

Creativity and its Assessment in a Design and Development of Food Products and Processes Course

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Abstract

Creative thinking in higher education can only be expressed productively within a particular domain. The student must have a strong foundation in the strategies and skills of the domain in order to make connections and synthesize. While demonstrating solid knowledge of the domain's parameters, the creative thinker, at the highest levels of performance, pushes beyond those boundaries in new, unique, or atypical re-combinations, uncovering or critically perceiving new syntheses and using or recognizing creative risk-taking to achieve a solution¹. Thus, a didactic intervention and its corresponding assessment was implemented with the purpose of enhancing creative thinking and improving the food product design and development processes in the studied *Design and Development of Food Products and Processes* capstone course²⁻⁵.

Assessment of creativity was grounded on the *Consensual Assessment Technique*⁶ (CAT), which is based on the idea that the best measure of creativity regardless of what is being evaluated, is the assessment by experts in that field. Therefore, a group of experts in the FE field were invited to evaluate capstone course final projects and developed food products by means of the *Creative Thinking VALUE Rubric*, which is made up of a set of attributes that are common to creative thinking across disciplines^{1, 7}. Possible performance levels were entitled *capstone* or *exemplar* (value of 4), *milestones* (values of 3 or 2), and *benchmark* (value of 1). Instructor, peer-, and self-assessments were also performed throughout the course and on final project. Additionally, a *Specific Course Rubric* that included technical aspects regarding food product development as well as abilities of the team to present their product and answering questions raised during oral and poster presentations, and during tasting of developed food products. For this specific rubric, the scale varied from 1 (*novice*) to 4 (*expert*).

Mean values from *Creative Thinking VALUE Rubric* assessment of final projects were 2.35 for *Acquiring Competencies* (attaining strategies and skills within a particular domain), 2.42 for *Taking Risks* (may include personal risk, fear of embarrassment or rejection, or risk of failure in successfully completing assignment, i.e. going beyond original parameters of assignment, introducing new materials and forms, tackling controversial topics, advocating unpopular ideas or solutions), 2.44 for *Solving Problems*, 2.44 for *Embracing Contradictions*, 2.40 for *Innovative Thinking* (novelty or uniqueness of idea, claim, question, form, etc.), and 2.24 for *Connecting, Synthesizing, and Transforming*. Regarding the *Specific Course Rubric* some teams performed better than others in selected aspects, probably due to the content and explanations given during presentations of their products. For the product design category, teams projects received scores higher than 2.5, which correspond to an intermediate level performance.

Introduction

The main task of a food engineer is to design and operate processes to transform raw materials into final products, particularly with the aim to control, prevent, or delay spoilage caused by chemical reactions, physical effects, and/or biological activity⁸. At *Universidad de las Américas Puebla* (in Mexico), food engineering (FE) students apply their knowledge and skills required to function in the different fields of FE in the capstone course entitled *Design and Development of Food Products and Processes*. A FE student must have a solid grounding in the disciplinary strategies and domain skills in order to make connections and synthesize in the development of an original food product. On the other hand, a creative thinker while demonstrating a solid knowledge of the parameters of the domain in the highest levels of performance, pushes him or herself beyond those limits by means of new, unique or atypical combinations; discovering or critically perceiving new synthesis, and using or recognizing risk taking to achieve a creative solution. Thus, creative thinking can only be expressed productively within a particular domain¹.

Theoretical framework

Parallel to the theories of learning, creativity has been developing into a social, cultural and contextual insight. From this new vision, creativity is not only an internal process as conceived in 1950 by Guilford⁹ that included fluency, flexibility, elaboration, originality, and redefinition; but rather a polyseme, a multidimensional construct mediated by various factors. Sternberg and Lubart^{6, 10} point out that according to their investment theory, creativity requires a confluence of six distinct but interrelated resources: intellectual abilities, knowledge, styles of thinking, personality, motivation, and environment. Although levels of these resources are sources of individual differences, often the decision to use a resource is a more important source of individual differences:

1. *Intellectual skills*. Three intellectual skills are particularly important: (a) the synthetic skill to see problems in new ways and to escape the bounds of conventional thinking, (b) the analytic skill to recognize which of one's ideas are worth pursuing and which are not, and (c) the practical-contextual skill to know how to persuade others of (to sell other people on) the value of one's ideas. The confluence of these three skills is very important.
2. *Knowledge*. On the one hand, one needs to know enough about a field to move it forward. One cannot move beyond where a field is if one does not know where it is. On the other hand, knowledge about a field can result in a closed and entrenched perspective, resulting in a person's not moving beyond the way in which he or she has seen problems in the past. Knowledge thus can help, or it can hinder creativity.
3. *Thinking styles*. Thinking styles are preferred ways of using one's skills. In essence, they are decisions about how to deploy the skills available to a person. With regard to thinking styles, a legislative style is particularly important for creativity, that is, a preference for thinking and a decision to think in new ways. It also helps to become a major creative thinker, if one is

able to think globally as well as locally, distinguishing the forest from the trees and thereby recognizing which questions are important and which ones are not.

4. *Motivation.* Intrinsic, task-focused motivation is also essential to creativity. The research of Amabile¹¹⁻¹³ and others has shown the importance of such motivation for creative work and has suggested that people rarely do truly creative work in an area unless they really love what they are doing and focus on the work rather than the potential rewards.
5. *Personality.* Numerous research investigations have supported the importance of certain personality attributes for creative functioning. These attributes include, but are not limited to, willingness to overcome obstacles, willingness to take sensible risks, willingness to tolerate ambiguity, and self-efficacy. In particular, buying low and selling high typically means defying the crowd, so that one has to be willing to stand up to conventions if one wants to think and act in creative ways. Often creative people seek opposition; that is, they decide to think in ways that countervail how others think. Note that none of the attributes of creative thinking is fixed. One can decide to overcome obstacles, take sensible risks, and so forth.
6. *Environment.* Finally, one needs an environment that is supportive and rewarding of creative ideas. One could have all of the internal resources needed to think creatively, but without some environmental support (such as a forum for proposing those ideas), the creativity that a person has within him or her might never be displayed.

Creativity involves the application of these six resources to specific tasks. Sternberg and Lubart^{6, 10} claim that when combined interactively, they can stimulate creativity beyond their individual limits.

The course: *Design and Development of Food Products and Processes*

The studied course is taught by means of an active learning environment based on Jonassen¹⁴ constructivist perspective that includes several problem-solving learning environments (PSLEs), a term that represents problem-solving instruction in a more open-ended way than problem-based learning¹⁵. Learning to solve problems requires practice in solving problems, not learning about problem solving. PSLEs assume that learners must engage with problems and attempt to construct schemas of problems, learn about their complexity, and mentally wrestle with alternative solutions^{15, 16}. Moreover, the course gives students the opportunity to be involved in a major undergraduate program integration project, which includes the creation of a new food product and design its processing. Course topics are divided into four categories (Table 1).

General objective. At the end of the course, students will be able to understand and apply the methodology for the design of food products and processes, integrating the knowledge acquired in previous courses regarding food science, technology, and engineering, as well as engineering economics and related areas. Implement procedures to obtain a high quality food product that could compete successfully on the market of processed foods, which will allow students to develop a new product and its corresponding processing, in order to demonstrate their learning.

Table 1. Modular Structure for the Course *Design and Development of Food Products and Processes*

Product design	Product description and evaluation	Processing description and evaluation	Safety
<ul style="list-style-type: none"> • Research • Problem insight • Idea generation • Feasibility Analysis • Idea selection • Financial Analysis • Start product fabrication 	<ul style="list-style-type: none"> • Formulation and Ingredients' functionality • Shelf-life • Packaging • Cost • Nutritional labeling 	<ul style="list-style-type: none"> • Processing flow diagram • Critical control points • Processing limits • Operation costs 	<ul style="list-style-type: none"> • Legislation – additives use • Good manufacturing practices • Use and safety for the consumer

Expected course learning outcomes are such that students will be able to:

- Identify consumer and commercial factors that should be considered when designing a new product
- Describe the product to be developed
- Develop and evaluate potential product formulations
- Propose the manufacturing process for the product to be developed
- Choose the most suitable packaging for the product
- Evaluate the shelf-life of the product
- Locate and describe the laws applicable to the ingredients used to ensure the safety of the developed product
- Develop a nutritional label for the product
- Identify critical control points and limits of the proposed process
- Estimate operating costs and investment required to start the production line.

Course main goal. Students must design and develop a food product with all its implications. The learning environment is designed to present the problem, simulating the conditions in order for them to experience a real work environment, where students have the opportunity to think and act as experts in the field do.

Students were organized into teams of two members; the group had a total of ten students (4 male). Course activities were carried out in a classroom during the first stage while the next three stages are designed for student teams to work independently in the required labs, depending on their product (Figure 1).

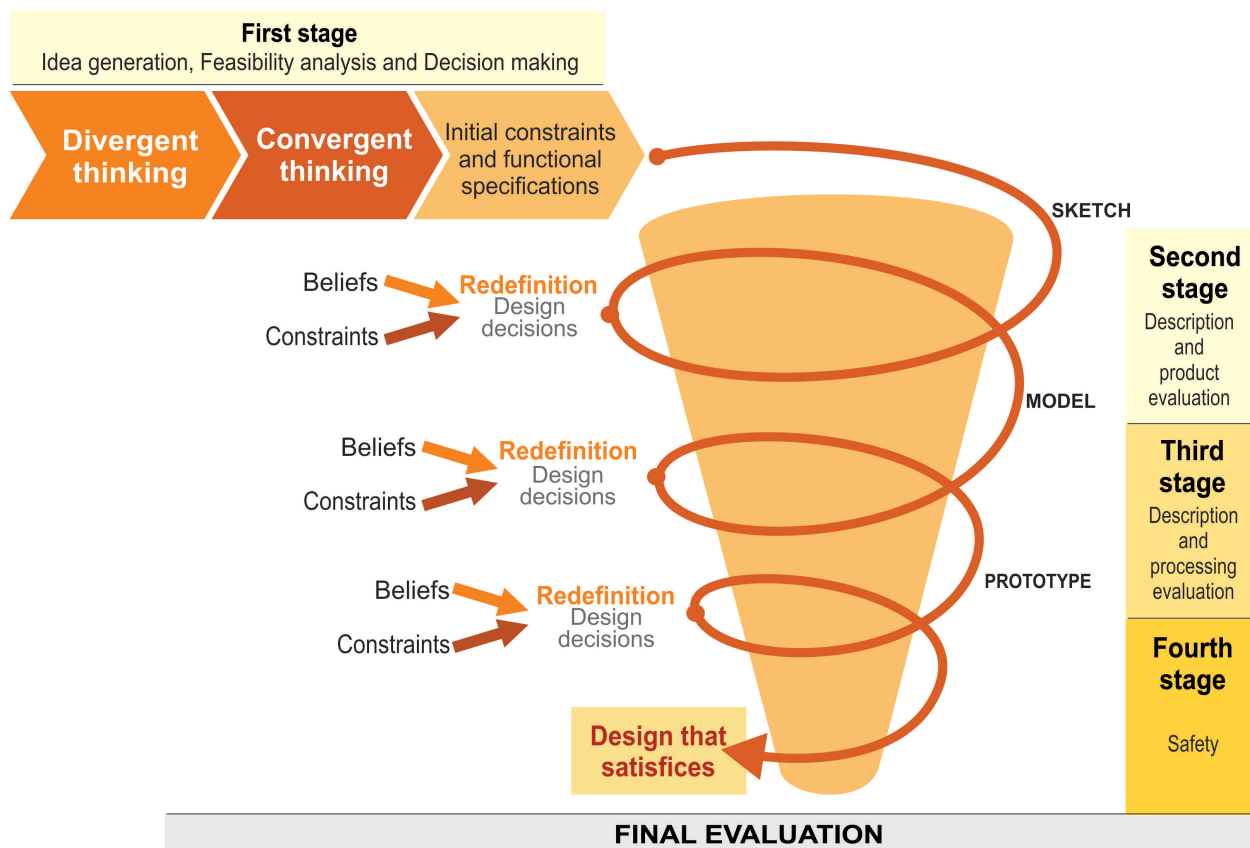


Figure 1. Outline of the Design Process for the Course *Design and Development of Food Products and Processes*.

The first stage: product design

This stage focuses on the information sources and related complementary analogies. Students at this stage were sensitized to the problem, for which they had videos, text documents, as well as some support documents regarding techniques for creative and analytical performance.

Decisions taken during the design process require analytical and creative thinking processes. Although many think that is a restricted process that omits the functions of creativity and inspiration. Jonassen¹² opposes this idea, arguing that even very creative designers must deal with a number of design factors such as material costs and functions that restrict the processes of decision-making. To strengthen the creative output of students, a module of two sessions was performed to enhance the quantity and quality of ideas generated. People generate ideas constantly, is a natural cognitive process. However, cognitive flexibility that the student possesses is determinant in the quality of ideas. The use of these techniques enhanced students' creative performance. Creativity techniques³ were presented in three phases:

- Phase 1. Idea generation
 - Prior unblocking exercise
 - Classical Brainstorming
 - Analog Brain-writing
- Phase 2. Decision analysis
 - Dunker Diagram
 - Kepner-Tregoe Decision Analysis
- Phase 3. Feasibility analysis.
 - Matrix Analysis: This matrix that includes a plurality of grounds for discrimination, was used to analyze the feasibility of the idea, this matrix was developed as a collaborative classroom activity, where every student was involved.

The Investment Theory of Creativity of Sternberg and Lubart^{5, 10} makes a metaphor of creativity based on financial investment; the authors say that creative people choose buying low and selling high in the world of ideas. This stage ended when the students had a clear idea of the product that they want to develop. In the next stage they begin the process of preparing to turn this idea into a valuable, appropriate, and original product.

The second stage: description and evaluation of the product

This stage facilitates the use of cognitive tools; students started with their product description, although this description will be modified during the design process. This description focused on the design and functionality of each of the ingredients that contains their product, its shelf-life, determined the cost and chose the right type of packaging for their product while initiated the development of product nutritional label.

Regarding the actual development of the product, in this stage teams were given required freedom, since the process was performed in the laboratories, they were free to use required tools and were given full autonomy to start its development. The design process is iterative, presents itself as a spiral of decisions that occur in cycles due to evaluations of the product to be undertaken to achieve the ideal (Figure 1). Decisions taken during the design process required creative and analytical thinking, so the whole process was considered a creative act¹⁷.

The third stage: description and processing evaluation

In this stage students continued with documentation of their processes, they made the processing flow chart for their developed product, identified critical control points, processing limits, and operating costs that were included in their reports. They already made their first prototype, it became evident the use of conversation and collaboration tools throughout the progress of their projects and a first tasting to evaluate their food products was performed, an activity that fostered

social and contextual supports. For the tasting of their prototypes, each team invited a certain number of participants to conduct a sensory evaluation of their product.

Each team invited at least 15 untrained judges to evaluate their products. For this evaluation, each team included some variation in the food prototype, for example: amount of sugar added, amount and/or type of natural coloring, ingredients, formulation, among many others that depended on the type of product. The evaluated sensory attributes included: flavor, texture, color, and overall acceptability. They utilized a 9-point hedonic scale (9 – like extremely to 1-dislike extremely). Each team conducted an analysis of variance for each evaluated attribute and verified if significant differences were detected among the evaluated products.

Results of these evaluations were analyzed to refine the product if needed; in such cases, each team met with course instructor to try to find a solution to the problems identified either during prototype development or sensory evaluation. The instructor only guided the team to further search for relevant information on new formulations, additives, equipment, etc.; with this new information and prototype, the team once again prepared samples for sensory evaluation.

Based on how teams responded to emerging constraints, the degrees of freedom of the spiral were decreasing; their models were gaining more elaborate features and approaching the ideal of consumer satisfaction^{14, 16}.

The fourth stage

This latter stage, allowed students to make alternate creative efforts, since they produced a visual image for their product, which included logo design, package label, audiovisual materials and a poster for formal presentation (a group of experts was invited to the final presentations), also integrated their final reports that included applicable laws of the use of product' ingredients, good manufacturing practices, use and safety for the consumer. Finally, they prepare final products for tasting as part of their final presentations.

Assessment of creativity

Creativity assessment was grounded on the *Consensual Assessment Technique*⁶ (CAT), which is based on the idea that the best measure of creativity regardless of what is being evaluated, is the assessment by experts in that field. Therefore, a group of twenty experts in the FE field were invited to evaluate capstone course final projects and developed food products by means of the *Creative Thinking VALUE Rubric* (Appendix A), which is made up of a set of attributes that are common to creative thinking across disciplines^{1, 7}. Possible performance levels were entitled *capstone* or *exemplar* (value of 4), *milestones* (values of 3 or 2), and *benchmark* (value of 1). Instructor, peer-, and self-assessments were also performed throughout the course and on final

project. Evaluators were further encouraged to assign a value of zero if work did not meet *benchmark* level performance. Final presentations were performed in two steps, first audiovisual presentations of projects and then poster presentations/tasting of food products.

Additionally, a *Specific Course Rubric* that included technical aspects regarding food product development (four stages of the course) and its relation to the creative product characterization proposed by Sternberg and Lubart¹⁰, as well as abilities of the team to present their product and answering questions raised during oral and poster presentations, and during tasting of developed food products. For this specific rubric, the scale varied from 1 (*novice*) to 4 (*expert*).

Results and discussion

Figure 2 presents the average scores obtained by the five teams of students enrolled in the course regarding the *Specific Course Rubric*. Some teams performed better than others in selected aspects, probably due to the content and explanations given during presentations of their products. For the product design category, teams projects received scores higher than 2.5, which correspond to an intermediate level performance.

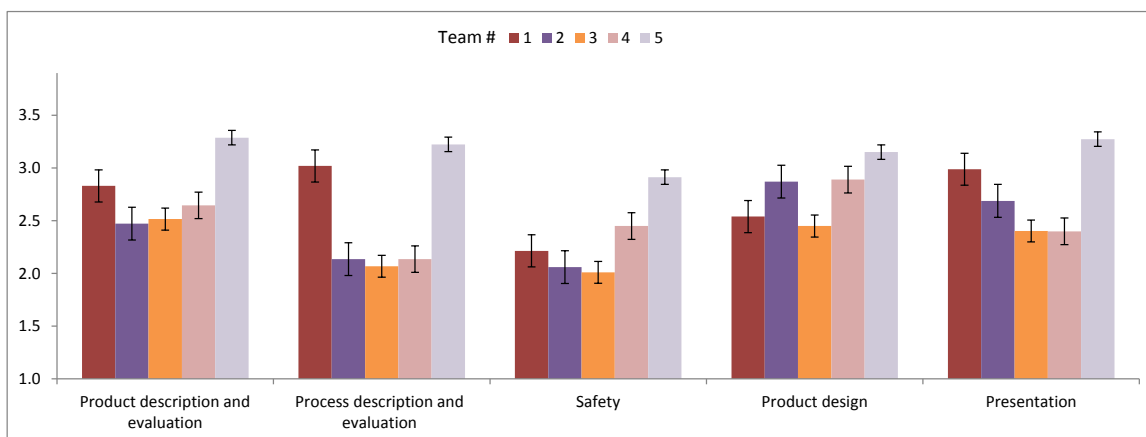


Figure 2. Team average scores and standard deviations (error bars) assessed by means of the *Specific Course Rubric*, (scale varies from 1: *novice* to 4: *expert*).

Figure 3 exhibits the average scores obtained by the five teams of students enrolled in the course regarding the *Creative Thinking VALUE Rubric*^{1,7}. Mean values from rubric assessment of final projects were 2.35 for *Acquiring Competencies* (attaining strategies and skills within a particular domain), 2.42 for *Taking Risks* (may include personal risk, fear of embarrassment or rejection, or risk of failure in successfully completing assignment, i.e. going beyond original parameters of assignment, introducing new materials and forms, tackling controversial topics, advocating unpopular ideas or solutions), 2.44 for *Solving Problems*, 2.44 for *Embracing Contradictions*,

2.40 for *Innovative Thinking* (novelty or uniqueness of idea, claim, question, form, etc.), and 2.24 for *Connecting, Synthesizing, and Transforming*.

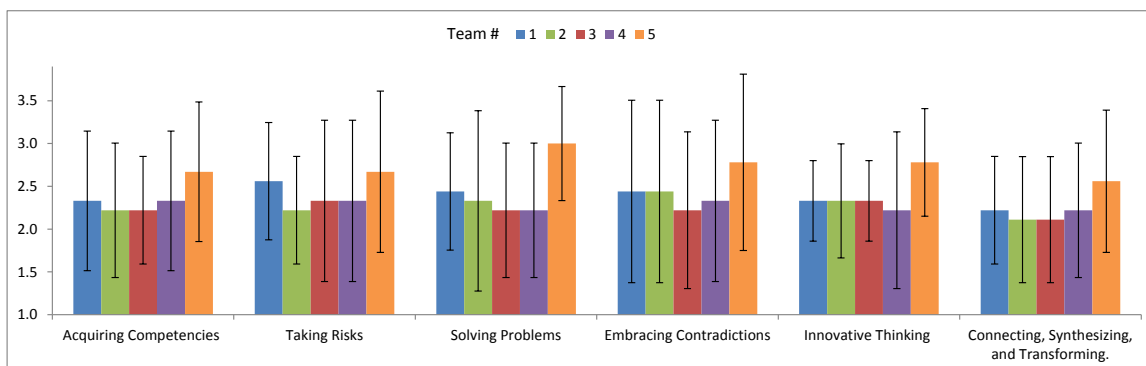


Figure 3. Teams average scores and standard deviations (error bars) assessed by means of the *Creative Thinking VALUE Rubric*^{1, 7}, (scale varies from *exemplar*: value of 4, *milestones*: values of 3 or 2, to *benchmark*: value of 1).

Students' creative thinking was at an intermediate level in both the capacity to combine or synthesize existing ideas or expertise in original ways and the experience of thinking, reacting, and working in an imaginative way. In general, scores around 2 (milestones lower level of performance) were assigned for four of the team projects, for team 5 higher scores were assigned (milestones higher level of performance).

None of the invited experts believed that food products and corresponding presentations of team projects did not meet the minimal expectations. However, since each expert evaluated products and presentations individually, some variations among scores were found.

Final Remarks

The presented results demonstrate that creativity assessment is not an easy task, but the applied rubrics allowed us to evaluate not only the final product of a creative process, but several important aspects during this creative process. Assessed rubrics allowed the identification of several opportunity areas to improve the studied food engineering capstone course. With sights set on this, additional didactic interventions are needed to further enhance creative thinking, make the food product design and development processes more efficient, as well as to overall improve the creative experience for students in this capstone course.

Acknowledgments

We acknowledge financial support from HEWLETT-PACKARD (HP) through the HP Catalyst Grant Initiative for the project "Critical Support Systems to Enhance the Development of 21st

Century Expertise in Engineering Students: Using Tablet PCs and Associated Technologies, the *Framework for 21st Century Learning*, and Guidelines from Research on *How People Learn*". Author Husted gratefully acknowledges financial support for her PhD studies from *Programa de Mejoramiento del Profesorado* (PROMEP) of the Mexican Ministry of Public Education (SEP) and *Universidad Autónoma de Ciudad Juárez*.

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Appendix A*

CREATIVE THINKING VALUE RUBRIC

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The VALUE rubrics were developed by teams of faculty experts representing colleges and universities across the United States through a process that examined many existing campus rubrics and related documents for each learning outcome and incorporated additional feedback from faculty. The rubrics articulate fundamental criteria for each learning outcome, with performance descriptors demonstrating progressively more sophisticated levels of attainment. The rubrics are intended for institutional-level use in evaluating and discussing student learning, not for grading. The core expectations articulated in all 15 of the VALUE rubrics can and should be translated into the language of individual campuses, disciplines, and even courses. The utility of the VALUE rubrics is to position learning at all undergraduate levels within a basic framework of expectations such that evidence of learning can be shared nationally through a common dialog and understanding of student success.

Definition

Creative thinking is both the capacity to combine or synthesize existing ideas, images, or expertise in original ways and the experience of thinking, reacting, and working in an imaginative way characterized by a high degree of innovation, divergent thinking, and risk taking.

Framing Language

Creative thinking, as it is fostered within higher education, must be distinguished from less focused types of creativity such as, for example, the creativity exhibited by a small child's drawing, which stems not from an understanding of connections, but from an ignorance of boundaries. Creative thinking in higher education can only be expressed productively within a particular domain. The student must have a strong foundation in the strategies and skills of the domain in order to make connections and synthesize. While demonstrating solid knowledge of the domain's parameters, the creative thinker, at the highest levels of performance, pushes beyond those boundaries in new, unique, or atypical recombinations, uncovering or critically perceiving new syntheses and using or recognizing creative risk-taking to achieve a solution.

The Creative Thinking VALUE Rubric is intended to help faculty assess creative thinking in a broad range of transdisciplinary or interdisciplinary work samples or collections of work. The rubric is made up of a set of attributes that are common to creative thinking across disciplines. Examples of work samples or collections of work that could be assessed for creative thinking may include research papers, lab reports, musical compositions, a mathematical equation that solves a problem, a prototype design, a reflective piece about the final product of an assignment, or other academic works. The work samples or collections of work may be completed by an individual student or a group of students.

Glossary

The definitions that follow were developed to clarify terms and concepts used in this rubric only.

- Exemplar: A model or pattern to be copied or imitated (quoted from www.dictionary.reference.com/browse/exemplar).
- Domain: Field of study or activity and a sphere of knowledge and influence.

CREATIVE THINKING VALUE RUBRIC

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Definition

Creative thinking is both the capacity to combine or synthesize existing ideas, images, or expertise in original ways and the experience of thinking, reacting, and working in an imaginative way characterized by a high degree of innovation, divergent thinking, and risk taking.

Evaluators are encouraged to assign a zero to any work sample or collection of work that does not meet benchmark (cell one) level performance.

	Capstone 4	Milestones 3 2		Benchmark 1
Acquiring Competencies <i>This step refers to acquiring strategies and skills within a particular domain.</i>	Reflect: Evaluates creative process and product using domain-appropriate criteria.	Create: Creates an entirely new object, solution or idea that is appropriate to the domain.	Adapt: Successfully adapts an appropriate exemplar to his/her own specifications.	Model: Successfully reproduces an appropriate exemplar.
Taking Risks <i>May include personal risk (fear of embarrassment or rejection) or risk of failure in successfully completing assignment, i.e. going beyond original parameters of assignment, introducing new materials and forms, tackling controversial topics, advocating unpopular ideas or solutions.</i>	Actively seeks out and follows through on untested and potentially risky directions or approaches to the assignment in the final product.	Incorporates new directions or approaches to the assignment in the final product.	Considers new directions or approaches without going beyond the guidelines of the assignment.	Stays strictly within the guidelines of the assignment.
Solving Problems	Not only develops a logical, consistent plan to solve problem, but recognizes consequences of solution and can articulate reason for choosing solution.	Having selected from among alternatives, develops a logical, consistent plan to solve the problem.	Considers and rejects less acceptable approaches to solving problem.	Only a single approach is considered and is used to solve the problem.
Embracing Contradictions	Integrates alternate, divergent, or contradictory perspectives or ideas fully.	Incorporates alternate, divergent, or contradictory perspectives or ideas in a exploratory way.	Includes (recognizes the value of) alternate, divergent, or contradictory perspectives or ideas in a small way.	Acknowledges (mentions in passing) alternate, divergent, or contradictory perspectives or ideas.
Innovative Thinking <i>Novelty or uniqueness (of idea, claim, question, form, etc.)</i>	Extends a novel or unique idea, question, format, or product to create new knowledge or knowledge that crosses boundaries.	Creates a novel or unique idea, question, format, or product.	Experiments with creating a novel or unique idea, question, format, or product.	Reformulates a collection of available ideas.
Connecting, Synthesizing, Transforming	Transforms ideas or solutions into entirely new forms.	Synthesizes ideas or solutions into a coherent whole.	Connects ideas or solutions in novel ways.	Recognizes existing connections among ideas or solutions.

* AACU. 2013. *Association of American Colleges and Universities (AACU) Value Rubrics*. Available at: http://www.aacu.org/value/rubrics/index_p.cfm?CFID=27703138&CFTOKEN=51989935; accessed 8/30/2013.¹

Rhodes, T. (Ed.). 2010. *Assessing Outcomes and Improving Achievement: Tips and Tools for Using Rubrics*. Washington, DC: Association of American Colleges and Universities.⁷