AC 2008-72: THE COGNITIVE AND AFFECTIVE DOMAIN IN ASSESSING THE LIFE-LONG LEARNING OBJECTIVE

Joseph Hanus, United States Military Academy

Scott Hamilton, United States Military Academy

Jeffrey S. Russell, University of Wisconsin - Madison

The Cognitive and Affective Domain in Assessing the Life-Long Learning Objective

Abstract

The success of the engineering profession requires students to be educated in the technical practices and inspired to develop the traits of life-long learning. The authors' objective is to demonstrate the use of the cognitive and affective domains in assessing life-long learning in a program's mission to inspire students and to achieve the American Society of Civil Engineers (ASCE) Body of Knowledge 2 (BOK2) Outcome. Recent published works will be integrated in the proposed process, which rely upon the well established Bloom's Taxonomy for the cognitive and affective domains. The authors believe that multiple domains used in the process will be repeated across similar assessments and beneficial in moving forward the ASCE BOK2.

Introduction

The purpose of this paper is to illustrate the use of the cognitive and affective domains to assess an outcome: life-long learning. This outcome is inherent to the first two authors program's mission to inspire students, and is required in the American Society of Civil Engineers (ASCE) Body of Knowledge 2 (BOK2) [1]. The development of life-long learning is an objective in many education programs and efforts to develop these skills are frequently reported. Reports include, but are not limited to: Briedis (1998) used a written report exercise to get students excited about life-long learning [2], Wells and Langenfeld (1999) created an environment through industry-university dialogue to foster the desire for life-long learning [3], Litzinger et. al. (2000, 2001, 2004, 2007) conducted extensive research through a Self-directed Learning Readiness Scale to assess student's readiness to receive and value life-long learning skills [4-8], Todd (2002) created a teaching module to develop in the students an appreciation for life-long learning [9], Cress (2002) implemented an exam review process in an effort to get students to value their self-assessment and learning processes [10], Waters (2007) assessed on-line techniques to measure student's motivation for life-long learning [11], and Murray and Raper (2007) instituted several activities across multiple courses to inspire students to continue developing life-long learning skills [12]. Studies such as these have similar descriptors to describe the learning objectives associated with their proposed activities. It is proposed in this paper that the commonality of these descriptors is encompassed in a taxonomy; that is, Bloom's Taxonomy for the affective domain. Although not as widely used as the cognitive domain of Bloom's Committee work, the affective domain has been proposed to assess specific courses [13], to assess programs [14], and to advance the ASCE BOK2 [15]. The authors of this paper believe there is an opportunity to utilize both the cognitive and affective domains in assessing program and BOK objectives; for example, life-long learning.

The paper's methodology is based on the integration of two recently published studies. The work presented herein is an extension of Hamilton and Meyer (2007), who proposed that inspiration in institutions of higher learning necessitates inspiring students to life-long learning, and they assessed their program's effectiveness in meeting this goal [16]. Hamilton and Meyer's process was fundamentally similar to previous assessments as were discussed [2-13]. This paper will extend previous work by considering multiple taxonomies, which will strengthen such assessments by utilizing established taxonomies. The use of the affective domain in the assessment process presented herein is based on the work of Lynch et al. (2008), who proposed the use of the domain for the American Society of Civil Engineers Body of Knowledge Outcomes [17]. The end-state of the paper is to establish a repeatable process, which can further the acceptance of the use of multiple domains of Bloom's Taxonomy in such assessments.

The paper is organized as follows. First, Bloom's Taxonomy is aligned with the mission of the United States Military Academy. A review of the cognitive and affective domains then follows, to include the relationship between the categories in these domains. The work of Hamilton and Meyer (2007) is then re-examined in the context of the cognitive and affective domains with respect to the ASCE BOK2 (2008) study and the work by Lynch et al. (2008). Conclusions are then drawn in terms of the overall process; that is, the use of the multiple domains in such assessments.

Alignment with Bloom's Taxonomy

The mission of the United States Military Academy (USMA) has evolved from the institution's inception in 1802 [18]:

To educate, train, and inspire the Corps of Cadets so that each graduate is a commissioned leader of character committed to the values of Duty, Honor, Country, and prepared for a career of professional excellence and service to the Nation as an officer in the United States Army.

The mission of the Department of Civil and Mechanical Engineering at USMA parallels the Academy's mission, while focusing on educating and inspiring students in the fields of civil and mechanical engineering [19]:

To educate cadets in civil and mechanical engineering, such that each graduate is a commissioned leader of character who can understand, implement, and manage technology; and to inspire cadets to a career in the United States Army and a lifetime of personal growth and service.

The mission includes educating and inspiring, and training at the Academy level. The three elements of the mission potentially align along a set of commonly accepted educational taxonomies; that is, Bloom's Taxonomy.

Bloom's Taxonomy is based on the seminar work of the 1950's educational committee chaired by Benjamin Bloom. The committee established a set of taxonomies in three domains of learning: cognitive, affective and psychomotor. The cognitive domain taxonomy is widely accepted in many fields and has been identified as, "arguable one of the most influential education monographs of the past half century [20]." The taxonomies are a language that is proposed to describe the progressive development of an individual in each domain and are defined as follows [21]:

- Cognitive: of, relating to, being, or involving conscious intellectual activity.
- Affective: relating to, arising from, or influencing feelings or emotions.
- Psychomotor: of or relating to motor action directly proceeding from mental activity.

It is proposed that Bloom's Taxonomies generally align with the Academy's mission; that is, the cognitive domain aligns with educating, the affective domain aligns with inspiring, and the psychomotor domain aligns with training. However, as the process will be shown in this paper, there is likely an overlap in the domains. For example, to develop emotional feelings (Affective) for a particular phenomenon, there possibly needs to be an intellectual understanding of the same (Cognitive). This is typical of the overlap observed in the work reported herein. The benefit of establishing a general alignment of the domains with the Academy's mission is to develop a common language to describe the student's development across the domains. The intent of this paper is to focus on the cognitive and affective domains with respect to their use in assessing the life-long learning as part of the mission to inspire students in the Department of Civil and Mechanical Engineering at the United States Military Academy.

Cognitive and Affective Domain of Bloom's Taxonomy

The cognitive domain is commonly used to describe a student's intellectual development. The original six categories and sub-categories are shown in Table 1 [22].

The affective domain is less widely used and was established by Krathwohl et al., of Bloom's Committee, in 1956 [23]. The domain consists of five categories and sub-categories as shown in Table 2. Also shown are the common affective terms, which lend to the appreciation that the categories in the domain may not be as definitive as in the cognitive domain.

Krathwohl et al. went on to describe the relations between the cognitive and affective domain, and this is shown in Table 3. It is interesting to note that the first three categories in the domains align fairly well, but the remaining categories are less clear in terms of alignment. Specifically the separation of the fourth affective domain category, *Conceptualization/Organization*. Additional discussion of the relations between the domains is available in Krathwohl et al. (1956) [23]. A similar set of relations will be proposed between the cognitive and affective domain in terms of learning objectives for life-long learning in the following section.

Table 1. Cognitive Domain Categories and Sub-Categories [22].

1.0 Knowledge	1.1 Knowledge of Specifics 1.2 Knowledge of Ways and Means of Dealing with Specifics 1.3 Knowledge of the Universals and Abstractions in a Field
2.0 Comprehension	2.1 Translation 2.2 Interpretation 2.3 Extrapolation
3.0 Application	
4.0 Analysis	4.1 Analysis of Elements 4.2 Analysis of Relationships 4.3 Analysis of Organizational Principles
5.0 Synthesis	5.1 Production of a Unique Communication 5.2 Production of a Plan, or Proposed Set of Operations 5.3 Derivation of a Set of Abstract Relations
6.0 Evaluation	6.1 Judgment in Terms of Internal Evidence 6.2 Judgment in Terms of External Criteria

Table 2. Affective Domain Categories and Sub-Categories [23].

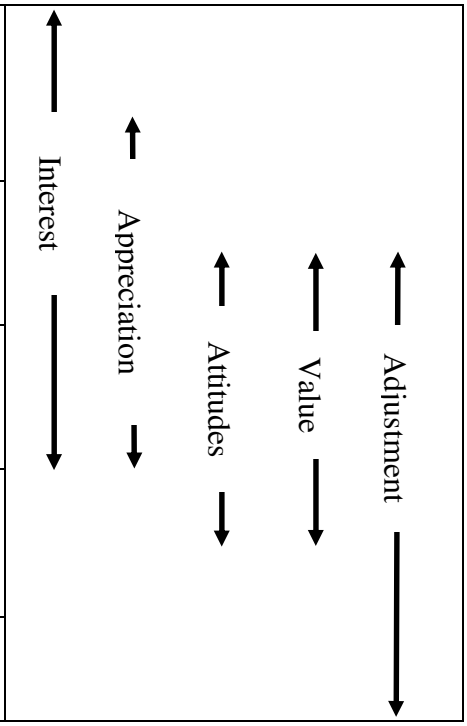
1.0 Receiving	1.1 Awareness 1.2 Willingness to Receive 1.3 Controlled or Selected Attention	
2.0 Responding	2.1 Acquiescence in Responding 2.2 Willingness to Respond 2.3 Satisfaction in Response	
3.0 Valuing	3.1 Acceptance of a Value 3.2 Preference for a Value 3.3 Commitment	
4.0 Organization	4.1 Conceptualization of a Value 4.2 Organization of a Value System	
5.0 Characterization by a Value Complex	5.1 Generalized Set 5.2 Characterization	

Table 3. Relations Between the Cognitive and Affective Domains [23].

Cognitive Domain	Affective Domain
1. The cognitive continuum begins with the student's recall and recognition of *Knowledge* (1.0),	1. The affective continuum begins with the student's merely *Receiving* (1.0) stimuli and passively attending to it. It extends through his more active responding to it,
2. it extends through his *Comprehension* (2.0) of the knowledge,	2. his *Responding* (2.0) to stimuli on request, willingly responding to these stimuli, and taking satisfaction in this responding,
3. his skill in *Application* (3.0) of the knowledge he comprehends,	3. his *Valuing* (3.0) the phenomenon or activity so that he voluntarily responds an seeks out ways to respond,
4. his skill in *Analysis* (4.0) of situations involving this knowledge, his skill in *Synthesis* (5.0) of this knowledge into new organizations,	4. his *Conceptualization* (4.1) of each value responded to,
5. his skill in *Evaluation* (6.0) in that area of knowledge to judge the value of the material and methods for given purpose.	5. his *Organization* (4.2) of these values into systems and finally organizing the value complex into a single whole, a *Characterization* (5.0) of the individual.

Learning Objectives for Life-Long Learning Outcome

Hamilton and Meyer (2007) proposed that meeting USMA's and Department's mission to inspire their students required developing the skills and desires for life-long learning. The authors established this requirement through examination of the National Academy of Engineering (NAE) publication *Education the Engineer of 2020 – Adapting Engineering Education to the New Century* [24] and the ABET Inc. *Proposed Criteria for Accrediting Engineering Programs* [25]. Life-long learning has also been established as Outcome 27 in the American Society of Civil Engineers (ASCE) *Civil Engineering Body of Knowledge for the 21st Century: Preparing the Civil Engineer for the Future (BOK2)* [1]. This outcome is related to the ABET Outcome 3i [25] and the ASCE BOK1 Outcome 9 [26].

Learning objectives that describe the development of life-long learning have been proposed in terms of the cognitive and affective domains in ASCE BOK2 [1] and Lynch et. al. [17], respectively. The learning objectives are shown together in Table 4. The fourth and fifth affective domain categories were purposely split across the fourth through sixth cognitive domain categories to reflect the split in the fourth affective domain category as was shown in Table 3. As previously discussed, many researchers have assessed courses and/or programs with respect to the development of life-long learning skills [2-13]. This paper links such assessments to multiple taxonomy domains to strengthen the assessments.

Table 4. Learning Objectives for Life-Long Learning Outcome

Cognitive Domain [1]	Affective Domain [17]
1. *Knowledge:* **Define** life-long learning.	1. *Receiving*: **Identify** the value of life-long learning in the career of the engineer.
2. *Comprehension*: **Explain** the need for life-long learning and **describe** the skills required of a life-long learner.	2. *Responding*: **Select** specific aspects of life-long learning that add value when approaching new problems, whether technical or Professional.
3. *Application:* **Demonstrate** the ability for self-directed learning.	3. *Valuing*: **Demonstrate** concrete steps toward establishing a habit of life-long learning and areas in which it has contribute to Professional performance.
4. *Analysis*: **Identify** additional knowledge, skills, and attitudes appropriate for professional practice.	4. *Organizing/Conceptualization*: **Show** an organized approach to the acquisition of new knowledge throughout a career. 5. *Characterizing*: **Evaluate** the relation between the aspirations of individuals and organizations, and life-long learning habits, plans, and programs.
5. *Synthesis*: **Plan** and **execute** the acquisition of required expertise appropriate for professional practice.	
6. *Evaluation*: **Self-assess** learning processes and **evaluate** those processes in light of competing and complex real-world alternatives.	

Of particular interest is the proposed level of outcome achievement within each of the domains. The ASCE BOK2 proposes that the first three categories in the cognitive domain are fulfilled through the bachelor's degree, the next two through pre-licensure experience, and the final category as a post-licensure fulfillment [1]. Lynch et al. proposes that the first four categories in the affective domain are fulfilled through the bachelor's degree [17]. This is interesting, because it may be problematic to achieve a high level of affective domain fulfillment without the associated level in the cognitive domain. Additional work is necessary to further consider the implication of unequal expectations in the domains and this is beyond the scope of this paper. However, accepting these categories, the learning objectives listed above will be used to re-examine the activities and metrics as published in Hamilton and Meyer (2007).

Assessing the Learning Activities for Life-Long Learning

Hamilton and Meyer (2007) identified seven learning activities, which they believed were effective in inspiring students in their development of life-long learning [16]. These learning activities are shown in Figure 1 with proposed category levels for each domain; that is, cognitive and affective. The learning objectives from Table 4, which are associated with the domain categories, are then discussed in what follows.

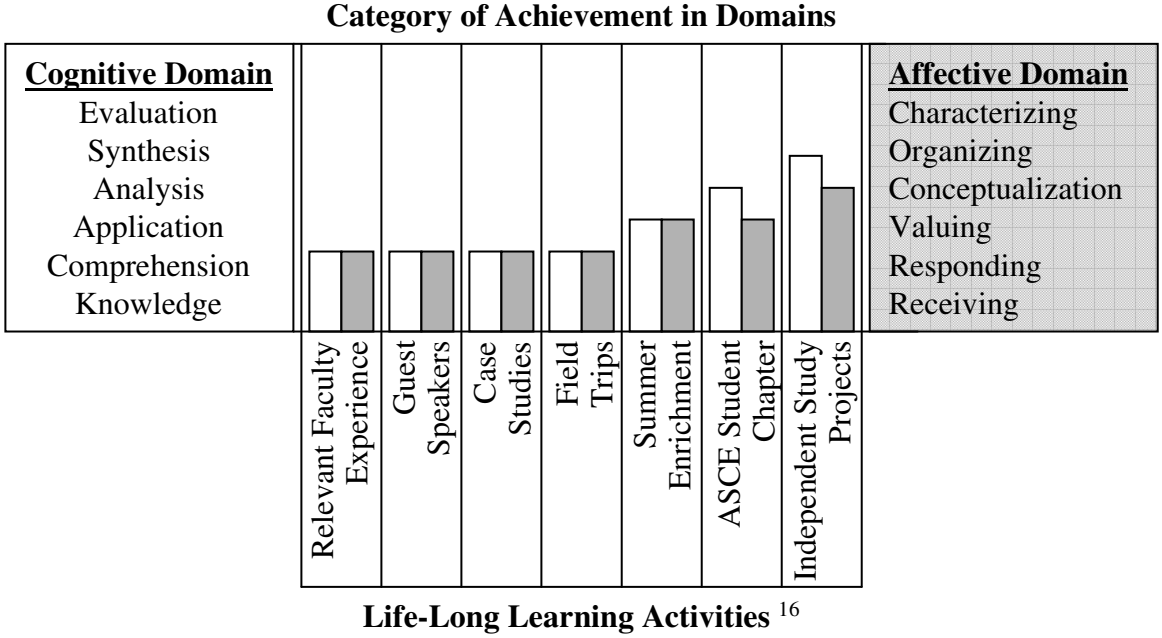


Figure 1. Level of Cognitive and Affective Domains for Life-Long Learning Activities.

The first four learning activities are similar in that they expose students to professional engineers and engineering projects. The Relevant Faculty Experience derives from the rotating junior faculty members at USMA. Most faculty members at USMA serve a three year assignment and then rotate back to the field army. As a result, the students are continually exposed to military engineers with recent and relevant field engineering experience. Guest Speakers, Case Studies, and Field Trips are also similar learning activities. At the completion of these type of learning experiences, it is reasonable to expect that students would be able to achieve learning objectives associated with the cognitive and affective domain categories shown in Table 5. For the cognitive domain: **Explain** the need for life-long learning and **describe** the skills required of a life-long learner. For the affective domain: **Select** specific aspects of life-long learning that add value when approaching new problems, whether technical or professional.

The Summer Enrichment Opportunities represent a step-up in the learning objectives as students are placed in environments where self-learning is typically required to meet expectations. Students at the Academy select from multiple options for these opportunities; to include, engineering internships at US Army Corps Engineering (USACE) Districts and research assistantships at USACE and Army labs. These opportunities are an integral part of the Department's CE program [27]. The learning objectives associated with the domain categories were proposed for the cognitive domain: **Identify** additional knowledge, skills, and attitudes

appropriate for professional practice, and for the affective domain: **Demonstrate** concrete steps toward establishing a habit of life-long learning and areas in which it has contribute to professional performance.

The ASCE Student Chapter Events raises the cognitive domain category to analysis because students are responsible for selecting and coordinating the professional development activities associated with the chapter; therefore, the associated learning objective could encompass the following: **Plan** and **execute** the acquisition of required expertise appropriate for professional practice. However, the learning objective for the affective domain may not increase because the time frame for this activity is limited when compared the time frame of a career.

The Independent Study Projects culminate in the highest level of learning objectives for both the cognitive and affective domain. These independent learning projects typically require the students to learn material beyond their classroom experiences. Hence, the synthesis category in the cogitative domain is now possible, with the objective: **Plan** and **execute** the acquisition of required expertise appropriate for professional practice. The associated affective domain category of organization/conceptualization is also possibly realized, with the learning objective: **Show** an organized approach to the acquisition of new knowledge throughout a career. The capstone project activities represents the initial stage of this organized approach to life-long learning in the student's career.

Assessing the Metrics for Life-Long Learning

Hamilton and Meyer (2007) identified three metrics to indirectly assess the learning activities effectiveness for inspiring the students with respect to life-long learning. The first three metrics shown in Figure 2 are from Hamilton and Meyer (2007) and the other metrics were defined herein.

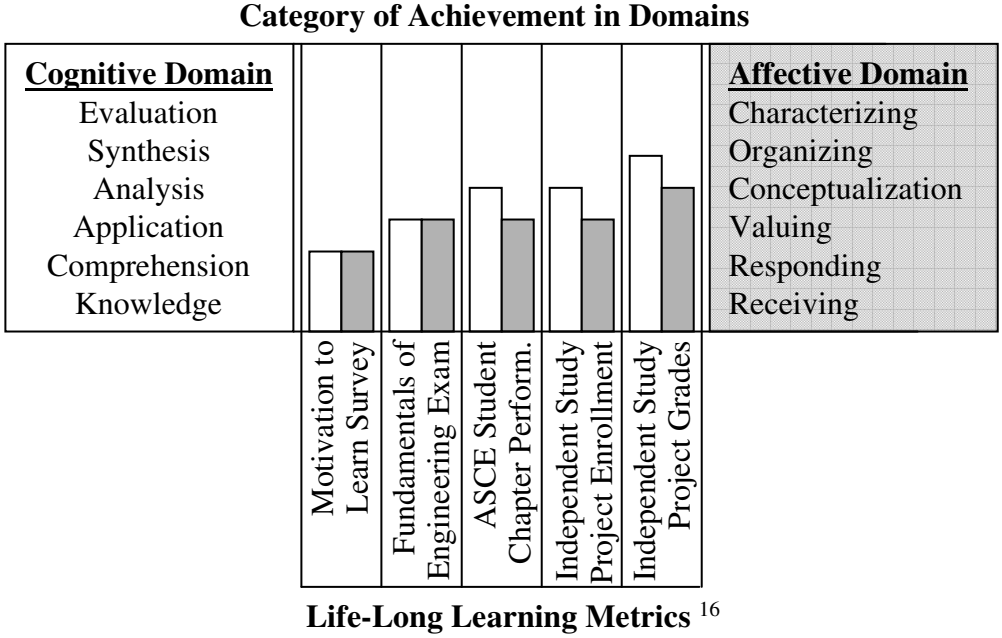


Figure 2. Level of Cognitive and Affective Domains for Life-Long Learning Metrics.

The Survey on Motivation to Learn represents a question in the Academy's on-line survey, "My motivation to learn and to continue learning has increased." Students respond on a five-point Likert scale, with 1 indicating strong disagreement and 5 indicating strong agreement. The Academy wide responses, since the inclusion of the question, have been between 4.0 and 4.5 each term, which indicates "agree" to "strongly agree" response [16]. These results indicate that the students can explain the need for life-long learning (*Comprehension*) and can identify the value of such learning (*Receiving*).

The Fundamental of Engineering Exam Results represents the students' performance on a significant exam outside of the academic program; that is, it is not a course for grade. Hence, student preparation takes on an individual learning process that is the initial step in life-long learning. The Civil Engineer (CE) Program average at the Academy has routinely surpassed the national average [16]. These results indicate that the students are identifying knowledge required, either new or review (*Analysis*) and are beginning to demonstrate the steps in establishing a habit of life-long learning (*Valuing*).

The ASCE Student Chapter Performance represents the results of cumulative out-of-class/personal time activities in support of a student organization. The Academy's ASCE Student Chapter is vibrant with nearly 100% membership by CE Majors. Moreover, the ASCE Student Chapter recently won the Ridgeway Award for the best student chapter in the nation, which built upon five years of recognition as the best chapter in the Northeast region [16]. Such consistent recognition is indicative of a program's performance versus a finite set of individuals in a particular year. The criteria used for this recognition is based planning, conducting and participating in a variety of specified and directed professional activities. These activities, deemed by ASCE to be critical activities for students to engage in to successfully introduce them to expected professional activities include technical seminars, ethics and licensure seminars, field trips, professional conferences, and local society meetings.[28] The sustained success in this activity implies the students are identifying knowledge and attitudes for professional practice (*Analysis*) and are developing life-long learning habits for professional contribution (*Valuing*) through their dedication to this professional organization.

The Independent Study Project metrics represent results associated with the culminating academic course in the CE program. The majority of the students in the CE program participate in the project based course and typically perform above their average academic performance; that is, the course out-going grade point average, based on course grades, exceeds the course in-coming grade point average, based on the students' academic record. These projects have been an instrumental in Department's mission to educate and inspire [29 – 31]. These results indicate that students again identify knowledge and attitudes for professional practice (*Analysis*), are developing life-long learning habits (*Valuing*), are acquiring additional knowledge (*Synthesis*), and are showing an organized approach to such knowledge acquisition (*Organizing/Conceptualization*).

Conclusions

Several conclusions were evident in the development of the work presented in this paper:

1. The mission to educate, inspire and train students at the United States Military Academy potentially align along Bloom's Taxonomy in the cognitive, affective, and psychomotor domains. However, a strict division may not be practical nor necessary. That is, categories in the domains may be closely related and overlap such that one may not occur without another. Additional work is needed in this area of using multiple domains in assessments.

2. The use of multiple domains in established professional criteria, such as the ASCE BOK2, may require careful consideration of the expected category levels of achievement. The consideration should include whether or not higher levels can be achieved in complementary domains. This also requires additional work and study.

3. The use of multiple domains is feasible and beneficial in assessing outcomes, such as life-long learning, as presented in this paper. The primary benefit of using multiple domains, specifically the cognitive and affective domains, is the ability to clearly communicate the assessment of educating and inspiring students to higher levels of learning objectives. The authors propose the use of such analysis for other BOK2 outcomes, in particular the professional practice outcomes.

The work outlined herein is subjective, but the process was methodical and definable. The terminology used was based on published works and encompassed accepted vocabulary associated with Bloom's Taxonomy. The process presented is repeatable and worthy of additional development because it extends previous work into the assessment of lifelong learning in courses and programs. Our profession requires students to be educated and inspired. These goals are supporting and complementary, but different. The use of multiple domains is ideally suited for assessing these goals in our profession because the cognitive and affective domains are different, yet complimentary in preparing the engineer of tomorrow.

Bibliography

1. ASCE (2008). *Civil Engineering Body of Knowledge for the 21st Century – Preparing the Civil Engineer for the Future.* Second Edition. Reston, Virginia: American Society of Civil Engineers.
2. Briedis, D. (1998). *Jump-Starting Lifelong Learning.* In *ASEE National Conference and Exposition.* Seattle, WA.
3. Wells, D.L. and G.P. Langenfeld (1999). *Creating an Environment for Lifelong Learning.* In *ASEE National Conference and Exposition.* Charlotte, NC.
4. Litzinger, T.A. (2000). *An Integrated Approach to Developing Professional and Technical Skills in Engineering Graduates.* In *ASEE National Conference and Exposition.* St. Louis, MO.
5. Litzinger, T.A. and R.M. Marra (2000). *Life Long Learning: Implications for Curricular Change and Assessment.* In *ASEE National Conference and Exposition.* St. Louis, MO.
6. Litzinger, T.A., J. Wise, S.H. Lee, T. Simpson, S. Joshi (2001). *Assessing Readiness for Lifelong Learning.* In *ASEE National Conference and Exposition.* Albuquerque, NM.

7. Litzinger, T.A., S.H. Lee, J. Wise (2004). *Engineering Student's Readiness for Self-directed Learning.* In *ASEE National Conference and Exposition*. Salt Lake City, UT.
8. Litzinger, T.A. (2007). *Using Writing to Address Lifelong Learning, Ethics, and the Global Context of Engineering in Mechanical Engineering Courses.* In *ASEE National Conference and Exposition*. Honolulu, HI.
9. Todd, B.A. (2002). *Short, Instructional Module to Address Lifelong Learning Skills.* In *ASEE National Conference and Exposition*. Montreal, Canada.
10. Cress, D. (2002). *The F Word in the Classroom: Fail and Learn.* In *ASEE National Conference and Exposition*. Montreal, Canada.
11. Waters, C. (2007). *Let BlackBoard Tracking Ease the Pain of Assessing Outcome I.* In *ASEE National Conference and Exposition*. Honolulu, HI.
12. Murray, S. and S. Raper (2007). *Encouraging Lifelong Learning for Engineering Management Undergraduates.* In *ASEE National Conference and Exposition*. Honolulu, HI.
13. Hanus, J.P. and J.S. Russell (2007). *Integrating the Development of Teamwork, Diversity, Leadership, and Communication Skills into a Capstone Design Course.* In *ASEE National Conference and Exposition*. Honolulu, HI.
14. Bostwick, W.D. (2002). *The Need to Establish an Affective Domain Assessment Strategy for Your Program.* In *ASEE National Conference and Exposition*. Montreal, Canada.
15. Russell, J.S., G. Galloway, T. Lenox, J. O'Brien (2007). *ASCE Policy 465 – The Means for Realizing the Aspirational Visions of Civil Engineering in 2025.* In *ASEE National Conference and Exposition*. Honolulu, HI.
16. Hamilton, S.R. and F. Meyer (2007). *Inspiring Students – The key to learning for the future.* In *ASEE National Conference and Exposition*. Honolulu, HI.
17. Lynch, D.R., J.S. Russell, J.C. Evans, and K.G. Sutterer (2008). *Beyond the Cognitive: The Affective Domain, Values, and the Achievement of the Vision*. ASCE Journal of Professional Issues in Engineering, Education, and Practice. Reston, Virginia: American Society of Civil Engineers, in press.
18. United States Military Academy (2008). *Mission Statement*. Accessed Jan 1, 2008. http://www.usma.edu/mission.asp.
19. Department of Civil and Mechanical Engineering, USMA (2008). *Mission Statement*. Accessed Jan 1, 2008. http://www.dean.usma.edu/departments/cme/CME%20Home/mission.htm.
20. Anderson, L.W. and L.A. Sosniak (1994). "Bloom's taxonomy: A forty-year retrospective." Ninety-third yearbook of the Nation Society for the Study of Education (NSSE), Part II. University of Chicago Press.
21. Merriam-Webster's Online Dictionary (2008). Accessed Jan 1, 2008. http://www.m-w.com/dictionary.
22. Bloom B.S. (1956). *Taxonomy of Educational Objectives, Handbook I: The Cognitive Domain*. New York: David McKay Co Inc.
23. Krathwohl, D.R., B.S. Bloom, and B.M. Bertram (1973). *Taxonomy of Educational Objectives, the Classification of Educational Goals. Handbook II: Affective Domain*. New York: David McKay Co., Inc.
24. Committee on the Engineer of 2020 (2005). *Educating the Engineer of 2020 – Adapting Engineering Education to the New Century, Phase II*. National Academy of Engineering, National Academies Press: Washington, D.C.
25. Accreditation Board for Engineering and Technology (2005). *PROPOSED Criteria for Accrediting Engineering Programs,* in CRITERIA FOR ACCREDITING ENGINEERING PROGRAMS – *Effective for Evaluations During the 2006-2007 Accreditation Cycle*.
26. ASCE (2004). *Civil Engineering Body of Knowledge for the 21st Century – Preparing the Civil Engineer for the Future*. Second Edition. Reston, Virginia: American Society of Civil Engineers.
27. Vander Schaaf, R. and R.W. Welch (2003). *Using Summer Programs to Excited Interest in Engineering.* In *ASEE National Conference and Exposition*. Nashville, TN.
28. ASCE, Committee on Student Activities, (2007) *Annual Report Score Sheet*, Reston, VA.
29. Welch, R.W. and S.D. Hart (2001). *USMA CE Model for Client-Based Multidiscipline Capstones.* In *ASEE National Conference and Exposition*. Albuquerque, NM.
30. Rabb, R.J. and R.W. Welch (2002). *Projects Day: Completion of the Engineering Capstone Design.* In *ASEE National Conference and Exposition*. Montreal, Canada.
31. Welch, R.W. and M.D. Evans (2004). *Undergraduate Independent Study Research Projects.* In *ASEE National Conference and Exposition*. Salt Lake City, UT.