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Web-enabled System for Managing Student Applications for a Selective Industry-sponsored Multidisciplinary Capstone Design Program

Abstract

Integrated Product and Process Design (IPPD) is an institutionalized two-semester industry-sponsored multidisciplinary capstone design option for seniors in engineering, business, and packaging science at the University of Florida. Preparing for the launch of the IPPD program in the fall semester requires coordinating with dozens of project sponsors, faculty and staff from nine academic departments and students from more than 12 disciplines. Obtaining 25 suitable multidisciplinary industry projects each year is a time consuming activity. So too is the process of recruiting and selecting 150 students of the appropriate disciplines to complete these projects. Ideally, as projects are identified and committed, students with the right discipline background are approved and enrolled in the capstone program. If all goes as planned, there will enough students of the right disciplines to complete every project. This balance between project and student recruitment is a challenging systems issue—ignore either and risk program collapse. Further, after spending many hours recruiting a sponsored project, it is particularly disheartening to inform a sponsor that their project cannot be undertaken because too few students of the appropriate disciplines were available to complete the work.

From 1995 to 2006, students at the University of Florida applied directly to their academic departments through a paper application for admission into the Integrated Product and Process Design. Academic advisors verified the applicant qualifications against discipline-specific prerequisites, and faculty coordinators approved or rejected applicants. The paper-based process worked, but left many information gaps in the project and student recruitment process. To address these gaps, an information system was developed to streamline the capture, processing, and disposition of student applications. Today, students apply over the web, advisors and coordinators review the applications online, and accept or reject decisions are based upon needs published in the system by the program director. The system has tools for ranking the applicants, provides automatically generated e-mail notifications, and alerts reviewers when new applications are ready for processing. The director now has dynamic access to student applicant data and student numbers.

The intent of this paper is to share the structure and features of this student application system. Improved communications with the undergraduate advisors in the participating academic disciplines will be discussed along with other benefits.

Introduction

Integrated Product and Process Design (IPPD) is an institutionalized multidisciplinary capstone design option for seniors in engineering, business, and packaging science at the University of Florida. Each year, approximately 150 students are accepted into the IPPD program. The participants work for two semesters in small multidisciplinary teams under the guidance of faculty coaches and industrial liaison engineers to design and build authentic industrial products for sponsoring companies. The purpose of the IPPD program is to provide an experiential
learning environment where students can develop their technical, communication, leadership, and project management skills completing a truly multidisciplinary senior design project. The projects begin in the fall semester and conclude at the end of the spring semester. Design projects undertaken include electronics, machines and components, processes (manufacturing, chemical, environmental, and business), and software. Sponsoring companies and agencies pay $20,000 per project. The project cost is free from overhead charges and sponsors own the design. On average, 25 sponsored projects are undertaken. Typically, 20 faculty serve as team “coaches” each year. The faculty and students are all affiliated with the University of Florida.

Beginning in the spring semester, students apply for admission to the upcoming fall IPPD program. In parallel with this activity, the program director recruits existing and new sponsoring companies and agencies to submit project ideas, commit financial resources, and identify suitable liaison engineers. Projects are screened by the director and experienced faculty. To be accepted, the technology has to be suitable for undergraduates (heavy on application and not too “researchy”), the scope has to be 600 to 800 hours for an experienced engineer, and be interesting to both students and faculty.

A successful IPPD program launch in the fall requires the following conditions to be satisfied for each project:

1. Faculty coach with appropriate qualifications (discipline, citizenship and interest) committed to project

2. Enrollment of enough students with the right qualifications (discipline, citizenship, prerequisite and co-requisite courses, and senior status)

3. Sponsored project definition and commitment

Each of these conditions is dependent on finite resources and other constraints. As projects are locked in, it is critical to allocate a faculty coach and insure that enough students of the right disciplines have been recruited to undertake the project. As more and more projects are defined and committed, student needs are aggregated by discipline. For example; suppose by June, ten projects have been recruited and to complete all ten, 15 electrical engineers, 12 mechanical engineers, 5 aerospace engineers, 10 computer engineers, 10 industrial engineers, and 8 chemical engineers are needed. Therefore, at least 60 of this discipline mix would need to either be accepted into IPPD or have applications in process. As projects are accepted, it is important to understand if enough students and faculty coaches of the right disciplines are available. Projects are declined if they cannot be adequately staffed.

**Student Recruitment and Selection**

Review and acceptance of IPPD student applications is handled by the students’ home departments. This decentralized approach was selected for the following reasons:

1. students are mostly drawn from nine academic departments that represent over a dozen undergraduate majors. Up to 500 students may be eligible each year to participate, and outreach through an “outsider” is not practical.
2. Students may choose to apply to the IPPD program in lieu of completing their discipline-specific capstone course (or sequence). Therefore it is important that the undergraduate academic advisors in each department understand and support the recruiting process.

3. Departmental advisors and IPPD faculty coordinators know their students and the capabilities of their students.

4. Undergraduate advisors are often aware of which students do not have time in their academic plans to participate in an internship, yet who could benefit from the industry experience gained through IPPD participation.

Students apply in the spring and learn about their acceptance status in the summer. Each department has an IPPD faculty member that serves as a coordinator to approve, waitlist, or reject applicants. So that the coordinator has accurate decision-making information, undergraduate advisors in these departments verify the application data such as grades earned for prerequisite courses and grade point averages. During the summer, the IPPD Director holds biweekly meetings with all the coordinators and project coaches to refine project discipline needs and share required aggregated discipline totals. This process requires some forecasting of expected needs in each discipline.

**The Paper Process**

Prior to 2007, students filled out paper-based applications and provided a copy of their resume. This applicant package was collected by undergraduate advisors in each participating department and passed along to the departmental IPPD coordinator. Once applications reached a critical volume or at some specified date, the coordinator would pass the applications back to the advisor to verify grades on prerequisite course and grade point average. If data were missing from the applications, the advisors would contact the students via e-mail or phone to provide accurate information. Some coordinators would request entry of applicant data into a spreadsheet for ranking of applicants. After verifying applicant data, the applications were returned to the coordinator for disposition. Students were either accepted, rejected, or waitlisted. The coordinator would contact the students to alert them of their status. The applications were then passed back to the advisors so that students could be registered for the course. If problems occurred during registration, then the students would be contacted again to clear any holds on their records.

**Drawbacks to Paper Applications**

The paper-based application process was rich in improvement opportunities—all of which could be addressed through a web-based integrated solution. These opportunities included latency and limited visibility of information, bottlenecks in the process, integrity of applicant data for downstream usage, and revision control of student prerequisites.

**Latency.** Since these applications were handled locally by each participating department and due to sporadic summer time faculty availability, it was possible for the director to be unaware of drastic recruiting shortfalls.
Limited visibility. Since the director did not have access to the paper applications, there were limited options for assessing quality of applicants and no sense of how many were in the process of applying. Students also had little sense of whether their application had been accepted or where their application might be in the application review process.

Process bottlenecks. Paper-based applications require lots of handling and manual data entry. If the student’s application was incomplete, then the advisor would have to compose an e-mail and request new information. Frequently, students have holds on their registration due to a financial aid issue (or an unpaid parking ticket, overdue book, *et cetera*), requiring more communication and tracking.

Data integrity. Once students are accepted into the program and assigned to projects, information on each student (phone numbers, e-mail addresses, student ID numbers, disciplines, team assignment, *et cetera*) would have to be manually keyed into a database. Data entry errors take time to find and correct—especially if 150 students are involved.

Revision control. Curriculum updates occur frequently across the nine participating departments and these changes often affected the published IPPD prerequisites. Often these changes would not be reflected in the paper applications for several years. This delay was due to lack of communication between the departments and IPPD. Further complicating the confusion was the proliferation of out-of-date application forms kept in paper files throughout the college.

**Integrated Solution**

To overcome the drawbacks of the paper application process, it was envisioned that an electronic process would be developed. Students would create and submit a soft copy of their application. Advisors would review and screen the electronic applications, and departmental coordinators would review and approve applicants digitally. No paper would need to change hands as the system would alert students and other users of the processing status and next actions.

Beginning in spring 2006, requirements were developed to create a system to capture student applications electronically and facilitate the process of reviewing and approving applications. An analysis of the various system users was conducted and a detailed System Requirements Specification was developed. An agile development methodology was followed to create the system. Lead users provided feedback throughout the process to set priorities for integration of key features. During the system rollout, advisors and coordinators were trained in using the system. Enhancements requested by these users were quickly incorporated—a key to obtaining buy-in from end-users.

The following sections briefly describe the development of the system, including an overview of the users, the technology selected for implementation, and the major modules and accompanying graphical user interface samples. Detailed specifications, testing activities, and implementation details are not included.

**Who Are the Users?**

The most important user for this system is the student. The system must be easy to find, available on campus and off, and provide some feedback during the creation and approval process.
Advisors responsible for reviewing the application for accuracy, are very busy and do not have time to fiddle with cumbersome systems. Coordinators responsible for approving the applications, need to know how many to approve and be able to rank the applicants. The Director needs to communicate project staffing requirements to the advisors and coordinators, and have visibility and control over the entire process. Table 1 summarizes the users identified for the system and their needs.

### Table 1. IPPD application system users and key needs

<table>
<thead>
<tr>
<th>System user</th>
<th>Key needs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Students applying to the IPPD program</td>
<td>availability, ease of use, no new passwords, feedback during data entry, ability to complete the process later, ability to upload a resume in a variety of file formats, ability to update the resume at any time, confirmation of success, visibility during the approval process, ability to withdraw the application after submission</td>
</tr>
<tr>
<td>Academic advisors in participating departments</td>
<td>availability, ease of use, productivity enhancement, no new passwords, single applicant or batch processing, spreadsheet output, integrated e-mail, tips for finding qualified applicants, reminders sent when new applications need attention</td>
</tr>
<tr>
<td>Coordinators in participating departments</td>
<td>availability, ease of use, productivity enhancement, no new passwords, single applicant or batch processing, spreadsheet output, integrated e-mail, ability to rank applicants</td>
</tr>
<tr>
<td>The IPPD Director</td>
<td>available remotely, ease of use, productivity enhancement, no new passwords, automatic capture of student ID number and campus e-mail, spreadsheet output, visibility by discipline and application status, ability to override or assist advisors and coordinators, ability to specify forecasted and actual needs by discipline, message board for advisors and coordinators, ability to update requirements for each discipline, integrated e-mail to communicate with all applicants statuses, ability to export accepted applicants to project registration database</td>
</tr>
<tr>
<td>The systems administrator</td>
<td>compliance with network and client standards, remote management</td>
</tr>
<tr>
<td>The system developer</td>
<td>utilization of open-source developer tools, remote management</td>
</tr>
</tbody>
</table>

**Technology Selection**

User needs for availability and ease of use led to the design of a web-based solution. Integration with existing campus authentication systems would be required to eliminate the need for creating new passwords. A database back-end would be necessary for managing all the application data. Based upon the unique needs for the student, advisor, coordinator, and director, it was decided to develop a separate module for each, and to release the student module prior to completion of the back-end modules required for approvals and process management. The system should handle 25 to 35 staff and faculty users (fairly stable across the years) and 150 to 200 students (new users each year). The system should handle up to 20 simultaneous users without significant performance degradation.

Open source technologies were selected to reduce expenses on development tool acquisition. Table 2 summarizes the key technologies utilized to create the system. PHP was specifically chosen as the base development language so that the system could run on multiple server platforms and behave properly on browsers such as Internet Explorer, Firefox, and Safari.
Table 2. Open source technologies employed to develop the application system

<table>
<thead>
<tr>
<th>Tool</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MySQL</td>
<td>Open source relational database available for free under the terms of the GNU Public License</td>
</tr>
<tr>
<td>PHPMyAdmin</td>
<td>Web-based management portal for creating and managing MySQL databases</td>
</tr>
<tr>
<td>PHP</td>
<td>Web scripting language for communicating with databases</td>
</tr>
<tr>
<td>PEAR classes</td>
<td>Framework of reusable PHP components, especially useful for managing form data</td>
</tr>
<tr>
<td>JavaScript</td>
<td>A scripting language for the web useful for validating form data</td>
</tr>
<tr>
<td>AJAX</td>
<td>Techniques for permitting JavaScript to communicate with a web server allowing web page updates without page refresh</td>
</tr>
</tbody>
</table>

Major Modules

The application was divided into four major functional modules, each accessible through the same web address. These modules include the following:

- student (where students complete the application, upload their resume or withdraw their application from consideration)
- advisor (where undergraduate advisors process applications)
- coordinator (where departmental IPPD coordinators make approval decisions)
- director (where the IPPD director can manage the entire system workflow and student requirement modifications)

The role of the user is determined at login. Anyone not already registered with the system is assumed a student, otherwise returning users are routed to their role-specific application. This starting screen also serves to inform students of some high-level eligibility considerations. See Figure 1.

Authentication for the system is handled through a campus-wide authentication service. This service returns the identification number and other pertinent information about the user. If the user does not exist in the university database, then authentication fails. If the user does exist, then the identification number is compared to the application system’s records to see if the login attempt is from a new or returning student, or from a staff or faculty member with defined system role.
The Integrated Product and Process Design program requires six hours of course work and is offered as a sequence of two three-credit courses during fall and spring of the senior year.

These two courses are pre-approved substitutes for a technical elective and for capstone courses (senior design).

**ELIGIBILITY**
To be eligible to apply for the IPPD Program, the applicant must:

1. have completed the prerequisites for his/her major
2. be a senior graduating in spring or later
3. not have more than 30 semester hours left to be complete for graduation (negligible)
4. attach his/her resume to the application (accepted formats - doc, pdf, txt)

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**Student Screens**

New student applicants are welcomed with a screen offering an opportunity to start a new application. See Figure 2.

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**Figure 1.** Login screen for the application system

The following sections illustrate graphical user interface for the student, advisor, coordinator, and director modules.

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**Student Screens**

New student applicants are welcomed with a screen offering an opportunity to start a new application. See Figure 2.

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**Figure 2.** Welcome screen for a first-time student visiting the application system

The welcome screen link is context sensitive based upon the status of the student’s application. If the student previously began an application, then the two different links appear, namely “Modify your existing application” and “Withdraw your application.”

The student application is captured in a five-screen sequence, including the following stages:
1. “Personal Information” where basic contact, classification, grade point average, and academic major and minor information is captured. See Figure 3.

![Figure 3](image)

**Figure 3.** Personal information screen at the start of a new student application. Note the UF-ID field is captured from a University of Florida directory service and cannot be modified by the student.

2. “Grades Information” where performance in discipline-specific prerequisite courses is entered. See Figure 4.
3. “Program Special Information” where students can describe their motivation for applying to the IPPD program and specify any special skills they may have. This information is especially important for assessing low-performing students. If unique skills are defined or a very strong desire is articulated, a low GPA may be overlooked by the departmental IPPD coordinator during the approval process. See Figure 5.

4. “Resume Upload” where students upload their resume in “doc,” “rtf,” “pdf,” or “txt” formats. See Figure 6.

5. “Application Confirmation” where students can review, edit or submit their application. See Figure 7.

Note that each phase is shown as a hyperlink to that phase at the top each student screen, with the current step highlighted in grey. See Figures 3 to 7. A “contact support” link (not shown) is included on the bottom of each page if problems occur during the application process.
Figure 5. Grades information screen with industrial engineering prerequisite and corequisite courses listed

Figure 6. Resume upload screen. The resume is stored using the student’s UF-ID number as the filename so that revised resumes will overwrite previously stored versions.
Application confirmation screen with options to print the application or edit the content. A submit button (not shown) is included on bottom of this page. After submission, the undergraduate advisor in the student’s home department is alerted that an application is ready for review.

**Advisor Screen**

The main screen for the departmental undergraduate advisor features information on the anticipated number of students required from the major and guidance on the number of candidates to accept. The workflow of the advisor is to move submitted applications to an in-review status, verify each applicant’s submitted information and either request clarifications from the student or move the status to “for coordinator’s approval.” Once the departmental IPPD coordinator approves the application, the advisor is notified to register the student for the IPPD course. Additional advisor workflow pages are accessed through the main page. See Figure 8.
During end-user training, the advising staff provided excellent feedback on the usability of the system. Improvements, such as the ability to e-mail students from within the system and automatically generated weekly e-mail notifications to advisors (alerting them of new submissions or new coordinator approvals) were implemented immediately. The advisors also commented favorably on the availability of system training materials.

Coordinator Screens

The main screen for the departmental IPPD coordinator shares some features from the advisor screen, such as information on the anticipated number of students required from the major and guidance on the number of candidates to accept. The workflow of the coordinator is to approve, reject or waitlist applicants of the status “for coordinator’s approval.” Once the departmental IPPD coordinator approves the application, an e-mail alerting the student is generated and new actions appear in the advisor’s workflow, such as a request to register the student for the IPPD course. Additional coordinator workflow pages are accessed through the main page. See Figure 9.
Coordinator start up screen showing student recruiting requirements and notes from the IPPD director. Note that the current “accepts” versus “needs” are highlighted in black.

The coordinators have features such as the ability to rank the applicants using an intuitive drag and drop feature. Weekly system generated e-mails alert the coordinators if actions are required.

Director’s Screen

The director’s screen provides an at-a-glance overview of the student recruiting status by major. This module also allows the director to modify status on any submitted student applications, alert advisors and coordinators with messages and recruiting needs, search through student applications and contact students via e-mail from within the system (individually, grouped by major, or grouped by application status). The director can also add advisors and coordinators to the system and determine which users will get weekly “chron” e-mail alerts for pending applications. Functionality to define prerequisites and co-requisites for each discipline was implemented, including the ability to define rigid and flexible requirements. A rigid requirement for industrial engineering applicants might be a requirement to complete courses EIN 3564 and ESI 4621, while a flexible requirement might be to complete two of the following four prerequisite courses and register for one 4000 level or higher course as a co-requisite.
Development of a web-enabled application processing system is not a casual undertaking. The process took one year and required devotion of a developer 15 to 20 hours per week, plus several hours weekly from the IPPD Director and the IPPD Systems Administrator. Further, a user’s guide and training materials were developed, followed by end-user training for advising staff and faculty. Annual retraining will be required, as well as system maintenance and enhancements.

Given the development resources expended were equivalent to the sponsorship fee for one IPPD project, was it worth the effort? Quantitatively, this question is very difficult to answer; however, qualitatively, “yes” comes easily. First, development of the system improved communications throughout the apply-review-approve cycle. Second, the process of analyzing end-user needs and later training end-users promoted teamwork and shared understanding of the IPPD program across multiple departments (after all, students rely on advisors for counsel when selecting course options). Third, a graduate research assistant got an invaluable systems development learning experience.

User Benefits Summary

Moving from a paper-based application to an online system has provided numerous benefits to the stakeholders of the IPPD program. For students applying for admission to the program, the online system offers the following enhancements over the paper-based process:

- convenience and security of a 24-hour, password protected, web-based portal
- step-by-step forms that can be partially completed and finished later
• visibility throughout the submission and approval process via automatically generated contextual e-mail notifications

For advisors responsible for verification of submitted student data, the online system affords the following improvements over the previous process:

• integrated e-mail to notify students regarding inaccurate data
• elimination of incomplete applications (system will not permit submission of partial applications)
• visibility of up-to-date recruitment needs
• weekly e-mail reminders indicating applications in need of processing

Coordinators responsible for approving applicants reap the following benefits:

• convenience of web-based access
• ability to download pertinent applicant data into spreadsheets for processing
• intuitive drag and drop applicant ranking
• visibility of up-to-date recruitment needs
• integrated e-mail to automatically notify students of their acceptance, rejection, or waitlisting

With the launch of the system, the IPPD Director finally got real-time visibility into the status of student recruitment and acceptance into the program. The system freed the Director from relying on asynchronous status reporting from various departmental coordinators. When deficiencies in student submissions are identified, resources can more quickly be shifted into student recruitment. For example, in July 2007, it was evident that fewer electrical engineering students were in the pipeline than needed—40 were required and only 25 were in submission or review. Aggressive action was taken to contact prospective students and close the gap.

Rapid communication with applicants was an unexpected benefit of the system. In the case of the electrical engineering shortage, the Director sent e-mails to “in-process” status students to urge them to complete their application. In some cases, the students thought they had completed the submission, but neglected to hit the “submit” button.

Future Work

To promote dissemination of this system, sharing through the SourceForge.net ® open source software development website is under review. To reduce workload on advisors, integration with student records will be investigated. Currently, student records are being transferred to an ERP system from a legacy flat file database. Once this database is operational, it may be possible to integrate and simplify/eliminate the prerequisite and GPA verification process. Improvements in
system security will be continually made to ensure maximum up time and data integrity. Usability enhancements will be considered on an ongoing basis.

Acknowledgements

The successful creation and launch of this application would not have been possible without the dedicated efforts of many people. Madhu Kallazhi Vasu, our primary developer, did an outstanding job of listen to his customers and quickly implementing their suggestions. Norman Miller, IPPD Systems Administrator, shared his extensive development and problem solving experience. Dana Ferguson handled creation of the user’s guide and the training presentation. Sowmya Marianallur Dhaneskaran provided system support and assisted with training end users. Numerous University of Florida students and advising staff provided excellent feedback, as well as faculty IPPD coordinators.

The author also thanks the ASEE DEED Division reviewers for their detailed comments and constructive criticism of the first draft. Most of the reviewer suggestions were implemented; however, details and trade-offs for various implementation decisions, specifications, security, and testing approaches were beyond what could be covered in this paper.

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