

TIDEE

Transferable Integrated Design Engineering Education



Conceptual Design

Section 1: Design Process

This section includes:

- **[IR]: Determining Students' Design Team Readiness**
- **Recognizing the Design Process**
- **Linking Design Project to Learning**
- **Applying TQM to Design**

As a starting point for this section, you may be given the opportunity to work through the Design Team Readiness Assessment (DTRA). The DTRA is helpful in preparing you to successfully complete Team Design projects. Specifically, it examines your knowledge of the engineering design process as well as your ability to collaborate in a group setting.

Recognizing the Design Process guides you through the basic elements of the design process. By visualizing product development as discrete steps from the definition of a problem to be solved on through the solution to that problem, you have a framework from which to tackle complex design projects. The video in this activity outlines these design steps.

Managers often lament about resources consumed “reinventing the wheel.” The second activity, *Linking a Design Project to Learning*, is geared at overcoming the tendency to relearn knowledge. By actively listening to a presentation given by your fellow students who have recently completed a Senior Level Capstone design project, potential project pitfalls may be avoided. The goal is to extract lessons learned in regards to product design, technical knowledge, and team interaction that will help your product development process.

The closing activity focuses on Total Quality Management (TQM). In today’s market, consumers expect quality products. TQM is a philosophy that integrates continuous improvement into all phases of production. An understanding of TQM will help you focus on process improvements that will satisfy the end customers.

[IR]: Determining Students' Design Team Readiness

[Instructor Resource] Teaching students engineering design requires both student and instructor understanding of student preparedness for team-based design. This mutual understanding guides defines instruction and motivates student learning. In this instructor resource, you will see how the Design Team Readiness Assessment (DTRA) can be used to jump-start instruction in a capstone engineering design course.

Objective: Learn how to implement the Design Team Readiness Assessment to orient students to your design expectations and to their need to learn team design skills.

Tasks

1. At the very beginning of a capstone engineering course, communicate to students your intentions to create an environment of openness and feedback that will maximize their learning. Oftentimes you will give them work assignments for which you provide them constructive feedback that is not graded. The purpose is to facilitate their learning. This first exercise is intended to determine their readiness for team-based design and to give them feedback; it will not be graded. The value of the feedback they receive will depend upon the extent to which they “show what they know.”
2. Allow 45 minutes to administer the DTRA. The DTRA instrument and scoring rubrics are available at the website url: www.tidee.cea.wsu.edu/assessment-tools/DTRA.html Administer Component 1 (Design Knowledge) in 15 minutes. Collect the students' work. Group students in 4-person groups for Component 2 (Design Performance). Collect team worksheets. Assign Component 3 (Design Reflection) as an individual homework assignment.
3. After collecting all student work, score the work using scoring rubrics provided. Determine class average scores and ranges for Design Process, Teamwork, and Design Communication. Identify topical areas where students have strengths and weaknesses.

Deliverables

1. Report to individual students their scores and overall class averages.
2. Discuss with the class your expected responses to the DTRA exercises. Probe for any misperceptions or misinterpretations. Identify topics that appear to need instructional time.
3. Ask students to identify:
 - a) A strength of the DTRA activity
 - b) An area for DTRA improvement
 - c) An insight gained through the DTRA activity

Criteria for Success

- Students engage in the DTRA and show what they know.
- The instructor establishes a trust relationship that encourages students to be open.
- Students and instructor gain understanding of design and student preparedness for design.

Resources

- Students' personal experience with engineering design
- *Design Team Readiness Assessment* (on TIDEE web site)
- 50 minutes total for administering DTRA

Activity: Recognizing the Design Process

The Engineering Design Process is a tool unique to the engineering profession. Use of this process empowers engineers to develop creative, viable solutions to problems of importance to both clients and society. Basic elements of this process become building blocks for problem solving in widely varying situations. In this activity, you will view a simple example of the engineering design process and relate it to steps envisioned in your team's design project.

Objective: Develop a simple representation of the engineering design process as applied to your team design project.

Tasks

4. Assign team members roles that support this activity.
5. As a team, brainstorm for elements or steps you believe to represent the Engineering Design Process. Record these on the Design Process worksheet.
6. View the *Engineering Design Process* video at the following web site URL:
<http://www.tidee.cea.wsu.edu/designprocess>
7. As a team, list the principal elements or stages of the Engineering Design Process as depicted by the *Engineering Design Process* video.
8. On the worksheet, also identify for each element of the engineering design process: Specific actions (e.g., interviewing clients, preparing drawings) your team will take as it completes its design project.

Deliverables

4. The team Reporter presents:
 - a) The team's list of design process elements
 - b) Selected design activities that fall under each design process element
5. The team Reflector presents:
 - d) A strength of your team in this activity
 - e) An area for team improvement
 - f) An insight gained through this activity

Criteria for Success

- Teams are able to list at least five elements of the design process
- Teams identify design actions that fall under each element
- Team members gain increased understanding of the Engineering Design Process

Resources

- Personal experience with engineering design
- *Engineering Design Process* video (requires *Flash* video player on computer)
- Worksheet: Design Process
- 20 minutes total for activity and video

Worksheet: Design Process

The Engineering Design Process is a series of steps between the statement of a problem or need and the final delivery of a design solution or product. The exact process varies from one design setting to another, but a generic design process includes a number of common steps or elements.

Brainstorm: List of Engineering Design Process Elements

From Video: List of Engineering Design Process Elements

Step or Element	Relevant Actions in Your Project
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Activity: Linking a Design Project to Learning

Engineering design projects serve as an exercise in applying previous knowledge and a context for new learning. The complexity of a typical team design project in a capstone design course provides you an opportunity to develop personal traits, interpersonal skills, and technical skills at the same time. In this activity, you will review a completed design project and identify the breadth of learning that was achieved through that project.

Objective: Develop an understanding of learning required and achieved in a typical capstone engineering design project.

Tasks

1. As a class, attend a student presentation of a completed capstone engineering design project, in which they discuss both their design process and their design results.
2. During the presentation, individually complete the (attached) Learning Outcomes worksheet.
3. After the presentation, as a class, summarize student learning outcomes recognized by anyone in the class.

Deliverables

1. Individual students report:
 - a) A learning outcome observed that is of great interest to you
 - b) A learning outcome that surprised you
2. The instructor presents a comparison of learning observed to learning expected in design projects planned for the class.

Criteria for Success

- Presenters are able to communicate their design processes and products and answer questions such that their learning is evident.
- Students recognize distinct learning outcomes from the project presented.
- Students gain an appreciation for the learning expected of them in their projects.

Resources

- Students who completed capstone design projects previously and are prepared to repeat their final design oral presentation.
- Worksheet: Learning Outcomes
- 30 minute presentation, 10 minute Q/A, 10 minute class discussion

Worksheet: Learning Outcomes

Student learning outcomes may be increased understanding, improved skills, or products that resulted from the application of knowledge. Identify examples of student learning outcomes observed (from the completed project) of the types listed below.

Design Products

Design Knowledge

Technical Knowledge

Interpersonal Skills

Personal Traits

Activity: Applying TQM to Design

TQM (Total Quality Management) is a philosophy that focuses on continuous improvement of processes to yield higher quality results. Key principles of TQM promote satisfying customers, continuously seeking to improve, preventing defects, and sharing responsibility for quality. In this activity, you will examine how the principles of TQM affect engineering design processes.

Objective: Determine ways that application of TQM in design can improve the quality of team design project achievements.
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Tasks

1. Assign team members roles that support this activity.
2. As individuals, review the TQM Philosophy and Principles handout.
3. As a team, develop a summary sentence that defines the essence of the TQM philosophy. Record this on the TQM Applied to Capstone Design worksheet.
4. Discuss those principles and elements of TQM that relate to the function of teams. Develop a consensus list of descriptors for team member interactions that reflect strong buy-in to TQM principles. Record this on your worksheet.
5. Discuss aspects of TQM that relate to design processes and design products developed for clients. Describe (list characteristics of) engineering design consistent with TQM principles. Record this on your worksheet.

Deliverables

1. The team Reporter presents:
 - c) Selected descriptors of TQM-compatible team interactions
 - d) Features of engineering design that reflect TQM principles
2. The team Reflector presents:
 - a) A practice of your team observed in this activity that reflected a TQM principle
 - b) An insight gained personally through this activity
3. Individual homework (due next class): A 1-to-2 page paper describing a high-performance design team engaged in a capstone engineering design project for a client.

Criteria for Success

- Students are able to articulate TQM principles in the context of team-based engineering design.
- Students understand how TQM principles can improve performance in engineering design.
- Students recognize TQM practices in action.
- Team members gain increased understanding of teamwork

Resources

- Personal experiences with teams, design, and improvement philosophies
- Handout: TQM Philosophy and Principles
- Worksheet: TQM Applied to Capstone Design

Handout: TQM Philosophy and Principles

Total Quality Management (or Continuous Quality Improvement) is practiced in many high performance organizations. It engages people positively to achieve higher levels of quality and greater satisfaction of people served. This produces happier employees and customers and overall success for organizations.

Total Quality Management Concepts

Four overall philosophies guide Total Quality Management.

Customer Focus

- Know your internal and external customers and their needs. Anyone affected by your actions may be considered a “customer.” Know their definitions of “quality.”

Continuous Improvement

- Recognize that there is always room for improvement. Maintain a commitment to continually seeking to improve.

Defect Prevention

- Defects (mistakes, errors, etc.) cause losses in time and damage to relationships. It is much better to anticipate and avoid problems than to recover after they have occurred. Seek to prevent potential problems. “A stitch in time saves nine.”

Shared Responsibility for Quality

- Together we succeed or fail. Everyone involved should be held responsible for quality within their area of assignment and in support of others in their areas of assignments.

Total Quality Management Elements for Implementation

Implementation of Total Quality Management philosophies occurs on many fronts and depends upon many people. The following is a list of elements of TQM found in many environments in which it is implemented effectively.

- 1) Sustained management commitment to quality: Commitment to TQM must occur at the top of an organization as well as everywhere else. It does not work without support of supervisors.
- 2) Focusing on customer requirements and expectations: The customer must be satisfied; this requires ongoing focus to know and respond to customer needs.
- 3) Preventing defects rather than detecting them: It is not good enough to allow defective work to occur, then detect it and reject it; we must prevent work from being substandard.
- 4) Recognizing that responsibility for quality is universal: It is not good enough to have a quality inspector; everyone must monitor their own quality so they can make changes to keep quality high.
- 5) Quality measurement: Whatever is defined as “quality” must be measured so everyone knows it and can monitor and control it.
- 6) A continuous improvement approach to doing business: The “if it isn’t broken, don’t fix it” philosophy allows stagnation and deterioration; always look for improvements.
- 7) Root cause corrective action: When a problem occurs, determine the root cause and correct the cause; this produces long-term improvement.
- 8) Employee involvement and empowerment: Everyone needs to contribute to improvement; that may require workers to be given authority to make decisions that affect quality.
- 9) The synergies of teamwork: An effective team produces more than the sum of the parts; this requires high level team development.
- 10) Process improvement: When improvements are needed, look at the processes being used; oftentimes faulty processes cause the problems to occur, so processes need to be improved.
- 11) Thinking statistically: Statistics are tools to quantify variation, anticipate problems, and monitor quality; people need to understand and use statistics to control quality.

- 12) Benchmarking: Be knowledgeable about competing products, learn from them, determine how to make your products strategically better than the competition.
- 13) Inventory reduction: Processes under control require less "reserve" to cover for problems, but large reserves or inventories cost money; seek high quality and low inventories.
- 14) Value improvement: Value of a product or process is its worth compared to investments; review quality with the goal of improving value while decreasing investments.
- 15) Supplier teaming: When using products supplied by others, we benefit by having quality raw products; teaming with suppliers enables them to know our needs so they can meet them better.
- 16) Training: Training is required to enable people to do their jobs better; get/provide necessary training to support high quality performance.

Worksheet: TQM Applied to Capstone Design

Total Quality Management Definition

Total Quality Management is:

Team Interactions per TQM

Team interactions consistent with TQM principles have the following characteristics:

Engineering Design per TQM

Engineering design consistent with TQM principles has the following characteristics: