

Construction Management Curriculum Transformation through Project-Based Learning; Part 1 of a Progressive Case Study

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An established Construction Management (CM) program at Purdue University held a faculty retreat in August of 2015. The two-day meeting had one agenda item; "If the curriculum was started over, what would it look like?" Currently, students struggle to synthesize the necessary skills and knowledge learned in discipline-specific courses and to integrate all of the critical construction components, particularly if the project is ill-structured or ambiguous. They have limited training to solve vague, real-world problems they encounter on the job after graduation. The proposed solution is a complete paradigm shift to vertical and horizontal integration through project-based learning during all four years. During the 2015-16 academic year, the faculty researched this educational foundation and established a five-year transition plan. Instruction will focus on the targeted competencies and student learning outcomes desired upon graduation. The skeleton of the process is utilizing the twenty learning outcomes developed by the American Council on Construction Education (ACCE). Additionally, the team determined that assessing the process would be valuable research and provide lessons learned for other programs considering curriculum changes. This paper is the first chapter in this process outlining the inception, tentative plan, and schedule.

Key Words: curriculum, student learning outcomes, competencies, project based learning, industry engagement

Introduction

In 2014 Purdue University's Polytechnic Institute went through a strategic planning process. One of the grand challenges was to transform the curricula and focus on competencies required upon graduation. Prior to the school year the Building Construction Management department decided to devote two days off-site to target how to transform their curriculum. The retreat resulted in a plan to completely transform the curriculum rather than make modifications.

Capstone courses became examples of how to connect multiple subjects into real-world problem solving learning. Capstones are often used in engineering and technical undergraduate curricula, particularly in the senior year, as an exercise for students to apply their accumulated foundational knowledge from subject-oriented courses utilizing an authentic industry-specific problem. To solve these problems, students must integrate multiple, interdisciplinary skills and abilities. For example, in a capstone course focused on construction in the built environment, students must be able to synthesize the design intent, plan the construction process, work with a team of various construction specializations, and manage the financial aspects of the project. Students in a single capstone experience often struggle to synthesize the necessary skills and knowledge learned in discipline-specific courses to integrate all of the critical construction components, particularly if the capstone project is ill-structured or ambiguous. As a result, students have limited preparation to solve vague, complex real-world problems they encounter on the job after

graduation, hindering their transition from college to industry. Programs in polytechnic institutions such as Worcester Polytechnic Institute, California Polytechnic State University, and Virginia Polytechnic Institute have taken steps to integrate these types of capstone experiences across the curriculum. Presentation of material is in a horizontal and vertical learning approach. In these curricula, horizontal learning refers to the integration of subject-oriented courses centered on an authentic project and vertical learning focuses on distributing the subject-oriented course material throughout the entire four-year curriculum. These expanded courses are based on authentic industry projects similar to a capstone experience. Material is presented in a co-teaching course format with two to three faculty focusing on independent learning, critical thinking and how the knowledge is applied.

The Retreat "What would our curriculum look like if it started over?"

In August of 2015 the team expanded the annual one-day faculty retreat to two days. These meetings typically discuss the new year logistics similar to any CM program: teaching loads, travel, grants, policies, etc. However, the dean had been challenging each program to "think out of the box" and find ways to transform their program. The entire retreat was devoted to this charge. The faculty were broken into four groups, each tasked with what a new curriculum would look like. The rules included the following:

1. Disregard what was done in the past. Do not let legacy be a hindrance. The cliché, "If it ain't broke, don't fix it," was not allowed.
2. Do not let money or facilities be a limiting factor.
3. Focus on, "Yes, but…" comments versus, "No," or, "Won't work!"
4. Create a curriculum that is not based on our current faculty strengths and weaknesses.

After several hours of debate, brainstorming, diagrams on boards, and post-it exercises, each group reported out. One group stood out with their graphic of a new curriculum. It became clear that this proposal should be explored further. The remaining day was spent adding details by the entire faculty.
The program was currently teaching subjects in "buckets" (separate content areas) and was missing opportunities for synthesizing subjects. A deck of playing cards was used as an analogy, each card representing an approximate credit hour of instruction. All of the cards were being taught in similar suits and in order. Figure 1 highlights how the current plan of study teaches in traditional "buckets." Discussions centered on how students connect the various subjects, such as connecting the logistics plan to the schedule, and the estimate. What if the cards were shuffled? What if those core subjects were broken apart and mixed around?

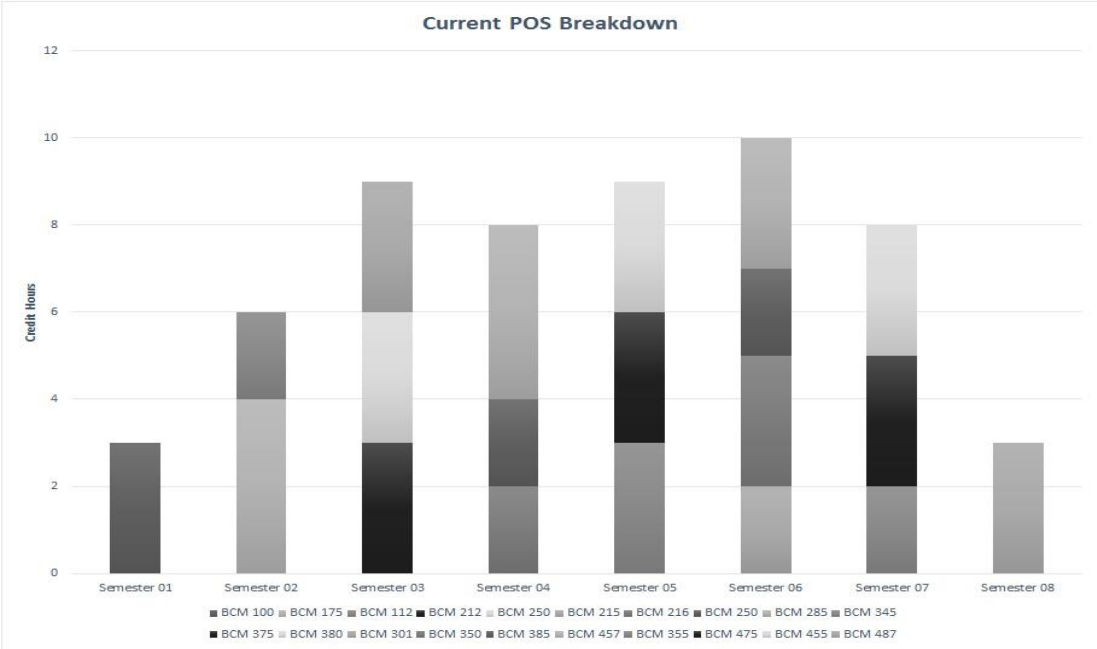


Figure 1: Current Plan of Study

The Proposed Curriculum Structure

The first day concluded with an enthusiastic dinner about this transformation. The next day was spent continuing to draft the proposed structure. See figure 2. Current literature was reviewed, and the team challenged themselves not to shy away from the difficult task ahead. Specific key points were determined:

1. One CM course per semester ranging from 3 credits to a maximum of 9 credits. Overall credit hours will remain approximately the same as the current program.
2. Each course will meet both in large group learning classes (lectures) and small group collaborations (labs).
3. There will be 8 total courses ranging from year 1-4 with an A or B designation.
4. During years 2-3, A courses will focus on traditional preconstruction competencies, and B courses will focus on traditional construction competencies.
5. Common projects will be used through each year in both A and B courses.
6. Courses will be team taught. Faculty will not be limited to one course. They will move throughout the curriculum to be exposed to all levels of students. This will allow each faculty to continue to be a subject matter expert (SME).
7. Courses will be project based requiring an extensive library of courses.
8. Projects will be compiled into four main categories: residential, heavy civil, industrial, and commercial.
9. The remaining core courses required by the university will remain the same.

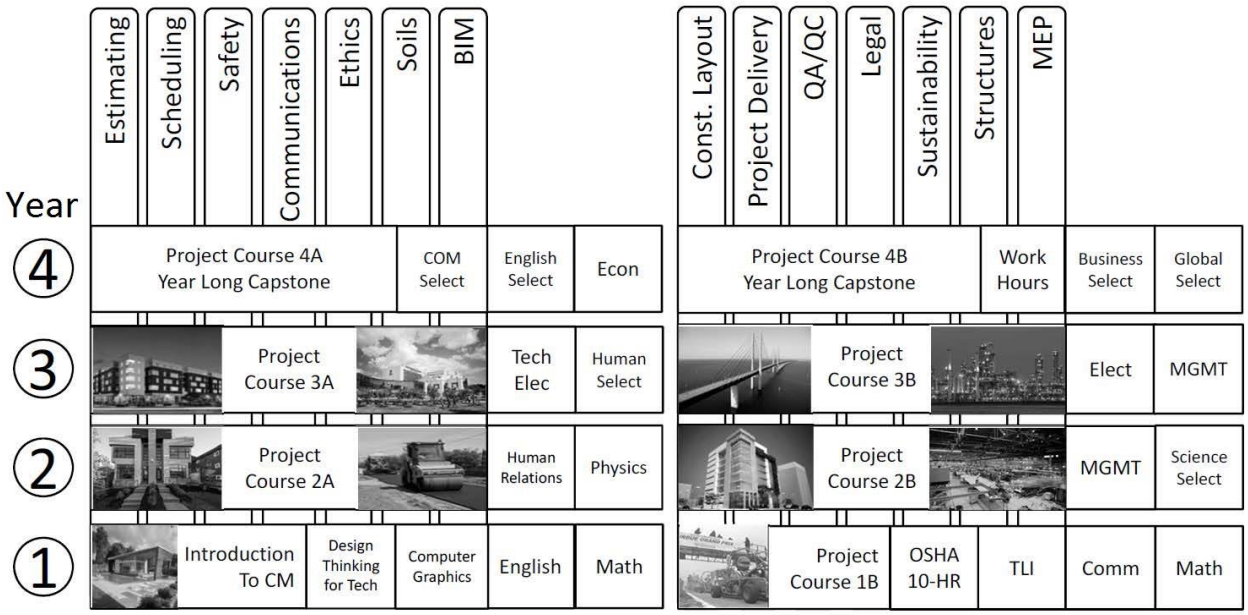


Figure 2: Visual Representation of the Overall Program

The Model

While the model continued to evolve, side conversations started about how would the curriculum be organized. It provided an opportunity to define key attributes if the program started over. These items included:

1. A common hour each day that faculty and students were not in class. This would allow for staff meetings, student organization meetings, industry presentations, and most importantly, a time for comradery.
2. A balanced schedule. Purdue University currently employs a Monday, Wednesday, Friday schedule and Tuesday and Thursday. This creates unequal time blocks and is often difficult to switch classes between schedules.
3. A day a week that was reserved for career fairs, jobsite visits, industry shows, and remedial work for students who are falling behind. While the larger credit classes have advantages, they do pose a serious threat to a student's ability to graduate if he or she falls behind. Some designated time to provide faculty mentoring will be required.

Utilizing several business school models, a four-day week was determined to be ideal. This allows for Monday and Wednesday to be equally balanced with Tuesday and Thursday. Fridays would remain for those things that often conflict with regular classes.

Literature Review

After the retreat, the team targeted other programs that have wrestled with the same thoughts. A committee was formed and began researching ideas with other institutions. The team also performed a literature review focused on project based learning.

The construction industry is ever changing and thus requires college graduates to be able to perform several tasks such as scheduling, quality control, and planning, just to name a few. In a recent survey, Ahmed, Yaris, Farooqui, &

Saqib (2014) found the following to be important skills required to optimally perform construction management tasks: "managerial, industry, business, professionalism, legal, contractual, technical, and people skills" (p. 244). There are many ways in which to gain these skills, however the ideal way to teach these skills in higher education has been evolving from traditional lecture pedagogy where students are passive receivers of knowledge to integration of project-based learning (PBL).

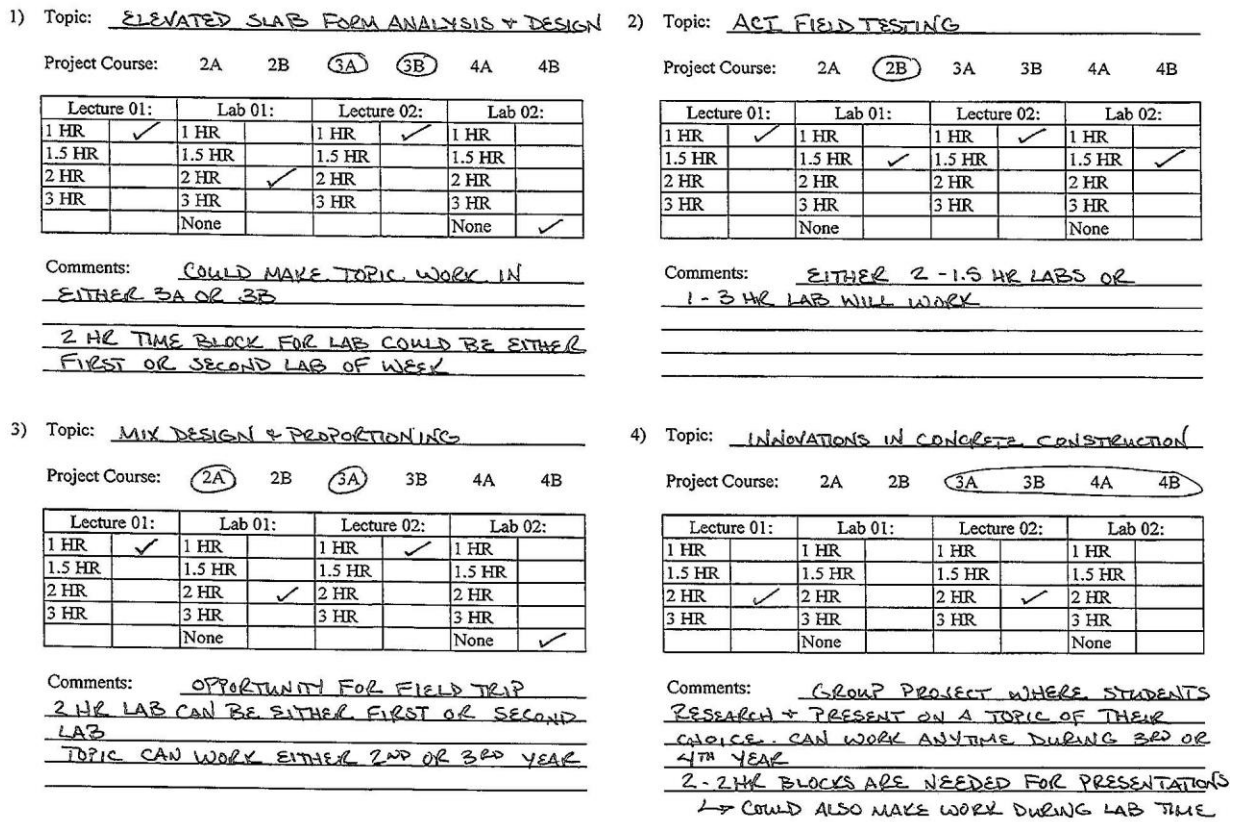
Project-based learning offers several pedagogical advantages over past instructional methods. This is especially true for construction management students where the field inherently requires successful teamwork (Gunderson & Moore, 2008). Working in groups on real-world issues has educational value as well, while working with others and gaining different perspectives, research proves that student learning increases and is more efficient (Von Kotze & Cooper, 2000; Frank, Lavy, & Elata, 2003; & Barlow, 2011; & Rau & Heyl, 2016). Additionally, Barlow (2011) states that soft skills which are typically not learned through passive learning are developed and honed through PBL. The theory of constructivism is the basis for PBL, while the spiral learning (SL) model adds to the efficacy. Constructivism suggests that people are inherently active learners who build knowledge upon past experiences and is improved through social (group) interaction (Frank et al., 2003).

Spiral learning enhances this process by introducing concepts at various points, subsequently increasing details (Jaime et al., 2016). Veladat & Mohammadi (2011) listed the goals of spiral learning as: conceptualization, creativity, teamwork, individual work, to declare thoughts and achieve a hypothesis, to acquaint with terms, to apply images, knowledge, to interpret and criticize, learning, connect unfamiliar concepts with familiar ones, feeling trust, to extend information and the capability to maintain, pre-organizer, scientific thoughts" (pp. 1118 – 1120). Further the researchers found that within two weeks of utilizing SL, student scores significantly increased. When combining PBL and SL, student performance improved even more (Jaime et al., 2016). Not only does PBL build added knowledge and skills, but students actually prefer PBL and feel that they learn and understand more while participating in these learning environments. Students felt an advantage in working with unknown individuals, being outside of their comfort zone (Gunderson & Moore, 2008). The content from real-world experiences helped to motivate students to learn and work together more effectively (Jaime et al., 2016; Frank et al., 2003; Maghiar, Sturges, Maurer, & Jackson, 2015). In a study performed by Farrow, Liu, & Tatum (2011), it was found that students prefer "teachers with industrial experience talking in the classroom; doing outside service projects, utilization of visualization, pictures, and videos; well organized field trips; conversions and open discussions in class; letting students teach; and group-teaching, etc." (p. 117). Another study by Chinowsky, Brown, Szajnman, & Realph (2006) found that students believed that they were able to communicate more effectively about their PBL experience in employment interviews, which provided an advantage over others and the employers thought the same.

Although there are several advantages to PBL, there are challenges as well. First and foremost, students typically prefer a passive learning environment that requires less effort on their part and are not familiar with an active, PBL environment (Frank et al., 2003). Groups provide their own challenges as well, such as members not participating, dominating members, pressure to accept differing ideas, and forceful conclusions (Gunderson & Moore, 2008). Finally, PBL requires more preparation time than lecturing and can therefore cause time-related stress for instructors (Chinowsky et al., 2006; Frank et al., 2003).

Identifying Learning Modules

Comfortable they were pointed in the right direction, the team spent the Fall of 2015 understanding what the parts and pieces might look like if they divided the learning into four levels with preconstruction and construction at each level. In discussions it was determined that most faculty had their courses broken in modules or sections. Most had their courses broken into the weeks of a semester. Following this lead, the faculty were asked to break their current subjects into 15 modules. This required a template. Please see Figure 3 below. This template asks for each module to be broken into ideal time blocks located where the faculty thought it would be most appropriate to teach.



1) Topic: ELEVATED SLAB FORM ANALYSIS + DESIGN

Project Course: 2A 2B (3A) (3B) 4A 4B

Lecture 01:		Lab 01:		Lecture 02:		Lab 02:	
1 HR	✓	1 HR		1 HR	✓	1 HR	
1.5 HR		1.5 HR		1.5 HR		1.5 HR	
2 HR		2 HR	✓	2 HR		2 HR	
3 HR		3 HR		3 HR		3 HR	
		None				None	✓

Comments: COULD MAKE TOPIC WORK IN EITHER 3A OR 3B

2 HR TIME BLOCK FOR LAB COULD BE EITHER FIRST OR SECOND LAB OF WEEK

2) Topic: ACI FIELD TESTING

Project Course: 2A (2B) 3A 3B 4A 4B

Lecture 01:		Lab 01:		Lecture 02:		Lab 02:	
1 HR	✓	1 HR		1 HR	✓	1 HR	
1.5 HR		1.5 HR	✓	1.5 HR		1.5 HR	✓
2 HR		2 HR		2 HR		2 HR	
3 HR		3 HR		3 HR		3 HR	
		None				None	

Comments: EITHER 2 - 1.5 HR LABS OR 1 - 3 HR LAB WILL WORK

3) Topic: MIX DESIGN + PROPORTIONING

Project Course: (2A) 2B (3A) 3B 4A 4B

Lecture 01:		Lab 01:		Lecture 02:		Lab 02:	
1 HR	✓	1 HR		1 HR	✓	1 HR	
1.5 HR		1.5 HR		1.5 HR		1.5 HR	
2 HR		2 HR	✓	2 HR		2 HR	
3 HR		3 HR		3 HR		3 HR	
		None				None	✓

Comments: OPPORTUNITY FOR FIELD TRIP
2 HR LAB CAN BE EITHER FIRST OR SECOND LAB
TOPIC CAN WORK EITHER 2ND OR 3RD YEAR

4) Topic: INNOVATIONS IN CONCRETE CONSTRUCTION

Project Course: 2A 2B (3A 3B 4A 4B)

Lecture 01:		Lab 01:		Lecture 02:		Lab 02:	
1 HR		1 HR		1 HR		1 HR	
1.5 HR		1.5 HR		1.5 HR		1.5 HR	
2 HR	✓	2 HR		2 HR	✓	2 HR	
3 HR		3 HR		3 HR		3 HR	
		None				None	

Comments: GROUP PROJECT WHERE STUDENTS RESEARCH + PRESENT ON A TOPIC OF THEIR CHOICE. CAN WORK ANYTIME DURING 3RD OR 4TH YEAR
2 - 2HR BLOCKS ARE NEEDED FOR PRESENTATIONS
↳ COULD ALSO MAKE WORK DURING LAB TIME

Figure 3: Course Module Breakdown Example

Upon collection of the course breakdowns, they were consolidated into the model in Figure 4. This model shows how the modules were distributed over the 4 years. The team was surprised that the initial distribution was close to matching the proposed credit hour structure. Asking faculty to provide multiple options assisted the team in leveling the modules.

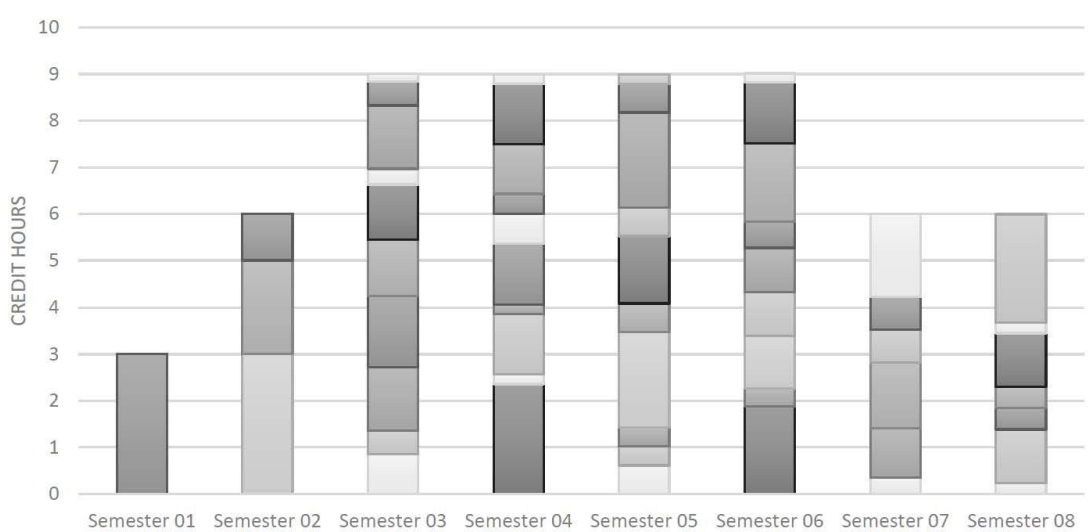


Figure 4: Revised Distribution of CM Modules

The Library

The current curriculum includes many examples of real projects. They include the drawings and specifications. The most useful projects include the project files: estimates, bids, and applications for payments, RFIs, and any other related documents. Unfortunately, attaining the project files is often difficult due to privacy issues.

During brainstorming, faculty agreed that a cloud based library of complete project files would be a necessary tool with the new emphasis on project based learning. These projects would need to be progressively more complicated as the students progress through the curriculum. It would also need a full breath of the types of projects. The curriculum and project focus on four major areas: residential, commercial, heavy civil, and industrial. The team decided to take this idea to their Industry Advisory Board (IAB).

During the Spring 2016 IAB meeting, the proposed library was discussed. Members were excited and willing to volunteer projects. Several requests were made by the group:

1. The Building Construction Management would need to come to the construction company offices to collect the material.
2. The materials would need to be redacted and approved by each company prior to being uploaded to the library.
3. The IAB recommended that the BCM program hire a designated person to build and manage the library.
4. Sixteen complete projects were set as the initial target with the hope for a much larger library over time.

Assessment

Although some universities have implemented horizontal and vertical learning on a small scale, the use of consistently integrated project-based learning across a complete bachelor's degree curriculum has not been instituted on a large scale. As a result, limited empirical evidence is available to assess the effectiveness of this approach. The transformation team is working with the College of Education to design a validated assessment system to test the effectiveness of a comprehensive horizontal and vertical, integrated project-based curriculum in the field of construction management. The 2016-17 academic year is focusing on this assessment while the current program is available for analysis. Future studies will be provided.

Transformation Schedule

The faculty is cautiously excited about the transformation. The plan has been outlined at all levels including the university's Board of Trustees. Administration, alumni, and the IAB all support the project. Funding has been provided for the library coordinator position, which will start in January of 2017.

Additionally, faculty are being asked to partner with colleagues to team teach and "dovetail" current courses. In Spring of 2016 proposals were reviewed and participating faculty were provided summer funding to prepare connected learning modules and a plan to team teach two or more courses. Faculty are required to provide a follow up report on lessons learned that can be utilized moving forward. New learning modules will also be transferable to the new curriculum.

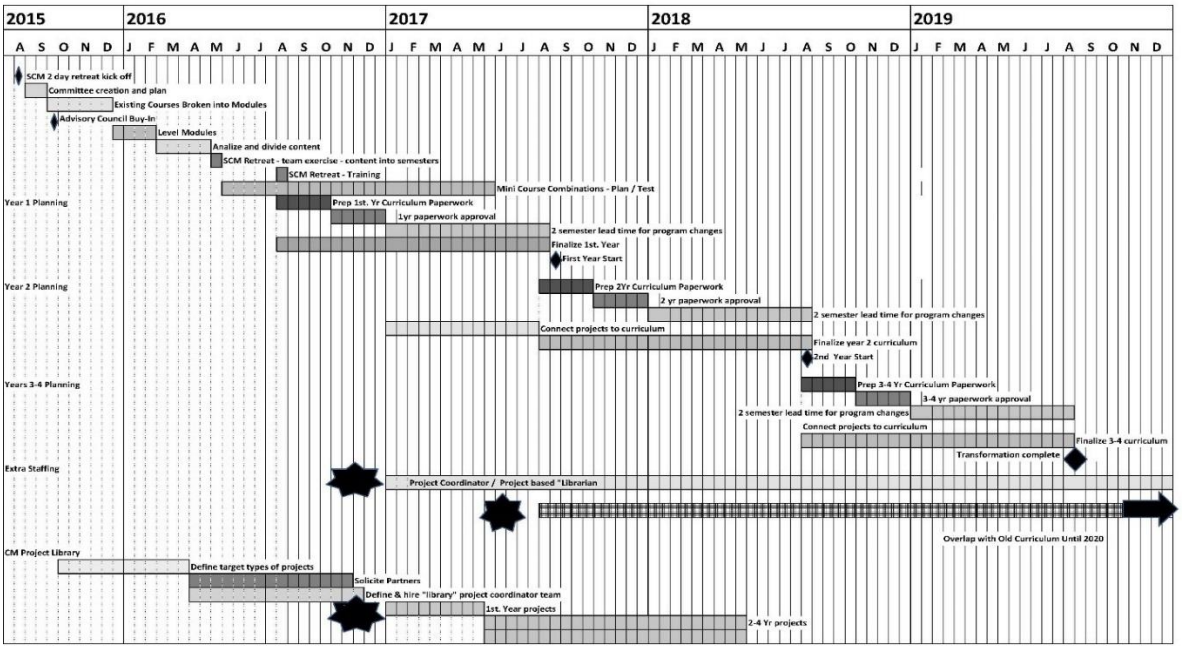


Figure 5: Transformation Schedule

Lessons Learned to Date

While this paper focuses on the positive, there have been stumbling blocks along the way:

1. It can be difficult to get faculty to consider changing a program that "isn't broken."
2. The majority of faculty have been committed to the new process, but several have expressed concern.
3. Some faculty welcome others into their classrooms to collaborate; others want to be more isolated.
4. This new model will require a much higher level of communication between instructors.
5. The approvals required for a complete curriculum change have been time consuming and cumbersome.
6. The faculty have to collaborate with other university offices (registrar, provost, and facilities) to make such a massive change.
7. The alumni and IAB are excited about the process, but don't understand the lead times required.
8. The large credit hour classes will make it unlikely to transfer current students into the new curriculum. During the transition the BCM program will have to deliver 2 programs.
9. The overlap of the old and new will require additional resources for delivery. This will include adjunct professors and additional graduate students.
10. New collaborative classrooms are in high demand with the university.

Next Steps

The 2016-17 academic year is committed to planning and preparation. An expression has been used recently, "We are putting the meat on the bones." Our to-do and concern list includes:

1. How will the old and new program be assessed to know it is making a difference?
2. How to plan the next accreditation from ACCE?
3. How to staff the overlap of the new and old? This will be a challenge in 2018-2020.
4. What training needs to be provided to faculty to prepare for the changes?
5. Even in the new structure, how are faculty kept from not continuing to teach in singular perspectives?

The BCM program is thankful for the scholarly work of others who have done similar transformations. The planning committee is keeping records, schedules, and supporting materials for sharing and research. There will be further papers on the progress, implementation, and assessment of this curriculum transformation.

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