Transitioning to Engineering Without Losing Experiential Learning

Dr. Jeffrey L. Newcomer, Western Washington University

Dr. Jeffrey L. Newcomer is a Professor of Manufacturing Engineering and Chair of the Engineering and Design Department at Western Washington University. He received his Ph.D. in Mechanical Engineering from Rensselaer Polytechnic Institute.

Ms. Nikki Larson, Western Washington University

After receiving my bachelor degree in Mechanical Engineering from Bradley University, I started working for Boeing. While at Boeing I worked to receive my master's degree in Mechanical Engineering with an emphasis in Materials and Manufacturing. After leaving Boeing I spent several years in equipment research and development at Starbucks Coffee Company.

From there I decided my heart lied in teaching and left Starbucks to teach Materials Science Technology at Edmonds Community College. I eventually moved to Western Washington University where I have been faculty in the Plastics and Composites Engineering Program (formerly Plastics Engineering Technology) for the past 13 years. My research interests are in composite manufacturing.

Prof. Todd D. Morton, Western Washington University

Professor Todd Morton is Program Director of the Electrical Engineering program at Western Washington University (WWU). He has BSEE and MSEE degrees from the University of Washington. He is the author of the text Embedded Microcontrollers, which covers assembly and C programming in small real-time embedded systems, and has been teaching the upper level embedded systems and senior project courses in EE/EET at WWU for 30 years.

Dr. Derek M. Yip-Hoi, Western Washington University

Dr. Yip-Hoi received his Ph.D. from the Department of Mechanical Engineering at the University of Michigan in 1997. His dissertation research focused on developing Computer-Aided Process Planning methods and software tools to support automation of machining on Mill/Turn machining centers. Following his Ph.D., he worked for several years with the NSF Engineering Research Center for Reconfigurable Machining Systems at the University of Michigan. His work focused on developing software applications to assist manufacturers design and plan operations on advanced machining lines that could be rapidly reconfigured to meet changes to a product's design or production volume. In 2003 he joined the faculty of the Mechanical Engineering Department at the University of British Columbia as junior chair of the NSERC sponsored research program in Virtual Machining. His work at this time focused on the modeling of cutter/workpiece engagement geometry to support process modeling for aerospace machining applications. In 2007 he joined the faculty of the Engineering and Design Department at Western Washington University where he is currently director of the Manufacturing Engineering program. His teaching and scholarship interests lie in the areas of geometric modeling, design, CAD, DFM, CAM and CNC machining.

TRANSITIONING TO ENGINEERING WITHOUT LOSING EXPERIENTIAL LEARNING

In summer 2013 Western Washington University (WWU) began the process of transitioning its three well-established and ABET ETAC accredited engineering technology programs in Electronics, Manufacturing, and Plastics into Electrical Engineering (EE), Manufacturing Engineering (MFGE), and Plastics & Composites Engineering (PCE) programs respectively. It took just over four years, but we have now successfully completed that process. All three engineering programs produced their first graduates in spring 2016, were reviewed for ABET EAC accreditation in the 2016-17 review cycle, and received ABET EAC accreditation late summer 2017, retroactive to October 2015, so graduates from the programs' first two years have ABET accredited degrees. While this transition was clearly a chance for us to improve the opportunities for program graduates, one of the major concerns for everyone involved was the maintenance of the experiential learning and significant laboratory components that had been hallmarks of the engineering technology programs and one of the major reasons behind the success of engineering technology program graduates.

We wanted to share our experiences with the transition of our engineering technology programs to engineering programs, because we found very little guidance from the literature for either accrediting new programs [1-2] or transitioning from engineering technology to engineering [3]. Therefore, we relied on anecdotal information through personal connections with acquaintances at programs that either transitioned engineering technology programs to engineering programs or added engineering programs to engineering technology programs and our own efforts. This paper briefly explains the engineering technology programs' history leading up to the transition to engineering programs. It then explains why we believed that transitioning to engineering programs was the right decision for students, employers, and the department. The engineering technology programs were all strong in that they were attracting large numbers of students (at least relative to our resources) and the graduates were getting good job opportunities, but we also saw many areas for improvement such as advancement opportunities for graduates, the ability to attract students to the programs, and the ability to attract new industrial partners and employers. This paper then outlines what we believe are the key lessons for: 1) curricular planning and implementation, including the role of Industrial Advisory Committees (IACs) in that planning, 2) hiring large numbers of new faculty and integrating them into the experiential learning culture of the department, 3) the transition of students from the engineering technology programs to the new engineering programs, and 4) getting ready for ABET EAC accreditation. Finally, this paper concludes by briefly outlining what we have found now that we have completed the transition.

Engineering Technology Programs at the Time of Transition

Prior to the 1980s, the only technical program at WWU was an Industrial Technology (IT) program with several concentration options that had grown out of an Industrial Arts Department. In the 1980s the administration at WWU funded the creation of Electronics Engineering Technology (EET) and Manufacturing Engineering Technology (MET) programs. At the time, Washington State law limited certain engineering degrees at public universities to the research campuses, so engineering technology was considered the only option, and it also fit well with the existing IT program. The EET and MET programs both received their initial ABET TAC accreditation in 1987. Once the initial accreditation was received, an IT-Plastics concentration was converted to a Plastics Engineering Technology (PET) program. The PET degree was first ABET TAC accredited as an MET-Plastics option in 1993, and was accredited as an independent program in 1999.

In 1993 the department name was also changed from Technology to Engineering Technology, although it continued to house the IT degree, an Industrial Design degree, and a Technology Education degree. Finally, in 2010 an IT-CAD/CAM concentration was converted to an MET-CAD/CAM option and the Technology Education degree was cancelled due to low enrollment. These five programs, EET, MET, including a CAD/CAM option, PET, ID and IT were the programs that existed when we began to switch the ET programs to engineering.

Two of the defining characteristics of the engineering technology programs at WWU were significant experiential learning through labs and projects and strong connections to local industry through both sponsored projects and active Industrial Advisory Committees (IACs). The heart of the Mission Statement for the Department was, and still is: "developing industry-ready graduates through a combination of creative problem-solving, analytical skills development, and experiential learning."[4] All three programs had IACs that met once or twice a year to give input on changes in the field and to review and give feedback on proposed program changes and assessment and evaluation findings. IAC members were also the primary sponsors of senior projects. The MET and PET programs both strove to have students work on industry-sponsored senior projects whenever possible and achieved that for 80-90% of students most years. The EET program had all students complete a project of their own choosing that included a set of technical requirements that had been vetted by the EET IAC. To prepare students for such capstone experiences, all three programs had large lab suites with industrial equipment identical or similar to that used by regional industry and professional software such as CATIA. Most classes in all three majors, especially upper division classes, included laboratories, so students gained familiarity with much of the equipment through exposure in multiple classes.

The model for the three engineering technology programs was effective. Over most of the years of the programs' existence until the late 2000s they each graduated 10-20 students per year. In the late 2000s interest in the degrees began to increase, starting with the PET program and then following with the MET program and to a lesser degree the EET program. In the period from 2009 to 2015, the average graduating class sizes were approximately 17 for EET, 25 for MET, and 31 for PET. That EET was the smallest program was a reflection of the additional challenge it had recruiting students into a program with a very similar name to its engineering counterpart. Many students and parents were leery of EET as a valid option compared to EE. This was less of a concern for MET and PET, for they had no direct engineering competition in the state, so those programs grew faster. Despite the growth, placement rates in the field were high, and most graduates were able to find jobs as engineers rather than technicians. Even while getting engineering jobs, however, some graduates found that they had fewer opportunities for advancement than their peers with engineering degrees, and we learned from our industrial partners that many of them only considered the engineering technology graduates for a much smaller set of job areas than graduates of engineering programs. We also found it difficult to attract new employers, for it seemed that many employers who did not already have engineering technology graduates on staff were, at best, hesitant to recruit engineering technology graduates. These were some of the reasons that there was interest among those on the faculty to transition the programs from engineering technology to engineering. Two other reasons were that the engineering technology programs did not include enough foundational math and/or science, primarily chemistry in the case of PET, to allow upper division classes to push to the depth that the members of the faculty felt was appropriate in certain topics, and we only had three faculty lines per program, which was enough to satisfy ABET, but left the programs very vulnerable to the impacts of personnel changes.

Given these limitations with the engineering technology programs, we believed that a transition to engineering programs would be a win-win-win scenario for the program graduates, the employers of those graduates, and the programs themselves, as long as we stayed true to our hands-on roots. The most obvious beneficiaries of transitioning to engineering programs would be the program graduates. We believed, and have since confirmed, that program graduates would get more opportunities from companies who had consistently hired our graduates and that we would be able to attract new employers more effectively as well. We also believed, and still do, that engineering graduates will have better career and advancement opportunities, but it is too early to confirm whether that is indeed true or not. For the employers of our graduates, we believed that with engineering programs we would be able to provide them with better prepared graduates than we could with the engineering technology programs. Part of this was due to aforementioned increase in foundational math and science courses, and the ability to achieve more depth in upper-division courses as a result. In addition, we knew that we would be able to increase the number of credits in the programs as we transitioned from engineering technology to engineering, so we felt that we could add content without having to give up any content that our IACs considered to be important or the experiential-learning aspects of our programs. This proved to be true for the most part, for we did have to make some compromises on program content to keep the programs from getting too large to allow students to graduate in four years without being required to take course overloads. Finally, we felt that the programs would benefit from the influx of the new faculty members that were required to switch to engineering programs, from the ability to realign program capacity in terms of the graduate-to-faculty ratio, and the ability to attract new industrial partners. The benefits of an expanded faculty were quickly confirmed, although by initially putting a very heavy load on the senior members of the faculty, and our improved ability to attract new industrial partners is slowly showing itself to be true as well.

Funding and Constraints for the Transition to Engineering

While there had been interest among members of the faculty for turning the WWU engineering technology programs into engineering programs for many years, the prerequisites for doing so were beyond our direct control. As was mentioned earlier, the research universities in the State were the only public universities able to grant engineering degrees. In the early 2000s State law was amended to remove the restrictions on engineering programs at public universities, but the economic downturns of that decade made obtaining the resources necessary for a transition to engineering impossible until just a few years ago. In spring 2012, as part of the University's budget planning process, a pair of proposals were submitted for consideration to be part of the 2013-15 biennial budget request to the State. Both proposals included transitioning all three engineering technology programs to engineering. The difference between them was that the larger one also included transitioning the last remaining IT program, IT-Vehicle Design, to engineering while the smaller one did not. The larger of the two proposals was selected in the University's internal process and submitted as part of the state budget request. The larger of the two proposals requested funding for 9.0 full-time equivalent (FTE) faculty and 4.5 FTE staff, and the smaller requested funding for 6.0 FTE faculty and 3.5 FTE staff. The goal was to get five faculty lines for each engineering program, for we felt that this was the minimum number to allow for stable and flexible programs that could weather an occasional open position. We also agreed that if our proposal was funded that we would not try to maintain the engineering technology programs, for we did not believe that we would have enough faculty to do so, and we knew that we did not have enough space available in the building to do so. This decision was fully supported by WWU's administration.

The good news for us was that in June 2013 the State Legislature decided to fund the expansion of computer science and engineering programs around the State, but that was somewhat tempered by the fact that the funding for WWU was less than what had been requested. Once computer science got its share of the new funding, the engineering transition was left with funding that was below the level of the smaller of the two original proposals. The new funds were able to provide 4.0 FTE new faculty positions and 3.5 FTE new staff positions, which left us looking at having fewer faculty lines than we believed we required. At the time we were notified that funding for the transition had been granted there was a vacant position in the IT-Vehicle Design program, so we elected to reassign that position to one of the engineering programs to make up for part of the smaller-than-requested funding levels. As mentioned above, we had determined that we wanted five faculty lines for each engineering program, so even reassigning the position from the IT program to one of the engineering programs left us one faculty position shy of what we felt we needed to accomplish the transition. The solution to this dilemma came through creative problem solving on the part of the EE program. In addition to the planned electronics concentration, the EE faculty proposed adding an energy concentration to support a newly created Institute for Energy Studies that the University had decided to develop with internal funds. In return, the University agreed to fund an extra faculty position for it. Once this idea was approved, the personnel resources were settled, and all three programs were able to plan on five faculty lines for the new engineering programs, although an open position in MET added to the challenge by increasing the number of faculty searches to seven.

Throughout the process of seeking funding for the transition and implementing it, WWU's administration was very supportive and flexible. They agreed to almost every request we made regarding the implementation plan for the transition. Of all of the key lessons, probably the most important is that the University administration must be invested in and supportive of the transition, for it does require resources if it is going to work. WWU's administration fully understood this and invested appropriately, but it did impose one constraint on the transition that made it more challenging for everyone involved. WWU's President wanted engineering graduates as quickly as possible. This created three challenges. First, we had to start teaching engineering classes before we had completely phased out the engineering technology programs. Second, we had to try to fill all seven of the open faculty positions the first year they were funded (2013-14). This meant that we had to try to successfully execute seven simultaneous faculty searches. Third, we had to get the new engineering programs and courses for them approved via the University's academic approval process before we had almost half of the faculty in place. The academic approval process also created an additional challenge. Unfortunately, it could not be completed before the students' major application period for the MFGE and PCE programs during winter quarter. Therefore, we accepted students into these two new majors with the proviso that their acceptances were contingent upon the approval of the engineering programs.

Under this implementation plan, the engineering technology programs were to have both junior and senior-level classes in 2014-15 and only senior-level classes in 2015-16, with the last program graduates in spring 2016. Meanwhile, the new engineering programs were to implement junior-level classes in 2014-15 and senior-level classes in 2015-16, with the first graduates also in spring 2016. Left to our own devices, we would have delayed the engineering programs by an additional year, spread the faculty hiring out over two years, and phased the approval of the courses for the new programs over two years as well, but this was not possible in our situation. Given our experiences, we recommend that any programs that are expecting to transition engineering technology programs to engineering programs without maintaining the engineering technology programs to not overlap the engineering and engineering technology programs if it can be avoided. For us it meant that we were temporarily running twice the number of programs while trying to successfully execute seven faculty searches for the new programs. At the same time, we were developing the courses and curricula, and navigating the proposals for them through the academic approval process with only eight of the fifteen intended faculty members involved, three of whom were still tenure-track at the time.

Making the Transition to Engineering Programs

The previous sections outlined the history of our programs and the conditions under which we were able to make the transition to engineering programs. While the exact set of conditions was, of course, unique to us, we thought that it was important to explain the context of the transition. In this section we will go over what we believe to be the key lessons that we learned for adapting the curricula, hiring and integrating new faculty members into the department, advising and managing students through the transition, and preparing for EAC accreditation while maintaining the experiential learning portions of our programs.

Curricular Planning and Implementation

We offer four key lessons for curricular planning and implementation: 1) do thorough research, 2) involve IACs in the decisions where their input matters, and do so as early as you can, 3) work with the people on campus in charge of the curricular processes to find and take advantage of flexibility in the system, and 4) support the people who have to do the work of developing the curricula. We will briefly explain how we addressed each one of these.

Researching curricula involved two aspects: thoroughly researching EAC requirements, including area specific requirements, and examining other programs for comparison. We did this work between receiving word that we would be funded to transition to engineering programs at the end of June and the beginning of the academic year in late September so that we were prepared to meet with campus officials and our IACs early fall quarter. When it comes to ABET, names sometimes matter. For our EET and MET programs, the obvious names for their engineering versions were Electrical Engineering (EE) and Manufacturing Engineering (MFGE), and those are what we chose. In both cases that introduced program-specific curricular requirements that had to be met in addition to the general EAC curricular requirements. Our PET program, however, elected to adopt the name Plastics and Composites Engineering (PCE), for they felt that it best described the historical content. By not using the word ‘polymer’ in the program name, the PCE program did not fall under the any of the EAC program areas, so that program only had to meet the general EAC curricular requirements.

The general and program-specific EAC requirements set minimums for the size of the math and science foundation and specified the inclusion of a small set of topics or courses, which still left us quite a bit of flexibility for determining the content of each program, especially at the upper division. To make sure that we were not going far afield, we took the time to research other programs. Because EE is a very large field, we started with a list of 93 programs at similar universities and then eventually narrowed that list to a set of six programs that we considered to be aspirational peers. MFGE, however, is a relatively small field, with not quite two dozen ABET EAC accredited programs at the time. After an initial review of every program, we selected a subset of seventeen ABET EAC accredited MFGE programs as a comparison group. PCE is a tiny field, with only three ABET EAC accredited programs at the time, so we included all of them in our comparison group. We used these comparison groups to study others' curricula both to examine what topics or courses were and were not required or available as electives (e.g. only about half of MFGE programs require Dynamics as a foundational class), and to sample the range of program sizes. Some programs sizes are limited by state law, but most are not, including ours. We knew that we would need to increase the number of credits in each of our programs to switch from engineering technology to engineering, which had the potential to be met with resistance on our campus, so showing the comparison information helped to explain national norms, and made getting our proposed programs accepted at a larger size than any others on campus – all three of our engineering programs have over 140 quarter credits required – relatively easy. To prepare campus for this request, we made a point of meeting with the Chair of our university-level curriculum approval body, the Academic Coordinating Commission (ACC), and the Provost at the start of fall quarter, and then proposed program target sizes to the full ACC early fall quarter in order to get a tentative approval for the anticipated size of each program.

Once we had established the requirements for each of the curricula and set the sizes of them, we began to plan out the specifics of each program. Each program did this work independently using a combination of historical content, ABET EAC requirements, and ideas from program comparisons to develop sets of courses that we intended to include and knew that we could include. The MFGE program also made significant use of the SME Four Pillars [5], which is outlined in some detail in [6], so we will not repeat that information here. We wanted to get input from our IACs, but we wanted to use their time well and only have them examine and give us input in areas where we felt that we had a choice in program content; we did not want to spend much time debating areas where we felt that there were not options. All three programs held IAC meetings in the fall, which was not normal practice for the EET/EE program or the PET/PCE program.

In order to efficiently gather feedback at meetings of reasonable length, programs went to their IAC meetings with partially developed curricular plans. Courses inside the curricula were included in one of three categories: 1) things we have to do (e.g. to meet an accreditation criterion), 2) things we think we should/would like to do (e.g. the balance of courses in MFGE relative to the SME Four Pillars), and 3) things that we could do. For example, in the MFGE program planning, the final category contained a list of senior-level classes that we felt should either be required or technical electives, but there was not room in the curriculum for all of them to be required courses. The IACs were able to vet the courses in second category and provide input on which of the courses in the third category to require and which ones to make into technical electives. The IACs also suggested other courses that would be good potential technical electives in the future. Overall, we were able to take advantage of the IACs' experience and perspective to polish the programs while avoiding having them spend time on content that was required due to other considerations. With that information in hand, we were able to complete the curricular planning, get the necessary campus approvals, and bring completed plans back to the spring IAC meetings.

While it may not be true at every college or university, for us getting the new programs through the curricular approval processes was a significant task. To get the new engineering majors into the catalog required us to get all of the new courses approved before we had the time to develop the details in them or hire the faculty to teach them. In addition, as was mentioned above, the timing of everything was such that our major application period for our MFGE and PCE programs occurred before we were able to complete the curricular approval process for those programs, so we were required to admit students contingently. While the details are quite mundane, the important lesson was that we were able to work with the ACC, the Registrar's Office, and the Provost's Office to find the areas where we could extend deadlines – we received an additional month to complete new course and new program proposals – and where we needed permission to bend rules or do things out of order, such as admitting students into programs that did not yet officially exist. Opening a dialog with the ACC, Registrar's Office, and Provost's Office early and working with them to find the places where there was flexibility in the system allowed us to stay on track and maintain the President's goal of having engineering graduates in spring 2016.

The final important part of the curricular planning and implementation was to support the people who had to do the work of the full curriculum development to allow us to teach the courses, not just the outlines required to get the courses approved for the catalog. Outside of support courses and general-education courses, courses in the new curricula roughly fell into one of three categories: 1) courses that required little to no modification from the engineering technology versions, 2) courses that were modified versions of the engineering technology courses, but essentially improvements rather than replacements, and 3) entirely new courses, even though some of them sounded very similar to old courses (more on that later). With the support of the Dean's Office and the Provost's Office, we were able to work out a plan in which individuals were assigned courses to modify or develop and then provided a summer stipend to do the necessary work at one of three levels that was roughly proportional to the amount of development work required. Because the new junior-level courses were introduced a year before the new senior-level courses, these stipends were spread over two summers. In round terms, WWU invested two years of the cost of one faculty position in the form of summer stipends to support curricular development by roughly a dozen faculty members. This was a relatively small investment of one-time funds on the part of the University, but it was a critical step for keeping the transition to engineering on track, for the senior faculty had so many other responsibilities during the academic year that there was no time for the development of curriculum.

Hiring and Integrating New Members of the Faculty

We offer three key lessons for hiring and integrating new members of the faculty: 1) provide sufficient administrative support for the searches, 2) make priorities and expectations explicit and clear in all of the documents and steps of the hiring process, and 3) integrate new faculty members into the department with plenty of support from senior members of the faculty. The first of these three is quite simple, we were going to run seven faculty searches, and computer science was going to run four more the same year. Therefore, the Dean's Office hired a full-time temporary search coordinator to manage the logistics of the eleven searches so that the permanent office staff in both departments could focus on other aspects of the transition.

The second part, making priorities and expectations explicit in the hiring processes, was only slightly more complicated than funding a nine-month staff position. Our department intended to hire seven new engineering faculty members to join a group of five senior and three junior engineering faculty members. Because of this virtual doubling in faculty size, there was significant concern that the new hires could shift our culture away from laboratory-based, experiential learning if we did not find people who were already supportive of such an approach to fill the new and open positions. To address these concerns, we reviewed our hiring practices and documents and added more explicit statements and requirements regarding the maintenance of our traditional approaches and department mission. Most of the changes involved moving preferred qualifications to required qualifications, but we did add two new required qualifications:

- Teaching and scholarship interests and experience that are closely aligned with the Mission of the department.
- Evidence of the ability and willingness to maintain currency in [discipline-based] engineering practice.

We believed at the time that these requirements would accomplish several things. First, serious candidates would take the time to read our Mission statement and hopefully understand from it something about our culture and priorities. Second, candidates would understand that maintaining technical currency, which is a program-specific requirement for ABET accredited Manufacturing Engineering programs but not for our other two areas, was an expectation for all of the new hires. Third, serious candidates would address these issues in their application materials. Finally, candidates who provided no evidence regarding one or both of these issues did not need to be considered any further. We also maintained recent, relevant industry experience as a preferred qualification, which was the same as we had done for our engineering technology searches in the past.

Overall the explicit search requirements seemed to work out. The searches had applicant pool sizes ranging from 20 to ~120, so it was easier to find appropriate candidates in some areas than others. The first year we filled six out of seven of the open positions, which was a significant improvement on our engineering technology faculty searches that had a roughly 50% success rate. The one position that we did not fill remained open because we could not find a candidate who was both technically qualified and interested in being part of an undergraduate only, industry-focused program. In addition, one of our new hires left after one year, and while the industry focus was not the primary factor in his decision to leave, it likely was a contributing factor. Other than those two instances, the more explicit expectations in the hiring process worked out well. Since that initial round of seven searches we have had one more person resign and have gotten funding for a second position in the EE-Energy concentration, leading to two more searches. With the successful completion of those searches last year, we have now added eight new engineering faculty members to the department, thus doubling the size of our engineering faculty, and have maintained our department's Mission and focus on experiential learning.

For the final part of the faculty hiring and integration process, the actual integration of new faculty members, we developed a mentorship program for each of our new hires. The basic model we adopted was to have a senior member of the home program serve as a primary mentor and a senior member of another program act as a secondary mentor. This plan put some extra burden on the senior members of the faculty, but we determined that it was important for all of the new faculty members to have a support team. Mentor responsibilities included visiting classes and giving feedback on teaching, ensuring new faculty members became familiar with equipment and comfortable in laboratory facilities, and helping them to understand and navigate departmental and university policies. It certainly was not a perfect system, and not all of the new members of the faculty wanted close guidance and feedback, but for the majority that did it worked out well. One other thing that helped new members of the faculty integrate into the department and university was participation in an active-learning workshop just before new faculty orientation. The workshop was offered for the first time the year we hired the first six new members of the faculty. Four of the new hires voluntarily participated in it, for which they received compensation, and they had such a positive experience that we all but require it of new hires now. The availability of the workshop was more happenstance than the result of good planning, but we do recommend having such a thing as a way to help new faculty succeed.

Transitioning Students from Engineering Technology to Engineering

We offer three key lessons for managing students during the transition from engineering technology to engineering: 1) work within your resources to maintain program quality for all of the programs, 2) work with each student to find a solution that is best for her or him, and 3) set clear standards and expectations to differentiate the engineering technology and engineering courses. We will briefly explain how we addressed each one of these.

As we mentioned above, we had to overlap the engineering and engineering technology programs, so we had to manage two years with parts of both programs existing. The 2015 graduating class was fairly simple – any students due to graduate that year who wanted to switch from engineering technology to engineering would have to wait an additional year to graduate. Given that situation, we did not encourage those students to try the new programs, and only four of them chose to do so, all in EE. The 2016 graduating class situation was more complicated. All three of our programs determined that the maximum number of senior-level students for the combined engineering and engineering technology programs that we could handle that first year was a total of 24 per area. Therefore, before letting students into the new engineering programs in the spring of 2014, all three programs had to estimate how many declared engineering technology majors would not have graduated by then and work with each student individually to determine if she or he was interested in and capable of switching to one of the new engineering programs. The number targets were set to attain an eventual graduates-to-faculty ratio of six to one for the engineering programs. This was a lower ratio than our engineering technology programs, which had targeted eight to one as an appropriate size, but it was still high for engineering programs at the time, at least according to the available ASEE data at the time [7]. It was, however, a ratio that we could justify to the University, so it became our planning target. Because the EET program had been under enrolled, managing student numbers was only a challenge for Manufacturing and Plastics programs. Both programs made a best estimate of the number of existing engineering technology students who would still be in one of the programs during the 2015-16 academic year and admitted enough new students into the engineering programs to expect to have 24 total graduates in each area for the 2015-16 academic year. In the end two students dropped out of MET and one switched from PCE to MFGE, so both programs ended up graduating 23 students instead of the targeted 24 (two of whom graduated after spring 2016), but overall it work well, and we did not push any of the areas past their intended capacities.

Working with the existing engineering technology students to determine each one's interest in and ability to switch to an engineering degree required detailed advising meeting with each one of them. We tried as much as possible to have the advising meetings during fall quarter to make sure that each student who wanted to switch from engineering technology to engineering would be able to take the extra classes without delaying her or his graduation. The big differentiator for most of the students was the extra foundational requirements in math or chemistry to allow them to take the new or modified senior level courses. In the EET program the majority of the students, nine out of fourteen, elected to switch to EE, and all of them were successful. In the MET and PET programs, for a combination of concerns about the additional requirements and time to graduation, only two or three existing students in each program elected to switch from engineering technology to engineering programs. Of those students, all but one was able to complete the required math or chemistry courses to make the transition, although one who committed to the transition a bit later than was ideal did have his graduation delayed until fall 2016 because of the additional program requirements.

Once we had a path planned out for each student, it was critical to both clarify the different expectations for similar sounding or related courses and to document that information for the eventual Program Evaluators (PEVs). We had heard anecdotally that one way for transitioning programs to get into accreditation difficulties was to not hold existing students to the new program standards, so we were determined not to fall into that trap, and documenting what we did was a significant portion of that effort. Relative to classes for the engineering technology programs, classes for the engineering programs ranged from essentially unchanged (e.g. Statics) to brand new, but inside that range were a group of classes that were very similar or appeared to be so from their titles. In some cases the solution was to simply have two completely separate sections or to not teach an optional course for one of the old or new majors. An example of the latter was our robotics courses, for we did not have the bandwidth to offer both versions, so we offered the MFGE version instead of the MET version, because it served a larger group of students. In some cases, however, the differences were more subtle but still important. For example, two of the new senior-level courses in PCE were expanded, 4 credit, versions of 3 credit courses from the PET program. They were all required courses, but we could not teach them completely separately. The solution was to have both PET and PCE students meet together for the old, shared content and for the PCE students to have an extra class meeting and extra course requirements in the form of projects and labs in order to make the additional requirements explicit. It was not an ideal solution, but it did satisfy two critical needs by maximizing use of our available resources and making the distinctions between the engineering and engineering technology versions clear to an external reviewer.

In addition to the differentiated courses, we also took care to review and approve, and to carefully record in program meeting minutes and IAC meeting minutes, those courses from the engineering technology programs that we considered to be valid for the engineering programs without additions or modifications. Finally, we also made use of a formal exception policy to document any individual deviations for any particular student for whom they were relevant. We have required students to make formal requests to get an exception from a course requirement, the relaxation of a pre-requisite, or to make a substitution for a required course for many years, and we highly recommend adopting such a process if you do not already have one. It was a valuable process to have in place for our transition from engineering technology to engineering, for the detailed records that resulted from the process were helpful when PEVs had questions about student transcripts.

Preparing for ABET EAC Program Reviews

On the subject of PEVs, we offer four key lessons for preparing for ABET EAC accreditation: 1) start early, 2) form and use a team that can work together through all of the learning and preparation steps, 3) realize that transitioning from one ABET commission to another is an opportunity to make significant improvements to your continuous improvement processes – take advantage of it, and 4) also take advantage of all that ABET has to offer to get you information and feedback. We will briefly explain how we addressed each one of these, although they are all heavily intertwined.

We had an existing outcomes assessment and continuous improvement approach. Our last ABET ETAC visit had been in fall 2012 – we had not even received the official final report for that ABET ETAC review when we started preparing for the ABET EAC visit – so the experience was fresh in our minds. Because of that, we saw the transition to engineering as an opportunity to make major improvements to our continuous improvement process, rather than just incremental ones, so we essentially redesigned it as we prepared for the ABET EAC review.

Several things were clear to us from our ABET ETAC experiences. The first was that we had never started the process of writing the Self-Study Reports (SSRs) early enough, so the moment we received the official word that we had the funding to transition our programs to engineering we began planning for ABET EAC accreditation, with the goal of determining our outcomes assessment plan as we developed our new curriculum. The second thing that we realized from our past experiences was that our approach to our outcomes assessment and continuous improvement process contributed to our starting to write too late, so we began working on a plan to implement a three-year assessment cycle. If everything regarding an ABET review were to go as hoped and expected, this would both allow us to complete two full cycles between each ABET visit and also allow us to end a cycle over a year before an ABET site visit, thus giving us more than sufficient time to write our SSRs and prepare for the site visit. This extra time is especially important for us, for WWU is on the quarter system, so our seniors complete their senior projects, the main source of our outcomes assessment data, roughly three weeks before the SSRs are due to ABET.

Since 2015-16 was the first academic year we had engineering graduates, that became year one of our three-year cycle. We wanted a sustainable continuous improvement process, but we also were developing new assessment tools – more on that below – so we decided that we would assess all eleven ABET EAC Student Learning Outcomes (SLOs) each of the first three years so that we could test and refine our tools. The plan at the time was that we would then switch to assessing three or four of the SLOs each year starting with the second three-year cycle in the 2018-19 academic year. As it turned out, ABET EAC announced the switch of SLOs from a-k to 1-7 as we were finishing our first three-year cycle, so we made the switch to SLOs 1-7 during the 2018-19 academic year as well, but we have stuck with our plan and only assessed SLOs 3 and 4 this year. Next year we will assess SLOs 5, 6, and 7, and the following year we will complete the cycle by assessing SLOs 1 and 2. We are also updating our assessment tools both for the new outcomes and to improve them based upon what we learned by using them through the first three-year cycle.

The third thing that we realized was that our Program Directors had done too much in isolation, which was related to starting to write our SSRs too late, so we organized our Department Chair and Program Directors into a leadership team and made a point of meeting regularly. This both saved us from duplicating effort and kept the Program Directors well informed as to the plans of the other programs. We did not standardize everything, for example our EE and PCE programs adopted unmodified ABET EAC SLOs a-k, while our MFGE program adopted a slightly modified version of a-k for its SLOs, but we standardized things that made sense to share and made compromises where we needed to in order to maintain some standard approaches. This allowed us to distribute some of the planning and tool development tasks among the programs rather than duplicating efforts.

The most significant and time-consuming change we made to our continuous improvement process was to switch to rubric-based assessment. Developing the rubrics ended up being a full team effort. We researched what ABET-relevant rubrics existed, but in the end made our own. We split the rubric development tasks between the engineering programs, and almost every engineering program faculty member was lead developer for one rubric. Eventually we were able to create shared assessment rubrics for SLOs a-j. SLO k is program specific, so we did have to develop unique rubrics for it for each program, but the switch to SLOs 1-7 has eliminated that problem. Our rubrics are far from perfect, and we have continued to amend them as we have used them, but they have added some ease to and improved consistency in our annual SLOs assessment and evaluation.

The fourth and final thing we realized was that we had not done enough to educate ourselves thoroughly or to develop redundant knowledge on the leadership team. We had one Program Director who had taken ABET's Fundamentals of Assessment Workshop and another who had recently become an ABET ETAC PEV, but we believed that we had relied too much on our interpretations of written documents for our ABET ETAC preparations, and we did not want to repeat that mistake. To address this last issue, we requested and received support from the Dean's Office to have the leadership team attend the ABET Symposium and to have at least some of us attend more of the ABET workshops.

The ABET Symposium occurs in April, so if a team goes to it the same year that SSRs are due, it is too late to take advantage of most of what you learn at the Symposium. By the same token, we did not feel that we had the bandwidth to attend in 2014 while we were doing all of the transition planning and hiring, so we planned to send the entire leadership team to the 2015 ABET Symposium. Due to the realities of life and other commitments, that plan did not work out as scripted. Instead we ended up having the Chair and two Program Directors attend the ABET Symposium in 2015 and the Chair and the third Program Director attend it in 2016. The Chair and one of the Program Directors took the Self-Study Report Writing Workshop in 2015 and 2016 respectively and the Chair also took the Fundamentals of Assessment Workshop. Although it was not part of our original plan, one advantage we found of sending someone to the Self-Study Report Writing Workshop in consecutive years was that the information from the first year helped us to draft our

SSRs and the Program Director who attended the second year was able to bring along a virtually complete SSR to the workshop and compare what we had drafted to the recommendations for best practice.

The ABET workshops are valuable, especially the Self-Study Report Writing Workshop, and the sessions at the ABET Symposium often contain valuable and useful information, but all of us who attended the ABET Symposium agreed that the most valuable part of it was the SSR room. For those who are not familiar with it, the SSR room is a repository of SSRs from the previous review cycle that were deemed by PEVs and Team Chairs (TCs) to have been exemplary. Symposium attendees are allowed to read the SSRs and take notes (no copies or pictures), which is a rare opportunity, since SSRs are considered to be confidential documents. All of us found the opportunity to read through well-written and thorough SSRs to be very helpful for our own SSR development. In addition to seeing well-done SSRs, the ABET workshops proved to be good places to get feedback on some of our assessment rubrics as we were developing them and starting to use them. ABET does have a number of tools and resources on line as well, but we found the opportunity to directly engage at the Symposium and Workshops to be much more valuable.

The Readiness Review Reports (RRRs) were another opportunity to get feedback from ABET that we found helpful, but not as detailed as we had hoped. RRRs are required for colleges and universities that will be working with an ABET commission for the first time, which was the case for us relative to ABET EAC. ABET will, however, waive the requirement for programs that are switching commissions, which also applied to us. While understanding that it would have saved some money to not do so, we elected to complete the RRRs. The RRRs were not very expensive, they forced us to completely draft most sections of the SSRs roughly a year before our site visit, so we had much less work to do the last year and were able to focus on the assessment and evaluation portions and editing the SSRs. The feedback from the RRRs broadly identified criterion where ABET felt either our continuous improvement process or our reporting of it needed work. The feedback was high level and only addressed criterion where the reviewer had concerns or questions, but it was helpful. The final thing that we did regarding ABET preparation was to have a retired ABET PEV come and give a mock review of our EE program. We were a bit lucky to find someone who was able and willing to do a mock review and do it at a relatively low cost, but it was very helpful feedback, so we recommend searching for someone who can do a mock visit of a program and budgeting for it as well.

Outcomes and Conclusions

The most important part of the transition process for us was making sure that our engineering programs and their continuous improvement processes met the standard for ABET EAC accreditation. Even before we had any feedback from the site visit team, we were satisfied with our preparations for our first ABET EAC review. Compared to our last three ABET ETAC visits, we were much happier with our SSRs, we were better prepared for the site visit, and everything ended up going more smoothly than things had gone in the past. Starting early and working as a team had the anticipated benefits. Although it took almost an additional year before it became official, all three engineering programs were ABET EAC accredited, and as a bonus, all three of our SSRs were selected for the SSR room at the next ABET Symposium. That honor was a nice reward for all of the members of the faculty who had contributed to the SSRs, but especially for our Program

Directors who had been lead authors for most parts of their program's SSR. We also have more confidence going forward, for another advantage of a team-based approach is that we have a much better understanding of the process and how to integrate new members onto the leadership team as Program Directors change.

Many of the outcomes that we anticipated as reasons to switch from engineering technology to engineering have come to pass. The influx of new faculty members and having a larger faculty have both been very positive changes. The engineering graduates are getting more job opportunities, and we have been attracting new corporate partners both for recruiting for internships and permanent positions and as project partners. We have also been able to increase the percentage of students working on industry-sponsored senior projects. There have also been a few positive outcomes that we did not foresee. For example, with new faculty members we have more industry-sponsored research projects occurring, and the number of students getting an industry-related directed research experience has increased dramatically. In our PCE program ~75% of students complete at least one quarter of directed research, and many complete multiple quarters of it.

One change that took us by surprise was a sudden shift in student interest. Prior to beginning the transition to engineering, the PET program was our most popular and EET was our least. When we changed to engineering programs, interest in our EE program skyrocketed and within two years we were turning away over half of the program applicants. We have managed to grow EE so that it is now has our largest program capacity, but we are still turning away many qualified students, so continuing to expand EE has become our top priority. While interest in EE was growing, interest in MFGE and PCE declined sharply to the point that we did not fill our 2018 graduating classes in either program. Once we were able to announce that we had earned ABET EAC accreditation both programs started to recover, although MFGE recovered more quickly and is attracting more students than PCE at this point, but both are once again full.

Overall the transition to engineering took a tremendous amount of effort, but for us the benefits have made it clear that it was worth the work we put in to achieve it. We have outlined what we believe are the key lessons for: 1) curricular planning and implementation, including the role of Industrial Advisory Committees (IACs) in that planning, 2) hiring large numbers of new faculty and integrating them into the experiential learning culture of the department, 3) the transition of students from the engineering technology programs to the new engineering programs, and 4) getting ready for ABET EAC accreditation. All of these are issues that must be addressed when transitioning programs from engineering technology to engineering, so we hope that our experiences and what we learned from them will serve as a helpful guide to others.

In terms of maintaining experiential learning and significant laboratory components in the transition from engineering technology to engineering, we found three things were especially critical to our success: 1) support from the university administration, 2) IAC involvement, and 3) hiring and integrating large numbers of new faculty members. The first two of these issues were relatively easy for us to address. WWU's upper administration recognized that our experiential-learning culture was integral to the programs' reputations and graduates' success, so they were also invested in maintaining it. As mentioned earlier, all three of the programs had active IACs that regularly gave input on curricular changes and valued our ability to produce industry-ready graduates, so they judged potential curricular changes with a focus on helping us maintain that characteristic, and provided important guidance and feedback along the way. The third issue, hiring and integrating large numbers of new faculty members into the department, was much more challenging. The changes we made to the required qualifications helped with both the clarification of our priorities and the filtering out of candidates who did not share those priorities. Even with such tools, however, there are no guarantees. Over the course of this transition, we doubled the size of our engineering faculty from eight to sixteen. One search failed and two of our new hires resigned during their probationary periods, so it took eleven searches to fill the eight new positions. Every search is a tremendous amount of work, but it is something that should not be rushed, for a bad hire is much harder to recover from than a failed search. It was not easy, but we learned to be patient and to fail a search if need be, because having people on the faculty who are committed to the department mission is critical to fulfilling that mission. As a result, all three of our engineering programs have faculty members that are committed to experiential learning and significant laboratory experiences, and that along with the support of our upper administration and our IACs allowed us to complete the transition from engineering technology to engineering while maintaining experiential learning.

References

[1] Jackson, A., & Horton, E. D., & Johnson, M. (2006, June), "First Time Accreditation: Lessons Learned From the ABET Accreditation Process," *Proceedings of the 2006 ASEE Annual Conference & Exposition*, Chicago, Illinois. https://peer.asee.org/1342

[2] Wear, L. L., & Baiocchi, O. R., & Alden, M., & Gutmann, R., & Sheng, J. (2012, June), "Getting ABET Accreditation Right the First Time Paper," *Proceedings of the 2012 ASEE Annual Conference & Exposition*, San Antonio, Texas. https://peer.asee.org/21425

[3] Sriraman, V., & Stapleton, W. A. (2011, June), "Lessons Learned in Implementing and Accrediting a Manufacturing Engineering Program," *Proceedings of the 2011 ASEE Annual Conference & Exposition*, Vancouver, BC. https://peer.asee.org/18275

[4] WWU Engineering and Design Department, "Mission Statement," https://cse.wwu.edu/engineering-design/assessment-and-accreditation

[5] Society of Manufacturing Engineers, "Four Pillars of Manufacturing Knowledge," https://www.sme.org/globalassets/sme.org/engage/communities/technical-communities/four-pillars-flyer.pdf

[6] Yip-Hoi, D. M., & Newcomer, J. L. (2015, June), "Conforming a New Manufacturing Engineering Curriculum to the SME Four Pillars," *Proceedings of the 2015 ASEE Annual Conference & Exposition*, Seattle, Washington. 10.18260/p.23732

[7] American Society for Engineering Education, "Engineering Ratios," *Engineering by the Numbers*, https://www.asee.org/papers-and-publications/publications/college-profiles/12EngineeringbytheNumbersPart1.pdf, p. 36, 2012