AC 2010-756: COMPETENCY-BASED ASSESSMENT OF ENGINEERING TECHNOLOGY PROGRAM OUTCOMES

Carmine Balascio, University of Delaware

Carmine C. Balascio, Ph.D., P.E. is an Associate Professor in the Department of Bioresources Engineering at the University of Delaware. He earned bachelor's degrees in Agricultural Engineering Technology and Mathematics from U.D. He earned an M.S. in Agricultural Engineering and a Ph.D. double major in Agricultural Engineering and Engineering Mechanics from Iowa State University. He teaches courses in surveying, soil mechanics, and storm-water management and has research interests in urban hydrology, water resources engineering, and assessment of student learning. He is a former two-term member of Delaware's Engineering Licensing board, the DAPE Council. He continues to be active on DAPE and NCEES committees.

Thomas Brumm, Iowa State University

Thomas J. Brumm, Ph.D. is an Associate Professor in the Department of Agricultural and Biosystems Engineering at Iowa State University (ISU). He also serves as the Director of Assessment and Online Learning for the College of Engineering. He earned a bachelor's degree in Agricultural Engineering from ISU, an M.S. in Agricultural Engineering from Purdue, and a Ph.D. in Agricultural Engineering, Chemical Engineering minor from ISU. He has research interests in biorenewables, biofuels, grain and seed quality, and student learning and assessment.

Steven Mickelson, Iowa State University

Steven Mickelson, Ph.D. is a Professor and Associate Chair in the Department of Agricultural and Biosystems Engineering at Iowa State University (ISU). He is the Director of the ISU Center for Excellence in Learning and Teaching, Director ISU Learning Communities, Co-Director Agricultural and Biosystems Engineering Department. He earned bachelor's, M.S., and Ph.D. degrees in Agricultural Engineering from ISU. His research focuses on the evaluation of agricultural best management practices for determining their effectiveness in reducing chemical and soil losses to surface water bodies. He also conducts research related to the scholarship of teaching and learning, focusing on effective classroom techniques for engaging students in learning.

Competency-Based Assessment of Engineering Technology Program Outcomes

Abstract

ABET[1] is the preeminent organization in the U.S. for accreditation of 2- and 4-yr college-level educational programs in applied science, computing, engineering, and technology. ABET accreditation regimes require program outcomes assessment. The Technology Accreditation Commission (TAC) of ABET is charged with accrediting two- and four-yr Engineering Technology (ET) programs. The 4-year ET major at the University of Delaware is a general ET program; and, for the purposes of TAC of ABET accreditation[2], must demonstrate its graduates have mastered the *a* through *k* program outcomes listed in TAC of ABET documentation for Criterion 3 of its *General Criteria for Accrediting Engineering Technology Programs*. The *a* through *k* program outcomes, which include such statements as:

a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines, and

d. an ability to apply creativity in the design of systems, components or processes appropriate to program objectives,

are notoriously difficult to assess because they require complex blends of interdependent skills, the evaluations of which may be influenced by considerable subjectivity.

Iowa State University (ISU)[3] has adopted a competency-based assessment approach to demonstrate program outcomes for Engineering Accreditation Commission (EAC) of ABET[2] accreditation of all its engineering programs in addition to its programs in agricultural systems technology and industrial technology. The ISU technology programs are accredited by the Association of Technology, Management, and Applied Engineering[4]. In consultation with graduates and industry partners, ISU developed a set of 14 "workplace competencies." Each competency was designed to be "clear, concise and independent of all others"[3]. Each competency is demonstrated by a "set of observable and measurable key actions." The confounding that plagues assessment of the ABET *a-k* program outcomes is avoided, and a measure of objectivity is introduced. The ISU competencies were determined to be "necessary and sufficient to address the EAC of ABET *a-k* outcomes" [3], and a matrix mapping the ISU workplace competencies to the EAC of ABET *a-k* outcomes was developed.

This paper describes the adaptation of ISU's competency-based assessment approach for outcomes assessment and TAC of ABET accreditation of the University of Delaware's ET program. University of Delaware student competencies, derived from the ISU student competencies, are mapped to the TAC of ABET *a-k* program outcomes. As with ISU's approach, a student ePortfolio system is utilized. Evaluations of competencies are informed by the student's performance in a "Discovery Learning Experience" – either a technical practicum in industry or an undergraduate research project.

Introduction and Background:

The University of Delaware's Department of Bioresources Engineering offers a B.S. degree in Engineering Technology (ET) that has been a TAC of ABET-accredited[2] general ET program since 1988. The program typically graduates 20 to 25 majors per year. Both EAC of ABET and TAC of ABET accreditation regimes require outcomes assessment. TAC of ABET documentation[2] under Criterion 3, Program Outcomes, stipulates that each program must demonstrate its graduates have:

a. an appropriate mastery of the knowledge, techniques, skills, and modern tools of their disciplines,
b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering, and technology,
c. an ability to conduct, analyze and interpret experiments, and apply experimental results to improve processes,
d. an ability to apply creativity in the design of systems, components, or processes appropriate to program educational objectives,
e. an ability to function effectively on teams,
f. an ability to identify, analyze and solve technical problems,
g. an ability to communicate effectively,
h. a recognition of the need for, and an ability to engage in lifelong learning,
i. an ability to understand professional, ethical and social responsibilities,
j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and
k. a commitment to quality, timeliness, and continuous improvement.

The general criteria apply to all ET programs at both associate and baccalaureate degree levels. For programs in different particular disciplines, additional outcomes, specific to the discipline and degree level are listed. The program criteria for "Civil Engineering Technology and Similarly Named Programs" are, for example, listed as follows[2]:

Outcomes

Associate degree programs must demonstrate that graduates are capable of:

a. utilizing graphic techniques to produce engineering documents;
b. conducting standardized field and laboratory testing on civil engineering materials;
c. utilizing modern surveying methods for land measurement and/or construction layout;
d. determining forces and stresses in elementary structural systems;
e. estimating material quantities for technical projects; and
f. employing productivity software to solve technical problems.

Baccalaureate degree programs must demonstrate that graduates, in addition to the competencies above, are capable of:

a. *planning and preparing design and construction documents, such as specifications, contracts, change orders, engineering drawings, and construction schedules;*
b. *performing economic analyses and cost estimates related to design, construction, operations and maintenance of systems in the civil technical specialties;*
c. *selecting appropriate engineering materials and practices;*
d. *applying basic technical concepts to the solution of civil problems involving hydraulics, hydrology, geotechnics, structures, material behavior, transportation systems, and water and wastewater systems; and*
e. *performing standard analysis and design in at least three of the recognized technical specialties within civil engineering technology that are appropriate to the goals of the program.*

The ET program at the University of Delaware, being a *general* ET program, has no program-specific criteria to satisfy; therefore, mastery of the *a* through *k* general criteria is all that is pertinent.

Competency-Based Assessment: Inspection of the TAC of ABET *a* through *k* general criteria confirms that the outcomes are broadly-defined and are certainly interdependent. The EAC of ABET [2] general criteria are very similar:

Engineering programs must demonstrate that their students attain the following outcomes:
(a) an ability to apply knowledge of mathematics, science, and engineering
(b) an ability to design and conduct experiments, as well as to analyze and interpret data
(c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability
(d) an ability to function on multidisciplinary teams
(e) an ability to identify, formulate, and solve engineering problems
(f) an understanding of professional and ethical responsibility
(g) an ability to communicate effectively
(h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context
(i) a recognition of the need for, and an ability to engage in life-long learning
(j) a knowledge of contemporary issues
(k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Mastery of these program outcomes, in addition to any discipline-specific outcomes, must be demonstrated for accreditation of *engineering* programs. As with the TAC of ABET criteria, the EAC of ABET analogues for accreditation of engineering programs are somewhat broadly-defined, complex, and interdependent. In particular, abilities (the majority of the outcomes) are "complex combinations of motivations, dispositions, attitudes, values, strategies, behaviors, self-perceptions and knowledge of concepts and procedures…a complex ability cannot be observed directly but must be inferred from performance"[5]. It was under these conditions that the competency-based assessment model for accreditation of engineering programs at ISU was developed[3].

Workplace competencies are the application of knowledge, skill, attitudes, values and behaviors in the workplace. ISU observed that a list of such competencies could be endless and thus developed and implemented a process to identify those competencies necessary to demonstrate the outcomes. Over 200 constituents or "stakeholders", that included employers and other industry representatives, educators, and students who had completed internships participated in focus sessions. A "critical incident" data gathering technique using a DACUM approach[6] was used to synthesize 14 "workplace competencies"[3] that were "necessary and sufficient" to demonstrate the 11 *EAC* of ABET Criterion 3, Program Outcomes . These competencies were identified from stakeholder stories of the successful demonstration of the EAC of ABET Criterion 3 program outcomes, which as noted, are very similar to those of the TAC of ABET regime.

Because the EAC of ABET program outcomes are interdependent and difficult to measure (as are TAC of ABET program outcomes) it was important that the methodology developed address those deficiencies [3]. The definition for each workplace competency was designed to be "clear, concise and independent of all others." Each competency was associated with a specific set of "observable and measureable Key Actions"[3] that when demonstrated by students confirm achievement of that particular competency. Definitions of all the ISU competencies and Key Actions are available at ISU Department of Agricultural and Biosystems Engineering web site [7]. As an example, one of the ISU workplace competencies, communication, along with its associated key actions is defined as follows [7]:

> ***Communication Competency:*** *Clearly conveying information and ideas through a variety of media to individuals or groups in a manner that engages the audience and helps them understand and retain the message.*
>
> ***Key Actions:***
>
> - ***Organizes the communication.*** *Clarifies purpose and importance; stresses major points; follows a logical sequence.*
> - ***Maintains audience attention.*** *Keeps the audience engaged through use of techniques such as analogies, illustrations, body language, and voice inflection.*
> - ***Adjusts to the audience.*** *Frames message in line with audience experience, background, and expectations; uses terms, examples, and analogies that are meaningful to the audience.*
> - ***Ensures understanding.*** *Seeks input from audience; checks understanding; presents message in different ways to enhance understanding.*
> - ***Adheres to accepted conventions.*** *Uses syntax, pace, volume, diction, and mechanics appropriate to the media being used.*
> - ***Comprehends communication from others.*** *Attends to messages from others; correctly interprets messages and responds appropriately.*

This process identified and defined the competencies and then mapped them to the program outcomes. Assessing student mastery of the competencies thus provides a means to evaluate achievement of program outcomes. At ISU, all engineering and technology students participating in experiential education (co-ops and internships) are assessed by their supervisors on their demonstration of the 14 workplace competencies. Some departments also use electronics portfolios as another way by which student demonstration of the competencies can be assessed[8].

Competency-based assessment provides a number of advantages:

- Difficult-to-measure ability-based outcomes are now defined as measureable workplace competencies.
- Competencies are used by numerous employers in developing and assessing their employees. Thus, students become familiar with future employment practices.
- Students more readily identify with competencies than they do with outcomes. Job descriptions for internships and full-time employment frequently contain competency-based requirements.
- Competencies provide students with a clear map and the navigational tools needed to address their goals[9].

Methods and Discussion

Adaptation of the ISU Competency-Based Assessment Model: Of particular relevance to the University of Delaware's ET program, ISU adapted the workplace competencies developed for *engineering* programs for outcomes assessment of its Agricultural Systems *Technology* (AST) and Industrial *Technology* (ITec) degrees, both of which are accredited by the Association of Technology, Management, and Applied Engineering. The outcomes for these two technology programs are very similar to the EAC ABET program outcomes for that department's engineering program. The e*ngineering* workplace competencies were "assigned" to the AST/Itec outcomes based on the engineering results. ISU then conducted a validation process with their External Advisory Committee to confirm that the competencies had been assigned correctly.

In fall of 2009, the Department of Bioresources Engineering at the University of Delaware decided to use a competency-based assessment approach, modeled after the implementation at ISU, to demonstrate mastery of the aforementioned TAC of ABET *a* through *k* general criteria[2] for the ET program. A preliminary mapping of the ISU "workplace competencies" to ET program outcomes was developed and is shown in Table 1. Competencies that are associated with numerous outcomes, as well as those consistently desired by employers of program graduates, are considered "core", that is, development and demonstration of these competencies contribute considerably to the overall achievement of the outcomes.

In conjunction with the move to competency-based assessment, it was also decided to initiate the use of ePortfolios in the ET program, following the example of the ISU Agricultural and Biosystems Engineering Department [8]. Students, as a requirement for graduation, must individually submit **integrative** and **reflective** ePortfolios that demonstrate their mastery

Table 1: TAC of ABET a *through* k *Criteria Mapped to ISU Workplace Competencies with* Core *Competencies in yellow.*

	ISU Workplace Competencies												
TAC of ABET Criteria	Engineering and Technical Knowledge	General Knowledge	Continuous Learning	Quality Orientation	Initiative	Innovation	Cultural Adaptability	Analysis and Judgment	Planning	Communication	Teamwork	Integrity	Professional Impact	Customer Focus
a. an appropriate mastery of the knowledge, techniques, skills and modern tools of their disciplines,	X		X	X			X	X						
b. an ability to apply current knowledge and adapt to emerging applications of mathematics, science, engineering and	X		X		X	X		X						
c. an ability to conduct, analyze and interpret experiments and apply experimental results to improve processes,	X		X	X	X	X		X	X		X			X
d. an ability to apply creativity in the design of systems, components or processes appropriate to program educational	X		X	X				X	X	X	X			X
e. an ability to function effectively on teams,					X		X	X	X	X	X	X	X	X
f. an ability to identify, analyze and solve technical problems,	X		X	X	X	X	X	X		X	X			X
g. an ability to communicate effectively,		X						X		X			X	X
h. a recognition of the need for, and an ability to engage in lifelong learning,			X		X	X		X						
i. an ability to understand professional, ethical and social responsibilities,		X	X	X			X	X				X		
j. a respect for diversity and a knowledge of contemporary professional, societal and global issues, and		X	X				X	X						X
k. a commitment to quality, timeliness, and continuous improvement.			X	X	X	X		X				X	X	X

of program competencies. The ePortfolio is intended to fulfill several purposes. First, completion and final submission of the ePortfolio during the last semester of a student's senior year will serve as capstone experience for the student. Second, the ePortfolio will be used as a means of documenting student mastery of ET program competencies and, hence, TAC of ABET *a* through *k* general criteria outcomes. The ePortfolios can then be used as evidence for TAC of ABET accreditation purposes. Finally, the ePortfolio, as a compendium of highlights from the student's academic career within the ET program, will also be useful for exhibiting student capabilities to potential employers.

Implementation: The planned revisions of the ET program will take effect in the fall of 2010. As a matter of best practice, compilation of the ePortfolios cannot be left until the senior year. Ideally, students should be exposed to the concept and begin working on their ePortfolios during the freshman year. Students must be given regular input and guidance regarding their progress in compiling the ePortfolio throughout their four-years of study. With those ideals in mind, the ET program revisions include the addition of a four-year seminar series focusing on professional development and documentation of student competencies / program outcomes through use of ePortfolios. Table 2 describes the five seminar courses in the series.

To provide feedback each year, a grading rubric will be used to determine if the developing ePortfolios meet acceptable standards and if reasonable progress is being made towards final submittal and acceptance of the ePortfolio in the senior year. Thus, multiple opportunities for submission, formative feedback, revision, and resubmission cycles will be available, including a final cycle in the senior year. Student ePortfolios will be routinely evaluated as part of the department's continuous quality improvement plan for the ET program and used as evidence for its TAC of ABET accreditation.

All seminars will meet in the spring semester except for BREG 165, which will be used for orientation to the major and to the university experience. In BREG 165 students will be introduced to concepts related to professionalism and the accreditation of their major, which will include mapping of ET program competencies to TAC of ABET program outcome criteria. Students will be introduced to the ePortfolio software platform and will start collecting artifacts and writing reflective commentary to begin documenting their mastery of program competencies. BREG 175 is a continuation of BREG 165 in which students will continue to refine their ePortfolio presentation and content. With BREG 175 meeting in the spring, first-year students will have two semesters of exposure and training with the ePortfolio system. A two- or three-hour common time slot will be reserved for the four seminars that meet during the spring semester. This time will be used creatively for various activities and will allow for joint meetings of all four classes or separate staggered 50-minute meeting times as needs dictate.

BREG 265 and 365 are sophomore- and junior-level seminars, respectively, in which topics related to entrepreneurship, professionalism, ethics, certification, and licensure will be examined. The University of Delaware has recently instituted a required Discovery Learning Experience (DLE)[10] for all majors, defined as "discovery-based and experiential learning that involves instructional experiences out-of-class and beyond typical curriculum courses" under the supervision of a faculty member. BREG 365 will include professional preparation for the

Discovery Learning Experience (DLE) – either undergraduate research or an internship in the ET program. Students will be encouraged to develop versions of their ePortfolios that can be released to potential internship sponsors or employers.

Table 2. Revised ET Program: Courses in the New Seminar Series:

New Courses and Catalog Descriptions	Credits
BREG 165 Freshman Seminar: Focuses on academic services, career exploration and preparation, campus resources, and practical skills helpful in mastering freshman year. Accreditation issues, ET program competencies, and introduction to ePortfolios. (fall semester)	0
BREG 175 Freshman Seminar: ET program competencies, ePortfolio development, Continuation of BREG 165. (spring semester)	1
BREG 265 Engineering Technology Sophomore Seminar: Accreditation, ePortfolio development, entrepreneurship, ethics, and professional practice issues. (spring semester)	1
BREG 365 Engineering Technology Junior Seminar: Accreditation, ePortfolio development, professional certifications and licensure, leadership and ethics, case studies, entrepreneurship, resume writing, preparation for internship experience. (spring semester)	1
BREG 465 Senior Seminar and Capstone Experience: Accreditation, professional practice issues, leadership and ethics, ePortfolio submittal for evaluation, report writing, oral presentations. (spring semester)	1

As ISU found with co-op and internship experiences[3], the DLE is an ideal opportunity for students to demonstrate mastery of many of the ET program competencies, which will be derived from the ISU "workplace competencies". Students doing either an internship or undergraduate research experience will be performing in a workplace-like setting and will be under the direction of a supervisor. Supervisor evaluations will be used for direct assessment of student competencies.

Seniors will have completed their DLE by the time they register for BREG 465. BREG 465 is meant to be an integrative capstone experience in which students will complete their ePortfolios and submit them for evaluation and exhibition. By this point, each ePortfolio should be a polished, comprehensive compendium of a student's experiences throughout his or her academic career. Through the ePortfolio, the student's mastery of ET program competencies will be documented. EPortfolios will include supportive artifacts that address program competencies and will be accompanied by reflective commentary, all of which will have been refined by several annual cycles of submission, faculty feedback, and revision.

Oral presentations about their internships or undergraduate research activities presented to students in freshman- through junior-level seminars will enrich the professional training of senior students in BREG 465 giving them a chance to polish their presentation skills and prepare for entering the professional job market. To provide the ET students in BREG 175, 265, and 365 with examples of program expectations and opportunities, they will observe and evaluate the presentations given by the seniors and will have the opportunity to examine the seniors' completed ePortfolios on exhibition. The current ET program, like the revised program, requires a DLE. During the initial years of implementing the revised curriculum when no seniors will need to meet the seminar and ePortfolio requirements of the revised program (i.e. before 2014), senior students, as part of the conditions for completing their DLEs will be asked to make oral presentations to the 100-, 200-, and 300-level seminars that *are* offered.

By fortuitous coincidence, the University of Delaware's Center for Educational Effectiveness initiated a grant program in the fall of 2009 to "fund several academic departments/programs to design, implement, assess, and sustain E-Portfolios as a required part of their majors' undergraduate experience." Conditions under which the grant would be awarded included the following stipulations:

- The ePortfolio spans every year of a student's time in the major, is focused upon integrative and reflective learning, and demonstrates student competency in achieving the program's student learning goals as well as at least three general education goals.
- The ePortfolio includes feedback mechanisms on student learning in the program at set points in the students' progress in the curriculum.
- The ePortfolio is used to assess student learning goals.
- The ePortfolio is introduced to students during their first year in the major and must include systems of accountability that encourage students' participation (grading, graduation requirement, etc).
- The ePortfolio is piloted in Fall 2010. The first round of feedback is provided by December 31, 2010. The second round of feedback is provided by May 31, 2011.
- The ePortfolio is required and implemented for every student entering the major in Fall 2011 and thereafter. However, this does not preclude the Department/Program from requiring and implementing the ePortfolio for all majors regardless of their point of entry.

The planned revisions to the ET program already satisfied all provisions of the grant program; no adjustments were necessary. The Department of Bioresources Engineering submitted a proposal and received funding as a part of the Center for Educational Effectiveness grant program. The objectives of the project were as follows:

- To adapt the ISU workplace competencies and key student actions that demonstrate mastery of each competency for use with the University of Delaware's ET program,
- To develop and validate a mapping of the derived ET program competencies to the TAC of ABET general criteria program outcomes, and
- To bring an ePortfolio system online that will support the needs of the department and its ET program. Specifically, the ePortfolio system will be used by students to document their mastery of program competencies and the ePortfolios will be used by the department as a direct assessment tool for continuous quality improvement and as evidence that TAC of ABET accreditation criteria have been met.

There are several software platforms available for support of the ePortfolio system. The university's open-source course management system, Sakai, has ePortfolio capabilities built-in. The proprietary system, LiveText, has been used by departments in the UD School of Education as an ePortfolio platform in connection with meeting NCATE accreditation requirements [11]. Google Sites [12] has a web site-hosting environment that has many of the features required of an ePortfolio platform. ISU [13] and Clemson University [14] have custom-designed systems that are worthy of evaluation. Because of the variety of software choices, an important initial goal of this project will be to identify an ePortfolio platform that meets the needs of the department and ET program.

The grant includes significant funds dedicated to providing technical support from the university Information Technologies (IT) / Academic Technology Services (ATS) for developing the ePortfolio system. Derivation of the ET program competencies from the ISU workplace competencies, development of associated key actions, and validation of the mapping between ET program competencies and the TAC of ABET general criteria will be accomplished through joint efforts of department faculty, its external industrial advisory committee, and ET students. The grant includes funds in each of the two years of the project for the meetings to accomplish those tasks. Travel expenses and modest honoraria are also available for experienced advisors/moderators to assist with the process.

Summary

Internal funding was obtained from a University of Delaware Center for Educational Effectiveness grant program that provides assistance with implementation of the ePortfolio system and adaptation of the ISU competency-based assessment model for use in the University of Delaware's ET program. Revisions to the four-year ET program at the University of Delaware will include provisions for use of competency-based assessment as a means of demonstrating TAC of ABET general criteria outcomes. The changes are based on a successfully implemented program in the College of Engineering at Iowa State University [3, 8]. Difficult-to-measure ability-based outcomes are now defined as measureable workplace competencies that resonate with students and employers. Competency-based assessment provides a means to assess the achievement of ability-based program outcomes.

Bibliography

1. ABET, Inc. ABET. *Home page* (2009).at <http://www.abet.org/index.shtml>
2. ABET, Inc. ABET. *Download Forms and Criteria* (2009).at <http://www.abet.org/forms.shtml>
3. Brumm, T.J., Hanneman, L.F. & Mickelson, Steven K. Assessing and Developing Program Outcomes through Workplace Competencies. *International Journal of Engineering Education* **22**, 123-129 (2006).
4. ATMAE ATMAE - Association of Technology, Management, and Applied Engineering. *ATMAE Home Page* (2009).at <http://atmae.org/>
5. Mentkowski, M. & Associates *Learning that Lasts: Integrating Learning, Development, and Performance in College and Beyond, 1st ed.* (Jossey-Bass, Inc.: San Fransisco, 2000).
6. CETE DACUM and SCID Training Information – The Ohio State University. *Center on Education and Training for Employment, College of Education and Human Ecology, The Ohio State University* (2009).at <http://www.dacumohiostate.com/index.htm>
7. ISU Department of Agricultural and Biosystems Engineering Assessment. *Department of Agricultural and Biosystems Engineering - Assessment* (2005).at <http://www.abe.iastate.edu/assessment.html>
8. Brumm, T.J., Mickelson, Steven K. & Kaleita-Forbes, A. Competency-Based Outcomes Assessment for Agricultural Engineering Programs. *International Journal of Engineering Education* **22**, 1163-1172 (2006).
9. Voorhees, R. Competency Based Learning Models - A Necessary Future. *New Directions for Institutional Research* (2001).
10. University of Delaware GenED. *Discovery Learning Experience* (2010).at <http://www.ugs.udel.edu/DLE/>
11. NCATE NCATE - Home Page. *NCATE - National Council for Accreditation of Teacher Education* (2009).at <http://www.ncate.org/>
12. Google Google Accounts. (2009).at <https://www.google.com/accounts/>
13. ISU Department of Agricultural and Biosystems Engineering Learning in ABE - ePortfolios. *Learning in the Department of Agricultural and Biosystems Engineering* (2005).at <http://learn.ae.iastate.edu/ABEeport.htm>
14. Clemson University Clemson University : ePortfolio : Clemson University. *ePortfolio Program* (2007).at <http://www.clemson.edu/academics/programs/eportfolio/index.html>