THE SYSTEMATIC COURSE DEVELOPMENT PROCESS: Building a Course in Sustainable Construction for Students in the U.S.A.

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ABSTRACT

The construction industry actively adopts the concept of sustainability to not only minimize the impact on the environment but also increase social and economic benefits through accepting sustainable design and construction practices. This growing trend in sustainable construction requires both new knowledge and new skills for sustainability, in addition to conventional knowledge, such as scheduling, estimating, contracting, etc. Due to this paradigm change in the construction industry, construction programs in the U.S.A. should offer sustainable construction courses in order to teach sustainable knowledge, technologies and skills to their students before their entrance into industry.

The purpose of this study is to develop a sustainable construction course designed for university construction programs using a systematic course development approach divided into three stages including preparation, development, and improvement. The course described in this paper is used to illustrate the systematic development process and can serve as an example for faculty at other universities on how to use such a method. During the preparation stage, a syllabus review is conducted in order to recognize and evaluate current sustainable construction courses offered by construction programs. In addition, in-depth literature review is performed to identify current trends in sustainable construction courses and related research. The development stage consists of: creating the framework for a sustainable construction course, choosing the goals and objectives for this course, choosing the contents of the course, organizing the chosen contents of the course, and planning the course schedule. At the improvement stage, the proposed course is improved, reviewed, and evaluated by experts from both the construction industry and academia through a detailed feedback process. From this systematically developed sustainable construction course, students in construction programs can learn basic knowledge of sustainability and the importance of sustainable design and construction. They will be exposed to different sustainable building rating systems such as Leadership in Energy and Environmental Design (LEED) and Green Globes, collaborative skills among construction participants, and the advantages and pitfalls of sustainable construction. In addition, construction students who become leaders in the industry will change the nature of the construction industry and society to help not only minimize environmental impacts caused by construction activities but also to secure our earth.

KEYWORDS

sustainable construction, construction education, course development, systematic approach

INTRODUCTION

Construction is a significant industry that profoundly influences our economy, natural environment, health, and productivity. The construction industry in the U.S.A. employed over 6.7 million people in 732,000 companies and generated annual revenue over $1.1 trillion in 2005 (U.S. Census 2005). At the same time, the industry contributes to major environmental problems including global warming, climate change, ozone depletion, soil erosion, desertification, deforestation, acidification, loss of biodiversity, land pollution, water pollution, air pollution, and depletion of fisheries (Kibert 2005; Shah 2006). Moreover, the construction industry,

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especially the sectors of that industry devoted to buildings, develops products that strongly affect human health and comfort, productivity, and overall quality of life (USGBC 2007). The most widely used definition of sustainability is in the context of development, where sustainable development "meet[s] needs of the present without compromising the ability of future generations to meet their own needs" (WCED 1987). With the recognition of these challenges and issues associated with construction activities, the building industry has begun to consider the concept of sustainability through sustainable construction.

Sustainable construction includes ensuring that buildings are designed, constructed, operated, and demolished in an environmentally and energy efficient manner which can reduce the impact of buildings on the environment, improve working environments for building occupants, and reduce building operation and maintenance costs (Bosch & Pearce 2003). The sustainability movement with its associated benefits not only has changed the construction processes but also has created needs for sustainable construction education for stakeholders involved in the various aspects of sustainable construction projects.

Construction programs have a vital role in sustainability education for their graduates because they produce members of the construction community who will be leaders and change agents in the future. Multiple scholars have mentioned the importance of sustainable construction education in construction programs in several countries such as the U.K., the U.S.A., and Australia (Chau 2006; Vanegas 2004; Cotgrave 2006; Graham 2000; Mead 2002; Woodruff 2006). Major topics of research for sustainable construction education follow: the current status of sustainable construction education (Mead 2002); needs of sustainable construction education in construction programs including civil engineering programs (Chau 2006; Tinker and Burt 2004) sustainable construction course case study for a specific program in Australia (Hayles and Holdsworth 2006; Hayles et al. 2006), and the needs of integration between existing construction courses and the concept of sustainability in construction curriculum (Graham 2000). However, previous studies, especially in the U.S.A., did not observe significant change within the construction curriculum's conventional courses in the areas of scheduling, estimating, and contracting.

The purpose of this study was to demonstrate the use of a systematic course development approach to develop a sustainable construction course designed for university construction programs. The three stages of this process include preparation, development, and improvement, which are key parts of a methodology for systematic curriculum development (Mager & Beach 1967). To illustrate the process completely, the authors focused on the development of a single, stand-alone course that could be added as a technical elective to a typical construction curriculum. The addition of such courses to the curriculum is one of the most visible ways in which sustainability has been added to construction education at the institutions inventoried in this study, and the systematic course development process demonstrated here lends itself to the development of stand-alone courses. Integration of sustainability as part of existing courses is another possible approach that was not considered in this study, but which is discussed further in the section on Future Research.

During the preparation stage, an analysis and review of syllabi is conducted in order to identify the status of and evaluate current sustainable construction courses offered by existing construction programs. In addition, an in-depth literature review is performed to identify current trends in sustainable construction courses and related research. The development stage consists of creating the framework for a sustainable construction course; choosing the goals and objectives for the course; choosing the contents of the course; organizing the chosen contents of the course; and planning the course schedule. At the improvement stage, the proposed course is improved, reviewed and evaluated by experts from both the construction industry and academia through a detailed feedback process.

From this systematically developed sustainable construction course, students in construction programs can learn basic knowledge of sustainability and the importance of sustainable design and construction. They will be exposed to different sustainable building rating systems such as Leadership in Energy and Environmental Design (LEED), collaborative skills among construction participants, and

the advantages and pitfalls of sustainable construction. Ultimately, these sustainable construction professionals will change the nature of the construction industry and society to help secure our earth.

Objective

The goal of this research is to develop a sustainable construction course for undergraduate students in construction education using the systematic approach. To accomplish the goal of this research, three research stages and fourteen specific objectives are created.

Phase I: Preparation

At the preparation stage, this process strives to

- Search for recent research on sustainable design & construction that includes similar names such as sustainable development and green building
- Perform literature reviews of course or course development processes
- Perform literature reviews about sustainability in construction education
- Perform literature reviews about construction education in general
- Perform background research of other sustainable construction courses and initiatives provided by other construction schools.

Phase II: Development

The development stage of the process strives to

- Construct an overview/framework of 'sustainable construction for undergraduate students'
- Set the goals and objectives for the course
- Develop the contents and activities for the course
- Develop the instructional strategies for the learning topic
- Plan the evaluation and assessment instruments for the course
- Create the syllabus for the course and the course draft for the sustainable construction class.

Phase III: Improvement

At the improvement stage, the process strives to

- Receive advice and evaluation from construction industry experts, construction education professors, and sustainable construction experts (LEED Accredited Professionals)
- Modify and make corrections to the course draft
- Document the outcomes of the process through publication.

RESEARCH METHODOLOGY

Research Scope and Procedure

The sustainable construction course from this research is designed for undergraduate students in construction programs. This course is the fundamental course for sustainable construction performed for one semester. It is beneficial for the undergraduate construction major students preparing for a future as construction leaders or innovators in the construction industry. Suggested prerequisite subjects for this course include materials, construction, scheduling, estimating, and others. These subjects are not mandatory, but are recommended for improving each student's comprehensive understanding and application.

To establish the contents of the course, there are several components involved with developing the course draft. First, the overview or framework is created in order to provide a comprehensive context. It should include the course descriptions and plan of study for "Sustainable Construction". Second, the syllabus for the sustainable construction course is created to address specific considerations such as the target, goal, objectives, contents/activities, assessment planning, and others.

Setting up the course development procedure is essential in order to generate efficient and meaningful outcomes. According to Randolph and Posner (1988), it necessary to set rules for planning successful research. In accordance with their rules, the initial step for the research is to set a clear project goal and objective. After that, researchers establish checkpoints at each milestone, activities, relationships, and time estimates.

Research Methodology

Course development using the systematic approach is the objective of this research. For more systematic research, the researchers set the stages of the course development through the literature reviews on systematic development theories. Just as "systematic course development" is also called the "objective model" in course theory, so the most important

point in this theory is the establishment of objectives or goals (Tyler 1949).

The course development is divided into three major steps including preparation, development, and improvement. This research reviews the systematic curriculum theories and considerations and follows objectives-based research (Mager & Beach 1967).

Literature Review

Literature reviews are performed in the initial part of this research. The literature review is divided into two main categories: systematic curriculum development theories (Table 1), and sustainable construction education (Table 2).

Curriculum development focuses primarily on content and areas associated with it. However, the curriculum should define the educational goals and mission for the time being during the development procedure. Tyler (1949) supported this idea, providing the four development procedures of setting educational goals, choosing educational experiences, organizing education experiences, and evaluating. In his curriculum development model, setting educational goals was the first initiation for curriculum development process. Also, Finch & Crunkilton (1989) supported this idea that curriculum developers should concentrate on setting their intended goals before the next developmental stage. Kwon & Yi (2003) employed a systematic curriculum development for secondary school manufacturing and construction technology program. Their development process was performed by four stages; constructing curriculum framework, setting educational goals, choosing content, and organizing content.

The second category of literature, sustainable construction education, is summarized in Table 2. For purposes of this research, the literature search was focused specifically on literature pertaining to

TABLE 1. Literature Lists on the Curriculum Development Theories.

Number	Related Literatures
1	Tyler, R. W. (1949). Basic principles of curriculum and instruction.
2	Finch, C. R. and Crunkilton, J. R. (1989). Curriculum Development in Vocational and Technical Education; Planning, Content, Implementation. Allyn and Bacon, INC.
3	Kwon, H. S. and Yi, S. B. (2003). The development of hands-on activities based production technology curriculum by objective model at the secondary school.

TABLE 2. Literature List on the Sustainable Construction Education.

Number	Related Literatures
1	Accreditation Board for Engineering and Technology. (2000). Criteria for accrediting engineering programs: Effective for evaluations during the 2000–2001 accreditation cycle
2	Graham, P. (2000). Building education for the next industrial revolution: teaching and learning environmental literacy for the building professions
3	Mead, S. P. (2002). Green building: Current status and implication for construction education
4	Tinker, A. and Burt, R. (2004). "Greening" the Construction Curriculum
5	Cotgrave, A. and Alkhaddar, R. (2006). Greening the curricula within construction programs
6	Woodruff, P. H. (2006). Educating engineers to create a sustainable future
7	Hayles, C. S., Robson, K. and Holdsworth, S. (2006). A case study from RMIT: Introducing property undergraduates to the immediate issues of housing sustainability and affordability within Australia and New Zealand
8	Hayles, C. and Holdsworth, S. E. (2006). Curriculum change for sustainability
9	Chau, K. W. (2007). Incorporation of sustainability concepts into a civil engineering curriculum
10	Murray, P. E. and Cotgrave, A. J. (2007). Sustainability literacy: the future paradigm for construction education

construction or building-related education, although selected references were also included from the engineering education literature where they were directly relevant to construction.

Many journal and conference articles discuss the importance of sustainable construction education in construction programs worldwide. In addition, the Accreditation Board for Engineering and Technology (ABET) emphasized the importance of sustainability in engineering education (ABET 2000). Graham (2000) explained resource efficient design and construction called "sustainable building" and proposed the importance of teaching and learning environmental literacy for the building professions to achieve sustainable building. Mead (2002) defined the status of sustainable construction in the construction industry and suggested the importance of sustainable construction education in construction programs. Woodruff (Woodruff 2006) surveyed the familiarity of the concept of sustainability from environmental engineering faculties and environmental professionals as representatives of recent graduates to compare their opinion of sustainability education. Cotgrave & Alkhaddar (2006) developed sustainable curricula within construction programs in U.K. Chau (2006) addressed the rationale behind the recent integration of sustainability concepts into a civil engineering curriculum in Hong Kong.

Tinker and Burt (2004) identified sustainability related courses in construction programs in the U.S.A. and explained the content of sustainable courses and the integration into the existing construction curriculum. Hayles & Holdsworth (2006) explained a number of initiatives to promote sustainability with the teaching of built environment disciplines at RMIT University Australia. In addition, Hayles, Robson & Holdsworth (2006) described an instruction regarding sustainability to undergraduate construction students at RMIT University in Australia. Murray and Cotgrave (2007) demonstrated the rationale for systematically embedding sustainability within the construction curriculum to the benefit of professionals, professional bodies and educators. From the literature review, the geographic context for these last studies indicates that leading institutions of sustainability education are located in the U.S.A., Australia, and the UK.

SYSTEMATIC DEVELOPMENT OF A SUSTAINABLE CONSTRUCTION COURSE

Preparation Stage of Course Development

Course development should be systematic because it provides an objective perspective or rationale for course development. The most interesting concern in the systematic approach to course development is the way a course maximizes its educational achievements. This systematic approach has been recognized as a classic in course development (Tyler 1949). The systematic approach in the course development begins with the establishment of the goals and objectives. Choi (2005) and Kwon and Yi (2003) stress the development procedure in course development to include 'conceptualization, statement of objective, decision of contents, and organization work on contents, instructional strategies, and assessment planning'. In the systematic approach, the statement of the goal is an important starting point for course development. The preparation stage for course development is composed of literature reviews in the areas of sustainable construction, course development theories, the current status of sustainable construction, and the status of sustainable construction education.

Development Stage for Course Development

In the development stage for course development, there are five sub-stages. At first, the basic framework for the sustainable construction course gives an outline or introduction of the course. Second, learning goals and objectives are set by reviewing other sustainable construction courses, research papers on sustainable construction, and construction industry interests. Third, learning topics are chosen by considering their relevance to the learning goals and objectives. With the systematic approach in mind, learning topics based on the learning goals and objectives are set. Fourth, instructional strategies and assessment plans are organized by pedagogical perspective. Considering the implementation of the learning topics in classroom, the research team concentrates on matching the learning topics with the appropriate instructional strategies. Finally, a final course syllabus is completed with the semester schedule plan (15 week plan).

A Framework for Sustainable Construction Course. At this step in the development stage, the course characterization (Table 3) and course framework (Figure 1) for '*sustainable construction course*' are developed to follow the systematic course development procedure. These are developed based on needs of sustainable education and research papers on sustainable education.

Setting Learning Goals. Setting learning goals is one of the most important procedures in the systematic course development process. The first step in setting up learning goals for a sustainable construction course in a construction program is to study other sustainable construction related courses which are offered by other universities in the U.S.A., summarized in Table 4. Two methodologies were applied for finding sustainable construction related courses: a literature review and a web search of undergraduate construction courses, which resulted in a sample of 11 such courses from a variety of institutions. The syllabi from identified courses were obtained by two ways: they were downloaded from each institution's website or instructor's personal websites if they were downloadable, or requested from instructors with a note as to their research purpose. From the collected syllabi, the authors summarized the objectives for the new course.

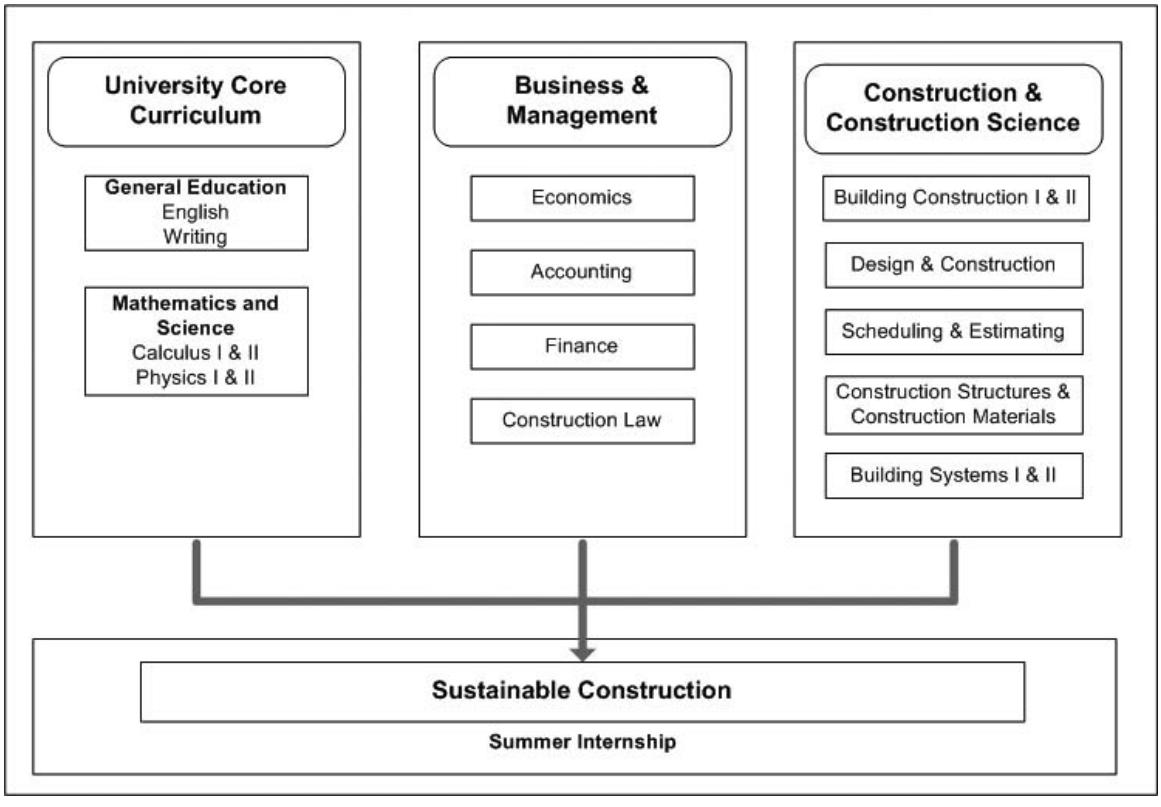
The setting of learning goals for the 'Sustainable Construction' course has to consider industry expectations of the course because the acquired knowledge of sustainability will be applied to actual construction. According to Ahn & Pearce (2007), requested sustainable knowledge from industry for graduates in construction programs was ranked in the following order:

- General knowledge of sustainability in built environment
  a. Sustainable building familiarity
  b. Basic green knowledge
  c. A general knowledge of the process
  d. In-depth instruction with principles and design application

TABLE 3. Characterization of Course for Sustainable Construction.

Course Name	Sustainable Construction
Target	Undergraduate Students in Construction Program
Prerequisites	1. Required over 24 credits: English I & II, Calculus I & II, Economics, Physics I&II (University Core Curriculum) 2. Fundamental construction courses required: estimating, scheduling, contracting, building science, etc. 3. Senior Students
Course Description	'Sustainable construction' is a course to teach sustainability in the built environment to undergraduate students in a construction school. This course will encourage students to comprehend the basic knowledge about sustainability in built environment, the importance of sustainability in construction, several sustainable rating systems in the industry such as LEED, Green Globes, etc. and to integrate the concepts of sustainability into other construction knowledge. In addition, it provides a basis for interest in sustainability in students' daily life and their career. Through a variety of activities related to sustainable construction, students can become more familiar with sustainable features; apply this knowledge to actual construction while working at the construction field; and transfer consideration for the health of our earth to our next generation.
Major Constructs & Considerations	1. Systematic approach in developing or designing the course • Curriculum development theory • The trends or needs of current construction education 2. Process-based curriculum (Activities based learning) 3. Case-based curriculum 4. Learner-centered instruction 5. Collaborative learning and continuous feedback

FIGURE 1. Framework for Sustainable Construction Course in Construction Education.



- Sustainable rating system and design for sustainability
  a. LEED requirements
  b. LEED certification course
  c. Economic feasibility of LEED
  d. Exposure to LEED
  e. Accredited LEED student
- Sustainable construction materials and methods
  a. Construction materials and sustainable methods for alternative energy
  b. Coordination of sustainable efforts with all parties at design phase
  c. Practical systems for building that save energy; study ASHRAE Standard 90.1-2007, Energy Standard for Buildings Except Low-Rise Residential Buildings
- Environmental philosophy

From the literature review and sustainability related course goals offered by universities, five learning goals and eighteen objectives were created for the *'Sustainable Construction course in construction program'* as shown in Table 6. The descriptions of learning goals and objectives are developed from the pedagogical background of Bloom's taxonomy that consists of the cognitive domain, affective domain, and psychomotor domain (Bloom & David 1956).

Choosing Learning Topics. In choosing learning topics, two major rules are employed as selection criteria: the learning topics should be 1) related to the learning goals, and 2) based on the learner's activities. The final learning topics consist of four learning topics and eighteen sub-topics as shown in Table 6.

Organizing Learning Topics. The next stage is to organize learning topics and provide descriptions and instructional strategies as shown in Table 7. Major instructional strategies are 'instructor's lecture and presentation', 'learner's presentations', 'learner's

TABLE 4. Sustainable Construction-related Courses Offered in U.S.A.

Course Name	Purpose of Course
Sustainable Building Methods (Penn State)	This course introduces students to concepts of sustainability and green design as applied in building construction. The goal of this course is to help students develop the vocabulary and skills to become productive contributors to sustainable building project teams.
Design-Build Montana: Sustainable American Indian Housing Solutions: An Interdisciplinary Service Learning Course (Penn State)	This course provides an interdisciplinary and hands-on experience in the application of sustainable building technologies and community-built construction methods through a culturally diverse community partnership with the Northern Cheyenne Indian tribe.
High-Performance Green Building Delivery Systems (University of Florida)	The purpose of the course is provide an overview of emerging delivery systems for high performance green buildings and the basis on which their sustainability can be evaluated. The U.S. Green Building Council Leadership in Energy and Environmental Design (LEED) criteria are discussed in detail.
International Sustainable Development (University of Florida)	The main objective of this course is to provide the students with a picture of how sustainable development is changing humankind's interaction with the world and their place in that world, to include its effects on the economic system, its effects on society, and its impacts on the survival of critical socio-ecological systems. From the course, students not only learn the basic concepts of sustainable development, key internal plans related to sustainable development and many sustainable community movement in the world, are exposed to key environment and resource issues and effects on humankinds.
Sustainable Practice-Design and Construction (Colorado State Uni.)	The course will focus on the major components of sustainable design and construction, including energy, healthy buildings, cultural, natural resource use and other environmental and economic issues of sustainable built environments.
Green Construction and Sustainability (University of North Florida)	This is the first in a two-course elective track for students specializing in green construction and sustainability. This course addresses the environmental impact of land development and construction. Topics include specific regulations affecting developers and construction managers, the environmental review of developments and methods to prevent or minimize the negative environmental impacts of construction and land development.
Sustainable Construction (Texas A & M Uni.)	This course contributes sustainable construction methods and materials to meet present and future needs. The goal of this course is to help identify and analyze international, national and local programs promoting sustainable construction. In addition students can learn characterization of components in successful sustainable construction projects.
Sustainable Construction (Southern Polytechnic State University)	The purpose of this course includes LEED certification techniques for sustainable sites, water efficiency, energy & atmosphere, materials & resources, indoor environmental quality, innovation and design. From the course, the student will study and analyze how management and LEED techniques are applied to current construction projects.
Sustainability (Carnegie Mellon University)	This course begins with an overview of the concept of sustainability and its history, including changing attitudes and values toward technology and the environment through the twentieth century.
Sustainable Case Studies (Carnegie Mellon University)	This course teaches the principles and tools of sustainability which have yet to be applied on a large scale to solving real-world engineering problems. In this course, we explore the use of these principles and tools to various case studies.
Sustainable Facility Systems (Virginia Tech)	This course provides a introduction to means, methods, and analytical practices associated with sustainability in the built environment, including an overview of best practices for sustainable projects in the areas of planning/development, site design, project management, energy and water conservation and efficiency, green building materials, and indoor environmental quality. Analytical methods include green building assessment tools and methods; Leadership in Energy and Environmental Design (LEED) rating system; economic analysis of green building alternatives; and evaluation for innovation and organizational change.

TABLE 5. Learning Goals and Objectives for Sustainable Construction Course.

Learning Goals	Learning Objectives	Type
1. Understand the general knowledge of sustainability	1.1 Identify the definition and concept of sustainability	Cognitive
	1.2 Understand the importance of environmental philosophy	Cognitive
	1.3 Understand the history of sustainability	Cognitive
	1.4 Describe terminology of sustainability	Cognitive
2. Comprehend the concept of sustainability as applied in construction.	2.1 Identify sustainable construction practice in the construction industry	Cognitive
	2.2 Understand why sustainable construction is important in construction	Cognitive
	2.3 Analyze the pros and cons of sustainable construction	Cognitive
	2.4 Identify sustainable alternatives to conventional construction practices	Cognitive
3. Understand and implement sustainable construction methods and materials	3.1 Identify sustainable materials	Cognitive
	3.2 Perform a basic sustainable construction practice to benefit the community	Psychomotor
	3.3 Appreciate the importance of collaborative and safe work	Cognitive
	3.4 Articulate feelings on working together	Affective
	3.5 Analyze the difference between theory and actual practice	Cognitive
	3.6 Be proficient with communication work	Affective
	3.7 Perform the strategies of communication and collaboration in a project	Psychomotor
4. Being familiar with sustainability rating systems	4.1 Be able to apply sustainable rating systems such as LEED, Green Globes, etc.	Cognitive
	4.2 Understand the roles of sustainability rating systems in the industry	Cognitive
	4.3 Analyze the pros and cons of current sustainability rating systems	Cognitive
5. Contemplating the future direction and application	5.1 Identify the future directions of sustainability	Cognitive
	5.2 Recognize the possible integration with other industries, disciplines, etc.	Cognitive
	5.3 More actively participate in industry for sustainable construction	Affective

research: case study', 'group work', 'field trip', 'assignment', and 'group and individual report'. The instructor's lecture and presentation are needed for quick class/assignments introduction and establishment of the basic notions. This course design especially emphasizes learner-centered instruction, collaboration through group discussion, reports, and presentations.

The assessment plan in this course was organized utilizing the philosophy of constructivism as a basis. In this educational trend, assessments emerge from learner-centered instruction and evaluation. In other words, many education experts and teachers are focusing on assessment of the whole learning process (Choi 2005; Kwon & Yi 2003; ITEA 2000). The assessment plan is strongly associated with grade issues. The assessment plan for this course is presented for each assessment category in Table 8.

Improvement Stage for Course Development

In order to improve the developed sustainable construction course, the evaluation stage with the expert group was performed. The expert group for evaluating the developed course consists of five sustainable experts and two course development experts listed in Table 9. The sustainability experts were purposively selected among professors in construction programs in the USA; two curriculum development experts were also purposively selected among professors in the School of Education at Virginia Tech.

The evaluations were generated by the descriptive and analytic comments of the evaluators with respect to the developed course plan. The developed course plan consists of five categories: [A] A framework of sustainable construction course in construction education, [B] Developing learning goals and objectives, [C] Selection of learning topics, [D] Organiz-

TABLE 6. Selection of Learning Topics for Sustainable Construction Course.

Learning Topics	Sub-topics	Related Objective
Background knowledge of 'sustainability'	• Definition and significance of sustainability	1.1/1.2/1.4
	• Historical background	1.3
	• Theoretical approach to sustainability	1.2/1.4
	• Sustainable issues in social background (Environmental issues)	1.2/1.3
Sustainability in Construction	• Historical cases of sustainable construction	1.3/2.1
	• Rationale and value of sustainable construction	2.2
	• Contemporary trends in sustainable construction research and practice	2.1/2.4
	• Means and methods in sustainable construction	2.1
	• Sustainable materials	3.1
	• Sustainable in construction industry	2.1/2.3/2.4/5.1
Analytic assessment for sustainable construction	• Critical analysis of current sustainable construction cases	2.3/3.5/5.2
	• Sustainable rating systems (LEED, etc.)	4.1/4.2/4.3
	• Assessment strategies for sustainable construction	4.1/4.2/4.3/5.1
Implementation for sustainable construction	• Sustainable design practice	2.1/3.2
	• Case study related to sustainable construction	2.1/3.2
	• Service learning for sustainable construction	3.2/3.3/3.4/3.5/ 3.6/3.7
	• Internship or practicum field trip	2.1/3.1/3.2/3.3/ 3.4/3.5/3.6/3.7/ 5.1/5.2/ 5.3

ing learning topics and instructional strategies, and [E] Assessment content in *'Sustainable construction course'*. The research team sent a letter of introduction, abstract, course description and the developed course plan to seven evaluators who are professors and/or course developers in the field of construction education. From the comments and reviews of seven evaluators, the first draft model of the course plan was improved and modified.

In the category of "A framework for sustainable construction course in construction education", one evaluator recommended that the framework should include two additional courses: chemistry and a design-emphasis course. Also, three evaluators requested clarification of the relationship between this developed course and the summer internship, although details of this relationship were outside the scope of this research. Designating specific courses could be flexible depending on the situation and institutional level in which the course will be deployed. The research team agreed to the comment that the developed course should not be in a subcategory of summer internship. The optimal semester for this course should be identified by the institutional situation but the minimum prerequisites were described in the framework. In the category of "learning goals and objectives", three evaluators pointed out the usage of Bloom's taxonomy describing learning objectives as a good point for this section. In the category of "learning topics", the balance between classical work and current cases regarding sustainable construction was an issue to two evaluators. They pointed out that this course should employ more current issues in the field of sustainable construction. However, this category contains a variety of applied or practical topics related to current sustainable construction. Two learning topics of "analytic assessment for sustainable construction" and "implementation for sustainable construction" are strongly associated

TABLE 7. Organizing Learning Topics and Description.

Learning Contents	Description	Instructional Strategies
1. Class Orientation	• Explanation of course syllabus • Introduction to assignments • Assigning groups for activities • Describing the field trip	Instructor's lecture & presentation Continuous feedback
2. Instructor's presentation on sustainable construction	• Explanation of environmental issues • Definition and theory of sustainable construction • Main causes of environmental issues • Reading articles and cases on sustainable construction	Instructor's lecture Assignment # 1 Group discussion # 1 Group discussion # 2 Assignment # 2
3. Learning the current sustainable construction practices	• Explanation of current sustainable construction practice • Components of sustainable construction practice • Issues of sustainable construction practice	Instructor's lecture Lecture & discussion Assignment # 3 Group discussion # 3
4. Learning sustainable construction assessment tools	• Definition of LEED • LEED rating system • Five LEED Strategies (sustainable site strategies; water efficiency strategies; energy and atmosphere strategies; materials and resource strategies; and indoor environmental quality strategies)	Instructor's lecture Assignment # 4 Group presentation # 1
5. Economics of sustainability	• Economic issues of sustainable construction • Imperative of global warming	Group discussion # 4
6. Site learning	• Field trip to sustainable construction site • Project description • Application of sustainable construction • Issues of sustainable construction	Assignment # 5 Field trip report
7. Sustainable construction case study	• Analyzing the components of sustainable construction in actual cases • Identifying issues of sustainable construction • Developing alternative solutions and recommendations	Project report: group work Group Presentation # 2 Peer evaluation
8. Future direction of sustainable construction	• Diffusion of sustainable construction • Future directions of sustainable construction	Assignment # 6 Guest speaker Group discussion

with the application and practice of current sustainable construction. In two categories of "organizing learning topics and instructional strategies" and "assessment plan", all evaluators gave positive reviews in terms of the level of depth and organization. The first section of the course plan was revised as presented in Figure 2.

CONCLUSIONS

Many previous studies have identified the importance of sustainable construction education in construction programs; the current status of sustainable construction education courses in the U.S.A.; the purpose of pioneering sustainable construction courses in construction programs in the U.S.A.; and the industry sustainable knowledge expectations of construction graduates. Based on the sustainable construction education needs identified in these studies, the authors developed a sustainable construction course through a systematic course development process including stages of preparation, development, and improvement. During the

TABLE 8. Assessment Contents for Sustainable Construction Course.

Assessment Contents	Percentage (%)
1. Assignments	**40%**
• Summarizing direct sustainable construction definitions	5%
• Reviewing different journal articles related to sustainable construction	5%
• Summarizing components of sustainable construction practices	5%
• Comparing different LEED certification strategies	5%
• Developing field trip report	10%
• Predicting future direction of sustainable construction	10%
2. Presentations	**20%**
• Group presentation on the five LEED strategies from a LEED silver certified building 10%	
• Group presentation for possible sustainable construction strategies for a newly constructed building 10%	
3. Project Report	**30%**
4. Participation	**10%**
• In class activities and field trip	
• Group discussion	

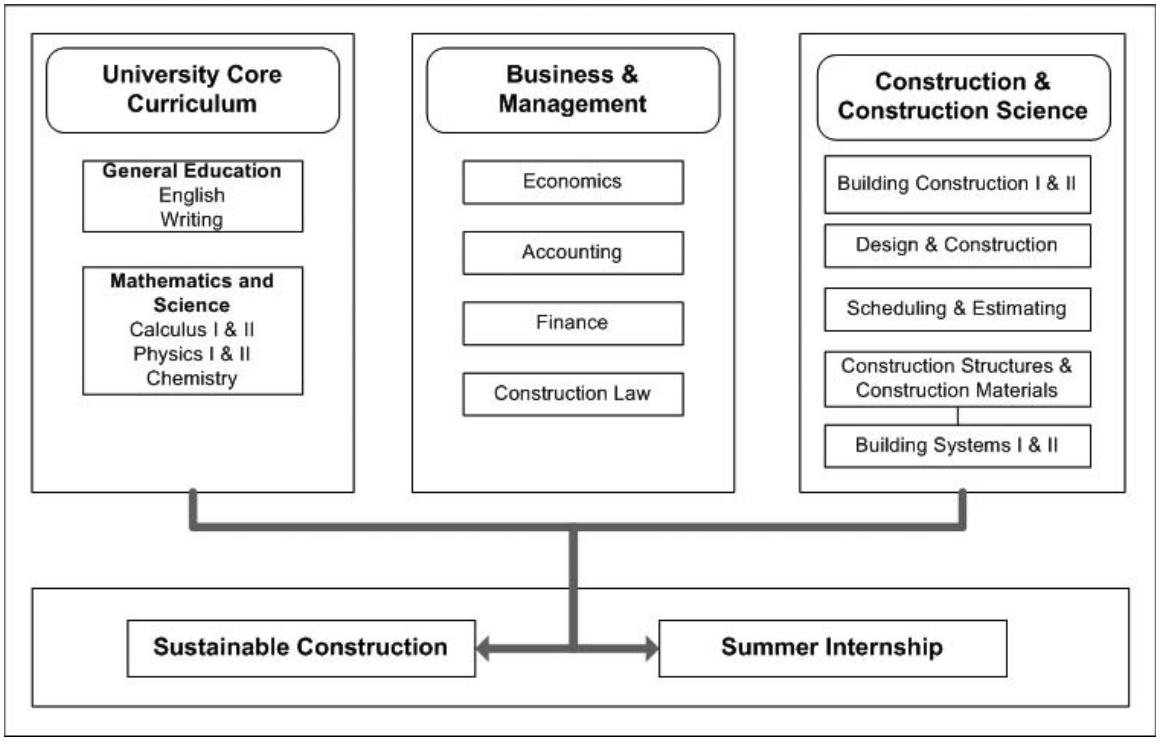
TABLE 9. The Expert's Experience in academia and the industry.

Expert	Experience	Expert	Experience
Expert A	Over 10 years	Expert B	Over 23 years
Expert C	Over 10 years	Expert D	Over 15 years
Expert E	Over 30 years	Expert F	Over 30 years
Expert G	Over 12 years		

preparation stage, the authors conducted analysis of the content of collected syllabi in order to recognize and evaluate current sustainable construction courses offered by construction programs. In addition, in-depth literature review was performed to identify current trends in sustainable construction courses and related research. The development stage consisted of: creating the framework for a sustainable construction course, choosing the goals and objectives for this course, choosing the contents of the course, organizing the chosen contented of the course, and planning the course schedule. At the improvement stage, the proposed course was reviewed and evaluated by experts from academia through a systematic feedback process. The main improvements were to clarify the framework (University Core Curriculum and Summer Internship).

The developed sustainable construction course content resulting from this process includes the syllabus, course goals and learning objectives, topical breakdown, and grading breakdown for the course. This course could be offered to senior students in construction programs in order to motivate students to integrate their basic construction knowledge with sustainable knowledge and skills. This course is presented as an example of the systematic course development process with the desire that construction educators will be motivated to implement sustainable construction courses and teach sustainable construction issues within their own curricula. The goals and learning objectives of the course developed here were based on the literature review, analysis of other courses, and inventory of industry expectations, and they do not purport to be comprehensive or exhaustive in this evolving field of study. This limitation was addressed through the use of expert review of the curriculum in the example course, and a similar approach could also be employed in the development of such courses for other contexts. Faculty considering the possibility of implementing a sustainability course in their own curricula should adjust these goals to suit their specific context and program goals. While the outcome of this research is of most benefit to construction educators who are contemplating how to teach sustainability concepts in their curricula, it will indirectly benefit both students and industry by facilitating a greater knowledge and understanding of sustainability concepts essential to the field.

FIGURE 2. Revised Framework for Sustainable Construction Course in Construction Education.



FUTURE RESEARCH

The interest in sustainable construction continues to grow among practicing construction stakeholders, and educational programs to address this need continue to evolve at leading universities. The course framework developed in this research provides a generalized structure that can be applied in the context of typical construction programs, and it builds upon and acknowledges the contents of courses already in place around the United States. As a single, stand-alone course, it represents the most visible approach to incorporating sustainability as part of the construction curriculum at universities, but it is certainly not the only approach. There is also a need to investigate appropriate approaches to integrate sustainability within the construction curriculum as part of existing courses, and to compare stand-alone vs. integrated approaches in terms of their effectiveness in various contexts.

Ongoing benchmarking of sustainable education in construction is also an essential means of tracking what works best in various educational contexts. Continued inventory and analysis of the evolving set of sustainable construction courses and curriculum modifications will be a key part of this benchmarking effort. The inventory of courses developed in this study is only a sample of the innovative pedagogy for sustainability being implemented in the U.S. and beyond. Future research should include more comprehensive, periodic inventories of pedagogical approaches and may also benefit from standardized evaluation of the educational outcomes that result.

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