AC 2011-43: TO WELD OR NOT TO WELD - EVALUATION OF AN UNDERGRADUATE ENGINEERING TECHNOLOGY WELDING AND FABRICATION COURSE

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To Weld…or not to Weld - Evaluation of an Undergraduate Engineering Technology Welding and Fabrication Course

Background

At a time when technology continues to accelerate toward computer driven activities which seek to remove the element of human error from tasks such as machining operations, micro-surgery, and vehicle stability control, the question arises as to whether degree granting institutions in the engineering technology and engineering science fields should continue to offer courses of study in the area of welding and hand fabrication. This field of study often conjures up images of soot-faced blacksmiths hand forging tools and weapons during the medieval ages, or high altitude tightrope walkers welding I-beams for skyscraper structures.

Western Washington University currently offers a 4-credit course entitled Foundry, Forming and Joining, which is required for Manufacturing Engineering Technology (MET) majors. It is also planned as a requirement for the soon-to-be revised Vehicle Engineering Technology (VET) program that is targeted for 2013 implementation. The course presently focuses on multiple welding process technologies, including gas, SMAW, GMAW, GTAW, gas and plasma cutting, as well as practical fabrication projects, project management topics, and foundry processes, which include dry sand and green sand casting. In response to comments provided by our industrial advisory committee in regards to the content and depth of coverage currently included in this course, the Engineering Technology (ETEC) Department has requested an evaluation of the curriculum in relation to technology relevancy, industrial application, and overall content. One side of the discussion favors increasing content, but decreasing depth of coverage and associated hands-on lab activities, providing a survey type course, with direction of students toward technical trade institutions for enhanced skills development. The other perspective looks to decrease current content, separate major focus areas into individual courses, and increase hands-on lab activities to allow for a deeper dive into critical areas, with more hands-on lab time.

This paper will focus on benchmarking similar course offerings from a representative sample of engineering technology and engineering science undergraduate degree-granting institutions, as well as an evaluation of industry and student perceived needs for experience in this area of study. Discussion will also include coverage of the desired course outcomes, challenges associated with maintaining this highly labor-intensive and consumables-intensive course, as well as a proposal for an optimized course and enrollment structure based on the analysis conducted herein.

The goals of this paper are to provide information for institutions engaged in similar situations concerning proposed curriculum change, to assist those that are contemplating adding to or removing a welding and fabrication course from their programs, and to provide program administrators with a more clear understanding of the level of activity associated with this type of course.

Since 1973, Western Washington University has been offering its ETEC students the opportunity to enhance their understanding and skills in the areas of welding, fabrication and
non-ferrous metals casting. Initially, there were two separate courses, which allowed in-depth focus on fabrication and welding in one course, and casting focus in the other course. Students studying in the MET program were required to take both courses. Course formats were established as three hour lecture and two hour lab session meetings per week, in a ten-week quarter system. In the early 1990’s, the individual casting course was dropped from the curriculum, and the remaining course was adapted to cover the three major areas of content (casting, fabrication and welding). In 2007, the author acquired the course and soon discovered the difficulty in attempting to cover the required content areas in the allotted thirty hours of lecture and twenty hours of lab time per quarter, while providing a sufficient degree of exposure and hands-on experience for the students. Additionally, based on the author’s industrial experience, it was noted that the majority of the ETEC students were not acquiring practical experience in the areas of project management and process planning. Coverage of these critical skills was also infused into the latest course offering, making for an intensive, project-based experience which has proven to be extremely challenging from a time management aspect for both students and faculty.

A new VET curriculum is under development and is intended to be an ABET accredited version of the existing Industrial Technology – Vehicle Design (IT-VD) program, that presently lacks accreditation. Within the IT-VD program there is an additional course that focuses on manufacturing economics, which was recently dropped from the requirements for all programs but those associated with vehicle design, including the Plastics Engineering Technology / Vehicle Engineering Technology (PET/VET) program. Likewise, the current Foundry, Forming and Joining course was recently dropped by all ETEC programs that required it, and as such, remains only as a lower division elective. Due to the present economic environment, it is unlikely that the course will be offered again in its present format after the final spring 2011 offering, unless it can be refined to fit specific program needs. Due to the project-based instructional elements contained in the vehicle design programs, and the continued need for tactile skills utilization, the current intent is to develop a course that will combine the hands-on skills development and practical applications of the welding, fabricating and casting course with the project management, process planning and economics aspects of the manufacturing economics course, into a single course that allows for pragmatic experience and application in all content areas.

Course Evaluation

Over the summer of 2010, the author engaged in a course development / evaluation study in an attempt to refine course objectives, confirm industrial needs for ETEC graduates in the primary areas of course content, and to explore opportunities for re-formatting course structure to provide students with an optimal educational experience. Items evaluated included existing course structure, lecture content, lab facilities organization, and lab productivity bottlenecks. Options for increasing lab time was also analyzed, as it continues to be the most requested aspect from student evaluations of the author’s course offerings. It has been the author’s experience that many students in the ETEC program desire to gain skills in welding, fabrication and casting topics, and once engaged, voice their need to practice their newly acquired skills through “more lab time”! An additional aspect of the summer course development activity included the need to
find a home for new welding equipment that was acquired through a student technology fee grant award, and a donation from a welding equipment manufacturer, which required reorganization of the lab to make room for the new technology acquisition. When the initial proposal was made for course development, it was unknown that the current ETEC programs would remove the foundry, forming and joining course from their required curriculum. This would leave the vehicle design programs as the only ones indicating a continued need for content in this area. This allowed for refined course outcomes to be tailored more toward the intended student users involved with the vehicle design programs.

An instrument was developed to survey representatives from organizations that are likely to attract graduates of the ETEC program, to determine the level of skills desired for entry level engineers in areas associated with course content. The instrument is included as Attachment 1, and was designed to capture general industry perspectives from regional and international organizations. Unfortunately, of the thirty-eight surveys sent out, a dismal 31.6% responded, making the results statistically insignificant. The results are presented as indicators, but additional input will be sought from the industrial advisory committee that has yet to be formed for the new VET program that is under development. The survey was intended to be a concise indicator of industry needs in the content area. Twelve questions were presented, eight of which focused specifically on welding, fabrication and casting skills, while the others were focused on more general skills thought to be critical for success in industry, or targeting organizational information. 83% of those responding were from manufacturing organizations. 84% of those responding were split between organizations that employed between 101-500, or more than 1000 people. 100% of the respondents worked with non-ferrous metals, and 83% with ferrous metals, suggesting that materials knowledge and metals processing skills would be valued. 92% of respondents indicated that they either were directly involved in or specified welding/joining and fabrication processes, with 58% indicating foundry process involvement. 67% of those responding desired a basic understanding of welding processes, with 42% looking for hands-on experience, yet 83% indicated that they use or specify GMAW and GTAW welding processes. After twenty years in the automotive industry, it has been the author’s experience that the possession of practical, hands-on knowledge of the manufacturing processes that are utilized for your employers’ products makes for a more robust design and higher quality result. Possessing these skills as an entry level employee can only strengthen a graduate’s employability potential.

Regarding foundry processes, 67% desired a basic understanding, with only 8% looking for hands-on experience. 50% of respondents indicated that they used die casting or lost foam/lost wax processes. 83% of respondents desired a basic understanding of metals fabrication, while 50% required detailed process knowledge. 67% were looking for process skills in sheet metal shearing / cutting, with 58% interested in sheet metal forming and joining skills. Regarding general / industrial skills, 100% of the respondents desired project management and presentation skills, with 83% looking for quality systems, team building and process planning experience. This information will be compared with statements from the current MET program industrial advisory committee for final curriculum direction, but in summary, suggests that a refined course should include the latter general industrial skills, as well as a basic understanding of foundry, forming and joining processes, with specific focus on sheet metal fabrication and the GMAW and GTAW welding processes.
An additional factor for needing to retain the hands-on emphasis of fabrication skills development in the VET program is due to the nature of the ongoing projects that the students and faculty engage. Such projects include the design, fabrication and testing of lightweight, alternatively fueled, high mileage vehicles that the Vehicle Research Institute has developed since its origination in 1975, by Dr. Michael Seal, and are embodied in examples such as Viking 32, a bio-methane / electric parallel hybrid vehicle, Viking 45, the Progressive Insurance Automotive X-Prize competition vehicle, and the Hybrid Bus, which is currently under development. Additional projects include design and fabrication of the Society of Automotive Engineers (SAE) annual international design competition vehicles for the Baja and Formula venues. While lightweight composite materials are increasingly targeted for use, there remain several areas of the projects that require metals fabrication, welding and foundry work.

In an attempt to gain a perspective of what types of related courses are provided by similar educational institutions offering engineering science and engineering technology degrees, a study was conducted. The targeted institutions were selected from those that entered the 2010 Baja SAE Western Washington competition, as our university hosted the event, which simplified
selection of potential institutions to research. It was also thought that institutions engaged in this competition would have graduates that would be targeting the same types of organizations that our graduates would be seeking employment from and would therefore have similar needs. A total of fifty institutions were selected from the ninety-three competing teams in order to obtain a representative sampling. The information was taken from the institutions’ websites by searching online course catalogs and posted syllabi. While unrelated to this paper, the author discovered that not all websites were created equal, and that six of the fifty sites were not able to be evaluated either due to the author’s inability to interpret the foreign language it was presented in, or navigation of the site was unable to readily provide detailed course information. The study provided the results summarized in Figure 5 below, which indicated some level of hands-on welding and fabrication courses offered at the overwhelming majority of institutions, however they varied in content from lecture only, or survey type, to in-depth laboratory activities, including one institution that offered certification in welding technology. A discussion of the results follows.

![Figure 5 – Summary of Institution Research](image)

Of the fifty institutions researched, the data indicated that forty-seven offered their students undergraduate baccalaureate of science degrees in a range of engineering fields, while eleven institutions offered engineering technology degrees, including eight that offered both science and technology degrees. Of the forty-four institutions evaluated for course content, 73% offered some coverage of welding and fabrication, with an increase to 82% for those that provide technology degrees. Of the thirty-two institutions that offered welding and fabrication content, nine (28%) offered a course of four or more credits, suggesting that depth of content was lighter for the majority, and similarly, only 16% indicated laboratory sessions greater than two hours per week. Although, as was the case with the author’s course offering, this does not account for any additional open lab sessions offered to those students interested in dedicating more time to developing their skills. (Based on student concerns and project progress evaluated at mid-quarter, the author has typically offered up to six hours of additional lab time per week.) Finally, based on information extracted from course descriptions and syllabi found online, 38% of courses offering related content included expanded coverage of GMAW and GTAW processes, which
are considered higher technology when compared to gas and SMAW processes. Summarizing this information and linking it to previous indicators from the industry data suggest that most institutions providing educational content in welding and fabrication are focusing in the right areas of higher technology processes that are used in industry. The author also suggests that the desired areas of project management and process planning, as indicated by industry representatives in this evaluation, may not be covered in sufficient detail, based on information contained in the online references; though this may be debated based on the limited room available for the online course descriptions. Additionally, it is unclear as to the level of projects engaged in these institutions, but it is the author’s assumption that due to the limited lab hours offered by the majority of those analyzed, lower level projects or “coupon-only” activities are likely. With the focus on practical, project-based experiences, additional lab hours are required to permit this level of activity.

Current Course Overview

Table 1 provides a concise listing of the current course content provided by the author, which is being targeted for refinement. The course is set up for a ten week quarter with three fifty minute lecture sessions and one two hour lab session per week, to combine for a four credit course. As previously indicated, initiating the fourth or fifth week, it is typical to add 3-6 hours of supplemental lab time per week, to allow the students additional time for completing welding coupon proficiencies in each of the four main welding processes, and to work on fabrication projects. The additional lab times are not contained within the departmental schedule for course load or compensation purposes, but are a necessity for those students not possessing prior experience, or for those selecting more complex application projects.

The current course suffers from cramming too much content into the allotted time period, however; the author feels that the majority of the topics covered are required to provide the students with a well-rounded educational experience, while providing practical examples of what to expect in the industrial environment upon graduation. It is also believed that the addition of the project and process management topics, while increasing overall content, provide greater academic rigor than traditional high school shop classes, or comparable “skills-only” classes. The course initiates with discussions of the scope of the fabrication projects, as well as an orientation in project management topics, including process planning documentation such as bills of material, detailed process sheets and creation of Gantt charts for project timing.

The basic welding and torch cutting processes are discussed, while the students engage welding experiences in the lab through a variety of weld types on three-by-three inch metal coupons, and tubing sections. Once the students have completed the required basic proficiencies with the coupons, they are ready to initiate group project activities which they have been preparing for during class meetings with their project groups. The projects are set up to allow individual effort on items such as fabrication of tool boxes and mechanic’s stools, to large scale projects involving up to four members, which can focus on items needed in the lab, or on campus, such as a vice table, or sand casting containment box, to items identified by the community, such as a bike rack for a renovated store front. Utilization of the projects allows for reinforcement of the concepts they have been studying and elevates the basic skills application
used for the coupons, to real world industrial projects. As Robyn Fogarty states, “By working with an authentic project, students begin to grasp concepts while putting their ideas on paper and eventually into a working prototype. In this way, abstract ideas are anchored for long-term memory and learning is ingrained in the mind of the learner.”

Table 1 – Existing Course Content

<table>
<thead>
<tr>
<th>Week</th>
<th>Discussion Topic</th>
<th>Lab Activity</th>
</tr>
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</table>
| 1    | - Introduction
       - Shop Safety
       - Lab Proficiencies / Projects Overview
       - Welding Material Properties & Heat Control | No lab – partial week |
| 2    | - Welding Processes & Equipment Overview
       - Design for Manfg. / Process Planning
       - Welding Process Consumables | - Lab orientation
       - Start welding coupon proficiencies |
| 3    | - Gas Welding (Oxy-acetylene)
       - Gas Cutting, Brazing & Soldering
       - Stick Welding (SMAW) | - Welding lab coupon proficiencies
       (gas / MIG / TIG / stick) |
| 4    | - Metal Inert Gas Welding (MIG /GMAW )
       - Tungsten Inert Gas Welding (TIG/GTAW)
       - Plasma Cutting | - Welding lab coupon proficiencies
       (gas / MIG / TIG / stick) |
| 5    | - Welding Project Design Reviews
       - Welding Fitting & Jigging
       - Casting Material Properties | - Complete lab coupon proficiencies |
| 6    | - Overview of Casting Processes | - Lab welding projects |
| 7    | - Casting Dimensional Considerations
       - Casting Process / Quality Considerations | - Lab welding & casting projects |
| 8    | - Mold / Die Design
       - Casting Sand Types | - Lab welding & casting projects |
| 9    | - Welding Project Presentations
       - Casting Process Progress Discussions | - Lab welding & casting projects |
| 10   | - Casting Project Presentations | - Complete welding & casting projects |

Discussions continue in the area of casting processes, while the students work on completing welding proficiencies and projects in the lab. Those that elected casting related projects initiate work on mold design and process preparation. Typically, the welding proficiencies run over their allocated time, and cut into project time, which initiates panic from the students’ perspective, and chaos in an already crowded laboratory environment. The lab is located in the basement of a facility adjacent to the ETEC building, and is limited on space. In its present configuration, the laboratory ventilation system prohibits simultaneous welding and casting operations, which further amplifies chaos and timing concerns. This is presently being addressed as a very welcome facility renovation project.

The classes have been filled to capacity with thirty-six students in lecture sessions, and three sections of twelve for each lab session, which produces overcrowding conditions in the lab, at times. With the proposed curricular revision to make the refined course a requirement for VET majors, enrollment numbers would go up, based on the population of students in the vehicle
design programs, making a desired reduction in lab section size impractical with the current single course offering per year.

Course Optimization

During the summer evaluation study, based on continued experience with developing and executing the course, several items have been identified as areas for potential improvement. Input from colleagues, the ETEC Department Chair, industrial contacts and students have all influenced the focus of targeted areas. Previously discussed events which include the withdrawal of other departments from requiring this course in their curriculum, to the need to revamp a current manufacturing economics course, and the continued need for hands-on vehicle related project experiences all contribute to the need for curricular refinement. Course objectives and desired outcomes have been revised to better address industry needs, technology demands, student needs, and ETEC project requirements.

When discussing overall course structure and the level of content coverage, the outer limits target either a survey type course, with shallow depth, or a separate course for each major topic, with in-depth coverage. Based on recent findings and ongoing discussions with all stakeholders, it appears that a single course with emphasis on welding and fabrication, while covering the basics of casting processes would best serve all. This is also supported in the results of the author’s course pre-assessments that are completed by the students at the initiation of each course offering, which indicate an average of 57% prioritizing welding over fabrication and casting topics. Based on industry feedback, the areas of project management, process planning and team building will be expanded on and targeted in the application project. Projects will remain as a selection completed by the students in the areas of welding / fabrication, with focus on GMAW and GTAW processes, which the students normally gravitate to, or casting processes contained in the lab. The gas and SMAW processes will be retained due to their more elementary content, and the value they provide in developing overall welding skills. As Finch indicates, “the heat control techniques used in gas welding are very similar to the heat control techniques required in most other kinds of welding, therefore; gas welding is usually taught first.” This is primarily due to the lower heat content of gas welding, and higher level of student confidence in working with this process, as opposed to the potentially more intimidating arc welding processes.

In an attempt to increase lab session time, a proposal will be made to revise lecture sessions from three hours per week to 2-1/2 hours, allowing for an increase from two to three hours per week for lab time. Additionally, a change in meeting day of one of the present lab sessions from Mondays to Wednesdays will allow for a lab meeting the first week of classes, which is typically a partial week. The current practice is to start lab sessions the second week of the quarter. This combination would increase total course lab time from eighteen hours to thirty hours, which represents a 67% increase, without changing the current four-credit course allowance.

Table 2 reflects a proposed revision to course content, as well as restructured lab sessions which will be attempted for the course offering in the spring of 2011. The requirement for casting projects in addition to the welding / fabrication projects has been replaced by a single
casting demonstration in the lab, with the possibility of those interested students engaging
casting in lieu of welding for their primary project. In week five, specific focus has been added
for fabrication topics, which will be added in other areas of discussion, and a lab overview
provided, as well. Project management and process planning topics are maintained early in the
course to allow students time to engage these areas, and allow for application to their group
projects. This approach has been successfully used in current course offerings which require
creation of planning documents ahead of the project, and offers time for reflection on their
practical application.

Table 2 – Revised Course Content

<table>
<thead>
<tr>
<th>Week</th>
<th>Discussion Topic</th>
<th>Lab Activity</th>
</tr>
</thead>
</table>
| 1 | - Introduction / Shop Safety  
- Lab Proficiencies / Projects Overview  
- Design for Manufacturing & Assembly  
- Process Planning | - Lab orientation  
- Start welding coupon proficiencies |
| 2 | - Welding Material Properties & Heat Control  
- Welding Processes & Equipment Overview  
- Welding Process Consumables (gas /rod/ wire types)  
- Welding Fitting & Jigging | - Welding lab coupon proficiencies  
(gas / MIG / TIG / stick) |
| 3 | - Gas Welding (Oxy-acetylene)  
- Gas Cutting, Brazing & Soldering  
- Stick Welding (SMAW) | - Welding lab coupon proficiencies  
(gas / MIG / TIG / stick) |
| 4 | - Metal Inert Gas Welding (MIG /GMAW )  
- Tungsten Inert Gas Welding (TIG/GTAW)  
- Plasma / Torch Cutting | - Complete lab coupon proficiencies  
(gas / MIG / TIG / stick) |
| 5 | - Sheet Metal Fabrication & Equipment Overview  
- Sheet Metal Types | - Fabrication tool orientation  
- Welding / Fabrication Projects |
| 6 | - Welding / Fabrication Project Design Reviews | - Welding / Fabrication Projects |
| 7 | - Overview of Casting Processes  
- Casting Material Properties | - Casting demonstration  
- Welding / Fabrication Projects |
| 8 | - Casting Media Types  
- Mold / Die Design | - Welding / Fabrication Projects |
| 9 | - Casting Dimensional Considerations  
- Casting Process / Quality Considerations | - Welding / Fabrication Projects |
| 10 | - Project Presentations | - Complete welding / fabrication projects |

A final area of concern that will be discussed briefly pertains to facilities and resource
limitations, which are brought up in this paper to alert administrators of potential pitfalls in
establishing a laboratory / course of this nature, and to provide the general reader with an idea of
other hurdles associated with this type of course. Provision of hands-on welding instruction can
be an expensive endeavor. Process consumables such as coupon materials, welding gas and rod,
and personal consumables such as gloves, body protective clothing and helmets combine to make
this one of the most expensive laboratory courses offered in the ETEC program, which does not
fare well with administration. Ongoing costs for abrasive wheels and belts, as well as saw and
shear blades for fabrication operations, add to student incurred lab fees and overall operating
expense. This is being addressed in the course refinement process through improved inventory control and by more closely monitoring student consumables usage patterns. Additionally, improved monitoring of, and the creation of a standardized usage fee for extracurricular use of the facility is planned for recovering costs associated with this frequent occurrence. Maintenance on equipment used by unskilled workers tends to run high, in addition to added expense when working with outdated equipment that can be difficult to locate service parts for. The majority of the welding equipment in the ETEC welding lab was acquired in the late 1970's and early 1980's, and while it has been quite reliable and valuable as educational tools, the older equipment tends to be large, creating a greater footprint and exacerbating the overcrowding concern, as well as consuming more energy than more efficient current technology. This is being addressed through the recent grant and donation which provided for three new machines, and has opened the door for future opportunities. As the need arises, review of the older machines will continue for trade-in on new equipment. This will also aid in reducing current equipment bottlenecks, as the newly acquired machines will increase the quantity of students able to access the critical GMAW and GTAW stations.

Facility concerns previously expressed are associated with the often overcrowded work space in the current laboratory due to the limited 2700 square foot facility which is populated by a variety of equipment and fifteen-plus students, faculty and lab assistants working on the range of welding, fabrication and casting activities. The Miller Electric Manufacturing Company Inc. suggests 7 x 10 foot individual booths for welding instruction purposes. Current welding booths in our facility vary in size, but average just under 5 x 5 feet. Location of support tools and equipment such as shears, grinders, and band saws, as well as material storage units, has not previously been optimized, which adds to the overcrowding issues. Sufficient workspace continues to be a challenge due to current space allocation, as well as the current economy, as funding is not available for additional brick and mortar to be incorporated. Reduction of lab section size is not feasible as the course is only offered once a year due to current demand and available faculty resources. Consideration of creating an additional lab section has been analyzed, and would create an overloaded faculty schedule. As such a plan has already been developed to improve materials and equipment storage locations, in addition to the previously discussed large welding machine replacement plan. The ventilation renovation project described previously will also assist in the removal of some large hardware sections and replacement with smaller, more effective alternatives.

An additional item that is related to facilities involves duplication of equipment. This occurs in many areas of the ETEC Building through the creation of independent welding and fabrication stations in individual program laboratories. Equipment capability is duplicated in many areas, yet is not accessible by the students enrolled in this course. While relocation of this equipment to the central laboratory is not foreseeable, access to critical stations is possible, and will improve productivity for this course, as well as some under-utilized equipment, such as a much-sought-after computer numerically controlled plasma cutter which is located in a very accessible area in the main ETEC building. Access to this machine is planned for improved course operating efficiency.

The final concern associated with the existing course pertains to proximity of the welding lab to the main ETEC Building, and related supervision issues. Due to the nature of the
operations conducted in the welding, fabrication and casting lab, constant supervision is required to assure safety of the students. While a student lab assistant and a volunteer retired faculty member assist with lab sessions, schedules do not permit extended hours supervision, as is present in the other labs in the ETEC Building, which have dedicated lab technicians. Additionally, trips to the adjacent building can be time consuming and are not often possible with hectic teaching schedules. This is one issue that does not really have a viable solution, as there are no workspaces within the ETEC Building that are large enough to house the equipment. Additionally, a significant amount of funding has been utilized for the foundry area, including installation and renovation of the ventilation system, which would be cost prohibitive to attempt to relocate.

In summary, a detailed analysis of the current Foundry, Forming and Joining course has proven to be valuable in planning the future direction of a proposed realigned course to replace it. A study of courses from comparable institutions has provided insight into the type of content and depth of coverage currently offered for engineering students engaging this type of educational experience. While it is important to offer unique opportunities, an understanding of the instructional “competitive” field is necessary. Even though limited data was available for the industrial perspective study, it is critical to assure that skills developed by the students in these courses will be valued by their future employers. Directional indicators obtained in this area will also be applied to the refined course direction. Based on the ongoing project-oriented skills desired for the Western Washington University VET program outcomes, the need for fabrication, welding and casting experience will continue to be a focus for the foreseeable future. While a portion of the students will likely not find the need to exercise their skills obtained in this course for their employers, an understanding of the processes is invaluable when creating product designs that will utilize them, or if they are engaged in working with the processes themselves. Additionally, many students continue to express interest in this area of study for personal projects and enrichment. Table 3 reflects a concise summary of proposed curricular revisions developed through reflection of previous course experience, the summer course evaluation and previously discussed research.

<table>
<thead>
<tr>
<th>Targeted Area</th>
<th>Proposed Enhancement</th>
<th>Justification</th>
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<tbody>
<tr>
<td>Course Content</td>
<td>- Maintain process planning / project management elements</td>
<td></td>
</tr>
<tr>
<td></td>
<td>- Increase fabrication / forming coverage</td>
<td>Industry survey; institutional benchmark</td>
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<tr>
<td></td>
<td>- Highlight GMAW &amp; GTAW welding processes</td>
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<td></td>
<td>- Reduce coverage of foundry topics</td>
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</tr>
<tr>
<td>Lab Sessions</td>
<td>- Initiate 1st week of quarter</td>
<td>Institutional benchmark; previous course experience; student requests</td>
</tr>
<tr>
<td></td>
<td>- Increase contact time</td>
<td></td>
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<tr>
<td>Lab Organization</td>
<td>- Implement new GMAW &amp; GTAW equipment</td>
<td>Industry survey; previous course experience</td>
</tr>
<tr>
<td></td>
<td>- Study equipment utilization / consumables</td>
<td></td>
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</tbody>
</table>
Western Washington University
Engineering Technology Department
Foundry, Forming & Joining Course Content Survey – Industrial Perspective

Your assistance is requested in helping us to understand the industrial perspective of the desired course content and industry needs in the area of casting, welding and fabrication processes, for students graduating from the Engineering Technology programs.

(For all questions, check all boxes that apply)

1) Please indicate the primary area of industry that your organization serves:
   - □ Manufacturing
   - □ Design
   - □ Service
   - □ Other

2) Please indicate the approximate number of employees at your organization:
   - □ < 10
   - □ 11 – 50
   - □ 51 – 100
   - □ 101 – 500
   - □ 501 – 1000
   - □ > 1000

3) Please indicate the types of materials your organization works with:
   - □ Ferrous Metals
   - □ Non-ferrous Metals
   - □ Polymers
   - □ Composites
   - □ Other

4) Please indicate which of the following processes are used in your organization, or those processes which your employees specify:
   - □ Welding / Joining
   - □ Casting / Foundry
   - □ Metals Fabrication
   - □ Forming / Shaping
   - □ Torch Cutting
   - □ Other

5) Regarding welding processes, please indicate which are used or specified in your organization:
   - □ SMAW (Stick)
   - □ GMAW (MIG / wire feed)
   - □ Spot Welding
   - □ GTAW (TIG)
   - □ Gas (oxyacetylene)
   - □ N/A
   - □ Gas Torch Cutting
   - □ Plasma Arc Cutting
   - □ Other
6) Please indicate what level of welding experience you desire your entry-level engineers to have:

- Basic Process Familiarity
- Detailed Process Knowledge
- Hands-on Experience
- Welding Certification
- Other

7) Regarding foundry processes, please indicate which are used or specified in your organization:

- Die Casting
- Dry Sand Casting
- Lost Foam / Wax Casting
- Green Sand Casting
- Other

8) Please indicate what level of casting experience you desire your entry-level engineers to have:

- Basic Process Familiarity
- Detailed Process Knowledge
- Hands-on Experience
- Casting Assoc. Endorsement
- Other

9) Regarding fabrication processes, please indicate which are used or specified in your organization:

- Sheet Metal Shearing/Cutting
- Sheet Metal Bending
- Riveting
- Manual Forging
- Other

10) Please indicate what level of fabrication experience you desire your entry-level engineers to have:

- Basic Process Familiarity
- Detailed Process Knowledge
- Hands-on Experience
- Skilled Trades Endorsement
- Other

11) Please indicate other general areas that you feel are critical for an entry level engineer to possess in order to be successful in your organization.

- Project Management
- Team Building Skills
- Presentation Skills
- Process Planning
- Quality Systems
- Economics /Finance

12) Please provide any additional comments that you would like to make regarding the indicated processes, level of desired experience, value placed on indicated prerequisite knowledge, or other areas of importance to your organization in your email response to this survey.

THANK YOU for your time!!

Please return to steven.fleishman@wwu.edu