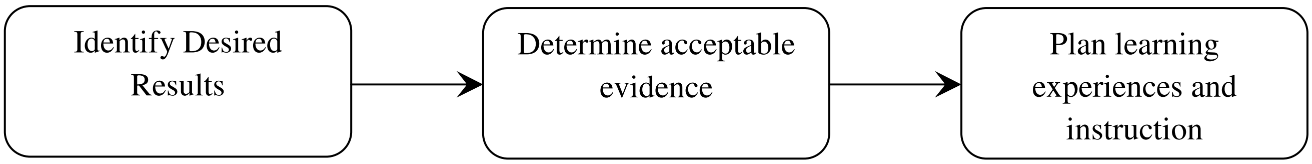


**Figure 2. Stages in the Backward Design Process[5] (p. 9)**

One of the most challenging components of the backward design process is to identify the desired results. A common mistake made when first using the Understanding by Design methodology is to assume that everything taught in the classroom is as important as everything else. However, one of the most powerful facets of UbD is the systematic development of the big picture ideas we want our students to truly learn versus material that is worth being familiar with. The three components of desired results in order of priority are: 1) "Enduring Understanding", 2) Important to know and do, and 3) Worth being familiar with.

"Enduring Understandings" are often referred to as overarching ideas. Overarching from the standpoint that goals, understandings, or processes represent enduring value beyond the classroom. These are the "big ideas" the students leave with. They are also the "linchpins" that hold the entire curriculum together. Furthermore, they are the most difficult and most important part of the UbD methodology because every subordinate action following "enduring understanding" must, in some direct or indirect manner, tie back to these identified understandings (often only 1-3 per course). Next on the priority list is "Important to know and do". The results at this level are not the big ideas but rather facilitate deeper understanding of the big ideas. Finally, there are other goals and information that have merit in their support of the overall curriculum without bearing heavily on the enduring understandings. These concepts and facts are considered "worth being familiar with" and can include a limited amount of remembering-type of information from an assessment standpoint.

Another critical aspect of the UbD method is using appropriate assessments to gauge the level of apparent understanding. In the second stage of UbD, what and how students are assessed is determined. Evidence of learning must differentiate between understanding and simply recalling facts. Wiggins and McTighe[5] suggest that, "Real knowledge involves using learning in new ways (what is often called "transfer"). They [Bloom and colleagues] distinguish this intellectual ability from knowledge that is based on recall and scripted use" (p. 40). With this knowledge "transfer" in mind, UbD presents the six facets of learning that reflect true understanding:

- Explanation: ability to thoroughly give an account of facts and data.
- Interpretation: ability to reveal from one's personal dimension through images, models, or analogies.
- Application: ability to effectively use the information in different contexts.
- Perspective: ability to see the big picture through creative critique.
- Empathy: ability to value another's feelings, perspective, or worldview.

- Self-knowledge: ability to perceive our own prejudices as shortcomings.

The facets of understanding are not to be confused with the types of assessment, such as informal checks, observations, quizzes/tests, academic prompts, or performance tasks/projects, but rather, the six facets of understanding are, "a multifaceted view of what makes up a mature understanding" (p. 44).

It is not until the final stage of the process that the syllabus, projects, and class activities are developed. More importantly, a textbook should only be selected on the basis of how well it bolsters the desired results. Although initially counterintuitive, planning learning experience and selecting textbooks after stages 1 and 2 are complete, makes the rest of the curriculum development process less ambiguous. Faculty often have a mass of information or activities to filter through to find what best suits their classes; however, at stage 3, they can evaluate activities, projects, tests, or textbooks based on the desired goals. Any material not conforming to the goals of the desired results, or "enduring understandings" are immediately disregarded for inclusion in the curriculum. Table 1, provides a snapshot of the UbD design approach, as summarized above.

| **Key Design Questions** | **Design Considerations** | **Filters (Design Criteria)** | **What the Final Design Accomplishes** |
|---|---|---|---|
| **Stage 1**: What is worthy and requiring of understanding? | National, State, and District Standards.<br>Teacher expertise, experience, or interest | Enduring Ideas<br>Engaging<br>Overarching ideas | Unit around enduring ideas and essential questions students will be able to answer |
| **Stage 2**: What is evidence of understanding? | Six facets of understanding<br>Assessment types | Valid, reliable, sufficient, authentic work, feasible, and student friendly | Educationally vital evidence of the desired results. |
| **Stage 3**: What learning experiences and teaching promote understanding, interest, and excellence? | Essential and enabling knowledge and skill.<br>Support of design consideration in Stage 1 | WHERE?<br>Hook the students<br>Exhibit and evaluate | Coherent learning experiences and teaching that evokes and develops desired understandings, promotes interest, and makes excellent performance more likely |

**Table 1. Overview of the UbD process (adapted from Wiggins and McTighe[5]).**

**Putting the UbD Process into Practice**

As mentioned above, the first step in the UbD process is identification of the enduring understanding(s) that will focus the curriculum for a particular course. Table 2 provides examples of enduring understandings from technology-related courses developed using the UbD principals.

| Course | Enduring Understanding |
|---|---|
| Lean Manufacturing | 1) Establishment of a pull system with linked manufacturing cells is a key component of maintaining global competitiveness.<br>2) Successful implementation of lean is a management process requiring total commitment from all employees that results in a complete change of the workplace culture. |
| Materials and Testing | 1) Industrial materials have unique properties that precipitate their use in different industrial and product applications.<br>2) The molecular structure (including chemical bonds) impact and explain material properties. |
| Metallic Processing | 1) Fabricated metal products require proper planning.<br>2) Proper selection of machine tools and process parameters is imperative prior to beginning any material removal. |
| Safety Management | 1) Workplace safety is a management function that requires commitment and involvement from all employees to be successful. |
| Occupational Safety | 1) As a manager or supervisor, you are responsible for the safety of all employees under you. |
| Safety and Public Health Issues | 1) As technologists and engineers, we all have a role to play in addressing society's safety and health issues. |

**Table 2. Examples of Enduring Understandings.**

Full appreciation of the UbD process can only be obtained through implementation. However, the examples provided here should give the reader insight into how the three stages of the UbD process fit together.

A vital step in developing courses for critical and creative thinkers is incorporating activities that engage students and encourage creative solutions to open-ended questions. For example, the first enduring understanding under the lean manufacturing course in Table 2 is, *Establishment of a pull system with linked manufacturing cells is a key component of maintaining global competitiveness*. What evidence will support the enduring understanding as well as encourage students to think critically? This question is answered in the second stage of the Understanding by Design process, **Stage 2: What is evidence of understanding**. In our lean manufacturing course example, there are several assessment evidences that ultimately point to the enduring understanding at hand; these are listed below:

- Students will demonstrate their ability to critically assess the efficacy of current manufacturing systems to determine how to convert those systems into lean manufacturing by individually completing labs, completing the semester project, via online discussions (moderated by the instructor), and as essay questions on written exams.

- Students will demonstrate their ability to identify manufacturing systems as either push or pull by visiting a manufacturing plant providing the instructor a short research paper outlining the current process and possible improvements.

Another example is taken from the Material Testing course above. What evidence of understanding is there for the enduring understanding: *Industrial materials have unique properties that precipitate their use in different industrial and product applications*?

- Students will demonstrate their knowledge of material selection by working in teams of 2 or 3 to develop a unique composite of concrete with other materials and test the new material to compare the advantage or disadvantages to standard construction-grade concrete.

- Students will demonstrate the ability to choose and justify industrial materials by redesigning an everyday product (stapler, toaster, chair) and evaluating the advantages and disadvantages based on standard data and testing.

Another example is taken from the safety management course above. What evidence of understanding is there for the enduring understanding: *Workplace safety is a management function that requires commitment and involvement from all employees to be successful*.

- Students will demonstrate their knowledge and understanding of the principles of behavior-based safety management by working in teams of 3-4 to develop a proposal to implement a peer-observation program to encourage safe behaviors and discourage at risk behaviors among employees.

- Students will demonstrate the ability to identify workplace hazards and the importance of having multiple perspectives on the audit team by working in teams of 3-4 to conduct a workplace audit using OSHA's Small Business Outreach Training Program as a guide.

It should be noted that the evidence identifies multiple assessment methods such as, observation/dialogue, quizzes/tests, academic prompts, and performance task/projects. All of these tie back to the enduring understanding. For example, students cannot fully appreciate the benefits of lean manufacturing without first understanding how it differs from push systems. Multiple assessments, like a mandatory field trip [observation/dialogue] to a manufacturing facility and subsequent critique [performance task] serve as the cornerstone of thinking critically. Additionally, the planned learning activities that include multiple assessment methods become metrics for course and program evaluations. How well an assessment measures the level of understanding can and should be recorded for future use.

## Concluding Thoughts and Recommendations

Too often curriculum design is based on the content and organization of a textbook. In this model the syllabus and assignments are based on what the author of the textbook deemed important regardless of the how a particular course fits into the overall curriculum or desired student learning experience. It is therefore not surprising that this disconnect in curriculum design later frustrates faculty as they struggle with achieving and measuring desired student outcomes that have been set for the curriculum. This paper provides an alternative for curriculum development where the desired student outcomes take center stage and the resulting curriculum follows naturally. The authors encourage faculty to experiment with the UbD methodology as part of the continuous improvement process for their curriculum.

## Stage 1 –Desired Results

Established Goal(s):

| Understanding(s): | Essential Question(s): |
|---|---|
| *Students will understand that…*<br>1. *Establishment of a pull system with linked manufacturing cells is a key component of maintaining global competitiveness.*<br>2. *Successful implementation of lean is a management process requiring total commitment from all employees that results in a complete change of the workplace culture.* | 1. *What is the difference between push vs. pull systems and why is this important in the current global environment?*<br>2. *What are some of the common pitfalls that prevent successful conversion to lean?*<br>3. *Who is involved in converting to lean manufacturing?* |
| *Students will know…*<br>• *The ten logical steps to lean conversion and how to apply them.*<br>• *How to work in Kaizen teams towards lean conversion.*<br>• *How to assess the efficacy of current manufacturing systems to determine how to convert those systems into lean manufacturing.* | *Students will be able to…*<br>• *Present professional-level rationale and results of pre- and post-conversion data using standard manufacturing economic principles and practices.*<br>• *Identify any manufacturing process as being a push or pull system.* |

•

## Stage 2 – Assessment Evidence

| Performance Task(s): | Other Evidence: |
|---|---|
| • *Students will demonstrate their knowledge of the ten logical steps of lean conversion through written examination and by individually developing a Gantt chart of a hypothetical manufacturing firm that requires lean conversion.*<br>• *Students will demonstrate their ability to work in and through Kaizen teams by working on their semester projects in teams of 3 or 4. Anonymous evaluation of each team member will also be submitted via a course webpage developed by the instructor.*<br>• *Students will demonstrate their ability to critically assess the efficacy of current manufacturing systems to determine how to convert those systems into lean manufacturing by individually completing labs, completing the semester project, via online discussions (moderated by the instructor), and as essay questions on written exams.* | • *Students will practice presenting professional-level rationale results of pre- and –conversion data (verbally and written) using standard manufacturing economic principles and practices via individual labs and a research paper. Students will later demonstrate their ability to present professional level material via the semester project.*<br>• *Students will demonstrate their ability to identify manufacturing systems as either push or pull by visiting a manufacturing plant providing the instructor a short research paper outlining the current process and possible improvements.* |

## Stage 3 – Learning Plan

Learning Activities:

- *In groups of 3-4, students will reverse engineer a small home or office tool and, using simulation software, will offer their best assumption of how the product is pushed out the door. They will then re-engineer their product using the Kaizen team principles. Using process simulation software, the students will simulate their new linked-cell manufacturing cell and use a statistical package to justify their findings. The students must incorporate standard manufacturing economics as a "bottom-line" justification to their new product and process designs.*
- *Online discussions: Students will engage in weekly online discussions to assess their knowledge of the text information as well as share their experiences with the topic at hand.*
- *Labs: Students will be given labs to demonstrate their knowledge of lean manufacturing principles and practices by applying them to sample problems using their critical thinking abilities.*
- *MS Project: Students will develop a comprehensive project file that incorporates all the steps of lean in converting a hypothetical factory of their choice.*
- *A mid-term and a final exam will be administered to gage the level of understanding of factual information.*
- *Research Paper: students will visit a manufacturing firm of their choosing (or their place of work) and write a short research paper to assess the current type of production system (push or pull) with their assessment of possible improvements.*