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Lessons Learned from the First Round of Course Assessments After Curriculum Restructure Based on ASCE BOK2

Dr. Kelly Brumbelow, Texas A&M University

Dr. Kelly Brumbelow is an Associate Professor and the Assistant Department Head for Undergraduate Programs in the Zachry Department of Civil Engineering at Texas A&M University. He has been a faculty member at Texas A&M since 2002, where his technical specialty is water resources engineering, planning, and management. Prior to this position, he completed his undergraduate and graduate studies at Georgia Tech, where he taught undergraduate courses for 7 years. His professional activities have included projects in East Africa, Central America, the Middle East, Alaska's North Slope, and throughout the "lower 48 states." His current activities at Texas A&M cover a wide spectrum from K-12 outreach and recruiting to undergraduate curriculum design to retention, monitoring, and post-graduation engagement.

Dr. Luciana R. Barroso, Texas A&M University

Luciana R. Barroso, Ph.D., is an Associate Professor of Structural Engineering in the Department of Civil Engineering, in the Dwight Look College of Engineering at Texas A&M University. Luciana has been with Texas A&M University since 1999, and in that time has taught 15 different courses ranging from the freshman to graduate levels. She has been active in academic program and curriculum development from the department level to the university level, where she served as co-chair of the Quality Enhancement Plan (QEP) committee that determined the academic course of actions to be taken over the next accreditation cycle to addresses critical issues related to enhancing student learning. She is currently the Director of Undergraduate Programs and chair of the Curriculum Assessment and Implementation Team committee. She also has been involved in several professional developments that were provided by the Aggie STEM Center to Texas ISD teachers. Her research interests include structural health monitoring and control, structural dynamics, earthquake engineering, and engineering education.

Dr. Debra Fowler, Texas A&M University

Dr. Debra Fowler serves as the Director of the Center for Teaching Excellence at Texas A&M University. Following 16 years working in industry she completed a Ph.D. is in Interdisciplinary Engineering with a specific focus on engineering education from Texas A&M University. Her research areas of focus are faculty perspectives and growth through curriculum design and redesign, interdisciplinary teaching and learning, reflective eportfolios and professional development of graduate students related to teaching.

Dr. James Michael Kaihatu, Texas A&M University

Associate Professor of Civil Engineering at Texas A&M University; at Texas A&M since 2006. Prior employment experience includes: Oceanographer for US Naval Research Laboratory (1995-2006), Post-Doctoral Fellow at US Naval Research Laboratory (1994-1995), Hydraulic Engineer at US Waterways Experiment Station, US Army Corps of Engineers (1987-1989). Ph.D. from University of Delaware (1994), M.S. from University of California, Berkeley (1987), B.S. from California State Polytechnic University (1986), all in Civil Engineering. Research interests include theory and modeling of ocean wave dynamics, beach erosion, coastal engineering, nearshore circulation, and ocean wave generation by wind.

Miss Veronica S. Rodriguez Chavarria

Veronica S. Rodriguez Chavarria is a graduate assistant for the Zachry Department of Civil Engineering at Texas A&M University. She assisted the curriculum assessment and implementation team with data gathering and logistical coordination. She is in the process of receiving an M.E. in Civil Engineering from Texas A&M University.

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Abstract

Texas A&M University's civil engineering department undertook a curriculum project based on concerns of conceptual gaps and redundancies in the degree program and a desire to holistically incorporate the outcomes from the American Society of Civil Engineer's (ASCE) Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future, 2nd Edition (BOK2). The process resulted in a comprehensive curriculum map, where each program learning outcome is explicitly connected to courses in the curriculum at one of three levels: "I" for when outcome is first introduced, "R" when outcome is being reinforced, and "D" when outcome is demonstrated and subject to a summative assessment. Based on the identified course program learning outcomes, individual course worksheets were developed to identify what student work-products, such as homework assignments or exams, would be collected to assess each outcome. This paper will discuss the assessment process used for the curriculum as a whole and for individual courses (including its place in the ABET continuous improvement criterion), the specific lessons learned after the first 3 years of implementation, the changes to be made for the next 3 year cycle, and conclusions on how these experiences may be transferred to other programs. A mixed-methods approach is used to evaluate this first cycle of implementation and assessment, include comparing expected vs. actual/measured: (a) courses evaluated in a given semester; (b) student artifacts; and (c) program learning outcomes.

Introduction and Background

During the period 2013-14 and 2014-15 academic years, Texas A&M University's civil engineering department undertook a curriculum transformation project base its program learning outcomes on the ASCE Body of Knowledge 2 (BOK2)[1]. This process, with the roots on the ASCE Body of Knowledge 2, inherently included an emphasis to move beyond "what courses does a civil engineering major take" to "what can a civil engineering student major *do*" and what skills are needed to carry out these tasks [2]. This project also aimed to address gaps and redundancies in the curriculum, to ensure consistent student development in learning outcomes, and to engage faculty in holistic thought on the curriculum through tools such as curriculum mapping and learning outcome rubrics.

The *curriculum map* (see appendix) identifies the required courses in the program and the corresponding program learning outcomes as part of the grid [2]. The grid can also identify whether the learning outcome is first being introduced, "I", whether it is being reinforced through additional practice or being drilled at deeper learning levels, "R", or when students are expected to fully understand and be able to demonstrate mastery of the learning outcome, "D". The map is helpful for ensuring that students are given sufficient opportunity to practice and master a learning outcome, and also for a program to identify appropriate opportunities for assessment. Such mappings may help identify gaps in the program (is the curriculum offering the opportunities claimed?) as well as providing a way to track proposed student learning growth.

The learning outcome rubric divides the outcomes into specific sub-components. The rubric provides predetermined criteria and expectations for each learning outcome. The expectation levels correspond to different depths of student learning and provide a link to mastery level expected for a particular course (i.e.: whether it should be at the “I”, “R”, or “D” level) [3]. This project was described in a previous ASEE conference paper, which was presented immediately before the implementation phase of the curriculum transformation effort [4].

This paper will present lessons learned from implementation of the transformed curriculum after the first 3 years, which was undertaken by the Curriculum Assessment and Implementation Team (CAIT). The assessment process developed by the CAIT included the overarching curriculum assessment as well as the individual course assessments. CAIT is responsible for coordinating and overseeing the program implementation and assessment.

This point in time is significant as it is the midpoint of the first complete cycle of evaluation of all undergraduate courses. Much insight has been gained in this first cycle that should be useful for other programs wishing to implement this type of systematic curriculum re-structuring and continuous evaluation process. While this particular civil engineering program is extremely large – more than 70 faculty and more than 200 B.S graduates per year – the lessons learned are applicable to any program.

Course Assessment Process

The first step in the development of the course assessment was the determination that each course would need a mechanism to: 1) track the program learning outcomes (PLOs) specific to that course, 2) identify what student learning artifacts would be used to assess a PLO, such as homework assignment or project, and 3) to what depth of mastery was that PLO required within the course (“I”, “R” or “D”). To this end, course development worksheets were created that included the learning outcome information as well as basic information about the course, such as benefits of taking the course and required pre-requisites. As the worksheet was also to be used for course improvement and refinement, the worksheets also documented the different student-centered high-impact learning strategies that would be expected to be incorporated into the course.

The course development worksheets were developed in different ways (see Appendix B). The original plan was for two CAIT members to meet and develop the course development worksheet together for one course. However, this was not always possible due to scheduling conflicts or lack of familiarity of enough CAIT members to substantively contribute to the worksheet development. Sometimes one member would develop the course development worksheet and the other member would look for any issues with the CDW. However, even this approach was not always fully successful, as occasionally none of the CAIT members had taught a specific course in the past 5 years if ever. This led to a disparity in the accuracy and level of detail in the initial course development worksheets.

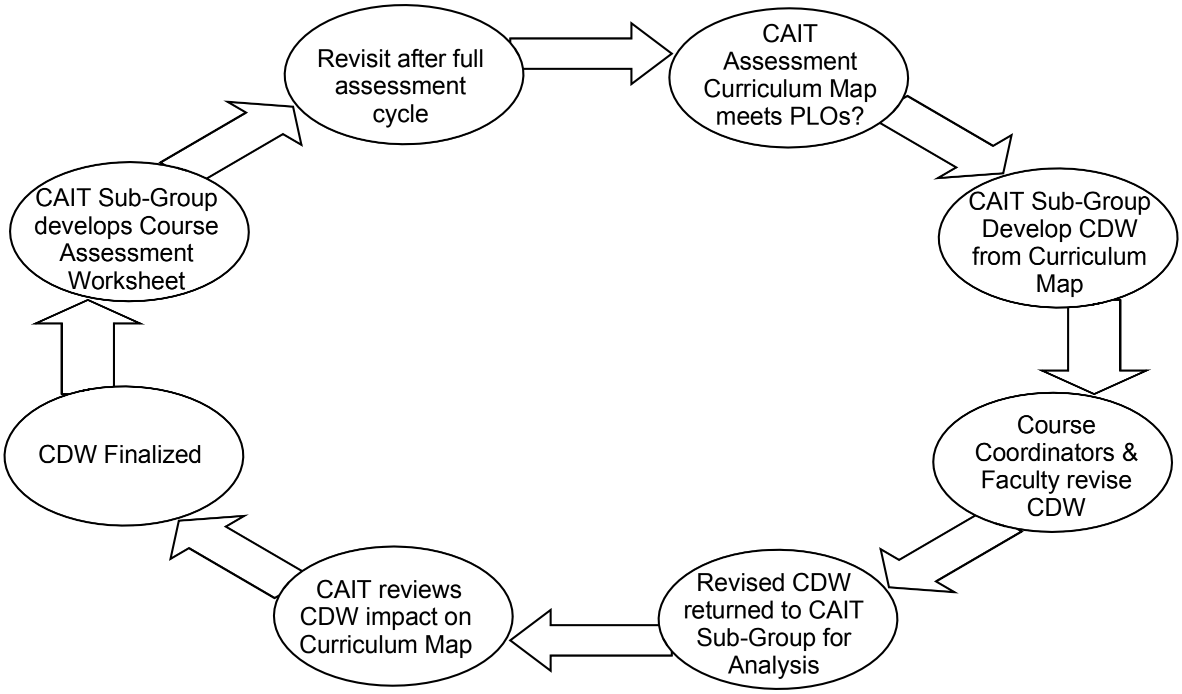

Figure 4. Course Development Worksheet Development (after a full assessment cycle)

In order to the partially address this issue as well as integrate more of the faculty into the process, the course coordinators were asked to edit the course development worksheet to ensure they covered the current Program Learning Outcomes as well as the material the course should cover. While this enhanced the course assessment worksheets, there were still consistency problems. The course coordinators do not have to teach the class that they coordinate regularly and for multi-section courses the variability in implementation can be significant, as each faculty member slowly customizes a course. Therefore, the course coordinators needed to contact the professors that taught the class for input, which didn't always happen. This led to inaccurate data being used in some of the course development worksheets during the initial cycle and has had to be amended during the assessment process.

The course development worksheets along with the course assessment documents are used at the Course Assessment Meetings to assess the courses on the cycle for that time period (see Appendix C). The course assessment documents are a compacted version of the course development worksheets to facilitate the assessment of the program learning outcomes. The course feedback is compiled and provided to the course coordinators. As part of this cycle, the amended course development worksheets are given to the course coordinators who then can work with the instruction team for a course to address potential issues.

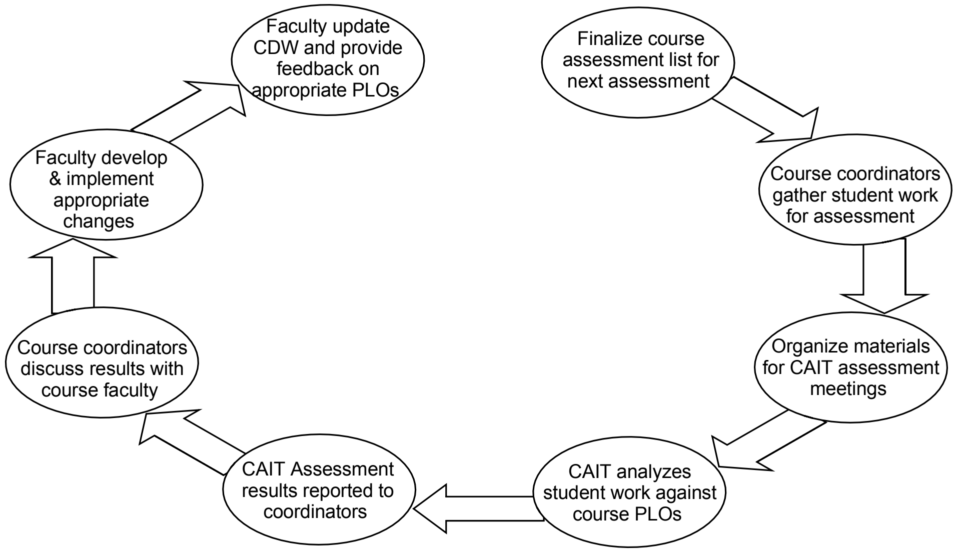

Figure 5. Subsequent Cycle Assessment Process Flow Chart

Curriculum Assessment Process

A three-year assessment cycle and rotation was determined by the CAIT members in order to assess all the undergraduate course offerings. The committee tried to plan the assessment of the courses according to their required undergraduate classification enrollment. However, the assessment cycle has had to be modified due to courses not being taught at certain times, and therefore, lack of course artifacts to assess the course. The committee has also used ABET material when there is no way of moving the course to another assessment period. Tables 1 and 2 compare the original assessment cycle plans against the actual assessment cycle for the current and past years of the process. Notice that the further we progress from the initial planning stage, the greater the number of changes.

Table 1: Comparison of course assessment for Year 1 – Original vs. Implemented Plans

Year	Term	Original Plan		Implemented Plan	
		Course	Required Artifacts	Course	Required Artifacts
1	Fall	207	Reflection, Quizzes	207	Reflection, Quizzes
		221	Homework, Exams	221	Homework, Exams
		250	Homework, Projects	250	Homework, Projects
		302	Homework, Exams	302	Homework, Exams
		303	Homework, Exams	303	Homework, Exams
		306	Homework, Labs, Exams	306	Homework, Labs, Exams
		311	Homework, Exams	311	Homework, Exams
	Spring	301	Homework, Exams	301	Homework, Exams
		305	Homework, Exams	305	Homework, Exams
		307	Homework, Exams, Projects	307	Homework, Exams, Projects
		322	Homework, Exams	322	Homework, Exams
		339	Homework, Exams, Projects	339	Homework, Exams, Projects
		342	Homework, Labs, Exams	342	Homework, Labs, Exams
		363	Homework, Exams	363	Homework, Exams

Table 2: Comparison of course assessment for Year 2 – Original vs. Implemented Plans

Year	Term	Original Plan		Implemented Plan	
		Course	Required Artifacts	Course	Required Artifacts
2	Fall	315	Homework, Exams, Projects	343	Homework, Labs, Exams
		343	Homework, Exams, Projects	345	Homework, Exams, Projects
		345	Homework, Exams, Projects	349	Homework, Exams
		349	Homework, Exams	365	Homework, Labs, Exams
		365	Homework, Labs, Exams	402	Homework, Exams, Projects
		399	Report	424	Memos, Exams, Presentations
		424	Memos, Exams, Presentations	458	Homework, Exams, Projects
	Spring	402	Homework, Exams	403	Homework, Exams, Projects
		403	Homework, Exams, Projects	405	Homework, Exams
		405	Homework, Exams	423	Homework, Exams
		413	Homework, Exams	435	Homework, Exams
		417	Homework, Exams	446	Homework, Exams
		418	Homework, Exams	457	Homework, Exams, Projects
		423	Homework, Exams	463	Homework, Exams, Projects

Table 3: Curriculum Assessment and Implementation Team Subsequent Cycle Procedures

	Timeframe	Members Involved	Action
Subsequent Cycles (per Semester)	***Previous Subsequent Cycle***	*CAIT, Faculty*	*CAIT asks faculty to collect and store chosen student artifacts from Fall and Spring semesters. Faculty teaching courses where those artifacts are created are responsible for collecting those items from students and placing them in clearly labeled folders on the shared drive.*
	Beginning of Current Subsequent Cycle	*CAIT*	*CAIT meets and following established Committee procedures evaluates stored student artifacts using the program learning outcomes rubrics.*
	Middle of Current Subsequent Cycle	*CAIT*	*CAIT analyzes data and identifies areas of improvement. CAIT also communicates with faculty and provides preliminary overview of results. Analyzed data is always from the previous semester.*
	End of Current Subsequent Cycle	*CAIT, Faculty*	*CAIT meets/communicates with faculty either as a group or individually to discuss the data, results, areas of improvement, and possible solutions.*
	End of Subsequent Cycle (Near the end of the semester.)	*CAIT, College of Engineering Communications office, College Website Administrator*	*CAIT makes a decision on areas of improvement and proposed solutions and disseminates—with the help of the College communications office—the information to the intended audience(s).*

The course assessment documents (CAD) were formulated from the course development worksheets. This is a document that is specific for each course that has all the pertinent information regarding the program learning objectives that were determined by the CAIT committee to be covered in that course. At the course assessment meetings, the artifacts are presented to the committee together with the assessment documents. The committee has the course development worksheets, the course assessment documents, the program learning outcomes, and the student artifacts presented to them in a binder. The course curriculum map is displayed in the room. Then, the committee goes through the provided artifacts to assess the program learning outcomes designated to that particular course and note any comments or thoughts they think are relevant. The assessment is documented on the assessment document. During each meeting, an average of three to four courses are assessed.

The Curriculum Map is displayed to the assessment team during the entirety of the assessment process. At the end of each set of course assessments, the team quickly reviews the impact of the PLO assessment to see if modifications need to be made in order to ensure all PLOs are being adequately addressed. The group discusses the actual results and the projected results of the courses to try to reach a solution. Table 4 summarizes some of the results from the assessment cycle for the current and past year of the process, including the number of students from whom artifacts were assessed, the number of course PLOs that were satisfied to the desired level, and the number of PLOs that were not satisfied to the desired level. Frequently, when PLOs were not satisfied, they were either satisfied at a lower level or a different PLO was being addressed than initially thought. This result has been connected to the challenges in developing the initial course development worksheets and so these are being refined with every course assessment.

The Curriculum Assessment has now reached the midpoint of the full curriculum assessment cycle. This means that the CAIT committee will revisit the curriculum map with the actual assessment outcome information and the feedback forms to determine ways to improve outcome results, reduce knowledge gaps, and edit the PLO's for the courses if necessary. There are also outside forces driving the Curriculum to change which will change the courses that the PLOs will be met in, and how they will be met. An outside force could be anything from the course not being taught that semester to not having the student artifacts to assess the course. Another outside force would be the university-wide assessment of the degree plans.

Specific Lessons Learned

Difficulty and Resource Needs

The assessment process at both the curriculum and course level has an appreciable degree of difficulty and needed resources. Undertaking this type of process requires significant commitment by faculty and department administration. The members of the CAIT attend about 3 assessment meetings per semester that each last 1.5 to 2 hours. All department faculty archive student work artifacts on a continuous basis (not just immediately before the next ABET visit). Course coordinators must collect student work, receive and reflect on assessment results, and work with faculty across multiple sections to implement assessment results and harmonize instruction.

Table 4: Comparison of course assessment for Year 2 – Original vs. Implemented Plans

Year	Term	Course	Artifacts	No. Different Artifact Types	Number of PLOs Met	Number of PLOs Not Met
1	Fall	207	Reflection, Quizzes	5	12	0
		221	Homework, Exams	3	3	3
		250	Homework, Projects	3	4	3
		302	Homework, Exams	2	2	1
		303	Homework, Exams	3	1	3
		306	Homework, Labs, Exams	3	4	5
		311	Homework, Exams	3	4	4
	Spring	301	Homework, Exams	3	3	0
		305	Homework, Exams	3	3	5
		307	Homework, Exams, Projects	3	2	5
		322	Homework, Exams	3	4	1
		339	Homework, Exams, Projects	3	5	2
		342	Homework, Labs, Exams	3	7	2
		363	Homework, Exams	3	3	6
2	Fall	343	Homework, Labs, Exams	2	4	6
		345	Homework, Exams, Projects	9	5	4
		349	Homework, Exams	2	3	1
		365	Homework, Labs, Exams	8	5	4
		402	Homework, Exams, Projects	3	9	2
		424	Memo's, Exams, Presentations	10	11	3
		458	Homework, Exams, Projects	3	9	4
	Spring	403	Homework, Exams, Projects	4	5	2
		405	Homework, Exams	9	4	1
		423	Homework, Exams	2	2	4
		435	Homework, Exams	2	2	3
		446	Homework, Exams	17	4	1
		457	Homework, Exams, Projects	7	3	3
		463	Homework, Exams, Projects	11	5	2

An important tool for easing the difficulty of the process is the department's hiring of a graduate research assistant exclusively devoted to the CAIT and its needs. Students in this position perform the work of gathering and organizing student work, planning meeting logistics, archiving and helping to disseminate assessment reports, and similar tasks. The department originally hired a graduate assistant during the original curriculum transformation process, and it has continuously maintained the position since. Students in this position have typically been masters students who completed their baccalaureate degrees within the department, making them familiar with the curriculum and faculty.

The resource-intensive nature of this assessment process also requires well-organized and timely communication strategies. Collection of student work artifacts, presence of key faculty, meeting schedules, and other necessities often require preparation up to a year in advance. E.g., if a course is only taught once every 2 years, it will be completely missed in a 3 year assessment cycle if student work is not collected on time. CAIT leadership must work with the dedicated graduate assistant on a long-term communication plan and strategy and be persistent in getting acknowledgements from faculty with many demands on their attention.

Assembling the Team

In a department of many faculty, it is not practical to involve everyone in the full effort of this process. Yet, the process targets the entire undergraduate curriculum and all its individual component courses, and the role and participation of non-team members requires careful consideration. While transparency is crucial and all meetings are open to any wishing to attend, respect for faculty time means that assessment meetings are "mandatory" only for CAIT members. Special meetings are called often for targeted needs, usually at the course level. Most of these have involved the coordinator for a specific course, other faculty who teach the course, and CAIT leadership. These meetings include back-and-forth discussion about the findings of assessment (e.g., a course does not include documented assessment on a mapped learning outcome) and constructive dialogue on how to improve teaching and learning.

A key philosophy of the implementation phase has been to identify positive incentives for faculty to participate. Inertia and perceptions of institutional priorities can diminish enthusiasm and participation, so CAIT leadership focus on concrete gains for faculty participation. As examples, the "recovered time" and ability to share teaching resources mentioned immediately above have been very popular.

A critical component to effectively and efficiently performing the assessment is choosing the right persons to contribute to the development of the course development worksheets and the curriculum map. In a large department where multiple sections of a course are offered during academic year, multiple faculty teach each course and there is variation in how sections are taught and in specific assignments that can grow with time. So while a subset of instructors might feel a learning outcome is being addressed in the course, a different subset of instructors might not incorporate that PLO in a meaningful way (e.g. teamwork).

Ideally, several sub-sets of instructors should be involved in the course development worksheets. They should represent the instructors of the course, instructors of pre-requisite coursework, as well as instructors of follow-on courses. The course instructors bring their familiarity with the current course content and student performance in the learning outcomes for the course. Instructors of pre-requisite courses know what students leaving their courses should know, and by becoming more familiar with follow on courses can enhance the transition and connection between the courses. Similarly, instructors of follow-on courses provide insight on what will be needed in the next stage of the learning process. Iterative cycles through the different groups helps refine all the individual courses as well as enhancing their connection and how students transition to deeper levels of learning. This then allows for refinement of the overall curriculum map.

Impact on Courses, Teaching, and Faculty Knowledge

One of the benefits of the ongoing process by the CAIT is the enhanced understanding by the faculty of how the curriculum, and its different options due to the specialization tracks, fits together and addresses both topical knowledge and skills. This is a continuation of the trends observed during the initial transformation process with the curriculum mapping and development of the program learning outcomes. A separate assessment external to the department has documented this impact [5]. A quote from the interview they performed clearly illustrates that:

> "We're a large faculty, we have a very broad curriculum that has all these different specialty paths that people can follow and it's very easy to fall into a trap of really all I care about is my particular specialty area. I think that I feel greater ownership over the whole thing"

The curriculum map (illustrated in the Appendix) provides a clear indication of where things fit and what learning outcomes (beyond content knowledge) need to be woven through a student's academic experience. This allows for better understanding of whether it is the first time the students are seeing something or whether they need to be pushed to deeper learning levels of learning in this area. This is particularly useful for learning outcomes that cross traditional tracks such as concepts and skills that are being addressed in environmental engineering track that also apply to the structural engineering track.

The CAIT has fulfilled the hopes of the original curriculum transformation process of improving courses and teaching in several ways. An explicit goal of the transformation was to eliminate curricular redundancies (elements of knowledge and skills repeated in multiple courses) and gaps (elements needed in later courses not being taught in preceding ones), as well as needed curriculum innovation. Some of these are summarized in Table 5 with changes in bold. By formalizing examination of course content, these redundancies and gaps have been identified. Doing so has typically led to "recovered time" each semester for instructors as they no longer spend time on redundant material, and they also know with confidence that they are not teaching past students' preparation.

An emerging set of tools is being developed in this effort. Readiness quizzes (i.e., taken at the start of a semester to gauge pre-requisite knowledge) have been written for many topics within the learning management system used on campus, and theses quizzes and individual questions are shared among faculty. Corresponding to the quiz topics are refresher resources (e.g., short videos, handouts, reading assignments) that students can consult on areas diagnosed by the quizzes as weaknesses.

This enhanced understanding has clear impact on streamlining the assessments of student learning in an individual course. With clear outcomes for the course, which include content knowledge, an instructor can focus on determining how well students actually perform on the specific target outcomes for the course. In developing assessments, whether homework assignments, projects, or exams, the instructor can then focus on whether the right questions are being asked and work is being assigned to achieve the learning outcomes at the depth required. It also ensures that there is a balance and motivation for student assessment and emphasizes the need to ensure students know why they are learning the content presented and the skills being used. For example, if development of teamwork or communication skills is a learning outcome, faculty are more aware of the need to explain their importance to engineering and incorporating those components in the grade of the course makes sense to both the instructors and the students.

Table 5. Current Curriculum Changes

Course	Current	Proposed Change
CVEN 345	Functions of structure, design loads, reactions and force systems; analysis of statically determinate structures including beams, trusses and arches; energy methods of determining deflections of structures; influence lines and criteria for moving loads; analysis of statically indeterminate structures including continuous beams and frames	Determination of internal forces for determinate systems is taught in two different pre-requisite courses (Statics and Mechanics of Materials). The course was restructured to remove explicit coverage of those topics, with review resources made available. The additional time was incorporated into further depth of existing topics, such as the analysis of framed with mixed member types (both bars and beams) as well as a course project to analyze a full framed structure using commercial software for structural analysis.
CVEN 322	Economic analysis and evaluation of engineering projects; application of systems analysis to civil engineering design; systems synthesis and optimization techniques; assignments apply engineering economics, statistical methods and optimization techniques to civil engineering problems.	Fundamentals of engineering economics; economic analysis and evaluation of engineering projects. Application of systems analysis to civil engineering problems: optimization modeling, **solution techniques and simulation analysis.** <u>Prerequisite:</u> STAT 211 or registration therein
CVEN 399	None	**(New course)** Participation in an approved high-impact learning practice; reflection on professional outcomes from civil engineering body of knowledge; documentation of experience appropriate to eventual professional licensure; self-assessment of learning at mid-curriculum point. High impact activities include internships, study abroad, undergraduate research, and participation in Engineers Without Borders.
CVEN 445	"Analysis of framed structures using linear algebra concepts; matrix algebra and solution of linear algebraic equations; energy principles and virtual work; stiffness; coordinate transformations; use of commercial software for structural analysis."	Analysis of curriculum demonstrated a need for greater application of programming skills learned in earlier courses. So course was modified so that students would be required to implement the direct stiffness method. This also allowed exploration of advanced topics, such as dynamic analysis Analysis of framed structures by the direct stiffness method using linear algebra concepts; matrix algebra and solution of linear algebraic equations; derivation of element stiffness; and **the computer implementation of the direct stiffness method for structural analysis.**

Next Cycle: Future Steps

Enhanced Communication and Iterative Refinement

One of the key action items in future assessment cycles is the enhancement of communication between the assessment team and the faculty teaching the courses. At the beginning of the semester prior to a course being assessed, course coordinators will not only be notified of the upcoming assessment but also given copies of the current course development worksheet and the assessment worksheet for their course. This will not only allow for the timely collection of student artifacts, but also allow the course coordinator to discuss and evaluate with the other faculty teaching the course the current course learning outcomes. This will allow the group to re-evaluate and refine the learning outcomes for the course. At the end of the semester, the course coordinator, together with the instructors teaching the course that semester, will complete the assessment worksheets and provide any proposed modification to the learning outcomes. The completed assessment worksheet will clearly indicate where the evidence of student learning for a specific learning outcome can be found within the student artifacts. This will not only provide continuous refinement and improvement of the curriculum map but also streamline the CAIT's assessment process for an individual course.

Learning Management System: Archiving and Assessment Integration

As the past 3 years have been the first assessment cycle of its kind for this department, collection of student work artifacts often relied on materials already collected for our regular ABET visit that occurred right at the beginning of the cycle. To have fresh student work artifacts, faculty now are asked to continuously collect materials and archive them (or have them available for the next 3 year assessment). This requires a fair bit of reminding as it is a new habit. The campus's learning management system has proven to be very useful for this task as it provides a no-additional-cost, paper-free system. However, there are adjustments to be made in the mechanics of student work collection, grading, and archiving. CAIT leadership is preparing workshops on how to effectively use the LMS for these tasks.

In addition to its use for archiving of student work, the campus LMS has functionality for useful analysis, if faculty integrate the tasks of grading and assessment. Proof-of-concept trials have been conducted where major assignments are graded using BOK2 outcome-based rubrics. The rubrics are encoded in the LMS, and the faculty member actively uses the rubric for the assignment grading process. The LMS then allows aggregate analysis and visualizations of the rubric data. This approach has yielded a seamless workflow of course grading and aggregate assessment with minimal additional overhead. Some adjustments in the mechanics of assignments and grading are needed, and CAIT leadership are preparing workshops to train faculty in this process.

Assessment of Structured High-Impact Learning Practices

The curriculum transformation project yielded a new junior-level, zero-credit course that mandates a high-impact learning practice for all undergraduates. The course has been specifically designed to address the so-called "problem objectives" of the BOK2 that focus on soft skills and non-technical issues (e.g., Leadership, Attitudes, Globalization, etc.). The lag between university approval and student succession has meant that the first students entering this mandatory requirement are doing so in the 2017-18 and 2018-19 academic years. With approximately 260 students per year, we expect large-scale and meaningful assessment of this approach to achieving these outcomes in this manner and the overall structured use of high impact practices.

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Appendix A

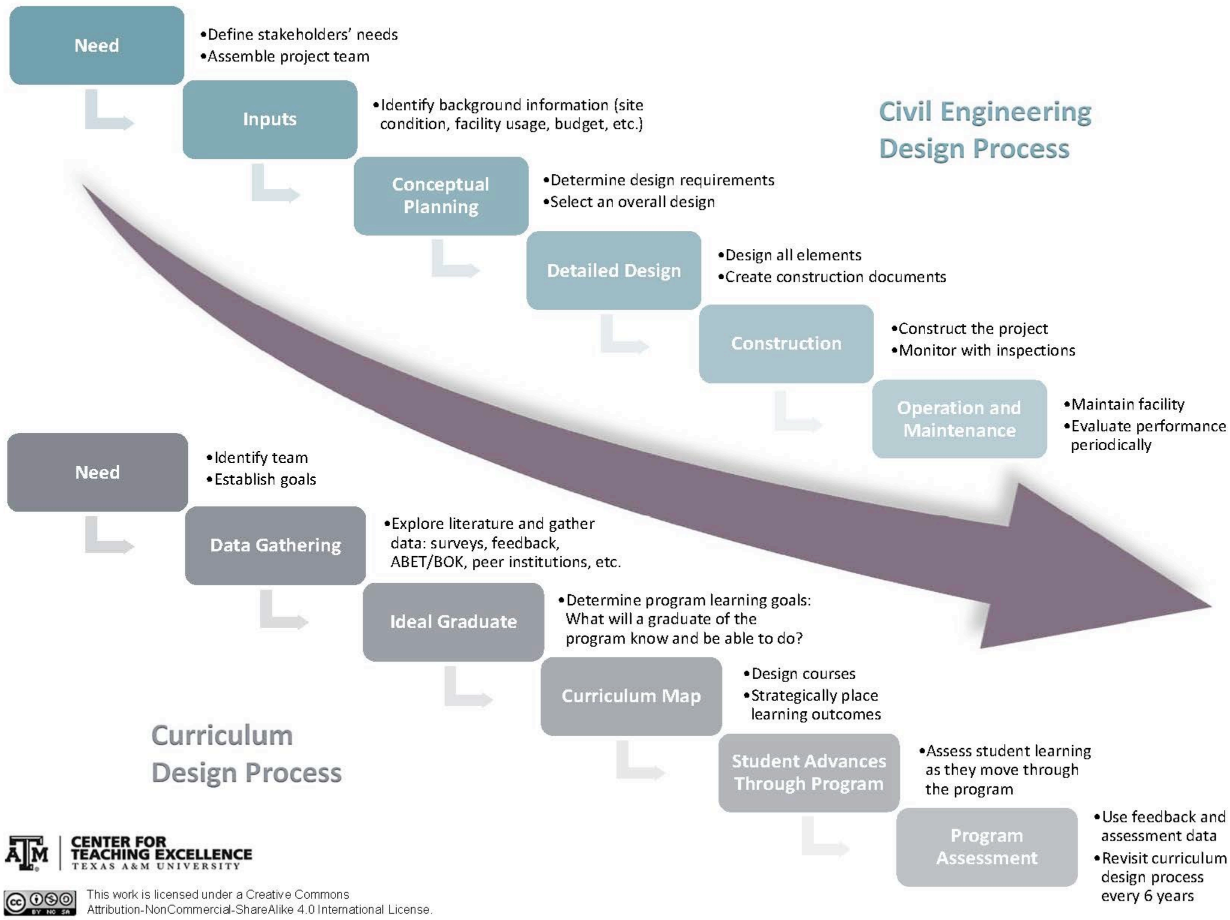

Figure 1. Curriculum Design Process

	Courses External to Department																							Foundation Courses									Gateway Courses			
	University Core						Common Body of Knowledge										Taken by ALL Civil Engineers		Thermo/ECEN Requirement					Taken by ALL Civil Engineers									Taken by ALL Civil Engineers			
Course Number:	POLS*	HIST*	CA*	SBS*	COMM	ICD*	ENGR 111*	ENGR 112*	MATH 151*	MATH 152*	MATH 251*	MATH 308*	PHYS 218* (L)	PHYS 208* (L)	CHEM 107* (L)	ENGL 104*	STAT 211*	ENGR 482*(W)	MEEN 315*	BAEN 320*	CHEN ___*	ECEN 215*	CVEN 315	CVEN 207	CVEN 250	CVEN 221	CVEN 302 (L)	CVEN 303 (L)	CVEN 305	CVEN 306 (L)	CVEN 311	CVEN 363	CVEN 322	CVEN 345	CVEN 399 (N)	CVEN 424 (W)
Credit hours	6	6	3	3	3	6*	2	2	4	4	3	3	4	4	4	3	3	3	3	3	3	3	3	1	2	3	3	3	3	3	3	3	3	3	1	2
Program Learning Outcome:	Federal (206) and State/Local (207) Government	American History	Creative Arts (formerly VPA)	Social and Behavioral Science	Technical Communication	International and Cultural Diversity	Foundations of Engineering I	Foundations of Engineering II	Calculus I	Calculus II	Calculus III	Differential Equations	Mechanics	Electricity and Magnetism	General Chemistry for Engineers	Composition and Rhetoric	Principles of Statistics I	Ethics and Engineering	Thermodynamics	Thermodynamics for Bio. and Ag. Engineers	Thermodynamics for Chemical Engineers	Principles of Electrical Engineering	Sensor Technology for the Built Environment	Introduction to the CE Profession	Introduction to Graphics in CE Design	Engineering Mechanics: Statics	Computer App. in Eng. and Const.	Civil Engineering Measurement	Mechanics of Materials	Materials Eng. for Civil Engineers	Fluid Dynamics	Engineering Mechanics: Dynamics	Civil Engineering Systems	Theory of Structures	Junior-level Soft Skills Seminar	Civ. Eng. Professional Practice
Outcome 1: Mathematics									I	I	I	I	R	R			I		R	R		R	R			R	I		R		D		D			
Outcome 2: Natural sciences													I	I	I				R	R		R	R			R			R	R	R					
Outcome 3: Humanities		I	I				I	I										D						I												R
Outcome 4: Social sciences				I																				I									I		R	
Outcome 5: Materials science															I								R						R	I						
Outcome 6: Mechanics													I	I									R			I			R	I	I	D		D		
Outcome 7: Laboratory and Field Methods													I	I	I								D					R		R		I				
Outcome 8: Problem recognition and solving							I	I	I	I	R	R											R		R		I	I	R		R	R	R	R	R	D
Outcome 9: Design							I	I															R		R				I					R		
Outcome 10: Sustainability																		D						I						R						R
Outcome 11: Contemporary issues and historical	I	I				I												D						I		R			R			R		R	R	D
Outcome 12: Risk and/or uncertainty																	I	D															R		R	
Outcome 13: Project management							I	I																	I								I		R	R
Outcome 14: Breadth in civil engineering areas							I	I															R	I			I							R		
Outcome 15: Technical specialization																							I	I									I			
Outcome 16: Communication					R		I	I	I	I	R	R				I		D					R	I	R	R	R	R	R	R		I		I		D
Outcome 17: Public policy	I																							I		I									R	R
Outcome 18: Business and public administration	I																																I		R	R
Outcome 19: Globalization						I/R												D						I											I	D
Outcome 20: Leadership							I	I															R					I		R						R
Outcome 21: Teamwork							I	I															R		R			R		R		I		R		D
Outcome 22: Attitudes							I	I	I	I			I	I	I									I			I			R					R	D
Outcome 23: Lifelong/Self-directed learning							I	I																I				R				I		I	R	D
Outcome 24: Professional and ethical responsibility							I	I										D						I												R
Count	3	2	1	1	1	2	11	11	4	4	3	3	5	5	4	1	2	7	2	2	0	2	12	12	5	6	5	6	8	9	4	7	7	8	10	14

Figure 2. CVEN Common Core IRD Matrix

	Advanced Courses																										EXTERNAL		Comm
	Required								Choose 3 hr																			**SCI ELEC.	Capstone
	General																												
Course Number:	CVEN 301	CVEN 307	CVEN 339	CVEN 342 (L)	CVEN 343 (L, S-622)	CVEN 349	CVEN 365 (L)	CVEN 444	CVEN 446	CVEN 402	CVEN 403	CVEN 405	CVEN 406	CVEN 413	CVEN 417	CVEN 418	CVEN 423 (S-638)	CVEN 435 (S-666)	CVEN 445	CVEN 454	CVEN 455	CVEN 456	CVEN 457	CVEN 458	CVEN 463	CVEN 473	OCEN 400	**SCI ELEC	CVEN 400
Credit hours	3	3	3	3	3	3	3	3	3	3	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Program Learning Outcome:	Environmental Engineering	Transportation Engineering	Water Resources Engineering	Materials of Construction	Portland Cement Concrete	Civil Eng. Project Management	Intro. to Geotechnical Engineering	Structural Concrete Design	Structural Steel Design	Engineered Environmental Systems	Applied Civil Engineering Surveying	Construction Management of Field Operations	Environmental Protection and Public Health	Natural Environmental Systems	Bituminous Materials	Highway Materials and Pavement Design	Geomatics for Civil Engineering	Geotechnical Engineering Design	Matrix Methods of Structural Analysis	Urban Planning for Engineers	Urban Stormwater Management	Highway Design	Urban Traffic Facilities	Hydraulic Eng. of Water Distribution Systems	Engineering Hydrology	Engineering Project Estimating and Planning	Basic Coastal Engineering	Any Science Technical Elective	Design Problems in Civil Engineering
Outcome 1 : Mathematics							R	D	D	D				D				R	D		D		D	D	D		R		
Outcome 2 : Natural sciences	R	R	R/D	R	R					D				D	R						D		D	D	D		R	R	
Outcome 3 : Humanities	I	I	R									R																	
Outcome 4 : Social sciences		R								R		R	D							R	D	D	I	D	I	R			D
Outcome 5 : Materials science				D	D		R								D	D													D
Outcome 6 : Mechanics			R	R	R		R	D	D	D				D	R	R		R	D										D
Outcome 7 : Laboratory and Field Methods				D	D		R				D				D	R													
Outcome 8 : Problem recognition and solving	R		R			R				D	R	R		D			D	R	R	D	D	D	R	D	D	R			D
Outcome 9 : Design				D	D		R	D	D	D		R			R	D		R/D		D	D	D	R	D		D	D		D
Outcome 10 : Sustainability	I		I	R	R								D									D		D					D
Outcome 11 : Contemporary issues and historical										R			D											R					D
Outcome 12 : Risk and/or uncertainty		R	R					R	R	R	R		D			R					D	D	R	D	D		I		
Outcome 13 : Project management						I/R						R				R										D			D
Outcome 14 : Breadth in civil engineering areas	R	R	R				R	D							R		D			R		D	R			R	R		D
Outcome 15 : Technical specialization								R	R	D		R	D	D			D	D	R	D	D	D	D	D	D	D			
Outcome 16 : Communication		R		R	R	R	R			D	R	D		R	R		D		R	R	D	D		R	R	D			D
Outcome 17 : Public policy	R	R											D							R	D			D					D
Outcome 18 : Business and public administration	I																					D							D
Outcome 19 : Globalization	R	R	R	R	R	R																							
Outcome 20 : Leadership		R		R	R		R				R				R							D				D			D
Outcome 21 : Teamwork				R	R					D	R				R				R		D	D	R	D	D	D			D
Outcome 22 : Attitudes											R				R		D					D							
Outcome 23 : Lifelong/Self-Directed learning																	D					D							D
Outcome 24 : Professional and ethical responsibility	R																				D			D					D
Count	9	9	8	10	10	4	8	6	5	11	7	7	6	6	10	6	6	5	6	7	11	13	9	13	8	9	5	1	16

Figure 3. CVEN General IRD Matrix

CVEN 423

Geomatics for Civil Engineering

Course Description	Prerequisites	Credit Hr.	Course Format (Online, Hybrid, Face-to-Face)
Use of GIS, GPS, Survey and Remotely-sensed data integrated with predictive models for infrastructure management systems.	CVEN 303 or approval of instructor.	3 hr (2-2)	Face-To-Face

Benefits in Taking Course
After taking this course, the students will be able to use GIS tools to approach civil engineering problems that involve location as a central variable.

Concepts to Know Before Taking Course	Developmental Resources
Calculus and Differential Equations	*http://ceresources.weebly.com/calculus.html*
One-Dimensional Motion	*https://www.khanacademy.org/science/physics/one-dimensional-motion*
Impacts and Linear Momentum	*https://www.khanacademy.org/science/physics/linear-momentum*
Moment, Torque, Angular Momentum	*https://www.khanacademy.org/science/physics/torque-angular-momentum*
Oscillatory Motion	*https://www.khanacademy.org/science/physics/oscillatory-motion*

Learning Outcomes

Course Outcome		*Assessment*
I,R,D	**Program Learning Outcome**	
D	**7. Problem Recognition and Solving:** Develop problem statements and solve fundamental civil engineering problems by applying appropriate techniques and tools.	
Use GIS tools to approach civil engineering problems that involve location as a central variable (7.a.3) (7.c.3)		Exams
D	**13. Breadth in Civil Engineering Areas:** Solve engineering problems by integrating knowledge from at least four civil engineering technical areas (defined as coastal/ocean, construction, environmental, geotechnical, materials, structural, transportation, and water resources engineering).	
Analyze and solve a well-defined problem about projections, vector data, and raster data (13.b.3)		Exams
D	**14. Technical Specialization:** State the process to become a specialist, solve problems, and analyze a complex system or process in one technical area of civil engineering.	
Analyze vector and raster geographic information with GIS software (14g.e.4)		Exams
D	**15. Communication:** Communicate clearly and effectively through verbal, written, mathematical, and visual means to promote understanding by both technical and non-technical audiences.	
Explain geospatial analysis in written form(15.d.3)		Exams
D	**21. Attitudes:** Demonstrate attitudes (curiosity, persistence, flexibility, etc.) conducive to effective practice of civil engineering.	
Eagerly participate in discussions and develop an interest (21.b.3)		Class participation
D	**22. Lifelong Learning:** Explain the need for self-directed learning and identify and gather appropriate academic and professional information.	
The class provides the knowledge to use GIS programs. No need for an additional class should be necessary (22.a.3)		(Difficult to Assess)

Critical Thinking Assignments
Reflection involves making conscious connections between ideas and experiences to understand and articulate their value. It is a metacognitive act (thinking about thinking) that asks the questions: "How do you know what you know?" or "How do you learn?" https://sites.google.com/site/ctereflectionhip/home/defining-reflection
Provide an example of a concept you learned in one class and applied in a different class or in a completely new context or format. How did this transfer of knowledge from one context to another help you to understand the concept better?
What positive attitudes (persistence, curiosity, flexibility, etc.) have you developed during this course? How will these attitudes make you a better civil engineer?
How does GIS help you to solve problems more efficiently?

Engagement, Active Learning, and Instructional Technology

Check the activities that are incorporated into this course (if any).

Less complex → **More complex**

Clarification Pauses	Cooperative Group Assignments	Active Review Sessions	First-year Seminar or Experience
One-minute Paper	Peer Review	Role Playing	Capstone Project
Self-Assessment	Group Evaluations	Jigsaw Discussion	Globalization: Study Abroad
Large Group Discussion	Brainstorming	Inquiry Learning	Internship
Think-Pair-Share	Case Studies	Forum Theater	Learning Community
Cooperative Group	Hands-on Technology	Experiential Learning	Writing-Intensive Course
	Interactive Lecture		Undergraduate Research
			Service or Community-Based Learning

Other engagement activity:____________________________

What resources will be required to implement your engagement activities?

____

____

Choose which technologies will be incorporated into this course (if any):

- ☐ PowerPoint
- ☐ Video
- ☐ eCampus/Moodle
- ☐ Web 2.0 Tools
- ☐ Other____

Checklist for Best Practices:

- ☐ Each course addresses 5 to 7 program learning outcomes
- ☐ Each program learning outcome is assessed:
  - If the outcome is level D (demonstrate), then the corresponding assessment will be summative at both the course and program levels.
  - If the level is I (introduce) or R (reinforce), then the corresponding assessment can be both formative and summative at the course level, but only formative at the program level.
- ☐ Engagement and Active Learning:
  - The course incorporates active learning and engagement techniques that allow the students to process and engage with the material.
  - At the program level, at least 2 high-impact practices are incorporated throughout the curriculum (it is not necessary that there is one in every course). If there is a high-impact practice in this course, it is noted on page 3.
    - Characteristics of a high-impact practice: 1) demand substantial and sustained effort on purposeful tasks that deepen students' commitment; 2) put students in circumstances that demand extended interactions with faculty and peers about substantive matters; 3) increase likelihood that students experience diversity through interactions with people who are different from themselves; 4) require frequent feedback to student performance; 5) help students applications of learning in different settings; and 6) often are life-changing experiences.
- ☐ Reflection
  - The manner in which reflection will be incorporated into the course is described. If specific prompts need to be utilized for program assessment purposes, those are listed.
  - *Reflection is important for helping students identify what they do and do not know. Reflection involves making conscious connections between ideas and experiences to understand and articulate their value. It is a metacognitive act (thinking about thinking) that asks the questions: "How do you know what you know?" or "How do you learn?"* For more information on reflection, visit https://sites.google.com/site/ctereflectionhip/home/defining-reflection

- ☐ Rubrics
  - The relevant program learning outcomes rubrics are attached to the course guide.

- ☐ Program Assessment Instructions
  - Specific instructions for program assessment are provided, if applicable.

Appendix C – Sample Course Assessment Document

Date ______________________

Course Number ______423______ Course Name Geomatics for Civil Engineering

Note: Course instruments were chosen at random form the document provided. Our finding are based upon ONLY what was provided to us.

Outcomes	Introduce, Reinforce, Demonstrate	Instrument (i.e. Exam, Homework, Etc.)	Instrument Assesses Outcome? (Y/N)	Outcome Attained at Level?	Comments
Outcome 7 : Problem Recognition and Solving Use GIS tools to approach civil engineering problems that involve location as a central variable (7.a.3) (7.c.3)	Demonstrate				
Outcome 13 : Breadth in Civil Engineering Areas Analyze and solve a well-defined problem about projections, vector data, and raster data (13.b.3)	Demonstrate				
Outcome 14 : Technical Specialization Analyze vector and raster geographic information with GIS software (14g.e.4)	Demonstrate				
Outcome 15 : Communication Explain geospatial analysis in written form. (15.d.3)	Demonstrate				
Outcome 21 : Attitudes Eagerly participate in discussions and develop an interest (21.b.3)	Demonstrate				
Outcome 22 : Lifelong/Self-Directed Learning The class provides the knowledge to use GIS programs. No need for an additional class should be necessary (22.a.3)	Demonstrate				

Member of CAIT

Signature ______________________ Date ____________

Printed Name ______________________ Date ____________

Department

Signature ______________________ Date ____________

Printed Name ______________________ Date ____________