on the project details and coach-assisted adaptation of the lecture topics to specific project requirements in the form of deliverables. These workshops typically involve the industry liaison(s) via teleconferencing. The process' underlying support is provided in terms of student training in the use of development tools and techniques.

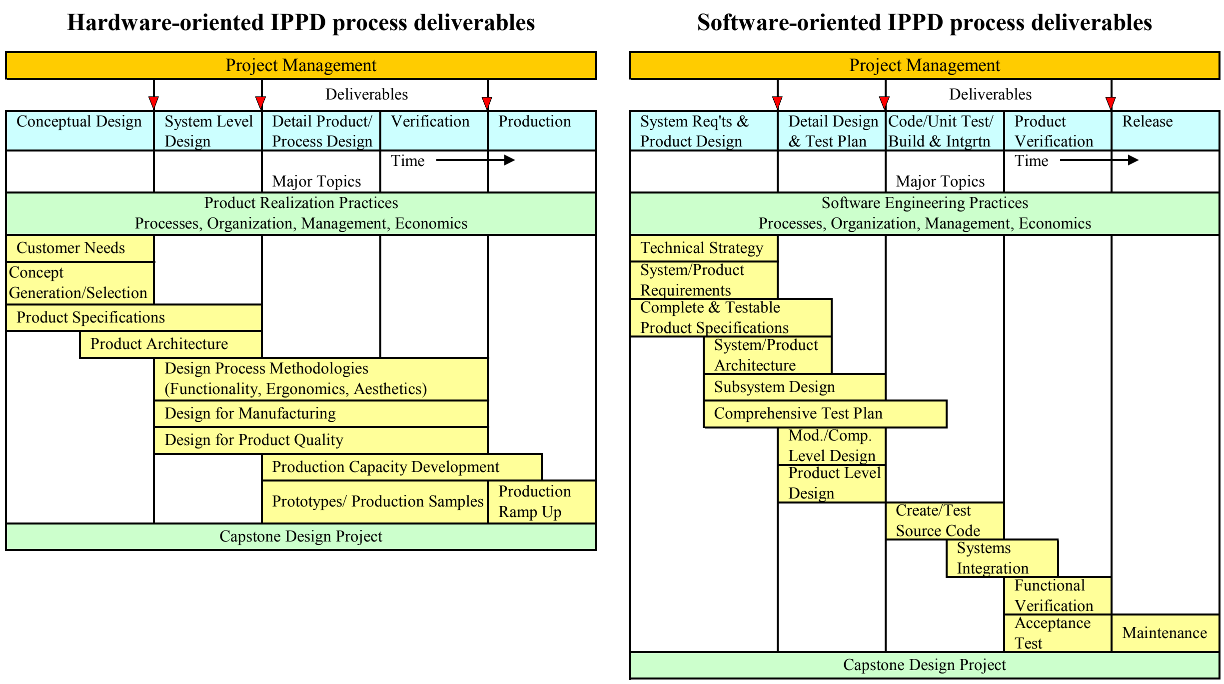

Figure 1. Integrated Product and Process Design Program structure

[1] The software process has similar phase divisions and is included here for reference

Student / faculty participation

The program started with six disciplines and now involves faculty from nine disciplines and students from ten. The fluctuations in the number of students involved from each discipline can be attributed to each project's required student expertise, or to the level of interest among the available students. Team composition is 5 to 7 students from appropriate disciplines, faculty coach, and an industrial liaison engineer and his/her technical support staff. As in industry, the team composition is driven by technical requirements. Successful student recruiting culminates with enough students of each discipline available to staff all the projects. There is some "mobility" between disciplines, e.g., aerospace engineers are often used interchangeably with mechanical engineers, and business students are frequently used in place of industrial engineering students.

Sponsors/projects

Since its inception in 1995, 51 companies have sponsored 159 projects in the University of Florida IPPD program. The program has reached a nominal operating level of approximately 26 projects and 23 sponsors. Approximately 70% of the projects each year come from repeat sponsors.

Lessons learned

Lessons learned are presented from the perspective of managing the IPPD program. The discussion is limited to experiences in project recruitment, project definition and project management. Months of effort are required to recruit, staff and manage 25 to 26 projects annually. Seven to eight months are devoted to project recruitment and definition and another 8 months to managing the project execution. An overall success rate of 90% is a key target for keeping the core sponsors satisfied and willing to repeat again.

Project recruitment

Project recruiting is a multi-faceted effort involving the IPPD director, faculty coaches, the University of Florida Foundation, the College of Engineering Dean and current sponsors. UF has very active industry participation—at the college level through the Engineering Advisory Council (EAC), and at the departmental level through Industry Advisory Boards (IAB). While the EAC provides college-wide direction, the departmental IAB typically provide curriculum feedback. Most of the IPPD project sponsors are active in either the EAC or an IAB—word of mouth between these corporate participants has led to additional project sponsorship. Faculty coaches are also instrumental in recruiting new sponsors—many times leveraging research contacts in industry and relationships with corporate staff.

The baseline recruiting process is as follows:

> **December**—list of potential project sponsors is compiled by IPPD director
>
> **January**—brochures and letters requesting project sponsorship—targeted at executive contacts within each potential sponsor company—are sent out
>
> **February & March**—follow-up phone calls and emails are made to gain commitment to sponsorship
>
> **April & May**—committed projects are defined—often requiring a visit from the director and a team of coaches

June to August—Coach is selected and projects are defined in a detailed project summary sheet

It is important to recognize that the recruiting process never goes according to plan and many factors sidetrack or delay the process. These factors include current economic conditions (most recently the down-turn in the telecommunications and semiconductor industries resulted in 4 companies dropping out of IPPD), turnover in the executive ranks within past sponsors, past project failure, and new contacts that are identified late in the process. Over the past seven years of project recruiting, the following has generally held true:

- it requires recruitment of 75 sponsors to secure and staff 25 projects
- approximately 13 contacts are required to close on a project per each new sponsor
- start at the top—sponsorship is committed by executives; less than 10% of our projects were recruited bottom-up
- target operations executive management (engineering and manufacturing); human resources folks all think this is a great program, but do not control the resources required to support a project
- concentrate initial recruiting efforts on gathering commitments from existing sponsors, then focus on new sponsor recruiting

Many of the IPPD projects were established as the result of the networking effort of the faculty coaches. For example, the projects funded by the US Special Operations Command (SOCOM) at MacDill Air Force Base in Tampa, Florida, was the result of the conversation between one of the authors and the head of the Directorate of Advanced Technology of SOCOM, during his visit to the department of Aerospace Engineering, Mechanics & Engineering Science in Fall 1999. After this conversation, we provided SOCOM with information brochures and web pages about the IPPD program at UF and about our past projects with Lockheed-Martin Corporation. Once SOCOM expressed their interest in developing funded IPPD projects with UF, we followed up with visits to SOCOM by the IPPD Program Director and faculty coaches to define projects appropriate for the IPPD program. Since then, SOCOM has sponsored three IPPD projects at UF.

Project definition

Once executive commitment is established, a project must be defined and resources assigned. Whenever possible, a site visit by the IPPD director and one or more faculty coaches occurs. In this visit, clear expectations can be presented to managers and engineers involved in the project. Ideally, the multidisciplinary faculty team can review project ideas during the visit and work to quickly focus in on a doable project. Many times, the sponsor does not have a clear idea of what they would like to pursue. In this case, the IPPD director and the coaches serve to "shake the tree." Project ideas begin to flow following a plant tour and overview of the operations and current projects. In these circumstances, it is important to listen closely to the customer and propose solutions aligned with their needs.

Realistic project definition is among the most technically challenging activities in the IPPD program. During this process clear project boundaries and realistic deliverables must be established, required technologies must be within the grasp of undergraduates, the project has to be realizable within an 8-month development cycle and the scope has to be approximately 600 hours. The projects should involve design and manufacturing, yet, many projects are heavily process-oriented or software-oriented. Any project requiring an invention to succeed should be avoided. Although faculty are naturally drawn toward research-oriented projects, these projects do not map well into the IPPD process and can frustrate the students when preparing deliverables.

Project management

An overall project success rate of 90% is a critical success factor for maintaining IPPD industry partnerships. Projects are considered a success if the student team learns the IPPD process, strives to meet the intent of the deliverables, satisfies the majority of the final negotiated product specifications, communicates effectively with all the project stakeholders and delivers a "no-surprises" final report and presentation. Although it is hoped that every project has a successful prototype, it is not always feasible within the constraints of the project. It can be extremely beneficial to learn that a given technology or solution path is not ready or capable. Projects are unsuccessful if the teams do not communicate well with the sponsor and liaison, and do not complete the work due to negligence or lack of effort. It is incumbent upon the coach to steer the team to a successful result. From experience over the past 6 years, the majority of the project failures could have been overcome with more effective mentoring from the coach. The following are among the critical success factors in project management:

- Create a project plan early, involve the students and the sponsor, review and update it often, and stick to the schedule
- Coach's role is to steer the team and help overcome obstacles—team does the work and makes the decisions
- Team members spend 10 to 15 hours a week on the project and treat it like a job
- One or more leaders emerges on the team, but not too many
- Project disciplines are evident from the project definition and students with the required disciplines are available and interested in the project
- Mid-project grades are based upon actual performance and not promised performance in the second term

Faculty coach perspectives

A key to continued success in IPPD is the sharing of accumulated project definition, management and execution knowledge among our faculty. Most faculty involved in IPPD participate for multiple years. Three of the most experienced faculty, all responsible for aerospace-related projects, share some of their project experiences in the following sections. The projects are grouped into NASA-related projects, Department of Defense (DOD) contractor projects and DOD projects. Common themes among these project sponsors for participating in IPPD are the need to build visibility within the university community, the opportunity to recruit new employees, access to "out-of-the-box" thinking, and contact with highly qualified faculty on a regular basis.

NASA-related projects

The Reusable Space Systems Division of the Boeing Company has continuously sponsored an IPPD project ever since the 1997-1998 academic year. The general theme of these projects has been reusable launch vehicle systems upgrade via vehicle health management technologies. As with most IPPD sponsor companies, Boeing's motivation for participating in the IPPD program has been to foster good relationships with the university, tap into the university's pool of potential employees, and leverage the technologies developed by the university.

The first project sponsored by Boeing was a feasibility study of non-intrusive techniques to monitor the health of 3-way solenoid valves used in the space shuttle's main propulsion system. The project was to determine whether or not an automated process could be developed to replace the current procedure of a technician using clamp-on ammeters to determine signature traces (i.e., current usage) during valve operation. Unfortunately, the IPPD team could not get access to the actual valves used on the space shuttle, and so commercial 3-way valves were obtained and used in the investigation. The team developed a working concept based on the use of Hall effect sensors. Based on the acquired signature traces, neural networks were trained and used to categorize the health of the health of the valve. However, for the commercial valves used, the signatures obtained from faulty valves were within the operational range of signatures obtained from the healthy valve. Boeing pursued the concept further on the actual shuttle valves.

The second year of Boeing's participation was devoted to the characterization of the Vacuum-Jacket Smart Connector (VJSC), a device developed jointly by Boeing and NASA. The VJSC is used to monitor the vacuum, and hence the thermal insulation capabilities of the vacuum-jacketed lines used in the cryogenic subsystems of the Shuttle. The device initially developed to be a screw on device for each thermocouple used along the propellant line. Because of the large number of thermocouples used, this approach was not cost effective. The IPPD team was tasked with the job of using a single VJSC to monitor multiple thermocouples. Also the device was to be used with different trace gases in the vacuum-jacket, so it had to be characterized for these different gases. The IPPD team designed and tested a multiplexer device which was capable of handling 16 thermocouples. They also calibrated the VJSC for use with nitrogen and carbon dioxide, gases used to purge the vacuum lines. Following the success of the second year's project, Boeing continued the VJSC project in the third year of their participation. This project entailed the development of a wireless network of VJSCs to monitor the vacuum-jacketed feed lines from the propellant tanks to the launch pad. The IPPD team successfully completed this project and the results have been used to propose the idea to NASA for implementation.

During the 2000-2001 year, the IPPD team was tasked with the development of a smart quick disconnect (QD) which interfaces the flight vehicle with the ground support equipment. The designed QD was a single interface that incorporated fluid, data, and power connections. It was also capable of unobtrusively monitoring the health of each connection within the interface. This success of last year's project leads to the current project which entails the design of an autonomous system to mate the designed QD.

Other than the technological challenges posed by the problems, another major challenge associated with these projects has been the development of appropriate business cases to justify the projects. All the Boeing projects to date have been the design of unique systems that would not be mass produced and would have to be certified before utilization. This experience has been beneficial to the students in that they are exposed, in some sense, to the business practices of the space industry where performance must be carefully balanced with cost and schedule.

The IPPD teams have consisted of mixture of aerospace engineering, mechanical engineering, electrical engineering, and industrial engineering (or decision and information science) students. Most have been five and six member teams with the exception of 2000-2001 when the team had seven members. This larger team proved to be quite a challenge from a logistics point of view.

As the number of students and disciplines involved increases, the availability of team members to find common meeting times diminishes rapidly.

During the past five years, Boeing has assigned the same two liaison engineers to the projects. This provides a certain degree of continuity and simplifies the annual project recruitment process. With a combined experience of over 35 years in the space industry, the two liaison engineers are quite knowledgeable about shuttle ground processing operations and are also quite familiar with the desired requirements for next generation of reusable launch vehicles. Each year, the students are given a detailed orientation tour of the launch facilities at Kennedy Space Center. They are exposed to all aspects of the launch ground processing with particular emphasis on the areas that provides the most technological challenges to the engineers. Unfortunately, the events of September 11, 2001 prevented this year's team from participating in an orientation tour.

DOD-contractor projects

Lockheed-Martin Corporation (LMCO) has been one of the earliest and staunchest supporters of the IPPD program at UF. So far, in its more than six years of operation, the UF IPPD program has received ten projects funded by LMCO: Three in 1996-97, four in 1997-98, and one project in each of the following academic year (99-00, 00-01, 01-02). Below, we record some of the experience by one of the authors (L. Vu-Quoc) in coaching LMCO IPPD projects.

Typically, each year, the LMCO Engineering Director, who has been a strong proponent of the IPPD program, would contact the leaders of on-going large-scale projects inside LMCO to inform these project leaders about, and to encourage them to support, the IPPD program by defining a portion of the work in their projects that would fit the IPPD project scope. The success of the previous IPPD projects funded by LMCO has been the key persuading argument that the LMCO Engineering Director used to convince the project leaders to subcontract a small portion of their project to the IPPD program. To this end, the LMCO Engineering Director kept in his office a successful IPPD prototype that has been accepted for actual production to show to the visiting project leaders. Once a project had been defined, one LMCO engineer working within that project would be designated as the liaison engineer for the IPPD project. This liaison engineer would iterate on the project description with the IPPD Director and a faculty coach to make sure that the project objectives meet the requirements specified in the IPPD project scope. The continuing success of the IPPD projects funded by LMCO has been the key for the continuing participation of LMCO.

In the academic year 2001-02, the project objectives for the LMCO IPPD project are to establish a nonlinear finite-element analysis procedure to analyze the curling behavior of tiny (micron to millimeter size) artificial eyelid micro-electro-mechanical system (MEMS) devices and to optimize the design of these devices. The research and development of the eyelid MEMS devices have been carried out in a project funded by DARPA (Defense Advanced Research Project Agency) to a consortium of organizations led by Prof. P. Holloway of the UF Materials Science and Engineering department, with LMCO being a member organization in charge of developing the applications for these devices. Most applications of these devices are related to sensitive optical sensors. In this project, the prototype is a series of nonlinear finite-element models and the analysis procedure using ABAQUS, a nonlinear finite-element program.

A challenge for this project is to find students who have strong analytical skills, and who are inspired by numerical analysis. Three students in a team of six were recruited after they took a numerical methods course with one of the authors. Typically, an undergraduate would be exposed to only linear finite elements. The concept of nonlinear finite elements is new and intellectually challenging to these students. It was necessary for the coach to provide lectures to the team on basic concepts of nonlinear finite element analysis.

Moreover, because of the multilayer nature of these eyelid MEMS devices, and due to the relatively thin layers of chromium, as compared to the thickness of the other layers, we need to coach the students in the mechanics of multilayer structure to develop equivalent single-layer concept to reduce the number of finite elements in the model, and thus the computational cost. Much of the first semester coach-team meetings were devoted to training (and to reviewing for) the team in mechanics and in nonlinear finite-elements.

It is important that the faculty coach points out the direct parallelism between what was taught in the IPPD lectures, which would in general focus on physical prototypes, and what the students in this project should deliver, i.e., a “numerical prototype.” Once the students understood this parallelism, they would feel more comfortable with the relatively more abstract work in this project, and were able to connect their work with the lectures.

The faculty coach should help students to overcome the tendency to fear the abstract, the unknown, and the impalpable. For example, before we had the ABAQUS software installed, to save time, the coach asked the team to read the ABAQUS manuals to prepare mentally for the modeling tasks ahead. Some students found the manuals “abstract,” were hesitating in their work, and as a result were making slow progress. These students needed to "touch and feel" by playing with the code. Much coaching was needed to guide the team, as mentioned above, and these students, in particular.

The mid-project review, called the System Level Design Report (SLDR) presentation to the industry participants, was a success, as reported to us by the industry participants themselves, and by representatives of LMCO, in particular. Another point worth mentioning is that before the formal SLDR presentation, the team had to go through a practice presentation before faculty coaches and other IPPD students, and to receive critiques about their presentation. Such a practice (or peer-review) session instilled a sense of competition among the teams, and helped this team to improve their own presentation.

Most other IPPD projects funded by LMCO had physical prototypes. The readers are referred to the web page www.aero.ufl.edu/~vql for more detailed documentation on these projects. In general, students also learned a great deal from the accomplishments of the IPPD teams in previous years, and as a result develop more confidence in their work. Therefore, it would be helpful for the coach to provide students with documents related to past projects. For example, before going to visit LMCO for the first time, students were asked to prepare a list of questions about their project to pose to the LMCO liaison engineer. They should e-mail this list of questions to the liaison engineer before their visit to LMCO. To help students prepare this list of questions, it would be helpful to provide them with the list of questions developed by the IPPD teams in previous years.

DOD projects

The US Air Force, via Wright Laboratory at Eglin Air Force Base, has funded a series of projects. They are motivated to participate for a wide variety of reasons including a desire to build a stronger tie to the University, getting a fresh perspective on problems, recruit students to work at the laboratory, and be a “good citizen” by supporting higher education within the State.

Project definition of these projects follows a standard pattern from year to year. A request for projects is circulated at the base, potential projects are collected at Eglin, and this collection is forwarded to the University of Florida for selection. The faculty mentor and the IPPD director make the selection. Sometimes this involves a trip to Eglin to get more information before a final selection is made.

In 1997-8, the project involved designing an aerodynamic package to be strapped onto an air dropped munition for the purpose of range extension. The class of munition for this application was a new category of small smart bombs intended for use in stealth aircraft. The students found out after the preliminary design process that there were corporate teams competing at the same time for large scale funding to produce just such a system. The usefulness of the project to the Air Force was in getting a fresh perspective on the problem, validating concepts, generating new concepts that might be incorporated into the corporate designs, and double checking feasibility by independent modeling. While this project was very interesting for the students and the customer was very pleased with the result, the customer received most of their value of the project by the midyear report. After that, the sponsor became less interested. The students could sense the lack of enthusiasm during the spring term and it became a challenge to the faculty coach to make the students complete the project so that all the educational objectives of the IPPD program were met. The lesson learned is that it is important to have the customer interested in the final project result and not just an intermediate result. If the customer is simply interested in getting a fresh set of concepts from a group of people that are not steeped within the collective knowledge, then they will not be that interested in the second semester's work. This motivational hurdle was overcome by making it plain to the students that there was a new customer: the faculty coach. They must therefore deliver a product that satisfies him even if the original customer is satisfied.

In 1998-9, a method to measure the force that a pilot exerts on the control stick of an A-10 fighter during maneuvers was developed for the 46th Flight Test Wing, 39th Flight Test Squadron (now part of the 40th FTS). The students came up with a very simple concept involving the measurement of the bending stresses at the base of the stick using four strain gages. The bridge circuit for the strain gage measurements was self-balancing and the data stream was digitized and sent back to the flight recorder in the tail of the aircraft. The largest challenge was to package the system into a very small space and design it to survive the harsh vibration environment within the A-10 cockpit. The students delivered a working system to the customer but it had one small problem: the wires used were did not have the correct type of insulation. The customer then had to rewire the system. The lesson learned is that *all* details in the product specification must be made explicit.

In 1999-2000 and 2000-1, the students worked on a two-part project that didn't start out to have a high degree of nondisclosure, but ended up that way. All we can say about technical aspects of these projects is that they involved redesigning fuze initiators for use in a wider operating envelope. Such secretive projects have large plusses and minuses. The largest plus was that there was very strong support from the customer with three liaison engineers supporting the project. The presentations to the customer included up to fifteen engineers and administrators, including some from other branches of the armed services. Such strong support from the customer is very heartening to the students and they did get to work very closely with a wide range of practicing engineers. On the minus side the students were not allowed to make any public presentations to their classmates or participate in the midyear and final public presentations. In addition, they could not discuss any details of their project with potential employers during their interviews.

The lesson learned is that care must be taken in the selection of the project to avoid too many issues of non-disclosure.

In 2001-2, the task is to ruggedize a hurricane hunter dropsonde so that it can be rocket launched and wind profiles determined. The potential uses are in improved targeting of air dropped munitions, determining wind profiles over test ranges, and getting wind data within strong thunderstorms. A major difference in this project compared to the others is that the proposing organization and liaison engineer are potential users of the project result rather than a supplier of the result to others. This makes the liaison engineer less of a provider of engineering knowledge, but a more realistic model of a true customer. So far, there have been no major difficulties in the project.

Getting projects from a very large organization like the U. S. Air Force guarantees a wide variety of projects. In addition, since they are not profit driven, many of the projects are involved in the early stages of product development. The exception was the fuze initiator project; unfortunately, we are not at liberty to discuss that project further.

Assessment results

The students complete self-assessments of educational objectives at the beginning and the end of the course. The educational objectives include the following: 1) applying engineering knowledge in design, 2) understanding how to integrate product and process design, 3) understanding structured design methodology, 4) understanding principles of teamwork, 6) understanding principles of effective oral communication, 7) communicating effectively orally, 8) understanding principles of effective written presentations, and 9) communicating effectively in writing. The composite results since the 1996 program indicate double-digit percentage increases from pre self-assessment to post self-assessment ratings of very good to excellent (4 to 5 on a 5-point Lichert scale) in most of these 9 categories. See Figure 2. In addition, over the same data collection period, 92% of the post-assessment respondents agree or strongly agree they are confident to practice design in industry, and 90% of the respondents agree or strongly agree the course improved their ability to conduct independent research.

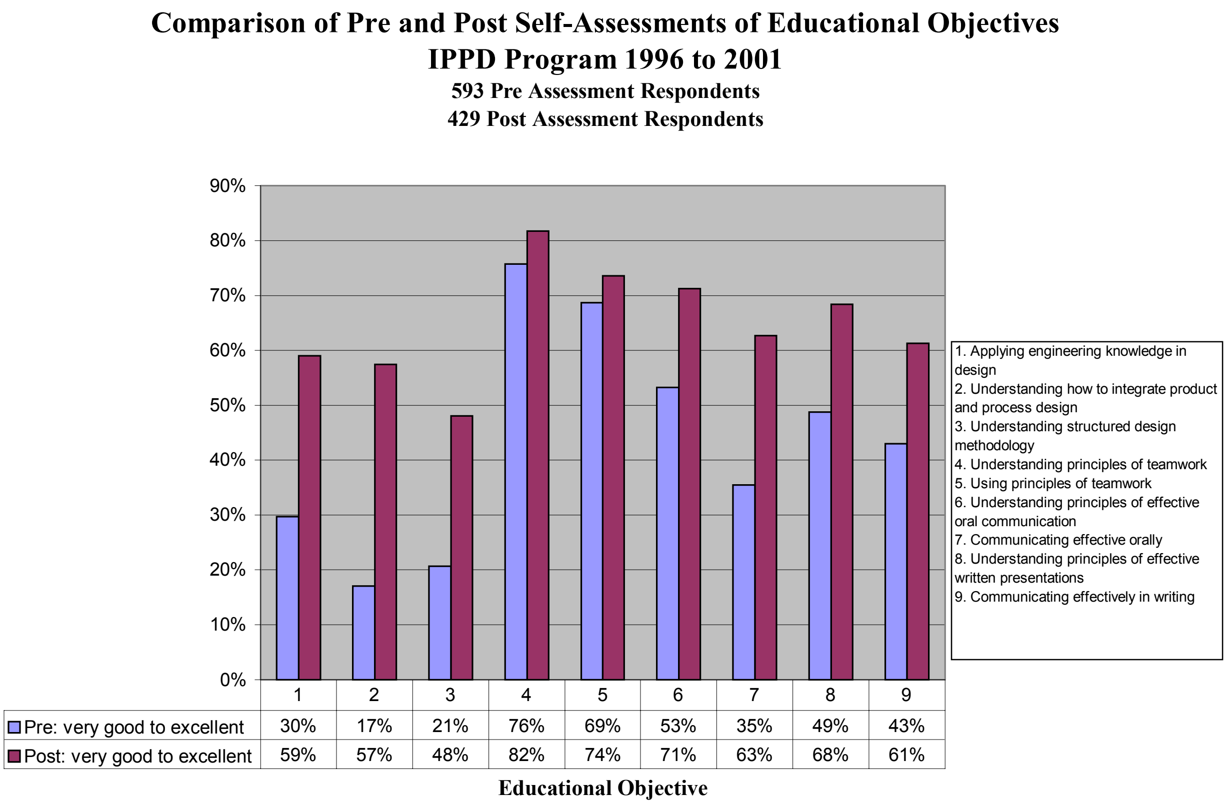

Figure 2. Integrated Product and Process Design Program Educational Objectives 1996 to 2001

Conclusion

This paper describes some of the lessons learned during 6 years of continuously improving the Integrated Product and Process Design program at the University of Florida. The program has provided an enriching experience for both the students and the faculty participants. The participating industry sponsors have benefited from early access to potential new hires, an opportunity to participate actively in the transition of students to professionals, and interaction with a talented and diverse faculty body.

Future growth opportunities include the development of a graduate version of the course and the integration of entrepreneurship within the curriculum. These avenues will require creative approaches to handle faculty and student incentives, intellectual property arrangements, realistic project funding levels, and industry participation.

Acknowledgements

The authors would like to acknowledge Heinz Fridrich, former IPPD Director, for his vision, perseverance and leadership in the creation and shepherding of the University of Florida's IPPD program. The following colleagues were also instrumental to the success and institutionalization of the IPPD program: the Original Task Force of S.X. Bai, R.B. Dickerson, A. Heggestad, K.S. Jones, M.E. Law, Y.W. Su, S. Svoronos (principal investigator), and J.C. Ziegert; the Implementation Task Force of W.R. Eisenstadt, S.S. Erenguc, R. Narayanan, S. Svoronos, S.

Tufekçi, E.D. Whitney, and J.C. Ziegert; Coaches J.R. Ambrose, M. Bermudez, G. Bosman, A.B. Brennan, T.F. Bullock, P.A. Chadik, J.N. Chung, O.D. Crisalle, W.W. Edmonson, R.M. Fox, M.P. Frank, F. Gamble, K. Gugel, A. Helal, W.E. Lear, S.M. Legg, R. Newman, K.D.T. Ngo, T. Nishida, J. Peterson, K. Powers, K. Rambo, S.M. Thebaut, A.J. Vakharia, L. Vu-Quoc, G.J. Wiens and J.N. Wilson; the College Advisory Committee of R. Abbaschian, T.J. Anderson (Chair), D.J. Elzinga, W.G. Tiederman, and, M.A. Uman; S.I. Peek, J.H. Perkins and A.W. Sistrunk. Lastly, we acknowledge the unwavering support of Deans W.M. Phillips, M.J. Ohanian (retired) and P.P. Khargonekar.

References

1. ASME Council on Education, Mechanical Engineering Curriculum Development Initiative: Integrating the Product Realization Process (PRP) into the Undergraduate Curriculum, American Society of Mechanical Engineers, 1995.
2. Chilton, K., 1994, "The Global Challenge for American Manufacturers", Center for the Study of American Business, Policy Study, No. 120, 54 pgs.
3. Jones, M., et al., 1994, "Essential Skills and Areas of Knowledge for Mechanical Engineers in the Product Realization Process", Internal Report from the ASME Best Practices in Industry Task Force, November 6, 1994.
4. National Research Council, Improving Engineering Design: Designing for Competitive Advantage, Committee on Engineering Design Theory and Methodology, Manufacturing Studies Board, Commission on Engineering and Technical Systems, National Academy Press, 1991, 107 pgs.
5. Stanfill, R.K., G.J. Wiens, W.E. Lear and E.D. Whitney, "Institutionalized University and Industry Partnership in Multidisciplinary Design and Build: Product and Process Realization," *Proceedings, 2001 ASME International Mechanical Engineering Congress and Exposition*, ASME Press, NY, NY.
6. Todd, R.H., S.P. Magleby, C.D. Sorenson, B.R. Swan and D.K. Anthony, "A Survey of Senior Project or Capstone-Type Engineering Courses in North America", Proceedings, 1994 Advances in Capstone Education Conference, Brigham Young University, 1994, pp. 3-12.
7. Wiens, G.J., "An Overview of Virtual Manufacturing", Proceedings of the Agile Manufacturing Conference 1995, Albuquerque, NM, March 16-17, 1995, pp. 1-15.
8. Ulrich, K.T., and S.D. Eppinger, Product Design and Development, 2nd Edition, McGraw-Hill, 2000.

Biographical Information

NORMAN G. FITZ-COY

Dr. Norman Fitz-Coy is an Associate Professor in the Department of Aerospace Engineering, Mechanics and Engineering Science. He received his Ph.D. from Auburn University in Aerospace Engineering in 1990. In January of 1991, he joined the faculty of the University of Florida. At the University of Florida, he lectures in the areas of aircraft dynamics and control, spacecraft attitude dynamics and control, control theory, and orbit mechanics. His research interests are in the areas of space robotics and autonomous satellite capture, multi-objective optimization using differential game theory, and modeling and simulation of multi-body dynamical systems. Dr. Fitz-Coy has twice been the recipient of the Bisplinghoff Award in recognition for his teaching and service to undergraduate education. He is the student advisor for the Aerospace Engineering Honor Society, Sigma Gamma Tau. Dr. Fitz-Coy is a senior member of the American Institute for Aeronautics and Astronautics (AIAA) and the American Astronautical Society (AAS). Dr. Fitz-Coy has been an IPPD Coach of Boeing sponsored projects for the past four (4) years.

DAVID W. MIKOLAITIS

David W. Mikolaitis received the B.S. in Engineering from Illinois Institute of Technology in 1975, and the M.S., and Ph.D. degrees in Theoretical and Applied Mechanics from the University of Illinois Urbana-Champaign in 1978 and 1981, respectively. In 1982 he joined the faculty of the University of Florida, Gainesville, FL, in the Engineering Sciences department (now called Aerospace Engineering, Mechanics & Engineering Science). His research is concerned with combustion modeling, especially in coupling between fluid transients and chemical kinetics and high pressure chemical kinetics, and advanced propulsion devices. He has won several teaching awards and is a regular member of the Combustion Institute's International Symposium Advisory Committee.

R. KEITH STANFILL

Keith Stanfill joined the Integrated Product and Process Design program in May 1999 as the Associate Director. Dr. Stanfill has over ten years' industrial experience with United Technologies, including 7 years with Pratt & Whitney and 3 years with Carrier Corporation. As an engineer at Pratt & Whitney, he designed gas turbine hardware for fighter aircraft—most recently the Joint Strike Fighter. At Carrier, he served on the New Product Development Council Steering Committee, facilitated Design for X (DFx) workshops internationally, developed business process linkages between new product development and lean manufacturing, and developed and implemented manufacturing systems software. He received his B.S., M.E., and Ph.D. in 1985, 1991 and 1995, respectively, all from the University of Florida Department of Mechanical Engineering. His interests include technology transfer, product development, design education and DFx. He is a registered professional engineer in the state of Florida and is a member of the American Society of Mechanical Engineers and the American Society of Engineering Education.

LOC VU-QUOC

Dr. Loc Vu-Quoc received the Diplome d'Ingenieur in Structural Engineering, Summa Cum Laude, from the Institut National des Science Appliquees, Lyon, France, in 1979. After graduation, he worked for two years (1979-81) developing finite-element codes at the Centre Technique des Industries Mecaniques, Senlis, France, for use in the French nuclear engineering and mechanical industry. He went on to receive a M.S. degree in Structural Mechanics from the Illinois Institute of Technology, Chicago, in 1982. Later, at the University of California at Berkeley, he was conferred in 1985 a M.S. degree in Electrical Engineering and Computer Science, and in 1986 a Ph.D. degree in Structural Engineering and Structural Mechanics. After two years of postdoctoral work at Stanford and Berkeley, he joined the University of Florida in 1988, and is currently Professor in Aerospace Engineering, Mechanics & Engineering Science. In 1990, he received the NSF Presidential Young Investigator award. His current research interests are in applied / computational electromagnetics / mechanics, and in power electronics simulation. In 1996, Dr. Vu-Quoc was bestowed with a Teaching Improvement Program Award for excellence in teaching both undergraduate and graduate courses. Dr. Vu-Quoc's research has been funded by NSF, Digital Equipment Corp., Florida Technological Research and Development Authority, Florida Space Grant Consortium, Stanford Linear Accelerator Center, DARPA/CFDRC, etc. Dr. Vu-Quoc has been a coach in the IPPD program since 1997; for the details on the IPPD projects that he coached, together with other info, see the web site www.aero.ufl.edu/~vql/