# Toward a Taxonomy of Learning Outcomes for Construction Management Education

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In recent years, there have been many efforts made to improve the outcomes assessment processes used to evaluate the effectiveness of undergraduate programs in construction management. Most outcomes assessment programs have emphasized opinion surveys of graduating seniors and alumni rather than the measurement of specified learning outcomes. The first task required for this measurement process is the establishment of a comprehensive list of appropriate learning outcomes. This paper describes the initial steps of a curriculum reform effort at Colorado State University by identifying the steps completed to date and outlining the remaining process to accomplish this goal. The major result at this point is the start of a complete taxonomy of learning outcomes for an accredited program designed to prepare construction management professionals and the development of evaluation techniques which will be used to analyze the success of the current curriculum in achieving these outcomes. The methods used to create this taxonomy are described as well as the results of the process to date.

**Key Words:** Learning Outcomes, Outcomes Assessment, Curriculum Reform, Curriculum Evaluation, Construction Education

## Introduction

To meet the requirements of numerous accreditation bodies -- and to determine ways to improve the delivery of undergraduate education in construction management -- there have been significant discussions of outcomes assessment in recent years. Segner & Toy (1991) presented the general case for outcomes assessment in construction education and the requirements for this process which were being introduced at that time by the American Council for Construction Education (ACCE). Slobojan (1992) discussed the implementation of essential components of an outcomes assessment plan in preparation for program accreditation or re-accreditation reviews. These authors sought to demonstrate the value of the *process* of outcomes assessment to improving construction management curricula but did not try to specify the desired *results*.

Similarly, Shahbodaghlou & Rebholz (1994) and Yoakum (1994) presented two models for the outcomes assessment process used at Bradley University and California State University - Chico, respectively. These models were similar in that they focused on collecting data from opinion surveys completed by graduating seniors, alumni, employers of alumni, and industry advisory committees. While these surveys, also used at many other Universities, provide valuable feedback on the general success of an academic program, they cannot directly assess the success of the graduates in attaining specific learning outcomes. In other words, these surveys of external constituencies generally target the measurement of administrative goals; such as, the success of

career placement or the attitudes of former students toward particular courses. These surveys are not designed to measure student success at demonstrating specified learning outcomes. To measure this success, outcomes assessment programs must be far more detailed than alumni surveys: they must measure classroom and graduate performance relative to the desired learning outcomes. The assessment of these learning outcomes is a major means of making significant improvements in university curricula. Evaluating proposed curriculum changes from a learning outcomes perspective can help "guide the process of evaluation and change so we do not have change for change sake but true continuous quality curriculum improvement" (Auchey, et. al., 1997, 88).

Successful curriculum reform has been listed as the primary reason university programs in construction management implement active outcomes assessment programs. In a survey of all known construction related programs, Huber (1994) collected data designed to measure the perceptions of unit administrators toward outcomes assessment. He found that the top three reasons cited by these administrators for using this process were:

1. Curriculum changes
2. Improving teaching/learning
3. Program or curriculum evaluation (Huber, 1994, 108).

Given the importance of outcomes assessment -- and the specification of desired learning outcomes -- to successful curriculum reform, it was surprising to find limited reference in the literature to a classification of the intended learning outcomes at the major construction programs. It may be assumed that these references exist only in administrative documents in each department or that departments rely on accreditation requirements to describe the academic output of their courses. More communication among construction programs, however, may be necessary. Auchey, et.al. (1997) provide a listing of intended program outcomes at Virginia Polytechnic Institute as part of their description of the Learning Outcome Template (LOT); a tool used in the continuous improvement of academic curricula (see discussion below). Perreault (1993) and Hauck & Rockwell (1996) report on survey results designed to measure the occupational requirements and desirable characteristics of managers of the construction process. These listings of requirements for the practitioner in construction certainly provide a starting point for the determination of an overall classification system for the desired learning outcomes of a construction education program.

It is in this environment that the construction management faculty at Colorado State University (CSU) has started a comprehensive curriculum reform effort. The goals for this effort include the following:

1. to make any desired changes by considering the curriculum as a whole; not by piecemeal changes to one course at a time.
2. to start the curriculum reform effort from a comprehensive list of desired learning outcomes; not from a list of course titles.
3. to create this list of learning outcomes from external sources; not just from the course objectives listed in current departmental syllabi.

4. to establish an outcomes assessment process which measures the success at attaining the stated learning outcomes; not just the graduates' perceptions of the program.

If successful, this "taxonomy" of learning outcomes will remain a dynamic document which helps identify the overlaps in curricular content as well as the weaknesses in the current curriculum. Hopefully, it will change the discussion from "Where do we need a new course?" to "Where do we need to modify the learning outcomes and what is the best place in the curriculum to accomplish each outcome?" The discussion below describes the results of this process to date.

**Method**

The concept of learning outcomes is not foreign to any faculty member. All faculty have grown accustomed to designing and implementing a course around a specified set of course objectives. These objectives, if stated in terms of specific, measurable behaviors, can be used as appropriate learning outcomes. An academic unit could develop a comprehensive set of learning outcomes simply by combining the stated objectives from all required courses, debating the veracity of the resulting list, and making modifications to the list as needed. While this may be a successful approach to describing the current curricular content of an academic program, there are at least two problems associated with this tactic. First of all, this approach is insular in that the results will describe what is currently being done rather than what could be done. If important content is missing from the current curriculum, those same shortcomings will exist in the resulting list of learning outcomes. The second problem relates to the course objectives themselves. Typically, these objectives are not detailed enough and they do not specify the competency level expected at the completion of the course. A course objective might be stated as the "ability to perform quantity takeoffs." One would have to be in the course, however, to know whether this implies takeoffs in all 16 CSI divisions and whether this means an introduction to this process or a demonstrated mastery level of competence. Because of these problems, another source for learning outcomes was sought. While course objectives eventually will be used for comparison with the program's specified learning outcomes, it was decided that starting with these objectives would lead to errors.

To avoid the circular logic implied by using existing course objectives, an external source of appropriate learning outcomes was sought. Two sources of valid outcomes were reviewed and combined in order to prepare a first draft of a total set of learning outcomes which would form a basis for the revised curriculum.

The first and primary source was the content descriptions for the Certified Professional Constructor (CPC) examinations. These exams were developed and are administered by the American Institute of Constructors' (AIC) Constructor Certification Commission (CCC). "In 1994, the AIC Constructor Certification Commission was organized under the auspices of AIC to expand the Constructor qualifying process to include a written examination and to offer an internationally recognized certification process to AIC members and nonmembers alike" (AIC Constructor Certification Commission, 1997, 1). The Commission has established a two tiered approach to full recognition of the professional Constructor. This process parallels the two step professional recognition process used in the field of engineering. To attain the first level

designation of Associate Constructor (AC), a candidate must qualify on the basis of education and/or experience and successfully complete the Constructor Qualification Examination (CQE) Level I. To attain the next designation of Certified Professional Constructor (CPC), an individual must have completed all AC requirements, acquired another seven years of acceptable professional experience, and passed the CQE Level II. After completing all requirements, certified individuals use the acronym "CPC" after their names to designate their professional status. The examinations described above were the result of an extensive process which included the input of numerous practitioners and educators in the field of construction -- referred to as Subject Matter Experts (SMEs) -- to determine a valid set of specifications for the content of the exams. Since the CQE Level I is intended to be given to graduating seniors in nationally accredited construction management programs, the description of the specifications for this exam was used as the major source for the learning outcomes discussed in later sections.

The second source for valid learning outcomes of construction management programs was the curriculum requirements of ACCE. This organization is the recognized accrediting body for university programs related to construction management. Current curriculum requirements for ACCE accreditation include a minimum number of credit hours in each of five categories:

1. General Education
2. Mathematics and Sciences
3. Business and Management
4. Construction Science
5. Construction

While current ACCE requirements establish the content in each of these categories by using course titles and general subject matter descriptions, there is currently a proposal before the ACCE Board of Trustees to replace these general descriptions in the last two categories with more specific "core topics" and "Essential Elements of Instruction (EEI)" (ACCE, 1997). For example, one of the core topics proposed within the Construction Science category is "Construction Graphics" which is further delineated with a listing of EEI including basic sketching and drawing techniques, orthogonal representation, notes and specifications, computer applications, etc. While still a subject of dispute among the members of the Board of Trustees, these more detailed descriptions of desired curricular content -- especially the EEI -- provided another excellent source for externally validated learning outcomes.

Since the construction management faculty at CSU are committed to retaining their ACCE accreditation and to promoting the completion of the CQE Level I among graduates of the program, it was decided that the two sources described above would be used as a starting point in the developing their list of desired learning outcomes. It was proposed that the curriculum reform effort would continue through the following steps:

1. The initial list of learning outcomes would be further refined through faculty discussion.
2. An appropriate competency level at graduation for each learning outcome would be specified.

3. The Learning Outcome Template (LOT) developed by Auchey, et. al. (1997) could then be used as a tool to analyze where in the current curriculum each learning outcome could be covered and at what competency level.
4. This analysis using the LOT will highlight changes which should be made in current courses. The analysis should also identify areas where courses safely can be deleted and where additional courses should be added to the new curriculum.

This process should accomplish the goals set for this comprehensive curriculum reform effort as outlined in the previous section.


## Results

First, it should be noted that the process described above is currently ongoing and that this section reports on results in progress. These results include 1) a classification of eleven "knowledge areas" which incorporate all of the learning outcomes desired from the new curriculum, 2) the current draft of the complete listing of desirable learning outcomes, and 3) a format to be used for the learning outcomes template which will accommodate the proposed curriculum analysis. These results are described in the following paragraphs. Much work remains to finalize the list of learning outcomes, establish appropriate competency levels for each outcome, modify courses and curricular content to align with the learning outcomes, and redesign the outcomes assessment process to include measures of student achievement of the specified learning outcomes. The success rate of graduating seniors on the CQE Level I will be one of the elements in this outcomes assessment process. It is anticipated that another one to two years will be required to complete the entire curriculum reform effort.

The first result was the determination of the major classifications -- or "knowledge areas" -- into which all learning outcomes would be sorted. This was adapted directly from the classification system used by the CCC for the content of CQE Level I (see Table 1). The CQE Level I ("Construction Fundamentals") uses the first ten of the eleven knowledge areas listed in Table 1 (AIC Constructor Certification Commission, 1997, 6). Knowledge Area #11 -- Personnel Development and Management -- was added by the CSU faculty to reflect a major program emphasis in this area. Additionally, when the first group of SMEs met in September 1995, they had included significant content in this area which was not well incorporated into the ten knowledge areas finally selected for the content of the Level I examination. Interestingly, much of this content appears to have been included in the Level II examination in categories such as "Developing Staffing Requirements" and "Creating and Enhancing Working Relationships". The percentages indicated in Table 1 after the descriptor for each knowledge area is the weighting assigned to that area in CQE Level I. For example, approximately 6% of the questions on this exam are intended to measure "Communication Skills."

Table 1

The next result was the current draft of the complete listing of learning outcomes as presented in Appendix A. This listing reflects the two major sources used to generate these learning outcomes: the description of the specifications for the CQE Level I examination and the "core topics" and EEI used to describe the curricular requirements of ACCE. Those learning outcomes derived from the latter source are indicated in Appendix A by the initials "ACCE" appearing in parentheses. For example, "Construction Graphics" apparently was not included in the specifications for CQE Level I but was added to Knowledge Area #1 (Communication Skills) because it is listed as a core topic in the "Construction Science" category by ACCE. Most of the subheadings for this topic are derived from the EEI listed in the ACCE proposal. Some of the listings by CCC and ACCE are duplicative within a given knowledge area. In Knowledge Area #3, for instance, "Generic Management Concepts" listed by CCC presumably overlaps greatly with "Principles of Management" as listed by ACCE. At this point in the development of this taxonomy, those duplications have not yet been eliminated to ensure that no areas are neglected. In future drafts, similar categories will be combined and redefined without reference to source.

Much of the detail in this list of learning outcomes results from an early draft of the specifications for CQE Level I which was prepared by the first meeting of SMEs in September 1995. This group consisted mainly of construction practitioners from all geographic areas and many specialties within the field. They prepared an excellent listing of the skills required to manage each of the phases of a typical project concentrating on the management of contracts, costs, schedules, personnel, and safety. The details of this listing of skills provided an excellent source for the description of appropriate learning outcomes for an academic program in construction management. This list was rearranged to align with the eleven knowledge areas included in Appendix A.

When finalized, this taxonomy of learning outcomes will have many uses in the restructuring of the curriculum at CSU. It should be noted that this classification does not necessarily relate directly to the content of specific courses - nor is it intended to. For example, writing and oral presentation skills listed in Knowledge Area #1 probably will be developed in many, if not all, courses. On the other hand, Knowledge Area #9 - Construction Surveying and Project Layout - may fit more easily into a single course. A listing by learning outcome categories rather than by

courses should encourage the integration of learning across the artificial boundaries of courses. Applying this concept, Virginia Polytechnic Institute has introduced generic "Integrated Lab" and "Construction Practice" courses which reinforce numerous learning outcomes from seemingly diverse knowledge areas (Auchey, et. al., 1997). Regardless of the final result in terms of courses, it is important that all faculty agree that the specified learning outcomes should be attained. Using the language of a work breakdown structure (WBS), all faculty should participate in the discussion through the third or fourth level of the WBS. It should be a departmental decision that the "ability to conduct a safety audit" is a part of the intended outcome of the curriculum. How that outcome is achieved may be up to a single instructor in just one course.

The final result of the process so far is the creation of a Learning Outcome Template (LOT) for each knowledge area identified. This idea expanded on the work of Auchey, et. al. (1997) in which they applied this matrix to a summary listing of program outcomes. An example of one LOT (for Knowledge Area #6) is presented in Appendix B. The matrix includes a list of all learning outcomes for that knowledge area along the left edge and a list of all courses currently required in the curriculum along the top edge. The goal is to indicate in which courses each of the learning outcomes is presented. In addition, since many learning outcomes will appear in several courses (e.g., "introduced" in one course and "mastered" in a later course), the faculty will also indicate the expected level of student learning (on a scale of 1 to 4) in each course. The first step is to complete the right hand column which indicates the expected level of mastery at graduation. This discussion and debate among the faculty as to which learning outcomes are expected -- and at what competency level -- greatly improves the ability of the faculty to define the values and mission of the academic program. When completed, these templates should 1) identify the expected content of all required courses, 2) highlight the existing overlaps in the curriculum, 3) identify the content areas where more emphasis is needed, and 4) help guide faculty decisions related to deleting existing courses and adding new ones.


## Discussion

What has been presented above is a "work in progress." As of this writing, four major steps have been accomplished:

1. two external, valid sources for the initial selection of learning outcomes have been identified.
2. a "broad scope" classification of eleven knowledge areas has been selected.
3. a complete draft of a comprehensive list of appropriate learning outcomes has been prepared.
4. Learning Outcome Templates for each knowledge area encompassing the entire list of learning outcomes have been presented to faculty for review.

In addition, five major steps which must be addressed to complete the curriculum reform effort have been identified as follows:

1. further debate about and refinement of the list of expected learning outcomes must be completed.

2. expected competency levels for every learning outcome at the time of graduation must be established by the faculty.
3. all Learning Outcome Templates must be completed in order to analyze the strengths and weaknesses of the current curriculum.
4. those areas in which courses should be modified, deleted, or added to accomplish the specified learning outcomes must be identified and revisions need to be completed.
5. the existing outcomes assessment process must be redesigned in order to measure the program's success at achieving the specified learning outcomes.

The final result of this effort should be not only a redesigned curriculum which is more responsive to desirable outcomes identified by the faculty. Just as importantly, the result should be a dynamic *process* though which future curriculum changes can be evaluated from a perspective of the entire curriculum rather than a single course. By creating a means of observing the "big picture" at any point in time, creative solutions to future curriculum challenges can be accomplished without fear of a negative impact on the outcomes of instruction.

### References

American Council for Construction Education (1997). Unpublished proposal to the Board of Trustees to change curriculum requirements. Dated March 18, 1997.

AIC Constructor Certification Commission (1997). *Certified professional constructor candidate handbook.* St. Petersburg, Florida: AIC Constructor Certification Commission.

Auchey, F. L., Mills, T. H., Beliveau, Y. J., & Auchey, G. J. (1997). Using the learning outcome template as an effective tool for evaluation of the undergraduate building construction program. *Proceedings of the 33rd Annual Conference of the Associated Schools of Construction.* University of Washington: Seattle, Washington.

Hauck, A. J. & Rockwell, Q. T. (1996). Desirable characteristics of the professional constructor, the initial results of the constructor certification skills and knowledge survey. *Proceedings of the 32nd Annual Conference of the Associated Schools of Construction.* Texas A&M University: College Station, Texas.

Huber, J. (1994). The assessment of future constructors. *Proceedings of the 30th Annual Conference of the Associated Schools of Construction.* Bradley University: Peoria, Illinois.

Perreault, R. (1993). Identification of the occupational requirements of the construction manager. *Proceedings of the 29th Annual Conference of the Associated Schools of Construction.* Colorado State University: Fort Collins, Colorado.

Segner, R. & Toy, G. A. (1991). Outcomes assessment in construction higher education. *Proceedings of the 27th Annual Conference of the Associated Schools of Construction.* Brigham Young University: Provo, Utah.

Shahbodaghlou, F. & Rebholz, F. E. (1994). Outcome assessment model for a construction program. *Proceedings of the 30<sup>th</sup> Annual Conference of the Associated Schools of Construction.* Bradley University: Peoria, Illinois.

Slobojan, J. (1992). Implementing outcome assessment for program accreditation. *Proceedings of the 28<sup>th</sup> Annual Conference of the Associated Schools of Construction.* Auburn University: Auburn, Alabama.

Yoakum, B. (1994). Program assessment, good management practice. *Proceedings of the 30<sup>th</sup> Annual Conference of the Associated Schools of Construction.* Bradley University: Peoria, Illinois.

# Appendix A

I. COMMUNICATION SKILLS
    A. Communication Skills
        1. Comprehension
        2. Vocabulary
        3. Writing
        4. Oral Presentation
        5. Listening Skills
            a. Construction Graphics (ACCE)
            b. Basic Sketching Techniques
            c. Basic Drawing Techniques
            d. Orthogonal Representation
            e. Graphic Vocabulary
            f. Detail Hierarchies
            g. Scale
            h. Drawing Organization/Content
            i. Drawing Notes
            j. Specifications
            k. References
            l. Conventions
            m. Computer Applications
            n. Visualization

II. DESIGN/ENGINEERING CONCEPTS & ASSOCIATED MATH AND SCIENCE
    A. Materials Science (ACCE)
        1. Soil
            a. Composition and Properties
            b. Terminology
            c. Units of Measure
            d. Standard Designations
            e. Sizes and Gradations
            f. Conformance References
            g. Testing Techniques
        2. Wood
            a. Composition and Properties
            b. Terminology
            c. Units of Measure
            d. Standard Designations
            e. Sizes and Gradations
            f. Conformance References
            g. Testing Techniques
        3. Steel
            a. Composition and Properties
            b. Terminology
            c. Units of Measure
            d. Standard Designations
            e. Sizes and Gradations
            f. Conformance References
            g. Testing Techniques
        4. Concrete
            a. Composition and Properties
            b. Terminology
            c. Units of Measure
            d. Standard Designations
            e. Sizes and Gradations
            f. Conformance References
            g. Testing Techniques
    B. Design Theory and Application
        1. Structural Mechanics
        2. Soil Mechanics
        3. Electricity
        4. Thermodynamics
        5. Basic Fluid Design/Hydraulics
        6. Electrical Systems
        7. Mechanical Systems
        8. Mechanics of Materials
        9. Structural Design
        10. Concrete Formwork Design

C. Statistics (ACCE)

III. MANAGEMENT CONCEPTS AND PHILOSOPHIES
    A. Generic Management Concepts
        1. Contract Forms
            a. Stipulated Sum, etc.
        2. Business Organization
            a. Corporation
            b. Partnership, etc.
        3. Basic Accounting Principles
    B. Management Philosophies
        1. Management Systems
            a. Total Quality Management (TQM)
            b. ISO 9000
            c. Partnering
        2. Leadership
            a. Ethics
            b. "Constructor Code of Conduct"
    C. Human Resource Management
    D. Economics (ACCE)
    E. Principles of Management (ACCE)
    F. Organizational Behavior (ACCE)
    G. Business Law (ACCE)

IV. CONSTRUCTION MATERIALS AND METHODS
    A. Materials and Methods by CSI Division
        1. Knowledge of Heavy Equipment
        2. Knowledge of Sitework/Excavation
        3. Knowledge of Concrete/Rebar
        4. Knowledge of Masonry
        5. Knowledge of Metals
        6. Knowledge of Rough/Finish Carpentry
        7. Knowledge of Insul./Roofing/Siding
        8. Knowledge of Doors and Windows
        9. Knowledge of Finishes
        10. Knowledge of Specialties
        11. Knowledge of Equipment
        12. Knowledge of Furnishings
        13. Knowledge of Special Construction
        14. Knowledge of Conveying Systems
        15. Knowledge of Mechanical Systems
        16. Knowledge of Electrical Systems
        17. Knowledge of Technology (Computer Networks, Fiberoptics, Video, etc.)
    B. Construction Methods (ACCE)
        1. Products
        2. Systems
        3. Interface Issues
        4. Site Organization
        5. Site Development
        6. Assembly Techniques/Equipment

V. ESTIMATING, PLAN READING, BID PROCESS, CODES, INSURANCE, AND ABILITY TO ESTABLISH WORK METHODS
    A. Identify, Obtain, and Process Relevant Information
        1. Knowledge of Bid Process
        2. Ability to Read and Draw Plans
        3. Ability to Write, Read, and Interpret
        4. Specifications
        5. Knowledge of Laws, Regulations, and Codes
        6. Knowledge of Site Conditions and Requirements
        7. Knowledge of Insurance and Bond Requirements
        8. Knowledge of Value Engineering
        9. Knowledge of Life Cycle Costing
        10. Ability to Establish Suitable Work Method
        11. Ability to Establish Site Layouts in Consultation with Subcontractors
    B. Costing
        1. Ability to Perform Estimating and Bidding

2. Ability to Generate Conceptual Estimates
3. Ability to Generate Preliminary Estimates
4. Ability to Define Work Breakdown Structure
5. Ability to Perform Quantity Take-off
6. Ability to Generate Detailed Estimate
7. Ability to Solicit Bids and Quotes
8. Ability to Analyze Subcontractor Bids
9. Ability to Analyze Materials Quotes
10. Ability to Analyze Equipment Costs
11. Ability to Analyze Labor Costs
12. Ability to Assess Appropriate Overhead
13. Ability to Assess Appropriate Profit
  C. Estimating (ACCE)
    1. Types of Estimates and Their Uses
    2. Quantity Takeoffs
    3. Labor Productivity Factors
    4. Equipment Productivity Factors
    5. Pricing
    6. Pricing Data Bases
    7. Job Overhead Costs
    8. General Overhead Costs
    9. Bid Preparation and Submission
    10. Computer Applications

VI. BUDGETING/COST ACCOUNTING, COST CONTROL, AND COST CLOSEOUT
  A. Budgeting and Cost Accounting
    1. Ability to Establish a Budget
      a. Ability to Obtain Budget Information
      b. Ability to Assign Cost Breakdown
  B. Cost Control
    1. Ability to Prepare Cost Report and Compare Expenditures to Budget
      a. Ability to Obtain Current Budget Information
      b. Ability to Evaluate Cost Breakdown
      c. Ability to Determine Progress of the Project vs. the Budget
      d. Ability to Determine Actual Equip. Costs vs. Projected Costs
      e. Ability to Determine Actual Labor Costs vs. Projected Costs
      f. Ability to Determine Actual Overhead Costs vs. Projected Costs
    2. Ability to Document Work Performed to Enable Pay Release
      a. Ability to Assess/Verify Earned Value
      b. Ability to Analyze Progress
      c. Ability to Review Schedule of Values
    3. Ability to Monitor and Make Adjustments due to Claims
      a. Knowledge of Entitlements
      b. Knowledge of Damages
    4. Ability to Document Change Orders
    5. Ability to Prepare Progress Payment Requests to the Owner
  C. Cost Closeout
    1. Ability to Finalize Costs Including Claims
      a. Knowledge of Retainage
      b. Knowledge of Backcharges
      c. Knowledge of Final Payments
    2. Ability to Determine Final Payment Requisition
  D. Cost Accounting and Finance (ACCE)
    1. Cost Accounting Formats
    2. Fixed Overheads
    3. Variable Overheads
    4. Insurance and Bonding
    5. Bidding and Procurement Practices
    6. Record/Report Practices
      a. Capital Equipment
    7. Depreciation and Expensing
    8. Forecasting Costs

9. Cash Flow Requirements
10. Payment Processes
11. Time Value of Money

VII. SCHEDULING AND SCHEDULE CONTROL
  A. Scheduling
    1. Ability to Establish a Logical Sequence and Relationship among Activities
    2. Ability to Estimate Duration of Each Activity
    3. Ability to Prepare Preliminary Schedule
    4. Ability to Create CPM Schedule
    5. Ability to Analyze CPM Schedule
  B. Schedule Control
    1. Ability to Monitor Progress of a Project
      a. Ability to Update a Schedule
      b. Ability to Review/Compare Target to Actual Schedule
      c. Ability to Evaluate Need for a Revised Plan of Action
      d. Ability to Create/Implement a Revised Plan of Action
      e. Ability to Evaluate Delay Claims
    2. Ability to Expedite Materials/Equipment to Avoid Delays
  C. Schedule Closeout
    1. Ability to Demobilize a Project Site
    2. Ability to Administer Substantial Completion Process
      a. Certificate of Substantial Completion
      b. Record of Final Completion Dates
  D. Planning and Scheduling (ACCE)
    1. Parameters Affecting Project Planning
    2. Schedule Information Presentation
    3. Network Diagramming with CPM
    4. Calculations for CPM
    5. Resource Allocation and Management
      a. Impact of Changes
      b. Computer Applications

VIII. SAFETY
  A. Safety Planning
    1. Knowledge of Applicable OSHA Requirements
    2. Ability to Establish Safety and Health Procedures on Site
    3. Ability to Perform Hazard Analyses
  B. Safety Administration
    1. Ability to Implement Safety Procedures and Policies
    2. Ability to Monitor Safety Procedures and Policies
      a. Ability to Conduct a Safety Audit
      b. Ability to Document Safety Audit Results
    3. Ability to Enforce Safety Procedures and Policies
    4. Ability to Comply w/ OSHA Requirements including Documentation
  C. Safety (ACCE)
    1. Mandatory Training
    2. Mandatory Procedures
    3. Mandatory Records
    4. Mandatory Maintenance
    5. OSHA Compliance
    6. OSHA Inspections
    7. OSHA Penalties

IX. CONSTRUCTION SURVEYING AND PROJECT LAYOUT
  A. Basic Construction Surveying
    1. Ability to Establish Distances from Existing Points
    2. Ability to Establish Elevations from Existing Points
    3. Ability to Set Up Surveying Instruments
  B. Project Layout
    1. Knowledge of Surveying Procedures
    2. Ability to Layout the Project
    3. Ability to Interpret Site Information
  C. Surveying (ACCE)

1. Basic Surveying Procedures
2. Construction Layout
3. Alignment Control

X. PROJECT ADMINISTRATION
  A. Procurement of Resources
    1. Subcontractors
      a. Ability to Determine Subcontractors' Qualifications
      b. Knowledge of Contracts and Subcontracts
      c. Ability to Write and Obtain Agreements with Relevant Parties
      d. Ability to Communicate Policy, Procedures, and Safety Requirements
    2. Materials
      a. Ability to Identify and Qualify Vendors
      b. Ability to Identify Lead Times
      c. Ability to Complete and Execute a Purchase Order
    3. Equipment
      a. Ability to Identify and Qualify Vendors
      b. Ability to Identify Lead Times
      c. Ability to Complete and Execute a Purchase Order/Lease Agreement
  B. Job Site Mobilization
    1. Ability to Set Up Project Site
      a. Field Office(s)
      b. Storage Areas(s)
      c. Site Layout
    2. Ability to Provide for Subcontractors' Startup Requirements
      a. Ability to Provide Work/Storage Areas
      b. Ability to Coordinate Subcontractors
    3. Ability to Implement Administrative System on Site
  C. Contract Administration and Control
    1. Documentation
      a. Ability to Issue Purchase Orders/Contracts
      b. Ability to Oversee Submittal Process
      c. Ability to Request and Evaluate Change Orders
        i. Responsibilities of Owner
        ii. Duties of Architect/Engineer
        iii. Responsibilities of Contractor
    2. Dispute Avoidance and Resolution
      a. Knowledge of Relationship between Planning and Dispute Avoidance
      b. Knowledge of Relationship between Documentation and Dispute Avoidance
      c. Knowledge of Relationship between Personnel Management and Dispute Avoidance
      d. Knowledge of Negotiation Options
      e. Knowledge of Arbitration
      f. Knowledge of Litigation
      g. Knowledge of Mediation
  D. Job Site Administration
    1. Materials and Equipment Handling
      a. Ability to Coordinate Deliveries
      b. Ability to Verify Receipt
      c. Ability to Track and Control Usage
      d. Ability to Handle/Dispose Debris
    2. Quality Control
      a. Ability to Review Submittals for Completeness and Compliance to Specs
      b. Ability to Control Construction Process to Comply with Contract Documents
      c. Ability to Control Project Compliance with:
        i. Codes
        ii. Zoning
        iii. Ordinances
        iv. Government Regulations
        v. Trade Organization Regulations
      d. Ability to Implement Corrective Measures
    3. Project Documentation
      a. Ability to Maintain Ongoing Project Records

        i. Daily Field Reports
        ii. Accident Reports/Records
        iii. Policy Manuals
        iv. Organizational Charts
        v. Requests for Information (RFI)
        vi. Correspondence
        vii. Progress Reports
        viii. Telephone Conversations
  E. Punchlists
    1. Ability to Create Punchlists
    2. Ability to Complete Punchlists
    3. Ability to Verify Punchlist Completion
  F. Turnover of Deliverables
    1. Project Documentation (files & records)
    2. Letters of Warranty
    3. Final Inspection Certificates
    4. Certificates of Occupancy
    5. Lien Releases
    6. Letters of Compliance with Government Regulations
    7. Specified Extra/Excess Stock
    8. Key Schedules
    9. Owner Training and Orientation
    10. Operation and Maintenance Manuals
    11. As-Built Drawings
  G. Project Management (ACCE)
    1. Concepts, Roles, and Responsibilities
    2. Administrative Systems and Procedures
    3. Cost Control Data and Procedures
    4. Documentation at Job Site and Office
    5. Quality Control Philosophies/Techniques
    6. Computer Applications
  H. Construction Law (ACCE)
    1. Construction Contracts
    2. Roles and Responsibilities of Parties
    3. Regulatory Environment
    4. Licensing Requirements
    5. Lien Laws and Contractor's Rights
    6. Local and National Labor Law
    7. Administrative Procedures to Avoid Disputes

XI. PERSONNEL DEVELOPMENT AND MANAGEMENT
  A. Selection and Assignment of Staff
    1. Ability to Determine Personnel Requirements
      a. Ability to Determine Areas of Responsibility
      b. Ability to Divide List of Responsibilities
      c. Ability to Design an Organizational Chart
    2. Knowledge of Hiring Requirements including Governmental Regulations
      a. Ability to Determine Job Descriptions
    3. Ability to Understand and Enforce Policies and Procedures
    4. Ability to Set Up Record Keeping for Staff
  B. Develop Teams and Individuals to Enhance Performance
    1. Ability to Designate Team Leaders
    2. Ability to assess Strengths and Weaknesses of Teams
    3. Ability to Determine Placement of Correct Teams for Jobs
    4. Knowledge of Team Process
    5. Ability to Plan Development of Teams
    6. Ability to Integrate Teams into Schedule
    7. Ability to Evaluate Team Members
    8. Ability to Train and Educate Team
  C. Human Resource Management
    1. Personnel
      a. Ability to Identify, Record, Assess, and Communicate Staffing Needs
      b. Ability to Take Action to Meet Future Requirements
      c. Ability to Evaluate Performance of Site Personnel

d.    Ability to Record and Act Upon Requests for Information from Site Personnel
e.    Ability to Understand Hiring Requirements including Government Regulations
f.    Identify and Select Staff
g.    Ability to Conduct Personnel Testing
h.    Determine Quality of Staff's Work
i.    Ability to Inform Staff of Legal Requirements
j.    Ability to Recommend Improvements

2.    Team Building
a.    Ability to Create. Maintain, and Enhance Effective Working Relationships
b.    Ability to Conduct Team Meetings
c.    Ability to Establish and Maintain Relationship with Co-Workers
d.    Ability to Identify, Minimize, and Resolve Interpersonal Conflicts
e.    Ability to Follow Through with Commitments to Team Members

3.    Community/Public Relations
a.    Ability to Implement Community/Public Relations Procedures
b.    Ability to Establish and Maintain Relationships w/ Clients and Representatives
c.    Ability to Establish and Maintain Relationships with the General Public

4.    Project Meetings
a.    Ability to Conduct Job Meetings
b.    Ability to Use Rules of Order
c.    Ability to Establish an Agenda
d.    Ability to Keep/Issue Minutes
e.    Ability to Select Appropriate Personnel for Meeting
f.    Ability to Evaluate Ideas
g.    Ability to Evaluate Views
h.    Ability to Disseminate Organizational Policy

# Appendix B

**LEARNING OUTCOMES TEMPLATE**
**CONSTRUCTION MANAGEMENT**

**KNOWLEDGE AREA #6 - BUDGETING/COST ACCOUNTING, COST CONTROL, AND COST CLOSEOUT (11.0%)**

Levels of Student Learning:
1. Preparatory Foundation
2. Knowledge Development
3. Proficiency/Practical Application
4. Mastery/Analysis and Evaluation

| | | Skills and Competencies | MTCM CORE | | | | | | CONSTRUCTION MANAGEMENT | | | | | | | | | | | | ENGINEERING SCIENCE | | | | | | BUSINESS | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | MC 110 - Teams & Leadership | MC 151 - Intro to Mfg & Const | MC 251 - Matls Test/Processing | MC 131 - Graphic Communic./CAD | MC 141 - Energy & Transportation | MC 241 - Energy/Control Systems | MC 232 - Arch. & Constr. Planning | MC 261 - Const. Surveying | MC 317 - Safety Management | MC 361 - Mech. Sys. in Bldgs. | MC 362 - Const. Contracts | MC363 - Quantity Surveying | MC 364 - Adv. Const. Systems | MC 365 - Const. Estimating | MC 366 - Const. Equip. & Methods | MC 461 - Project Scheduling | MC 464 - Project Administration | MC 487a - Internship | CE 256 - Statics | CE 358 - Mechan. of Materials | CE 350 - Soils Engineering | CE 364 - Prop. of Materials | CE 370 - Elem. Structural Design | F 432 - Design of Wood Structures | BA210 - Financial Accounting | BG 260 - Legal Envir. of Business | BN 300 - Mgmt. Fundamentals |
| A. | | Budgeting and Cost Accounting | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1. | Ability to Establish a Budget | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | a. | Ability to Obtain Budget Information | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | b. | Ability to Assign Cost Breakdown | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| B. | | Cost Control | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1. | Ability to Prepare Cost Report and Compare Expenditures to Budget | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | a. | Ability to Obtain Current Budget Information | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | b. | Ability to Evaluate Cost Breakdown | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | c. | Ability to Determine Progress of the Project vs. the Budget | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | d. | Ability to Determine Actual Equipment Costs vs. Projected Costs | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | e. | Ability to Determine Actual Labor Costs vs. Projected Costs | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | f. | Ability to Determine Actual Overhead Costs vs. Projected Costs | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2. | Ability to Document Work Performed to Enable Pay Release | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | a. | Ability to Assess/Verify Earned Value | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | b. | Ability to Analyze Progress | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | c. | Ability to Review Schedule of Values | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3. | Ability to Monitor and Make Adjustments due to Claims | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | a. | Knowledge of Entitlements | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | b. | Knowledge of Damages (Cost/Time) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4. | Ability to Document Change Orders | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5. | Ability to Prepare Progress Payment Requests to the Owner | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| C. | | Cost Closeout | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1. | Ability to Finalize Costs Including Claims | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | a. | Knowledge of Retainage | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | b. | Knowledge of Backcharges | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | c. | Knowledge of Final Payments | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2. | Ability to Determine Final Payment Requisition | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| D. | | Cost Accounting and Finance (ACCE) | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 1. | Cost Accounting Formats | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 2. | Fixed Overheads | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 3. | Variable Overheads | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 4. | Insurance and Bonding | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 5. | Bidding and Procurement Practices | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 6. | Record/Report Practices | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 7. | Capital Equipment | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | a. | Depreciation and Expensing | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 8. | Forecasting Costs | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 9. | Cash Flow Requirements | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 10. | Payment Processes | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 11. | Time Value of Money | | | | | | | | | | | | | | | | | | | | | | | | | | | |