

# **AC 2008-924: TEACHING CRITICAL THINKING USING UNDERSTANDING BY DESIGN**

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## Teaching Critical Thinking using Understanding by Design Curriculum Development Methods

*“It is only when students apply what they are learning to actual situations or problems that they come to see the value in what they are learning”<sup>2</sup> (p. 4).*

### Introduction

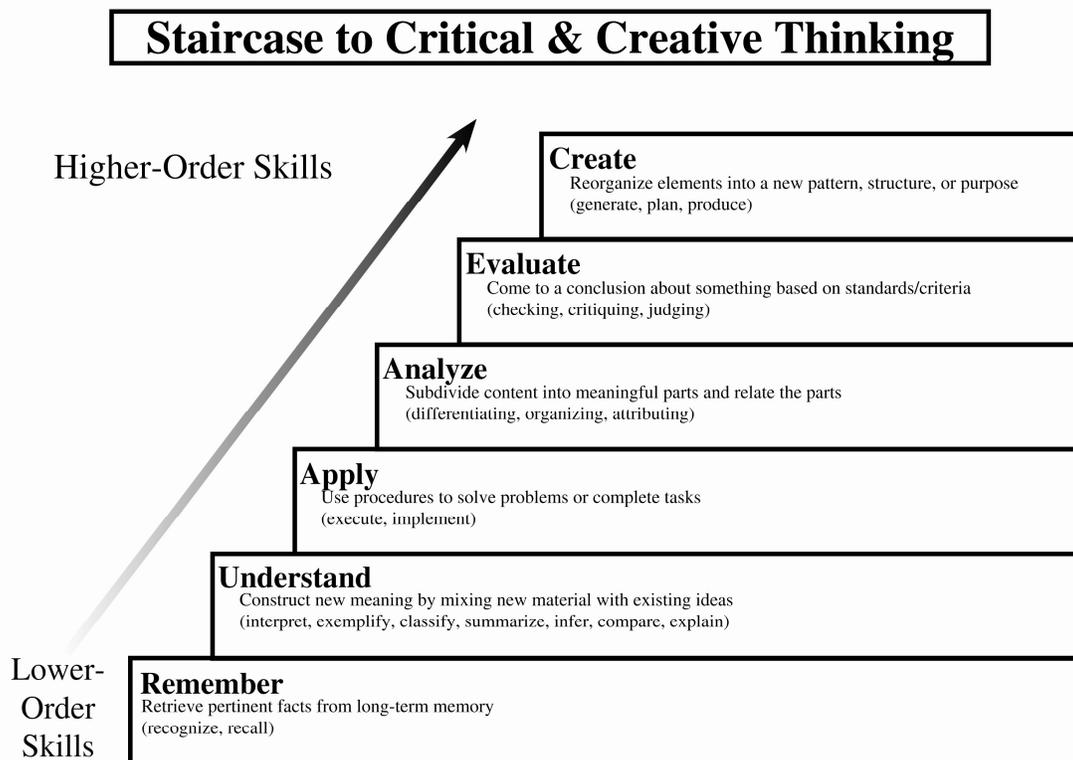
Academia is buzzing with the idea of teaching students to think critically and creatively. This article introduces the reader to the use of the Understanding by Design<sup>5</sup> methodology, also known as the “Backward Design Process”. This is an approach to develop technical courses that aim to cultivate higher-order skills in students. By incorporating recommended critical thinking design features, this article provides examples and a framework for the development of new courses or the revision of current courses. A list of websites devoted to critical thinking and Understanding by Design tools is included at the end of this article for additional information.

### Critical Thinking

Critical Thinking can be defined as, “the art of thinking about thinking in such as way as to: 1) identify its strengths and weaknesses, and 2) recast it in improved form (where necessary)”<sup>3</sup> (p. 22). Chaffee<sup>1</sup> defines critical thinking as, “An active, purposeful, organized process that we use to carefully examine our thinking and the thinking of others, in order to clarify and improve our understanding” (p. 51). This is further warranted by Paul and Elder’s<sup>3</sup> observation about the importance of creativity in critical thinking in the following manner:

The most important sense of creativity in thinking, the sense of thinking as a making, as a process of creating thought, as a process that brings thoughts into being to organize, shape, interpret, and make sense of the world – thinking that, once developed, enables us to achieve goals, accomplish purposes, solve problems, and settle important issues we face as humans in a world in which rapid change is becoming one of the few constants (p. 7).

In this sense, creativity refers to a level of high-quality thinking where the mind is able to both generate and judge how information gravitates towards a system of meanings<sup>3</sup>. Research suggests that both the student and society benefit from the development of critical and creative thinking<sup>6</sup>. Zhang<sup>7</sup> hypothesizes that critical thinking requires both ability [to think critically] and disposition [propensity for thinking critically]. Some introductory courses may appropriately be designed with only lower-order skills (i.e. recognize, recall, remember). However, courses bearing heavily on critical and creative thinking require higher-order skills and corresponding assessments as shown in the Staircase to Critical & Creative Thinking<sup>4</sup> (See Figure 1). Although successful academic programs depend on many good characteristics, Zhang<sup>7</sup> finds two characteristics to be notable; they are, “...(a) facilitates critical thinking and (b) recognizes a variety of intellectual styles” (517).

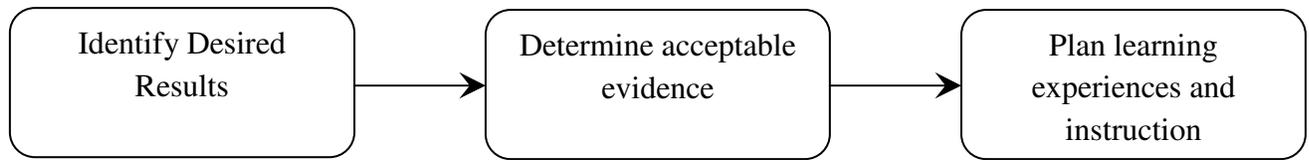


**Figure 1. Staircase to Critical and Creative Thinking<sup>4</sup>**

As demonstrated in Figure 1, remembering or retrieving information, although the first step towards higher-order skills, is not evidence of unique perspective and exploration of situations with questions and assessments. Instead, proficient critical thinkers go beyond constructing new meanings by mixing new material with existing ideas (Understand) and ultimately reorganize elements into new patterns, structures, or purposes (Create). Asking students to recall chemical symbols and atomic numbers is a lower-order skill (Remember). If those chemical symbols and atomic numbers are used to demonstrate how different chemicals react or bond with one another in a predictable pattern (Apply) or students mathematically and logically evaluate their own compounds based on the memorized chemicals, they demonstrate higher-order skills (Evaluate and Create).

### **Understanding by Design (UbD)**

Understanding by Design (UbD) or the Backward Design Process is so called because of the suggested format of designing curriculum beginning with desired results. Learning experiences and instruction are planned to help students achieve those desired results. Overall, it is a 3 stage process as shown in Figure 2.



**Figure 2. Stages in the Backward Design Process<sup>5</sup> (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<sup>5</sup> 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.

<b>Key Design Questions</b>	<b>Design Considerations</b>	<b>Filters (Design Criteria)</b>	<b>What the Final Design Accomplishes</b>
<b>Stage 1:</b> What is worthy and requiring of understanding?	National, State, and District Standards.  Teacher expertise, experience, or interest	Enduring Ideas  Engaging  Overarching ideas	Unit around enduring ideas and essential questions students will be able to answer
<b>Stage 2:</b> What is evidence of understanding?	Six facets of understanding  Assessment types	Valid, reliable, sufficient, authentic work, feasible, and student friendly	Educationally vital evidence of the desired results.
<b>Stage 3:</b> What learning experiences and teaching promote understanding, interest, and excellence?	Essential and enabling knowledge and skill.  Support of design consideration in Stage 1	WHERE?  Hook the students  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<sup>5</sup>).**

## 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	<ol style="list-style-type: none"><li>1) Establishment of a pull system with linked manufacturing cells is a key component of maintaining global competitiveness.</li><li>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.</li></ol>
Materials and Testing	<ol style="list-style-type: none"><li>1) Industrial materials have unique properties that precipitate their use in different industrial and product applications.</li><li>2) The molecular structure (including chemical bonds) impact and explain material properties.</li></ol>
Metallic Processing	<ol style="list-style-type: none"><li>1) Fabricated metal products require proper planning.</li><li>2) Proper selection of machine tools and process parameters is imperative prior to beginning any material removal.</li></ol>
Safety Management	<ol style="list-style-type: none"><li>1) Workplace safety is a management function that requires commitment and involvement from all employees to be successful.</li></ol>
Occupational Safety	<ol style="list-style-type: none"><li>1) As a manager or supervisor, you are responsible for the safety of all employees under you.</li></ol>
Safety and Public Health Issues	<ol style="list-style-type: none"><li>1) As technologists and engineers, we all have a role to play in addressing society's safety and health issues.</li></ol>

**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.

### **Referenced Cited**

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5. Wiggins, G. & McTighe, J. (1998). *Understanding by Design*. Association for Supervision and Curriculum Development. Alexandria, VA.
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## Online Resources for Further Exploration of these Topics

### *Critical Thinking*

- Critical thinking: <http://www.criticalthinking.org>
- How to keep your students thinking:  
[http://trc.virginia.edu/Publications/Teaching\\_Concerns/Spring\\_1995/TC\\_Spring\\_1995\\_Students\\_Thinking.htm](http://trc.virginia.edu/Publications/Teaching_Concerns/Spring_1995/TC_Spring_1995_Students_Thinking.htm)
- Recommendations for department self-evaluations:  
<http://www.criticalthinking.org/resources/recomendations-for-self-evaluation.shtml>
- Grading standards in critical thinking: <http://www.criticalthinking.org/resources/college-wide-grading-standards.shtml>
- Grading policies in critical thinking: <http://www.criticalthinking.org/resources/ct-class-grading-policies.shtml>
- Critical thinking motivators:  
<http://www.calstatela.edu/dept/chem/chem2/Active/index.htm>
- Teaching students to think critically:  
[http://trc.virginia.edu/Publications/Teaching\\_Concerns/Spring\\_1993/TC\\_Spring\\_1993\\_Voytko.htm](http://trc.virginia.edu/Publications/Teaching_Concerns/Spring_1993/TC_Spring_1993_Voytko.htm)
- Strategies for teaching critical thinking: <http://pareonline.net/getvn.asp?v=4&n=3>

### *Understanding by Design*

- Understanding by Design Resources:  
<http://www.ascd.org/portal/site/ascd/menuitem.6a270a3015fcac8d0987af19e3108a0c/>
- Understanding by Design Exchange: <http://www.ubdexchange.org/>
- Course Development Template:  
[http://www.d.umn.edu/~hrallis/courses/3204sp05/assignments/ubd\\_template.htm](http://www.d.umn.edu/~hrallis/courses/3204sp05/assignments/ubd_template.htm)
- Authentic Education: <http://www.authenticeducation.org/ubd.html>
- Multiple Methods of Assessment:  
[http://xnet.rrc.mb.ca/glenh/understanding\\_by\\_design.htm](http://xnet.rrc.mb.ca/glenh/understanding_by_design.htm)

