Volume 1
Number 1

Summer 1996

The Journal of Construction Education

K. C. Williamson III, Ph.D., ***Editor/Publisher***

Thomas H. Mills, ***Associate Editor***

A TRI-ANNUAL PUBLICATION OF
THE
ASSOCIATED SCHOOLS
OF
CONSTRUCTION

ISSN 1522 8150

Host Journal of
The Associated Schools of Construction

Building Science Department
119 Dudley Hall
Auburn University
Auburn, AL 36849-5315
Tel: 334.844.4518
E-mail: molhend@mail.auburn.edu

Journal Published by

Illinois State University
Turner Hall, Room 210
Normal, IL, 61790-5100
Tel: 309.438.3661
E-mail: kcwilli@ilstu.edu

Editor/Publisher

Kenneth C. Williamson III, Ph.D.,
Turner Hall, Room 103
Normal, IL, 61790-5100
Tel: 309.438. 2633
E-mail: kcwilli@ilstu.edu

Associate Editor

Thomas H. Mills, RA,
Virginia Polytechnic Institute and State University
122B Burruss Hall
Blacksburg, VA, 24061-0156
Tel: 540.231.4128
E-mail: thommill@vt.edu

Editorial Advisory Board

Abdol Chini, Ph.D., PE,
University of Florida
152 Arch. Building
Gainesville, FL, 32611-5703
Tel: 352.392.7510
E-mail: chini@ufl.edu

Jay Christofferson, Ph.D., GC
Brigham Young University
230 SNLB
Provo, UT, 84602
Tel: 801.378.6302
E-mail: jay_christofferson@byu.edu

Neil Eldin, Ph.D., CPC
Oregon State University
Apperson Hall, Room 111
Corvallis, OR, 97331-2302
Tel: 541.737.6146
E-mail: neil.eldin@orst.edu

John Gambatese, Ph.D., PE,
University of Nevada - Las Vegas
UNLV Box 454015
Las Vegas, NV, 89154-4018
Tel: 702.895.1461
E-mail: jgam@ce.unlv.edu

Shahran Varzavand, Ph.D.,
University of Northern Iowa
ITC 31
Cedar Falls, IA, 50614-0178
Tel: 319.273.6428
E-mail: varzavand@uni.edu

William Welsh, Ph.D.,
Pennsylvania State - Harrisburg
Olmsted Bldg, W 255
Middletown, PA, 17057-4898
Tel: 717.948.6124
E-mail: waw1@psu.edu

The *Journal of Construction Education* (ISSN 1522 8150) was founded in 1996 by the Associated Schools of Construction, an association of 84 international colleges and universities with construction education programs. The purpose of the *Journal* is to provide an important process necessary for the preservation and dissemination of manuscripts that report, synthesize, review, or analyze scholarly inquiry. The *Journal* is an important way of our focusing international attention on and contributing to the understanding of the issues, problems, and research associated with construction education and training. The recognition of scholarly work within the realms of curriculum information, contemporary educational practices, educational research and instructional application development within construction departments, schools and colleges, and industry are the reasons for the *Journal's* existence. The *Journal's* mission is to provide construction educators and practitioners with access to information, ideas, and materials for improving and updating their understanding of construction education and training. It is also intended to help its constituency become more effective in developing the talents of learners within construction programs. This *Journal* is not only a living textbook of construction education, but also a perpetual and dependable learning source for construction professionals whether they are within academia or within industry. The *Journal* will be published tri-annually (Spring, Summer, and Fall issues). The divisions of the *Journal* include invited and editorially reviewed Book Reviews and Teaching Profiles, and blind peer reviewed Educational Practice and Research Manuscripts.

Copyright and Permissions: The copyright for this *Journal* is owned by the *Journal of Construction Education* and The Associated Schools of Construction. Any person is hereby authorized to view, copy, print, and distribute material from this Journal subject to the following conditions:

- No written or oral permission is necessary to copy, print, and distribute material from this *Journal* if it is for classroom or educational purposes.
- Materials must include a full and accurate bibliographic citation.
- The material may only be used for non-commercial purposes.
- Any publication or reprint of this material or portion thereof must be by request and include the following *Journal of Construction Education* copyright notice.

  First Copyright is held by the *Journal of Construction Education* and The Associated Schools of Construction. Reprint permission granted on _________ . (*Date*)
- This material is provided "as is" without warranty of any kind, either expressed or implied, including, but not limited to, the implied warranties of merchantability, fitness for a particular purpose, or non-infringement.
- This material could contain technical inaccuracies or typographical errors.
- The *Journal* may make improvements and/or changes in the information in this material at any time.

Any requests, suggestions, questions, or reports regarding this service should be directed to:

Editor/Publisher
Kenneth C. Williamson III, Ph.D.
Illinois State University, 102 Turner Hall
Normal, IL, 61790-5100
Tel: 309.438.2633
E-mail: mailto:kcwilli@ilstu.edu

Author Instructions for Submitting

Submission to the *Journal* implies the manuscript is original and is not being considered nor has been published in whole or part within another journal. It is encouraged that author(s) present their works at annual conferences and other conferences in addition to journal submission. In that papers submitted, reviewed, presented or published within conference proceedings are considered a "work-in-progress," it is expected that manuscripts submitted to the *Journal* will reflect changes resulting from that presentation process. Manuscripts not modified in part by this process will not be considered to represent an original work and the *Journal* will not consider the manuscript publishable. Manuscripts accepted for publication will require authors to sign the Assignment of Copyright Agreement. This agreement must be signed and submitted with the manuscript's review documentation.

Authors should prepare manuscripts according to the Publication Style Guide, which conforms to the Publication Manual of the American Psychological Association (4th ed). All manuscripts must include an abstract, which is limited to one paragraph, containing a maximum of 200 words. Immediately following the abstract, a maximum of five key words must be included. Typing instructions and instructions on preparing headings, paragraphs, text body citations, tables, figures, references, appendices, and abstracts appear in the Publication Style Guide. All manuscripts are subject to editing for personal, university, program and sexist language. Manuscript length per se is not an issue, although length should be relate to the manuscript's "information value."

The *Journal* considers it unethical for authors to withhold the data on which their conclusions are based from other competent professionals who seek to verify the substantive claims through reanalysis and who intend to use such data only for that purpose, provided that the confidentiality of the participants can be protected and unless the legal rights concerning proprietary data preclude their release. *JCE* expects authors submitting to the *Journal* are expected to have available their data throughout the editorial review process and for at least five years after the date of publication.

Manuscripts being submitted for review by the JCE Board of Reviewers must be submitted electronically from the JCE Website. The work submitted by authors will be circulated to review board members electronically and all correspondence with the authors, editors, and review board members will also be handled in this manner. The Editor and Associate Editor are responsible for managing the electronic review process.

Educational Practice and Research Manuscripts that appear in the *Journal* are subjected to a blind review by a minimum of three members of the *JCE* Board of Reviewers. All contributions, whether invited or unsolicited, are critically reviewed. Manuscripts must demonstrate clear communication and authority of knowledge of the topic to ensure acceptance. Authors are encouraged to make liberal use of multimedia to visually present data and ideas. Reviewers are selected from those having content knowledge concerning the manuscript's topic. This review process generally takes from four to six weeks. Authors are notified upon receipt and completion of the review process.

The Journal of Construction Education

Summer 1996

Volume 1
Number 1
pp. 1 - 60

Copyright © 1996 by the Associated Schools of Construction

Editorial

6 - 10 **Editor/Publisher's Commentary**, Kenneth C. Williamson III, *Illinois State University*

Educational Practice Manuscripts

11 - 22 **Teaching Right-Brain Thinking in a Construction Curriculum** , W. Max Kirk, *University of Nebraska – Lincoln* and Don Mulligan, *Arizona State University*

23 - 33 **Integrating Research into Undergraduate Coursework to Provide Professional Experiences**, Kenneth W. Stier, *Illinois State University*

34 - 44 **The Development of a Vertically and Horizontally Integrated Undergraduate Building Construction Curriculum for the Twenty First Century**, Thomas H. Mills, Flynn L. Auchey, and Yvan J. Beliveau, *Virginia Polytechnic Institute and State University*

45 - 49 **Infusing Actual Management Experiences into Construction Education** , H. Stephan Egger and Shahram Varzavand, *University of Northern Iowa* and Stanley P. Lyle and Donald O. Rod, *Library-University of Northern Iowa*

50 - 58 **Enhancing Communication in the Design and Construction Industry through Multi-Disciplinary Education**, Kenneth F. Robson, Mack Caldwell, and Jerlene Reynolds, *The University of Oklahoma*

Other

59 Contributing Reviewers
59 Acknowledgements
60 The Associated Schools of Construction Membership

Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 6 - 10
Copyright 1996 by the Associated Schools of Construction
1522-8150/96/$3.00/Editorial

Editor/Publisher's Commentary

Kenneth C. Williamson III, Ph.D.
Illinois State University
Normal, Illinois

Introduction

Among some members of the Associated Schools of Construction there seems to be limited or at least restrained enthusiasm for the introduction of a research journal in construction education, others however, rejoice in its arrival. ASC members seem to fall into several distinct groups. Those who publish in journals specific to their professional skill, those who are satisfied with the current level of scholarly activity provided by the annual ASC, and those who need and want more for their chosen academic profession -- construction education. Among the enthusiastic, I have found significant differences in opinions as what should constitute the Journal. The majority of these members only have a vague idea of what it should be, therefore, I hope the following discussion will address some of the current issues and help to solidify the majority into a loyal readership.

In this commentary, I would like to explore some advantages of a reviewed research journal and comment on its inherent strengths. My focus is a narrow one -- restricted to a scholarly research periodical, marketed primarily to construction educators, through an electronic media. In particular, I want only to address a publication whose authors, reviewers and editors are unpaid and unstaffed, and who know the true meaning of volunteerism. Moreover, I want to address the Journal as currently distributed via the Internet.

Why the Journal?

The question is; why publish the *Journal* at all? The fact is that to some faculty within the ASC, journals of any sort are not an absolute necessity, and again, there are others who would consider a publication within an education journal as insignificant. This discussion therefore is not addressing issues of immediate concern to them even though they are professional construction educators.

In the past, the dissemination of scholarly information was presented through a print medium, in that there was no alternative. Within the ASC our print medium is currently limited to the Annual Conference Proceedings and this only began in 1987. With the recent widespread use of computer technology and networks, this new Internet alternative has become available. According to Stevan Harnad going truly electronic can reduce the costs of publishing of a fully edited and refereed journal by 70 percent or more (Harnad, 1995). Although initial networking and computing hardware and software costs money the editorship needed within the ASC should be considered as a service function to construction education.

In order to be acceptable to scholars, electronic journals must at least offer or exceed the functionality provided by the print journals. The quality control provided by peer review is not dependent upon the medium. Some promote a conservative view of closely mimicking the current paper journal formats and ways of working in an electronic form. The Publication Committee within the ASC has chosen to mimic the print mediums as closely as possible within the *Journal*. However, some visionaries such as Stevan Harnad think that the quality control can be improved, and experiment with models of refereed interactive publications in the form of (refereed) open peer commentary on published work (Harnad, 1990; 1995). Others like Andrew Odlyzko go further, and envision a continuum of peer review, in which publications would gain weight by unsolicited and finally solicited comments (Odlyzko, 1995).

In 1993 John Franks (Franks, 1993) with the Department of Mathematics at Northwestern University in Evanston, Illinois wrote a paper on an issue similar to the one before us here. I really cannot improve upon his description and analysis; therefore I include his work pretty much intact with editorial inclusions directed to this commentary. There are at least three important functions that a journal can provide beyond mere distribution of text:

> The first function is academic certification. The journal's editor chooses a referee or referees to read a submission and attest to its scholarly worthiness. The editor also maintains quality control in non-content areas such as standards for language and guidelines for presentation. This process provides a peer review mechanism for certifying the quality of scholarly work. Academic institutions rely on this process when judging the merits of an individual for promotion or tenure. While an author may have no direct monetary incentive to publish in a journal, the indirect one can be significant.
>
> The second function is document archiving. An author would like to know that twenty or thirty years from now, perhaps after retirement, their work will still be available to other researchers. Additionally, educators in the field would like to have an authoritative version of the author's text together with, at least, a definitive date of its creation. Traditionally, archiving is a function not provided by the journal, but by libraries that purchase the journal and maintain its preservation. The modern shift in information technology allows for ease of electronic storage and access without the downside cost associated with the traditional approach.
>
> The last function discussed here is research marketing. If I simply write an article and make it available from my personal or departmental computer to anyone on the Internet, how will other construction educators know of its content or its existence? In contrast, if I publish in a traditional journal, other educators are much more likely to be aware of my work. This might be because the journal is in their library, on their desk and they glance at its contents on a regular basis. The ASC web pages also provide the previous utility, only within a faster and more accessible media, if accessed on a regular basis.

For a growing number of ASC faculty, the current ASC proceedings publication does not provide academic certification for tenure and promotion. There are construction programs that do accept the current ASC publication efforts because they are a result of a blind review process and are of high quality. The ASC archive is based upon annual conference attendance, and whether or not the institutional copy makes it to the library. Our research marketing is severely limited because of the dependence upon the archival process described above. Access is at best occasional, and probably rare. These three functions, certification, archiving, and marketing constitute the primary value added for the author who publishes in the *Journal*, and the whole of the ASC membership.

There are significant differences between scholarly publishing and commercial trade publishing, as provided for example by the American Institute of Constructors (AIC). Scholars are also the main users of scientific information. The main objective of scholarly authors is to be read by their (limited number of) peers, to influence them and gain academic prestige. The productivity of a academic researcher is usually assessed by the quantity (number) and the quality (prestige of the journal published in) of his or her publications. Since the academic tenure and grants system rewards "productive" researchers, there is also profound but indirect economical reason for writing and publishing articles.

It is in the interest of scholars, both as producers and consumers of peer reviewed journal articles, to have the widest possible distribution with the fewest encumbrances. While a scholar's strongest motivation in selecting a journal for their work will likely be to place it in the most prestigious journal which will accept it, it seems likely that other factors being equal the author will opt to publish in a professionally sponsored journal where the article's exposure is likely to be greater. The Associated Schools of Construction fulfills this professionalism within construction education.

Conclusion

The primary advantage for most consumers of construction education literature will be the ease of access. Member of the academic community may browse the articles and print out any articles deserving of more detailed consideration, without leaving their desk. The advantage to the authors will be a reduction in the time delays inherent in print media publication and the speed of an innovative refereeing process, both providing for approved articles to appear shortly after the peer reviewing process is complete. From an institutional point of view, there is a big financial advantage in promoting nonprofit electronic publications. The cost of producing, distributing, and archiving an electronic journal is smaller than that for a print journal (Odlyzko, 1995). In a time of declining resources and escalating prices for print journals, this is an important advantage.

There are also additional capabilities available with electronic media. For instance, abstracts may be distributed over mailing lists, notifying the reader of the availability of the articles. Electronic links may be made to past and future manuscripts, reviews, and comments on the work in question. And keyword searches may be made to identify articles of interest to researchers and readers. These capabilities vastly increase the ability of the author(s) and the *Journal* to provide information to the readers.

Editorial Issues

The *Journal's* Editor feels the quality of the construction education pedagogy in its manuscripts is of utmost importance. Therefore the *Journal* has implemented the traditional peer review process in its full rigor. Papers are blind-refereed for quality and correctness, as is done for high quality print media journals. The *Journal* will be governed under the direction of the ASC Publication Committee but will have its own governance Editorial Advisory Board as directed by the Journal's bylaws.

From the standpoint of the issues surrounding electronic publication, the Editor has taken the following considerations to be fundamental:

1. The appearance of every paper printed out from the *Journal* will be uniform and appealing. Therefore, manuscripts will be distributed in graphical formats only, using *pdf* and *static html* text and image processing. The manuscripts will be typeset in a traditional format, in accordance with the *Journal's* Style Guide, a statement of copyright, and a registered ISSN.

2. The standards for succinctness in writing will be consonant with those applied by the other journals in closely related academic fields. It is important to follow the standards of consensus in our fields. If these standards change in the future, the *Journal* must change with them.

3. The written record (archive) must be maintained intact in perpetuity. The ASC as the host organization has endorsed this commitment, agreeing to insure the integrity of the Journal's archive in perpetuity.

4. The *Journal's* volumes and manuscripts will be fixed at time of publication, with their pages numbered consecutively throughout each volume, in the traditional manner.

In the Editor's view, electronic publication is not a panacea or a superior form of scholarly communication; he feels that these new and innovative technologies are upon us, and for better or worse are increasing use, and confront us with issues and choices we within construction education must react to.

Educational research and scholarly works may be affected more significantly than other fields by this technology change. The highest priority is placed on academic pedagogical collaboration, particularly across institutional boundaries, may be well served by innovative modes of scholarship exchange if it accommodates the special needs of those in different or closely related context settings. The inherently multidisciplinary nature of construction education inquiry should be well suited to the electronic format and media. Concerns are however expressed that these very features of educational research may result in a dispersion or lack of coherence that will make the task of understanding and evaluating research immeasurably more complex.

References

Franks, John. (January, 1993). What is an electronic journal. newsgroup: bit.listserv.pacs-l, 21.

Harnad, S. (1990) Scholarly Skywriting and the Prepublication Continuum of Scientific Inquiry. Psychological Science 1: 342 - 343 (reprinted in Current Contents 45: 9-13, November 11 1991). ftp://princeton.edu/pub/harnad/Harnad/harnad90.skywriting

Harnad, S. (1995) Implementing Peer Review on the Net. Scientific Quality Control in Scholarly Electronic Journals. In: Peek, R. & Newby, G. (Eds.) Electronic Publishing Confronts Academia: The Agenda for the Year 2000. Cambridge MA: MIT Press.

Odlyzko, A. M. (January, 1995) Tragic loss or good riddance? The impending demise of traditional scholarly journals. *International Journal of Human-Computer Studies (formerly International Journal of Man-Machine Studies)*, to appear. Condensed version to appear in Notices of the American Mathematical Society.
ftp://netlib.att.com/netlib/att/math/odlyzko/tragic.loss.Z

Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 11 - 22
Copyright 1996 by the Associated Schools of Construction
1522-8150/96/$3.00/Educational Practice Manuscript

Teaching Right-Brain Thinking in a Construction Curriculum

W. Max Kirk
University of Nebraska – Lincoln
Lincoln, Nebraska

Don Mulligan
Arizona State University
Tempe, Arizona

Students in Construction Management programs take mathematics and science courses to aid them with the engineering aspects of their discipline. These are subjects that rely on the left hemisphere of the brain, which processes verbal, mathematical and scientific information. Imagination, holistic awareness, and spatial recognition are right- brain processes, and, unquestionably, desirable traits to possess as a constructor. However, construction education most often emphasizes left-brain activities, to the virtual exclusion of the right brain. As construction educators, we believe we are educating students to become good problem solvers through the knowledge of mathematics and physical science. Yet, are we effectively teaching students the skills of critical thinking and problem solving using intuition and application of knowledge? The answer is probably no. To accomplish these skills, students must develop both hemispheres of the brain. Critical thinking skills are very important in the construction industry for visualizing the components of a construction project and the finished project, reading working drawings, and communicating with construction industry personnel. This paper discusses how construction educators can teach their students simple, right-brain exercises to aid in the development of these skills.

Key Words: Right Brain, Critical Thinking, Creative Thinking

Introduction

Is construction an art, or a science? Those from an engineering background would likely reply a "science." They relate to the mathematic and convergent thinking aspects, and probably interpret the word "art" as representing paintings and sculptures created by artists. Those with an architecture background relate to the design aspects, and would probably respond with an "art." However, the response of a construction management faculty member would most likely be "both" or "neither." Please do not think the authors are trying to categorize people by their backgrounds. Not in the least. We are merely relating a non-scientific observation from our conversations with numerous faculty and people in the industry over the years.

Construction involves producing various buildings, structures, roads, highways and bridges. Industry personnel are faced with solving complex problems on a daily basis utilizing people, machinery, raw materials and sometimes-complex mechanisms. Construction requires the ability to visualize and plan, to think creatively and intuitively, and deals with accuracy, time constraints and lineal sequence. Therefore, is construction an art, or a science? The answer is definitely: both.

Now, if we ask whether the learning process uses the left hemisphere or right hemisphere of the brain, one would likely say both. However, in postsecondary education, particularly in construction education, we primarily (and unknowingly) educate to the left side of the brain. At the same time, we ask students to think creatively without adequately developing the right side.

For example, in construction courses we ask students to solve problems based on directed analytical facts by using relational, holistic and imaginative reasoning. They proceed to do so relying on intuition and their previous knowledge. Many times the results are fantastic, but many times they fall far short of our expectations. Why? Unfortunately, it is often due to our teaching methods.

Imagination, holistic awareness, and spatial recognition are right brain processes. These processes can be developed in students by exercising the right brain. In this paper we will discuss these processes and describe some simple exercises that have proven to work in right brain development. We will also describe one university's seven-year experiment in adopting the right-brain concept into the curriculum.

Left-Brain vs. Right-Brain Thinking

The human cerebral hemisphere is divided into two distinct hemispheres. Thinking strategies and learning styles vary in individuals based on the development of the left and right hemispheres. We are not experts in neurological studies, but would like to point out some facts concerning the development of the brain and the cognitive development of each of its hemispheres. The rationale of the two-sided brain structure/function forms the basis of our discussion on the right-brain relationship to construction education.

For example, left-brain characteristics include the ability to be objective, abstract and analytical (see Table 1). The left side is also rational, time conscious and goal-oriented, and is where verbal language processing takes place.

Right hemisphere characteristics include the ability to be creative, divergent, intuitive, subjective and nonlinear. The right side also provides the cognitive skills needed to solve problems (see Table 1). In general, the right brain is more proficient in visualizing and remembering events and faces, and in other spatial and emotional functions, such as visual construction tasks, artistic awareness, musical appreciation and intuitive insight (Beakley, et al., 1987). Also, the right hemisphere is not completely void of language. Scullion Moscovitch, in his *Communication and effect: Language and thought*, claims that the right side can attain the vocabulary of a 5-year-old.

The role of the left hemisphere in education is well documented. Reading is considered to be a principal left hemisphere function as is mathematics, particularly calculus and algebra. Using a computer for spreadsheet applications "... relies on an orderly, sequential, lineal, analytical style of thinking, particularly the programming aspect is predominantly left brain orientation" (Rubenzer, 1985).

Table 1

Comparison Of Left Brain And Right Brain Processing Modes

Left brain	Right brain
Verbal Temporal, convergent, using words to name, describe and define	Non-verbal Awareness of things, minimum word image and speech
Abstract Disassociated from any specific instance, theoretical, detached, no pictorial representation	Analogical Inferences, resemblance correspondence, seeing likenesses between objects
<u>Sequential</u> Succeeding before or after, continuation of events, step by step process	<u>Diffuse</u> Spread freely, distribute
<u>Temporal</u> Time conscious	<u>Non-Temporal</u> Not conscious of time
<u>Mathematics/Digital</u> Calculations, numerical methods by discrete units	<u>Geometry</u> Properties/relationships of points, lines, angles, etc.
<u>Analytical</u> Separate into components, figure out in a step by step process	<u>Synthetic</u> Blending together into one composition
<u>Symbolic</u> Relationships characterized by symbols representing items	<u>Visual</u> Producing mental images relating to what is seen
<u>Explicit</u> Externally visible, fully developed or formulated ideas	<u>Spontaneous</u> No external constraints, no contrived/manipulated stimulus
<u>Logical</u> Linked ideas, one thought leading to another often to a convergent conclusion	<u>Holistic</u> Relationships between parts and wholes, see whole things all at once
<u>Logical</u> Formulating conclusions on a logically based hypothesis	<u>Intuitive</u> No external constraints, no contrived/manipulated stimulus
<u>Convergent</u> Move toward a point in a step by step	<u>Spatial</u> Visualizing parts to form a whole, and nature of space

Writing is basically a function of both hemispheres, as is geometry. When reading (a left-brain function) and language (a right-brain function) are combined, we have speech. However, the verbal communication of the right hemisphere is relatively limited, and dependent on upon the left hemisphere (Rubenzer, 1985).

In post-secondary education, especially construction education, students are taught in subjects that exhibit left-brain thinking processes. Students who have limited ability on the right side, or under-exercise their right side due to the left-brain demands of their studies, can be at a great disadvantage when it comes to using critical thought processes.

Construction curriculums complicate the matter further when they eliminate the only right-brain thinking courses -- basic mechanical drawing and construction detail courses -- and replace them with computerized drafting. Today, many of these courses have gone the way of the slide rule. The pencil has been replaced with a mouse. Communicating our ideas through handmade drawings and sketches inspired creative thinking. Now, we merely have to push the right buttons to produce a drawing. We have relinquished control of our cognitive thought processes to what is in essence only a tool -- an electronic slide rule. We are not advocating the return of the slide rule, but we are suggesting that with the advent of the calculator and computers, some basic problem solving processes have weakened.

Many students can now simply go through the motion of solving mathematical problems without truly understanding what they are solving. The tradeoff is speed versus the slower process of solving problems by "hand." Both methods may seem to use left- brain reasoning; however, when solving mathematical problems by hand, we are actually using intuitive, divergent, and relational reasoning steps to solve the problem -- all right-brain processes.

Have Students' Critical Thinking Processes Been Changing?

Critical thinking is a popular buzzword, and various definitions have been offered depending on its application. For our purposes, critical thinking as it pertains to construction education can be viewed as stated by Robert Yinger, "... the cognitive activity associated with the evaluation of products of thought. This cognitive activity, more accurately called critical or evaluative thought, is an essential element of problem solving, decision making, and creative production" (Young, 1980).

Have you noticed that students today seem less creative in their answers, and are not as intuitive in the pursuit of researching information as they were five to ten years ago? At the same time, are you finding that students are more dependent on having answers given to them? In addition, are you finding that students are deducing solutions to problems based on linear thought or abstract reasoning without consideration of other pertinent facts? If your answer to these questions is yes, then you have noticed what many other educators are finding in postsecondary education. That is, students these days seem less inclined to develop reasoning skills and less creative in their thought processes than they were a few years ago. At this time, we do not have scientific proof to substantiate this statement. However, it is a consistent observation based on discussions with colleagues across the disciplines, and has been a topic at several teaching seminars over the past few years.

In fact, the U.S. Department of Education Office of Educational Research and Improvement have taken the issue of developing students to think critically seriously. In their June 1992 publication, *National Assessment of College Student Learning: Issues and Concerns*, one of the five objectives listed under the National Education Goal 5 (Goals 2000) is, "The proportion of college graduates who demonstrate an advanced ability to think critically, communicate effectively, and solve problems will increase substantially." However, they have not found concrete data to substantiate their informal findings as to the decrease in students' ability to think critically. In the March 1991 Interim Report of the National Goals Resource Group it was noted that, "... neither national nor state information is currently available on the ability of college graduates to 'think critically, communicate effectively, and solve problems'." The report suggested that "a new kind of assessment will have to be created" to measure this ability.

This is not to say that students today are less intelligent than their counterparts of five to ten years ago -- in fact, just the opposite. Students today are retrieving more information and utilizing that information more resourcefully than we could even imagine ten years ago. The problem as we see it is that students of the computer age are less inclined to develop the right brain since the computer or calculator can perform the creative function for them. New technology is aiding the retrieval and usage of information, but is smothering the development of creativity and right brain development.

Teaching strategies that do not address both left and right brains will contribute to lopsided development of individuals. It is common knowledge that we are tapping only the tip of the brain's "potential iceberg." Furthermore, in order to equip the future citizens of the 21st century with the skills to creatively use the vast information storage, retrieval, and manipulation capacities (all left brain processes) of the computer, it is imperative that educators today understand and cultivate right brain creative processing skills so that these students will be able to maximally exploit the computer's left brain potential (Rubenzer, 1985).

Let us use a realistic example of what is happening in the construction industry today to illustrate the point made above. The estimating process has always been considered to be both an art and a science. The science function involves the quantity survey and mathematical extensions, much of which is done with the use of computer software. This is a very analytical endeavor and hence, is extremely left-brain oriented. The "art" function is employed when the estimator begins making decisions on choosing the appropriate labor crew mix, the proper equipment and applies the correct overhead and markups to the basic estimate. Each of these decisions requires a large amount of intuition based on many years of experience and a thorough understanding of the project being estimated.

In addition, with the introduction of new procurement methods in construction during the past 10 to 20 years, e.g. design-build, the estimator is expected to take on additional responsibilities. The most prominent of these are the conceptual estimates and value engineering -- both of which are based on innovation, intuition, creativity, and cognitive problem solving. With estimating being one of the more critical skills taught in our construction curricula, it seems obvious that we must prepare our students for their expanding role as "para-designers/estimators," equipped with the capacity to use the right-brain endowments in either creating a design or improving one.

Table 2 indicates the brain's cognitive development in using both hemispheres for the construction applications of estimating and scheduling.

Developing Right Brain Processes Through Drawing

In creating this paper, we primarily processed information in our left-brain, since we used a keyboard to input our ideas into a computer, in lieu of a pencil or pen to write out the manuscript. Previously we stated that communication (reading, writing and computer programming) is a left-brain activity. However writing with a pen or pencil in hand is a right brain activity (Edwards, 1979; Hanks and Belliston, 1992; Rubenzer 1985).

Table 2

Brain Function Matrix Pertaining To Construction Functions And Activities Of Estimating

Left Mode Processing Activities	**Construction Function**	**Right Mode Processing Activities**
	ESTIMATING	
Symbolic Convergent Orderly Linear Mathematics Reading	**Quantity Survey** Reading working drawings, visualization of the parts and removing the quantities in a methodical fashion	Visual Spatial Random Holistic Geometry
Logical Verbal Abstract Analytical	**Pricing & Bidding** Creating prices which reflect the project's predicted construction cost	Insight Non-verbal Analogical Synthetic
Explicit Facts Positive	Perception of the validity Profit margin	Spontaneous Feelings Negative moods
Temporal	Time constraints	Non-temporal

Advocating that students should write their term papers in longhand would be completely counter-productive. In fact, if we had to read some students' handwriting, it would probably drive us mad! But there is another way to incorporate the process of using the hand to transform ideas from an abstract to a real form: through exercises in basic free-hand drawing.

Now the mere mention of the word "drawing" turns off many adults, particularly academics. Early on in a child's development, when drawing is as natural as breathing, we tell them to stop. We become art critics of eight-year olds, criticizing and ridiculing drawings, which creates insecurity and stifles most people's desire and willingness to draw (Hanks and Belliston, 1992). In our society, beginning around the fourth grade, teachers tell Jill and Johnny to quit drawing and doodling, and return to their assignments. This rebuke continues throughout most of their education. Drawing becomes art, and art becomes something we do as a hobby or when we have time. Sadly, a person's measured creativity actually decreases as the student proceeds through the educational system. This reduction in creative thinking abilities counters the development of the right hemisphere of the brain (Rubenzer, 1985).

If your doctor informed you that you must do certain exercises to become healthier, wouldn't you heed the advice and exercise? Thus, one should view drawing as an exercise to develop right brain functions. Just as there is a proper way to exercise your body, there is a proper way of teaching drawing to enhance the development of the right brain. You do not need to be an artist or an art teacher to instruct the proper methods. However, the method of teaching this style of drawing is very important. If not properly taught, most students will only draw from the left side of the brain with little, if any, improvement on the right side.

Experiment Using Right-Brain Concepts In A Freshman-Level Drawing Course

In 1986, the College of Engineering & Applied Sciences at Arizona State University introduced two 3-semester hour courses that were mandatory for all students entering the College. The first of these courses was ECE 105, Introduction to Languages of Engineering, which is the focus of our experience in right-brain teaching.

Table 3

Brain Function Matrix Pertaining To Construction Functions And Activities Of Scheduling

Left Mode Processing Activities	Construction Function	Right Mode Processing Activities
	PROJECT PLANNING AND SCHEDULING	
Analytical Symbolic Explicit Temporal Linear	Separating out activities and determining sequence of activities; determining duration and critical activities and adjusting	Synthetic Spatial Spontaneous Non-temporal Holistic
Sequential Abstract	Re-examining durations and scheduling activities	Defuse Analogical
Reality Positive	Insight as to validity of schedule activities	Awareness Negative
Reading Writing Mathematics	Diagramming	Logos (Art) Geometry
Convergent	Critical path and adjusting duration	Spatial

Basically, ECE 105 was a 3-credit hour course that was divided into two distinctive parts that were completely unrelated. One dealt with introducing the students to computer programming and used the lecture format. Class size was usually about 300 students in a large lecture hall, and there were two such sections per semester. The other part of ECE 105 involved the dozen or so drawing laboratories, which generally contained about 40 students each and conducted in a room with individual drafting -type tables available for each student. It was in this se cond part that the right-brain concepts were practiced.

We tried to convince the students that if they could perform a simple function such as signing their name, they could learn to draw using primarily their right brain mode. The environment/ atmosphere created by the instructor was crucial to the learning process, as all of these students were enrolled in one form of engineering, technology or construction discipline. Hence, they were more or less "programmed" to function with their left -brains. One instructor used to turn off all of the lights and have the students close their eyes for the first five minutes. Sound like shades of kindergarten days? Possibly, but the effect was dramatic. Students would relax and begin to experience the left/right -brain "shift" much faster than if instruction began immediately after coming in from the "real world."

The following is a direct quote from the ECE 105 syllabus for the lab portion:

> "Drawing from direct observation of nature is the basis of visualization and visual communication. Drawing is a skill that can be learned by anyone, and is the outcome of acute perception coupled with effective practice. As a learner, you must take an active role in the process of learning to draw from observation, for you cannot learn to draw by reading a book, or by listening to someone talk about it. In this course, you will not be required to memorize a list of terms, or learn a step-by-step procedure, for drawing skills cannot be acquired in that way. Instead, you must observe and draw, intently and frequently. If you do so, your progress will amaze you. At the end of the course, you will be able to think and communicate graphically. This will undoubtedly help you to formulate and solve design problems."

The first week was spent on "pure contour" drawings, which are accomplished using the opposite dominant hand and never looking at the paper during the actual drawing process. For example, a right-handed person would hold the pencil in their left hand. They would then focus their eyes on the object being drawn and let their eyes follow the contours of the object as the pencil created the drawing on the paper. During the course of one drawing, they could pause about every ten minutes to re-orient the pencil, but they were never allowed to look at the paper while drawing. To facilitate this, we would generally have them set the object 90 degrees to paper to discourage any peeking. In other words, the pencil/hand/arm simply became an extension of their eye movement and at the same, slow pace. They were given over an hour to do a pure contour of a pinecone (the most complex of our "objects") -- and many never completed it. The ones that finished in a matter of minutes had not shifted to the right brain and were asked to try again! Put yourself through this exercise and we guarantee that if you don't learn anything else, you will have achieved a great degree of discipline. Most of the students absolutely hated these exercises at first, and many never were able to adapt. Those who did adapt came to enjoy the experience and felt that it helped them think with less inhibition.

Subsequent weeks covered other types of contour drawings, gesture (or "movement") drawings, portrait drawing, color, shading, texture, shadows, reflections, and basic geometric "primitives" (shapes such as cubes, cylinders, etc.). The final exercises involved the student assembling some type of "model" using Styrofoam geometric primitives and toothpicks. The model was whatever they could come up with from their imagination, usually a mechanical device such as a robot, vehicle, aircraft, etc. They were asked to draw the model at varied stages of design, starting with a rough outline and progressing to a finished description of their creation, using all of the tools learned during the semester (see Figure 3). The ultimate objective, which we emphasized to the student, was that this would be used in some future presentation as a solution to an engineering concept or problem.

In order that we might have some quantitative measure of improvement (not that we graded on this, but just an indicator of "course effectiveness"), during the first week we asked each student to accomplish a self-portrait drawing, or, if possible, a portrait of another person. At the end of the semester, they would repeat the exercise using the same model and again incorporating all of the drawing tools, with emphasis on shading techniques. They would do the same for two other drawings, usually a tree and a chair, but the portrait of a human face is definitely the greatest challenge.

The self-portrait, done on a pre and post basis, is chosen for three reasons. One, we can measure improvement in the pre and post drawings; two, portrait drawings are possibly the hardest drawings to perform -- thus, the biggest confidence-builders when accomplished; and three, the right brain specializes in recognition of faces. So, it only makes sense that if we are trying to develop the right brain, we should choose a subject the right brain is familiar with (Edwards, 1979).

In course sections where the instructors properly applied the concepts of right brain thinking, the results were astonishing. By observation, approximately 70% of the class showed great improvement, 20% some improvement, and, of course, there were those that showed no improvement. Keep in mind, the goal here was not to make students better artists, but to use these drawing exercises to enhance right-brain activity.

In our estimation, there were two factors that diminished the effectiveness of this course. One was the use of instructors who had no experience in this type of teaching and/or a total lack of understanding of the concept behind the use of the right brain as a creative part of learning. A department chair that needed a "body" to fill a requirement usually assigned these instructors. Consequently, many of them looked upon the assignment to teach the lab portion of ECE 105 as a type of "penance".

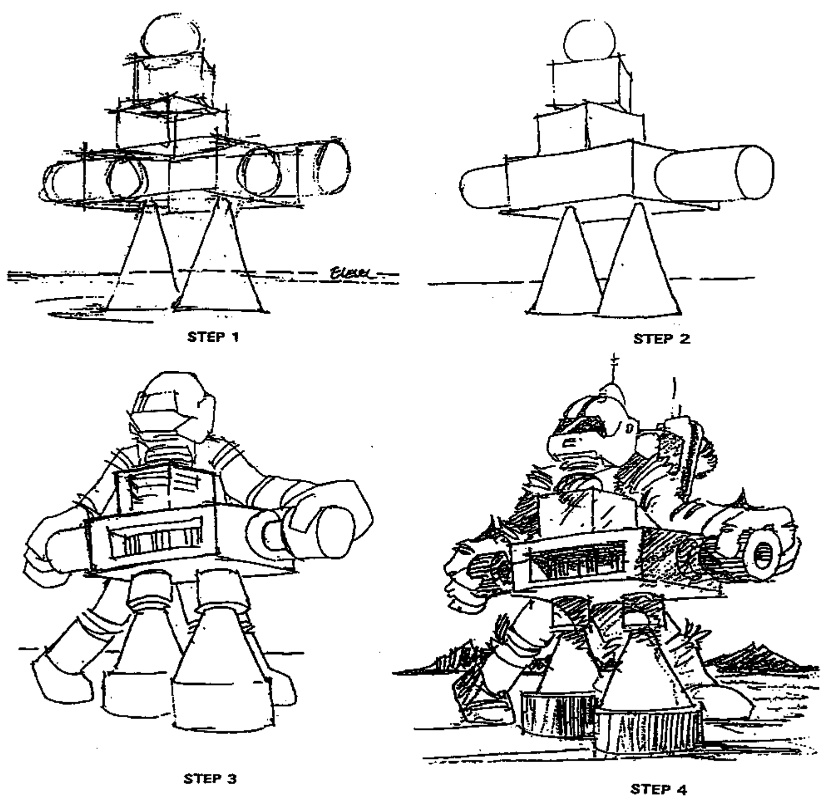


Figure 1. Model at varied stages of design.

Some thought that teaching "art" to students was frivolous and could not see the value of drawing in engineering disciplines. It is not fair to say everyone held these attitudes, as some accepted it as a challenge and really did quite well. The second factor involved was the fact that the lab was one-third of a 3-semester hour course in which two-thirds dealt with learning about computer programming. The computer part of the course had nothing whatsoever to do with the lab portion. In fact, due its left-brain emphasis, it became impairment to achieving our goals in the drawing lab.

The follow-up course for ECE 105 was ECE 106, Introduction to Computer-Aided Engineering. This 3-semester hour course was divided into three segments -- a lecture, recitation and lab -- each taught by a different instructor, and emphasized design and problem solving. The first 2 to 3 weeks of the lab portion was spent doing hand (pencil) drawings as a refresher of ECE 105 concepts and a precursor to the CAD-generated drawings. At this point the right-brain exercises were essentially completed.

Students were then assigned a major semester project that compelled them to think creatively. One of these project assignments (which changed every semester) was to design a storage building for storing organic fertilizer. The building could have no sides except for an office area, and was constrained by certain width, length and height measurements. The building was also to be located in a rainy, windy area and the product being stored would need weather protection without the aid of tarps. In addition, these freshman students had virtually no previous education in design, structural engineering or construction. Lack of prior knowledge about construction and engineering factors was actually an advantage, because the students had less inhibition to restrict their creative thought. Throughout the semester the instructors would guide them as to the feasibility of their designs and ideas, and they were graded on their creative thought process as well as their data. Some faculty stated that freshmen couldn't think in those terms. Our observation was the opposite. A majority of the students excelled in this assignment. The computer data and drawings were compelling examples of their creative thought processes.

Unfortunately, most of the instructors did not understand or appreciate the concept of right-brain thinking, thus failed to teach these activities properly. This led to an increasing dissatisfaction with the ECE 105/106 courses, and in 1994, ECE 100, Introduction to Engineering Design, a 4-semester hour course, replaced the ECE 105/106 series. All right-brain thinking exercises were eliminated.

Conclusion

The authors recommend that to properly teach right-brain thinking exercises, certain strategies should be considered. First, they must be introduced in the students' freshman year. The drawing exercises do not need to be a complete 3-credit course, but can be incorporated in an existing course dealing with design and/or critical thinking. Second, the drawing portion of a course must be given the credence and time needed to accomplish the goals of the specific exercises. Approximately 90 minutes of continuous lab time twice weekly is recommended. Third, the exercises must integrate with the application of critical thinking concepts in the curriculum. Fourth, reinforcement of right brain and critical thinking concepts throughout the students' education is vital. And finally, faculty must accept the benefits of teaching these exercises, and be properly trained in their delivery.

Enhancing critical thinking by exercising the right brain shows great promise for students in construction programs. Just as a good football team needs both a strong offense and a strong defense, our students need to develop both the left and right sides of brain to fully develop their thinking processes, and increase their chances of success in the construction industry.

References

Beakly, G.C., Evans, D.L., & Bowers, D.H. (1987). *Careers in Engineering and Technology* (4th edition). New York: Macmillan Publishing Co. & London: Collier Macmillan Publishers.

Corrallo, S., Fischer, G., & Greenwood, A. (1992). *National assessment of college students learning: Issues and concerns* (Report NCES 92-068). Washington, DC:Department of Education.

Edwards, B. (1979). *Drawing on the right side of the brain.* Los Angles: J.P. Tarcher, Inc.

Ennis, R.H. (1992). The degree to which critical thinking is subject specific: Clarification and needed research. Norris, S.P. (Ed.). *The generalizability of critical thinking.* (pp 21-39). New York & London Teachers College Press.

Hanks, K. & Belliston, L. (1992). *Draw!: A visual approach to thinking, learning and communication*. Los Altos, California: Crisp Publication, Inc.

Johnson R.H. (1992). The problem of defining critical thinking. Norris, S.P. (Ed.). *The generalizability of critical thinking.* (pp 1-20). New York & London Teachers College Press.

Kinney, J.J. (1990). Why bother?: The importance of critical thinking. Young, R.E. (Ed.). *New directions for teaching and learning: Fostering critical thinking.* (pp 1-9). San Francisco: Jossey-Bass Inc., Publishers.

Nicolaides, K. (1969). *The Natural Way to Draw.* Boston: Houghton, Mifflin Company.

Norris, S.P. (1992). Introduction: The generalizability question. Norris, S.P. (Ed.). *The generalizability of critical thinking.* (pp 1-20). New York & London: Teachers College Press.
Raudebaugh, R.A. (1987). [Instructor guide: ECE 105 Graphics Labratory]. Unpublished raw data.

Rubenzer, R.L. (1985). *Educating the other half: Implications of left/right brain research.* Washington, DC: Department of Education. (ERIC Clearinghouse on Handicapped and Gifted Children. The Cou ncil for Exceptional Children.)

Young, R.E. (1990). Editor's note: Critical thinking; A renewed interest. Young, R.E. (Ed.). *New directions for teaching and learning: Fostering critical thinking.* (pp vii-xii). San Francisco: Jossey-Bass Inc., Publishers.

Wonder, J. & Donovan, P. (1984). *Whole brain thinking: Working both sides of the brain to achieve peak job performance.* New York: William Morrow and Company, Inc.

Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 23 - 33

Copyright 1996 by the Associated Schools of Construction
1522-8150/96/$3.00/Educational Practice Manuscript

Integrating Research into Undergraduate Coursework to Provide Professional Experiences

Kenneth W. Stier
Illinois State University
Normal, Illinois

This paper explains how a funded research project was incorporated into a materials technology class to expose the students to real world problems early in their course work. Both construction and manufacturing majors were combined into teams to work on this project and apply their knowledge. The research project was conducted for a local company that refurbished plastic display racks. Damaged display racks were being landfilled and the company was interested in exploring other alternatives. The project was completed in two phases and involved the students from two different semesters. The first class of students identified alternative methods of reducing and recycling the plastics. They also prepared non-air-entrained concrete specimens that contained granulated plastics in various quantities by volume for commercial testing. The next semester's class investigated the effects of replacing specified quantities of aggregate with granulated plastics in air-entrained concrete. The students helped prepare concrete specimens for compression, flexure, and freeze-thaw tests that were conducted by commercial testing facilities. Each semester the students had to analyze the data from the tests and present their findings to management.

Key Words: Field Experiences, Material Testing, Concrete, Plastics, Recycling

Introduction

Field experience is an essential component in the formal education of engineering and technology students (Liedtke, 1994; Liu, 1994; Shapira, 1995; Ward, 1990). Students in these programs are more frequently being required to complete industry internships, professional practice arrangements, or cooperative work experiences to meet the requirements for graduation. These approaches help enhance the curriculum and improve the qualifications of the graduate through real world experience prior to graduation. They help reduce the anxiety and confusion sometimes experienced by graduates as they enter the real world. Often these field experiences can improve the career opportunities of the student or lead directly to employment with the host company.

Field experiences are a valuable part of the undergraduate curriculum and can help students more clearly understand the relevance of their course work through assigned activities in industry. However, prerequisites often prevent students from enrolling in any field experience until their senior year. In order to better prepare students for their professional career it is important to integrate industry-related work at an earlier point in their curriculum. One way to accomplish this goal is to integrate funded research projects into the classroom.

This paper discusses a funded research project that was integrated into an undergraduate course that the author taught. The project involved researching alternatives to landfilling plastics waste for a local company. The firm will be referred to as company "XYZ" for purposes of this paper. The specific name of the company has been withheld to enable honest discussion of the project.

Background of the Project

One of the services company XYZ provides is to refurbish plastic display racks for a larger firm. Used racks are shipped to a local warehouse where the XYZ employees inspect them for damage. During the 1994 spring semester the author was made aware of the fact that company XYZ was landfilling plastic display racks that were beyond repair. At the time of this study, approximately 30% of the display racks were damaged beyond repair and ended up in the local landfill. This typically amounted to about 12 open 30 -yard capacity dumpsters of plastic waste per month.

The racks consist of three plastic materials bonded together with an adhesive: polystyrene (PS), acrylonitrile butadiene styrene (ABS), and acrylic. Plastics that are combined together like this are known as commingled plastic. Commingled plastic can consist of a mixture of multilayered bottles, coextruded films, copolymers, thermostats, high -melting polyesters, thermoplastics, etc. This mixed plastic waste component of the post-consumer solid waste stream is the hardest to recycle without innovative technological advances (Ehrig, 1992). Commingled plastics are also the biggest constituent in the post-consumer waste stream. Consequently, this segment of the municipal solid waste problem is ripe with opportunity to solve e xisting recycling problems. It is also a crucial part of the challenge facing the plastics industry if it is going to meet the EPA's goal of 25% recycling (Rowatt, 1993).

XYZ's management was determined to discover more environmentally conscious alternati ves to their present disposal methods. Not only was XYZ concerned about the impact they were having on the local landfill, but they were also faced with collection and disposal costs that were slowly rising.

Preliminary analysis of the problem was done du ring the spring semester while the author was having students complete several other capstone projects for XYZ. This project appeared to have the potential to be a very practical and plausible way for students in the author's materials technology course to practice the theory and laboratory methods they encountered in this class as well as other course work. The enrollment in this course normally consists of both construction and manufacturing majors. Thus, their backgrounds were consistent with the needs o f the project and provided them with an opportunity to experience how people with different areas of expertise need to work together as a team to solve real world problems. Additionally, the project would provide the students with field experience early in their curriculum since this was a sophomore and junior level course.

Contract Proposal

It was agreed that a proposal for funding would first be sent to the Central Illinois Manufacturing Innovation Consortium (CIMIC) and if additional resources were re quired then company XYZ would provide monetary support for the project. A proposal for $3000 in funding was submitted to CIMIC during the summer. CIMIC agreed to provide $1000 for purchasing materials and to cover the cost of testing a limited number of concrete specimens. CIMIC also agreed to provide additional funding at a later date if the results of the first phase were positive.

Another contract proposal was written during the following semester for the second phase of this project. This proposal called for joint funding by CIMIC and the company producing the display racks. Total funding for the second proposal was $4130.

The contract proposals consisted of several components designed to briefly describe the tasks to be performed, the timeline for the activity, the participants, and the projected budget. The contract for the first phase of the study proposed conducting preliminary research to identify recycling and source reduction methods. It also called for conducting compression tests on non-air-entrained concrete specimens containing granulated commingled plastic. This proposal was submitted through the Technology Transfer Program at the University.

The contract for the second phase of the study proposed using commercial testing facilities and conducting compression, flexure, and freeze-thaw tests on air-entrained concrete specimens containing granulated commingled plastic. Funding was included in the contract to construct flexure and freeze-thaw forms to make the specimens for the tests and for transportation to the testing facilities since one was located approximately sixty miles from the campus. The second contract was submitted through the Office of Research and Sponsored Programs at the University. For this process to occur approval was obtained for the project at the Departmental, College, and University levels.

The Course and Project

The materials technology course is a four credit hour class that meets six hours each week. Two hours each week are used for lecture and the other 4 hours are devoted to hands-on laboratory activities. The major categories of engineering materials (metals, polymers, ceramics, and composites) are covered from a materials science perspective in the lecture. The laboratory component consists of strength of materials activities such as tensile, compression, shear, hardness, flexure, and impact. The students complete the laboratory activities in teams by conducting the tests according to the American Society for Testing and Materials (ASTM) Standards, collecting data, and submitting a report.

In order to allow for the cure time that was needed for testing the concrete in the two phases of this project, the preparation of the specimens had to occur no later than midsemester. Consequently, the recycling project had to be interwoven into the rest of the course. Students were introduced to the major engineering materials and testing methods as before, but with an emphasis on using this information to complete the recycling project. Laboratory time was scheduled to cast the concrete specimens in the first half of the each semester. While the concrete specimens were curing and being tested in the commercial testing facilities the students continued on with the rest of their course work. This forced the students to work on multiple activities at one time similar to what they may encounter in the real world.

Plant Visits

Each semester the author had different students enrolled in class who were new to the project and had to be given an orientation to XYZ company, its operations, and the goals of the project. During the initial visit the Director of Operations for XYZ would describe the plant functions, services, and modes of operations. He would give the students a tour of the facilities, provide handouts and information concerning the company's operations, and discuss the scope of the problem.

Students took notes on the information presented with regard to the scope of the problem. They asked questions of the director with regard to refurbishing methods used to reuse the racks and disposal procedures utilized by the company. The questions ran the full gamut and gave them more insight into the scope of the problem. Students were invited to return to the plant and schedule future meetings with XYZ's management as needed.

The plant tour helped orientate the students to the assigned project and motivate them. It also gave them a better understanding of the expectations of XYZ's management and the author. They began to realize that the classroom extended beyond the University's laboratory and into a company's facilities similar to what they may encounter in their career. It was an attempt to help the students make the transition from the classroom to the real world early in the academic program.

Teamwork

Liu (1994) states that the team approach with three to five students per group is best when working on industry projects. Consequently, the class was divided into groups consisting of approximately four members. The author tried to maintain an even balance of construction and manufacturing majors in each group. The teams were formed by the author in this manner to help guarantee that each group had students with expertise in plastics and construction to provide the synergy required for this project.

When having students work in teams it is important for the instructor to provide support to the team. In the beginning of the semester the author discusses past experiences with the team approach and provides suggestions that can help groups be successful. This can include such things as the importance of good communication among team members and how to function in a group meeting. One of the first things the students are required to do is assemble in their teams and exchange names, phone numbers, and e-mail addresses so they can communicate outside of class time. The group members also share their schedules and identify a time that is convenient for everyone to meet outside of class. Do not assume that just because the instructor forms the students in teams that they are going to learn how to function as an effective group.

Once the teams began work on the project the author became more of a facilitator. Some of the facilitation provided by the author included referring students to appropriate references such as the ASTM standards, scheduling laboratory time for each group, providing tools and materials, scheduling plant visits, etc.

Another support mechanism that can be used is a peer evaluation as a means to keep students involved throughout the project they are assigned. Figure 1 shows the peer evaluation form used by the author in laboratory assignments. It contains six items that the student can use to evaluate their other team members performance. The evaluation form also has a place where the student can rank their peers' performance and write any additional comments they want to make. The ranking of one's peers and listing comments are considered optional components of the evaluation form. However, the students are asked to list each of the other group member's names and rate them according to the six performance items listed. The student adds up the totals for each member rated and writes it at the bottom of the column. The student is instructed to fill out the form in private and submit it directly to the instructor. This helps insure anonymity of each student and a more honest evaluation of their peers. The instructor then makes a subjective evaluation of each student's performance based on the feedback from the peer evaluations.

Peer evaluations can be a motivational tool. They can be a means for students to commend their peers for exceptional contributions or to vent their frustrations about poor performance or a personality conflict that has occurred. Ultimately, the peer evaluation is a means to practice evaluating the performance of others that is something that students will have to do eventually as managers. This is a tool that helps prepare them for that responsibility.

Preparation And Testing Of The Specimens

Company XYZ supplied the class with damaged display racks for the research project. The material was cut into small pieces approximately the size of kitty litter (granules 3-7mm in size) with a granulating machine in the department's plastics laboratory.

In both phases of the project the specifications for making one cubic foot of concrete (non-air-entrained concrete for the first phase and air-entrained concrete for the second phase) with three-quarter inch maximum size coarse aggregate was used as a basis for the batch mix (Kosmatka and Panarese, 1992). The absolute volume formula was used to determine the volume of the concrete and plastic material in the mix.

Calculating the batch mixes with the absolute volume formula gave the students a chance to work with the formula and become familiar with the Portland Cement Association reference. It also gave them a better understanding of the difficulties encountered in specifying concrete batch mixes. Additionally, it challenged them to use analytical and problem-solving skills.

In phase one of the project each team cast 5 standard 6 by 12 inch compression specimens containing non-air-entrained concrete using the quantities of plastic in Table 1. In phase 2 of the project each team cast 5 compression specimens containing air-entrained concrete using the quantities of plastic specified in Table 2. The company that conducted the tests for the students supplied the compression specimen forms. The quantities of plastic used in this study were based on a related study that the department's plastics professor had conducted for a different company using other plastics (Weede, 1993).

The students were instructed to read the ASTM Standards for preparing a laboratory concrete compression specimen (ASTM C192) and for testing the compressive strength of cylindrical concrete specimens (ASTM C39). Each team was required to understand and follow these standards in this project. The importance of preparing the specimens to the ASTM standard was emphasized to the students.

The compression test was chosen because it is the most common quality control tool in the industry (Hover, 1993). It was also a simple and low-cost test ($9.00 each) that fit into the course very well.

In the second phase of the project steel forms for flexure specimens were constructed in the department's laboratory. Two freeze-thaw forms were also constructed in the laboratory and another twelve were borrowed from a commercial testing facility. All the freeze -thaw forms required steel plates on both ends which held and centered a special machined bolt that was inserted into the specimen for testing purposes. Twenty-eight plates were precisely machined on a computer numerically controlled (CNC) milling machine. The department's maintenance supervisor and a graduate assistant, to maintain the precision and quality of work required by the ASTM standards, constructed the forms. Each team cast 3 flexure specimens and 2 freeze -thaw specimens.

The flexure test was chosen because it is a means to determine how concrete will perform in common applications like pavements and floor slabs. Likewise, the freeze-thaw test was chosen for its ability to determine how well the concrete would work in the natural environment.

Table 1

Percentages of Plastics in the Non-air-entrained Concrete Batch Mixes

Specimen Number	**Percentages of Plastics**
1	0% (Standard concrete mix)
2	5% (by volume) of the coarse aggregate
3	15% (by volume) of the coarse aggregate
4	5% (by volume) of the fine and coarse aggregates
5	15% (by volume) of the fine and coarse aggregates
6	5% (by volume) of the fine aggregate
7	15% (by volume) of the fine aggregate

Table 2

Percentages of Plastics in the Air-entrained Concrete Batch Mixes

Batch Number	**Percentages of Plastics**
1	5% (by volume) of the coarse aggregate
2	15% (by volume) of the coarse aggregate
3	5% (by volume) of the fine and coarse aggregate
4	15% (by volume) of the fine and coarse aggregates
5	5% (by volume) of the fine aggregates
6	15% (by volume) of the fine aggregate
7	0% plastic (Standard concrete mix

The department supplied the students with a cement mixer, slump cone, rodding device, and trowels for preparing the concrete. The students to determine the quantity of each material in the batch mix when casting the compression, flexure and freeze -thaw specimens used precise instruments such as a scale and 500 milliliter beaker. Each team was scheduled for approximately 45 minutes to mix the concrete and cast their specimen for a specific type of test on a given day. The students and the author each kept a written copy of the batch mix ingredients used by each team. Care was taken to clean the mixer, tools, and containers to avoid build up and contamination between the batch mixes.

A slump test was completed on each batch of concrete that was mixed according to ASTM C143 (Standard Test Method for Slump of Portland Cement Concrete). The students were instructed to stay within the range of 2 to 5 inches of slump. They also determined the water -to-cement ratio to help determine if the quantity of water used influenced the results. This gave the students practical experience with slump testing and water -to-cement ratios. It also allowed them to see first hand how the water can greatly affect the concrete.

During the second phase of the project an air meter was borrowed from a local contractor to determine the air content in the batch mixes. Six percent was the desired air content based on American Concrete Institute specifications. The ASTM standards were used as a guide for taking the readings with the air meter.

As each specimen was cast, they were marked and tagged for testing. The specimens were stored in a controlled environment in the laboratory for 24 hours and then transported to commercial testing facilities. The compression and flexure specimens were taken to a local commercial testing facility while the freeze -thaw specimens were taken to another facility that had the capabilities to conduct this test. The specimens were placed in a mist room upon arrival for continuous moist curing according to the ASTM standards.

The compression specimens were tested on the 7th, 14th, 28th (two specimens were broken at this time period), and 56th day. The flexure specimens were tested on the 14th and 28th (two specimens were broken at this time period) day. The freeze -thaw specimens were subjected to approximately 350 cycles of freezing and thawing.

The test results were sent to the students on an official report form in the same manner, as they would have been for any other commercial project. Each group had to keep an on-going file of the reports as they arrived. The students were expected to extract information from the reports, analyze it, and compare it with the results of other groups. At the end of each semester they used this information to make a presentation to XYZ's management and write a project report.

Visits To The Commercial Testing Facilities

The students toured the commercial testing facilities each semester during the testing phase of the project. They were given a tour of the facilities and a demonstration of the tests that were being conducted. The management at these facilities also explained the services they provide and how they are involved with the construction industry.

The students were given questions to answer that pertained to the project. They also asked questions of their own with regard to the curing and testing of their specimens. These tours gave them another opportunity to see facilities that they may encounter in the real world and to be better prepared to make their presentation to XYZ's management.

Report And Presentation

At the end of each of the two phases the teams had to prepare a report based on their findings which contained major sections such as the: introduction, objectives/goals, purpose and rationale for the study, procedures, test results, applications and recycling alternatives (including a cost justification and supporting documentation), recommendations for further study, long range plan, and appendices. The presentations were given at company XYZ's facility.

Recommendations were made to the management in the first phase of this project for source reduction of the plastics waste and for recycling. The managers and students engaged in constructive dialog regarding these recommendations. The direction of future research for phase 2 and a long-range plan for the project were also discussed. The management of company XYZ expressed their appreciation to the students for the excellent alternatives that they suggested. They also indicated that they would pursue some of the suggestions such as granulating the plastics, redesigning the display racks, and recycling some of the plastics through injection molding or extrusion. The continuation of the project into phase 2 can be credited to a certain extent to the impressive work that was done by the students in phase one.

The presentations in phase 2 focused on the results of the compression, flexure, and freeze-thaw tests as well as other alternatives that the company might explore since the material failed the freeze-thaw tests. They formally presented the methods of testing and data collection, their analysis of the data, and results of their work using media that included charts and graphs.

Benefits of the Research Activity

It is the author's opinion that the students benefited from this experience in that they were able to apply what they learned in the materials course to a real industrial problem. It was not just another simulation activity in the laboratory. The author encouraged the students to keep copies of their reports and other materials for the project as part of a portfolio for interviewing for a job. This project provided the means for students to bring real world experience into an interview that employers are often seeking in a potential employee.

The students also received the benefit of touring several companies in the process of completing the project. This gave them an opportunity to observe the operations and practices of companies similar to those in which they will be employed. Additionally, the students had the opportunity to network with the management in company XYZ and the companies that did the testing. The students were in a position to impress the management in these companies and perhaps even gain a reference for internships or job interviews.

Completing this research activity also helped prepare the students for their culminating experience that, in the author's department, is either an internship or a capstone course. This activity provided the student with experience that could be expanded upon in either of the two culminating requirements for the author's department. One of the companies even announced that they would be looking for interns during the summer while the class was working on the project.

Furthermore, this project gave the students a chance to receive recognition for their work across campus. The best reports were sent to the University's Honors Office for publication in their journal that publishes outstanding undergraduate scholarship and is circulated throughout the campus.

Company XYZ benefited from the synergy that resulted in this research activity. The students provided ideas and recommendations that XYZ's management had not been aware of prior to that time. As the company begins to implement these recommendations, they should save money and become more efficient in their business. The project also provided research with regard to recycling plastics in concrete that was something company XYZ did not have the time or facilities to begin.

The University benefited from this activity as well. It was a means of providing community service to a company that helps the community and local economy. The public image of the University is greatly improved through this type of service. Most importantly, it is a means for the University to provide high quality education to its students and further advance its programs.

Conclusions

Quite often the majority of the student's preparation for their career is through classroom learning. Liedtke (1994) states "students will best apply that learning when faced with real problems to solve in the work setting". Contracts with industry and funded research projects are both a means to involve students in real world problems while bringing classroom learning to the forefront. These industry experiences can enhance the student's preparation for culminating program requirements and job opportunities.

This research activity provided the students with a vehicle to apply their learning to a real problem in a company. It challenged the students to produce solutions for company XYZ and gave them the opportunity to grow professionally. The students accepted the challenge and company XYZ's management was impressed with their level of performance. This was another example of how students will rise to our expectations when faced with a meaningful challenge. In this case, a funded research project was used as the means to provide the students with opportunities to excel.

Faculty need to continually be creative with regard to involving students in real world activities, especially early in their course work. It is through this creativity that opportunities to excel originate for both students and faculty. These opportunities are an essential ingredient to reducing the culture shock graduates may experience when starting that first job and to improving the quality of the program and its graduates.

References

Ehrig, R. J. (1992). *Plastics recycling: products and processes.* New York, N.Y.: Hanser Publishers.

Hover, K. (1993). Testing hardened concrete. *Concrete Construction, 38*(10), 727-732.

Kosmatka, S. H., & Panarese, W. C. (1992). *Design and control of concrete mixtures,* (13th edition). Skokie, IL: Portland Cement Association.

Liedtke, J. A. (1994). Industry contracts provide alternative professional experiences for industrial t echnology students. *Journal of Industrial Technology, 10*(3), 10-14.

Liu, Y. H. (1994). Integrating course work in design with industry projects. *Tech Directions, 53*(10), 14-16.

Rowatt, R. J. (1993). The plastics waste problem. *Chemtech, 23,* 56-60.

Shapira, A. (1995). Bringing the site into the classroom: A construction engineering laboratory. *Journal of Engineering Education 84*(1), 81-85.

Ward, J. S. (1990l). Bringing the practice of engineering into the civil engineering classroom. *In Education and Continuing Development for the Civil Engineer, ASCE Conference Proceedings,* 871-874.

Weede, G. D. (1993). [A study on recycling RRIM plastic]. Unpublished raw data.

Appendix

Peer Evaluation Form

**NOTE: Complete this form privately. This information will b e used to help determine individual contribution Grade and will not be available to anyone but the instructor.

Student Name ____

Group Number ____

Date ____

I. Distribute 17 points to the members of your group (excluding yourself) for each of the following categories. Total points for each category should add up to 17. Higher number points implies more contribution and lower points implies less contribution.

(Alphabetical last name here) ___________

1. Amount of work contributed
2. Attendance at group meetings
3. Quality of individual meeting participation
4. Completion of assigned work within sched ule
5. Quality of assigned work
6. Individual' value and over all contribution to the group

II. Rank the members of your group (excluding yourself) in the categories below. Do not place all members in the same category.

1. Best performer (s) ____
2. Good performer (s) ____
3. Average performers (s) ____
4. Minimal performer (s) ____

III. Add any comments you would like to make

Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 34 - 44
Copyright 1996 by the Associated Schools of Construction
1522-8150/96/$3.00/Educational Practice Manuscript

The Development of a Vertically and Horizontally Integrated Undergraduate Building Construction Curriculum for the Twenty First Century

Thomas H. Mills, Flynn L. Auchey, and Yvan J. Beliveau
Virginia Polytechnic Institute and State University
Blacksburg, Virginia

This paper describes a curriculum model designed to help construction education programs achieve and maintain national and international recognition as premier sources for dynamic, practical and innovative building construction knowledge. Specifically documented is an approach the Building Construction Department at a Southeastern university is exploring. This approach will to help each student master the competencies necessary to succeed in the 21st Century as a building constructor in a changing global market place. The curriculum described in this paper will meet this goal by balancing the construction education concepts of practical experience based knowledge with academic inquiry, being a dynamic, practical, applied academic model, providing a construction program that maintains a strong identity positioned between architecture and engineering, integrating people and communication skills with the pragmatic building construction skills. Strategically this task will be accomplished by weaving vertical and horizontal integration into the curriculum of the Building Construction Department at a Southeastern University.

Key Words: Curriculum, Curriculum Development, Construction Curriculum, Vertical Integration, Horizontal Integration

Introduction

The goal of many national construction education programs is to achieve and maintain national and international recognition as premier sources for dynamic, practical and innovative building construction knowledge. The cornerstone of building a strong construction education curriculum is balancing practical experience based knowledge with academic inquiry. To accomplish this goal our graduates must possess technical strength combined with the people and communication skills necessary to be successful in the global construction industry of the Twenty-First Century.

At a time when many universities including this university are being asked to do more with less, a challenge has been tendered forcing us to re-evaluate the way we do business. Faculties are smaller, student populations are growing and graduate programs are added without the benefit of added resources. No longer can universities continue with "business as usual." This environment creates an opportunity not only to examine a program's curriculum but also to implement changes that strengthen the educational mission. Strategically this will be accomplished by adjusting the current curriculum to provide for vertical and horizontal integration of the learning experiences in all Building Construction student course-work.

To meet these objectives a construction program must:

1. Balance the construction education concepts of practical experience based knowledge with academic inquiry
2. Become a dynamic, practical, applied academic model
3. Have a construction program that maintains a strong identity within the university and the industry
4. Integrate people and communication skills with pragmatic building construction skills

National Perspective

The concept of curriculum integration has been talked and written about for numerous years. L.T. Hopkins (1937) described the concept of curriculum integration as a means of fostering unity between the learning process and the learner. What occurs through "integrati on" is the integration of student behavior. Knowledge becomes experience and experience becomes knowledge, thus begetting wisdom. A broadened curriculum as proposed, structured to utilize horizontal and vertical integration will unify experienced based lea rning with the academic knowledge. The learner becomes the teacher and continues to learn long after the teacher has "gone home." Thus the true essence of education, that of self directed problem solving is accomplished.

The philosophical foundation of cr eative problem solving has aroused National Science Foundation and industry support. This has led to establishment of the Synthesis Coalition. This coalition includes eight national universities, working to reform engineering education. These reforms empha size "multidisciplinary content, teamwork and communications, hands -on and laboratory experiences, open ended problem formulation and solving, and examples of 'best practices' from industry" (Synthesis Strategic Plan, 1995). Construction education at this university and many other universities has been doing this since the 1940's. While this university 's Construction Education program is not an engineering program it is excited about the prospect of engineering's shift toward a pragmatic problem -solving curriculum. "The goal of Synthesis is to develop curricular strategies and alternate modes of instruction and access that foster horizontal and vertical integration of engineering knowledge within the context of broader societal factors. This approach to curriculum structure is based on a woven fabric metaphor, ... with 'integrating threads' extending from the freshman through the senior years and across disciplines." (Synthesis Strategic Plan, 1995)

Construction education and the construction industry may b e unique in that its focus has always been pragmatic problem solving in team -oriented situations. this university 's Building Construction Department has been unifying experience and academic inquiry through its senior capstone course for twenty years. Nowis the time to integrate that experience across the curriculum in a vertical sense. It is noteworthy that a major component of the Synthesis Coalition's mission is to develop a multidisciplinary "Bridging the Architectural/Engineering/Construction Gap" cu rricular sequence. It can be suggested that they look at existing construction education models already bridging this "gap."

The National Science Foundation is also funding Project Succeed, a consortium of nine southeastern universities engineering progra ms. This funding is directed to developing a "system for creating transparent boundaries and methods for integration between courses, departments, schools, and colleges, and institutions within the academy." (Project Succeed Strategic Plan) This is leading to many engineering curriculums exploring integrated curriculums. The April 1995 Journal of Engineering Education devoted a third of the issue to discussion of curriculum integration.

Much of the literature discusses the concept of an integrated senior c apstone course stressing participatory learning and creative problem solving. (Lonsdale, Mylrea, and Ostheimer; Lumsdaine and Lumsdaine; Wilczynski and Douglas) An example of integrating students of multiple skill and academic levels in a common capstone e xperience with common open-ended problem solving task is missing from the literature. Having developed and direct a participatory senior capstone course for twenty years we consider vertical integration of the experience the next logical step.

This univer sity's Building Construction is moving in this direction. We consider this the next stage of development in creating a learning process that becomes one with the learner. We are confident that the creation of a learner that is also a teacher unifies and en hances that student's learning process. Cooperative Learning, prepared by Johnson, Johnson, and Smith lends justification to the beneficial concept of group work for both student and faculty.

Our philosophy and approach as follows, are consistent with cur rent academic strategies to shift the paradigm of academic thinking in the technical/managerial fields to a non -linear right brain pervasiveness. (Lumsdaire and Lumsdaire) Industry is aware of the need for communicators and creative problem solvers in a lo ng-range global society. The university educational system is responding to this charge by a shift in educational philosophy that prepares students to solve problems successfully with dynamic and less then complete information. A strategy, construction educators teach and construction professionals do on a daily basis.

Horizontal and Vertical Integration

Continuous quality improvement requires that a contemporary Building Construction program look within both the university and its own program for mechan isms to achieve its objectives in more efficient ways. One model being used to achieve these objectives is a vertically and horizontally integrated curriculum. Vertical Integration relates to the process of actively involving all building construction (BC) students in the work and experiences of BC students at all undergraduate academic levels.

Specifically, the program being developed at this university provides vertical integration by organizing and scheduling BC core major courses so that during the spr ing semester an opportunity is presented for all students to participate in a common lab course. In this way, first semester students learn concepts they can use in the following semester's integrated lab. In a common lab period, all freshmen, sophomores, and junior students will work in teams directed by a senior working on a capstone project. Horizontal or cross integration relates to the process of assuring that all information presented in service courses, (engineering, communications, math, business, etc.) relate directly to skills being developed in the BC core major courses.

The concept of horizontal integration also uses the larger context of the university to provide BC service courses for undergraduates in other curriculums. The construction curriculum being revised must first examine its goals and objectives and all courses necessary to achieve these goals. Figure 1 provides a flow diagram of the curriculum investigation. This process continues by further examining the existing curriculum to determine the strengths established in the courses already being taught. It may simply be a matter of fine tuning existing course content to allow for vertical and horizontal integration. Each construction program has unique goals and objectives depending on the program's mission.

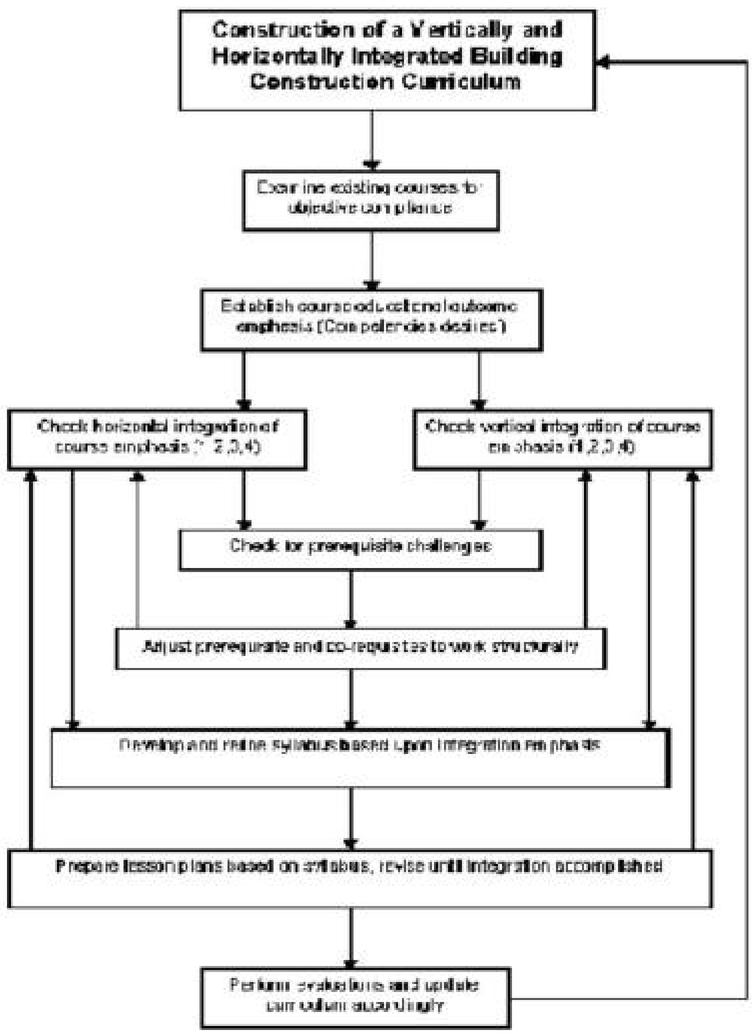


Figure 1: Flow process for implementing a fully integrated curriculum.

This university 's objective is to retain a strong technical emphasis based in engineering skills balanced by practical business and managerial skills. Horiz ontal integration requires close coordination and acceptance by departments outside the construction core courses. This task is accomplished by working closely with departments teaching the service courses.

In this context, BC core courses are taught by BC faculty and support courses are taught by other departments. This collaborative approach to course delivery uses facilities and faculty more efficiently, especially since this university has strong engineering and business courses. Horizontal integration provides the construction faculty with opportunities to improve the students' learning experience even as resources are diminishing.

The restructured curriculum has increased the number of courses; however the overall hours have decreased. In addition, t he realignment provides an opportunity for non -BC students to participate in BC core courses. The net result of the horizontal integration opportunity is a cross integration with positive response from non -BC curriculums including, architecture, civil engineering, mechanical engineering, technology education, business management, and interior design.

A critical component of structuring a successful vertically integrated curriculum is the establishment of learning outcomes expected to be achieved within the curriculum. These competencies provide the theoretical framework used to structure the curriculum for reaching departmental program objectives. Determination of curriculum competency is essential for defining course and curriculum goals.

This university' s Building Construction Department uses a Learning Outcomes Template (LOT) to enhance coordinating and focusing each course and therefore, each student's progress toward educational mastery. The "LOT" (Appendix A) is prepared for each course and coordinate d as a matrix within the curriculum to confirm, verify and correct course content and focus. The curriculum competencies are organized in a systematic format that allows both lateral and vertical progressions in the student's development to a mastery level of professional constructor. Student competencies are achieved by a coordinated progression through four levels of skills acquisition:

- philosophical
- competency
- proficiency
- mastery

Four Level Progression of Competency Evaluation

Level 1 Philosophical (Preparatory Foundations)

Job Description: Beginning office work (Gopher, report writer, etc.), Beginning job site (Laborer, etc.) These courses establish "Why" and "How" the student has chosen to come into the program and chooses to stay. Components include:

- Attitudes and Ethics
- Educational Background and Assessment of Previous Knowledge (beginning skill sets)
- Personal Background and Evaluation of Commitment
- Foundation Courses in Preparation For a Career in Construction
- Communication Skills i.e. writes and speaks effectively
- Problem-Solving Skills

Level 2 Competency (Construction Course Knowledge Development)

Job Description: Continue office work with greater emphasis on the job site (after safety courses!) These courses establish the foundation for the skill sets needed for a professional constructor. Components include:

- Basic Construction Concepts (in and out of construction emphasis)
- Basic Construction Vocabulary (understanding and use)
- Using Problem-Solving as it relates to industry (beginning case studies)

Level 3 Proficiency (Practice and Application In- and Out-of-Class)

Job Description: Work closely with Mentor/Manager with greater emphasis to On-Site application. These courses apply the skill sets of a beginning project manager, who works with the contractor and sub-contractors and, possibly, owner. Components include:

- Mentorship Preparation -- Application of Theory -- Case Studies at Site
- Problem-Solving at Applications Level (Construction Case Studies)

Level 4 Mastery (Analysis, Evaluation and Controls)

Job Description: Project Manager (trainee?) These courses prepare the project manager with the skills to fully integrate his/her knowledge in a meaningful, real-life situation in order to analyze, evaluate and control 'challenges' faced daily by the construction project manager. These skills will prepare the Building Construction graduate to be productive for their employer upon graduation.

Vertical Integration

Motivation to improve this university's Building Construction curriculum grew from several facts. At present our BC students take no BC core courses in two of the eight semesters in residence. This causes the student to lose touch with the faculty, student associations, and fellow BC students for 25% of their time in the construction program. A second motivation is pressures from outside sources are insisting undergraduate program time to graduation be reduced to fewer credits. These issues coupled with our desire to provide the finest full time undergraduate construction program is best achieved using the concept of vertically integrating our undergraduate courses.

A graphical representation of an integrated curriculum is shown in Appendix B. This chart shows the central curriculum core, composed of BC courses, supported on one side by science, math and engineering courses, and the other side by communication and business courses. Course prerequisites and co-requisites are linked based on competencies. Each of the core courses is designed and developed systematically using the learning outcomes (competencies) as an organizational tool defining content and competency. The BC core courses are organized to provide BC student contact hours every semester and to provide a combined integrated lab in each spring semester. This lab is intended specifically for BC undergraduates; it occurs at a common period to allow all BC students to participate. On a team basis, varying skill levels will interact in responsible roles of interactive learning. Therefore seniors will facilitate the learning process for lower division students thus enhancing the knowledge retention of the facilitator and all students.

Opportunities and Benefits

There are many opportunities and benefits derived from a fully integrated curriculum as previously described. Principal among these is:

- Students learn by teaching each other in the team driven integrated lab.
- Conceptual and philosophical reinforcement of technical knowledge is developed in addition to the student improving in leadership, and team building skills.
- More effective utilization of faculty.
- More efficient use of equipment and facilities.
- A higher concentration of student time on task in Building Construction competency development.
- Less chance of missing or unintentionally duplicating key concepts in the overall course syllabus.
- Continual evaluation of curriculum relevancy, particularly concerning pre-requisites and co-requisites.
- Anticipating and offsetting the potential negative effects of forced curriculum hour reductions.

Attributes of the Proposed Model

Each challenge becomes a positive means of improving the integrated approach because it:

- Turns the concept of change for change sake into continuous quality improvement.
- Causes the development of problem solving skills at all levels of curriculum progression.
- Overcomes the "If it ain't broke don't fix it" resistance that some faculty, administration, and alumni might have.
- Recognizes and capitalizes on varying skill levels to teach management, leadership, and team building skills.
- Accommodates the entire undergraduate population for the integrated lab.
- Develops improved faculty team teaching and communication skills to prevent disjointed teaching approaches.
- Accommodates students in transition.
- Helps students learn by teaching.

Evaluation

The final piece of the game plan necessary to implement a vertically and horizontally integrated curriculum is to create mechanisms for continuous evaluation and feedback. Evaluation at this university is intended to occur both internally and externally. To make this work, the faculty will continually be asking each other, "Is it working, and how do we know it is?" Internally we will prepare, distribute, and record responses from students on how they perceive the courses to be working. Perception of the user is an important component of any evaluation. Using hierarchical levels of skills in the vertically integrated labs will encourage multiple perceptions from both novices and experienced students. One unique component of the evaluation is that it deals not only with what a student learns but also what was a student able to teach.

Externally we will be soliciting follow up responses from graduates and their employers relative to the quality of the preparation of the graduate to be successful on the job. Discussions will also be held with the ACCE accrediting team during their next campus visit.

References

Hopkins, L.T. (1937). *Integration: It's Meaning and Application.* New York: Appleton-Century Company, Inc.

Johnson, D.W., Johnson, R.T., & Smith, K.A. (1991). *Cooperative Learning: Increasing College Faculty Instructional Productivity.* ASHE-ERIC Higher Education Report #4, George Washington University.

Lonsdale, E. M., Mylrea, K. C., & Ostheimer, M. W. (1995). Professional Preparation: A Course that Successfully Teaches Needed Skills Using Different Pedagogical Techniques. *Journal of Engineering Education, 84*(2), 187-191.

Lumsdaine, M., & Lumsdaine, E. (1995). Thinking Preferences of Engineering Students: Implementations for Curriculum Restructuring. *Journal of Engineering Education, 84*(2), 193-204.

Martin-K., Giselle O., Feige, D. M., & Soodak, L. C. (1995). Curriculum Integration: An Expanded View of an Abused Idea. *Journal of Curriculum and Supervision, 10,* 227-249.

Southeastern University and College Coalition for Engineering Education (1992). Engineering Education for the Twenty-First Century: 1992-1993 Strategic Plan. The Process of Engineering and the Engineering Education Process. Version #4, Project Succeed, October.

Synthesis Coalition (1995). The Synthe sis Strategic Plan. *http://synthesis.org/synthesis.html or http://pawn.berkeley.edu/"aogogino/synthesis/strategic.plan.html*.

Wilczynski, V., & Douglas, S.M. (1995). Integrating Design Across the Engineering Curriculum: A Report from the Trenches. *Journal of Engineering Education, 84*(3), 235-240.

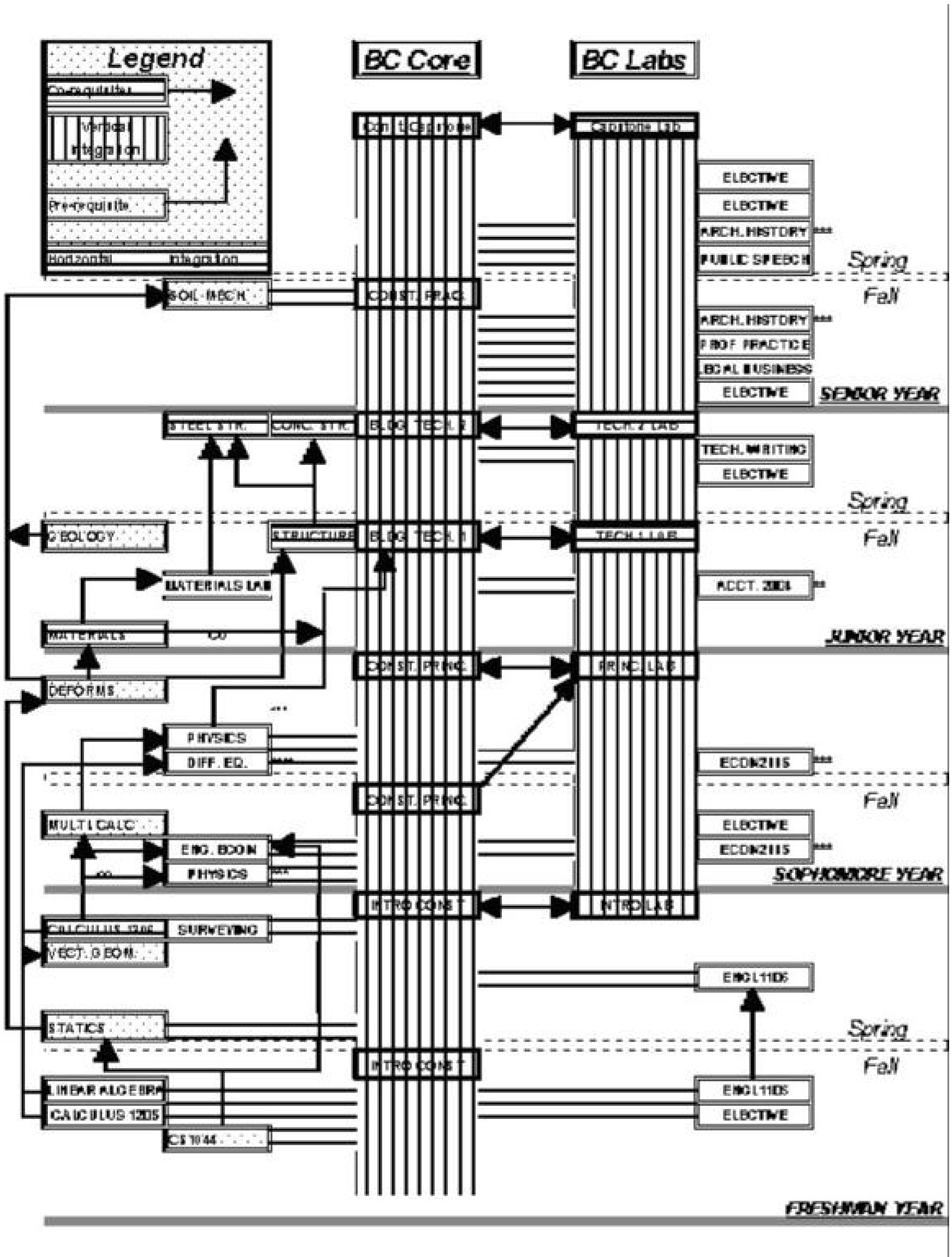
Appendix

Learning Outcome Template

Emphasis of where competencies are developed throughout the curriculum

50t #comp	Credits For This Course	3	(Note Course Title Here)		
draft #1	**Curriculum Competencies** →		*Levels Of Expectations To Be Achieved By The Student By The Conclusion of This Course*		
I	Building Sciences	0	1. Attainment Of Philosophical Foundation;		
	Be Familiar W/Construction Materials		i.e. Why is this material important to the Building Construction Student?		
	Understand Const. Mech. & Elect. Systems		2. Has attained a competency in this objective in this course		
	Design/Analyze Building Structures		3. Has attained a proficiency in this objective in this course		
	Understand Influence Of Bldg. Codes		4. Has attained a level of mastery of this objective in this course		
II	Means and Methods	0			
	Understand Const. Language & Methods		Note: Indicate Level Of Expectation In Numbers Only For		
	Be Able To Select Bldg. Sys. & Comp.		Those Objectives To Be Addressed In This Course !!!		
	Accurately Interpret Project Specifications				
	Accurately Interpret Construction Drawings				
III	Project Control	0			
	Structure and Maintain Project Controls				
	Develop and Maintain Project Budgets				
	Develop and Maintain Project Schedule				
	Coordinate Overall Project Activities				
IV	Performance Improvement	0			
	Use effective Graphical Communications				
	Communicate Well Orally & In Writing				
	Implement Continuous Quality Control				
	Applying Team Building Principles				
	Apply Value Engineering Concepts				
V	Labor Management	0			
	Understand Principles of Managing People				
	Develop and Implement A Safety Program				
	Develop and Manage Incentive Programs				
VI	Field Operations	0			
	Coordinate Project Disciplines				
	Control Material Delivery & Handling				
	Expedite Purchase Orders & Subcontracts				
	Handle Shop Drawing Procedure				
	Verify Construction Details For Accuracy				
	Close Out Project Successfully				
VII	Estimating	0			
	Compile Project Information				
	Perform Quantity Take-off				
	Perform [illegible] Estimates Assemble and Manage The Bid Process				
	Apply Computerized Estimating				
VIII	Planning / Scheduling				
	Develop A Project Plan & Schedule				
	Perform Computerized Scheduling				
IX	Company Operations	0			
	Understand Const. Co. Financial Mgmt.				
	Be Able To Set Up Co. Cost Control Sys.				
	Coordinate Governmental Reviews				
	Use Computerized Spreadsheets				
	Use Word Processing System				
	Use Computerized Data Base				
	Understand and Apply Professional Ethics Understand Construction Contract Law				
	Be Able To Negotiate Well				
	Total Emphasis On BC Goals In This Course	###			

Graphical Representation Of The Vertical And Horizontal Integration Of The BC Curriculum.



Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 45 - 49
Copyright 1996 by the Associated Schools of Construction
1522-8150/96/$3.00/Educational Practice Manuscript

Infusing Actual Management Experiences into Construction Education

H. Stephan Egger, and Shahram Varzavand
University of Northern Iowa
Cedar Falls, Iowa

Stanley P. Lyle, and Donald O. Rod
Library - University of Northern Iowa
Cedar Falls, Iowa

The intent of the class, Special Topics in Construction revolves around the concept of students utilizing previous coursework to plan, research and solve real live construction industry problems. Construction students at a Northern University have demonstrated they can successfully handle undergraduate research projects and work closely with representatives of the construction industry to solve problems pertinent to the field.

Key Words: Management Skills, Undergraduate Research, Industry Relations, ACCE Topics

Introduction

In an effort to prepare better construction management graduates, actual management experiences have been incorporated into a construction course called Special Topics in Construction at this university (UNIX Offered to students in their final semester, the course encourages students to operate in a real industry setting while still in college. Within the structure of the course, students work independently to solve a real industry problem or concern.

The Special Topics course was designed partially on the concept of cooperative education. The intent of cooperative education is to integrate "classroom study with planned and supervised work experience and would involve a position such as a superintendent, assistant project management, etc. and related responsibilities. This educational pattern allows students to acquire practical skills as well as to be exposed to the reality of the world beyond the boundaries of the campus, enhancing the self -awareness and direction of the individuals" (National Commission for Cooperative Education [NCCE], 1993).

Course Rationale

The rational behind the special topics course is to involve students (in teams of two or three) with a construction company to solve a management -related problem. The team has the opportunity to conduct a planned research project, function in a management capa city, and become directly involved with representatives of the construction industry.

Objectives for the course, center on developing the students' management skills. These major objectives include:

- The ability to plan, implement, and carry out an effici ent and effective research project.
- The ability to work with an entity in the construction industry to solve an industry or company problem or concern.
- The ability to function in a middle -level management capacity with an emphasis on time management commun ication skills, goal setting, problem identification, development of team problem solving and presentation skills.

Additionally, students are encouraged to address topics identified in the standards and criteria of the American Council for Construction Ed ucation (ACCE) (American Council for Construction Education [ACCE], 1994). Some of the major areas student have addressed include:

- To communicate, both orally and in writing, and to understand human behavior.
- Industrial Relations -personnel management, lab or relations, supervision, productivity.
- Management -business, industrial management, organizational behavior.
- Estimating and bidding -quality surveying, pricing, manpower estimates, bid compilation, bidding strategies.
- Project execution-construction methods, equipment selection, work analysis, safety, field records, quality control and assurance, job supervision.

Course Overview and Requirements

The course gives students the opportunity to interact with industry representatives and combine this experience with their academic preparation in the field of construction management. Throughout the course students must clearly and professionally present themselves over the telephone, in face -to-face contacts, and in writing. Additionally, students are provided th e opportunity to enhance their management skills with direct and indirect contact with an array of company personnel from the president down to craftspeople. In essence the team that represents the university becomes the resource center for the construction company.

The faculty member's responsibility is to monitor a teams' (students') progress and maintain high professional standards. Also, the instructor assists in supplying expertise primarily in areas of problem identification, contacts with industry, problem solving strategies, and identification of resources. A primary requirement to make the course successful is the establishment of deadlines when specific items of course work must be accomplished. Throughout the course the teams of students are required to update the instructor in writing (weekly), attend weekly sessions, and keep an ongoing written log of activities. These logs include information gained from sources such as personal contacts, magazines, and books. On a weekly basis each team meets for 15 minutes with the instructor to discuss progress. The teams are brought together as a class twice every month to update and share experiences about their projects.

The course is broken down into several discrete areas each with its own deadline. The deadlines for completion of specific segments of the courses help undergraduates pace their progress. The main areas are listed in Figure 1.

During the semester, the students consult with the staff at the library and utilize various print and electronic information resources. At the beginning of the term, a reference librarian gives a one-hour presentation on these resources. The librarian reviews more sophisticated aspects of searching the local online library catalog. Students are also shown how to connect through the Internet to other, larger online library catalogs in Iowa, as well as to the online catalogs of other institutions around the country known for their strong collections in construction management. Through such searches, students can identify sources not available locally but which might be available through "interlibrary loan."

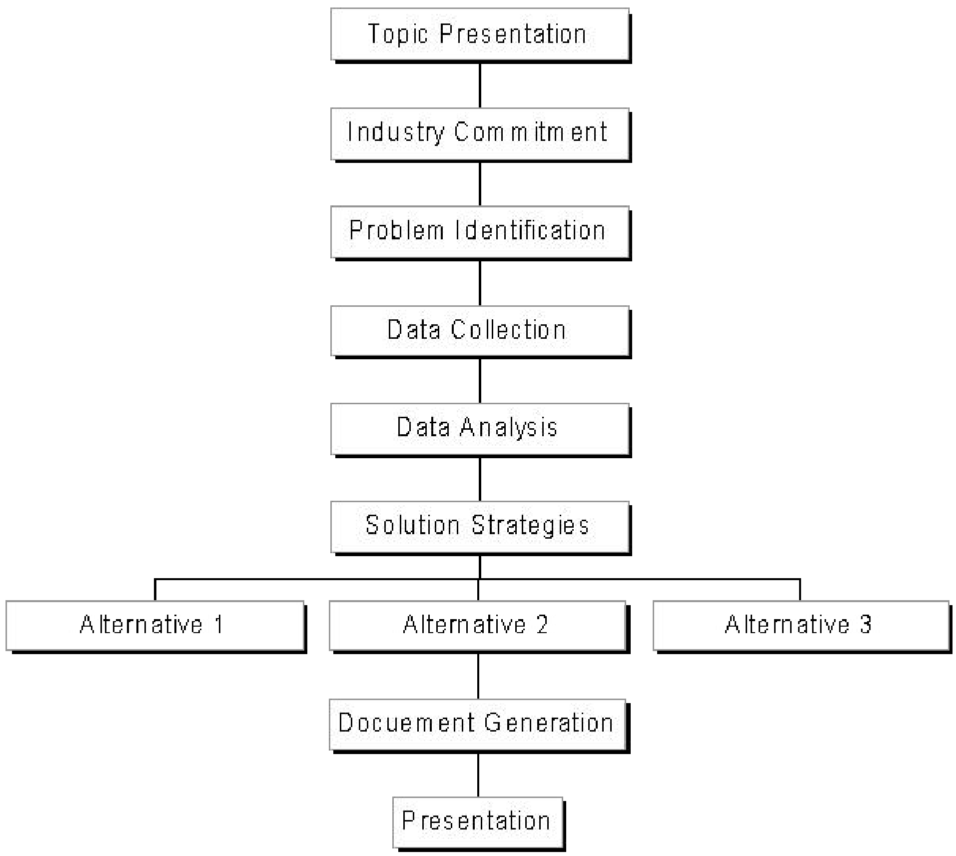


Figure 1: Special topics flow chart.

The library session also covers tools for locating trade and scholarly journal article citations. Specific sources covered include Applied Science and Technology Index (1995), Engineering Index (1995), and ABII INFORM (1995), (an electronic index which focuses on management and related topics as reported in trade, practitioner, and scholarly journals). Also covered is LEXIS-NEXIS (1995), an online information service that includes the complete text of various business and construction journals; state and federal statutes, regulations, and court cases; and various company reports. (Education license requirements place restrictions on how students may use this service.)

Students also learn how to use local, state, and national directories and other tools to identify experts on various topics. For example every geographic region in which future graduates may be working is likely to have its own directory of associations and a few such sources for Iowa are covered to illustrate the types of tools likely to be available for most states and metropolitan regions. Students also are exposed to important sources with a national scope, such as the Encyclopedia of Associations (1993), which are likely to list organizations whose staffs may include experts on various topics likely to arise in construction management.

In addition to academic research, students are encouraged to contact professors in related departments on campus as well as professionals in the construction industry. The support from professors in departments such as English and Business/Management has been instrumental to the success of various projects. Students also have worked with individuals from the Iowa Well Drilling Association, Department of Labor (OSHA), Scaffolding Association, and Lawyers representing ADA. In almost all cases these industry contacts have been extremely helpful for our students. The concept of involvement with an industry-related project has generated excitement, because students have opportunities to be directly involved in the "real world."

Actual Student Projects

The following listings demonstrate the type of projects recently completed by construction management students at UNI.

Safety analysis/planning of a well drilling company

Students worked on the assessment of field safety practices as utilized by a large well drilling firm. The team worked closely with field and office personnel in the development of a company-wide safety manual. In addition student utilized OSHA consultants in assessing the firm's existing conditions and proposed improvements. The manual discusses strategies for incorporation of motivational and human developmental theories. During the semester students became very familiar with OSHA manuals specifically 1910 and 1926.

American Disability Act (ADA)

This project involved developing an ADA plan for a mechanical/electrical firm with 63 employees. Students collected facts and information pertaining to the new law mandating the implementation of ADA. The primary emphasis of the project was development of a company policy and manual for ADA. Specific attention was directed toward analyzing job hiring techniques, identifying appropriate job titles, and related tasks. Students had the opportunity to work with professional associations and state entities in interpreting the ADA mandate and its repercussions. Students also attended various ADA conferences.

Management Information Systems (MIS)

Two students had the opportunity to work with the upper management of an international construction firm in the area of the analysis of data flow pertaining to fiber systems network technologies. The bulk of the project involved research on better ways to handle information, faster reporting and the usage of such information to allow for more sound decision making, increased communication, and decision making. The team critiqued the company's information and data collection systems. In the process, alternate software and bar coding were examined. Additionally, throughout the semester the faculty of the construction management program and Business School worked together with the team.

Total Quality Management for Field Personnel

This team concentrated on the concept of TQM with primary attention on the training and education of field personnel (superintendent, foreman, craftspeople). With the aid of office and field management, the team focused on identifying the concepts/techniques/methods related to TQM that could be incorporated in every day construction operations. Concepts such as developing better rapport between management and employees, better supervision, quality, and preplanning strategies were researched. The company has implemented many of the ideas recommended by the team.

Conclusion

The Special Topics course is designed to give students management experience in a real live construction industry setting. With appropriate guidance and direction, students can gain a professional experience pertaining to current problems in the construction industry. Viable topics such as Management Information Systems (MIS), Total Quality Management (TQM), and American Disability Act (ADA) can be adequately researched from an academic and industry setting. The interaction of students, faculty, and industry representatives in such a problem solving arrangement is in essence a form of an outreach program that encourages a sharing of information and ideas. In summary, students gain a more realistic outlook on putting research into practice.

References

ABI/INFORM. (1995) AnnArbor, MI:UMI.

American Council for Construction Education: Annual Report 1994.

Applied Science & Technology Index. (1995). New York: H.W. Wilson.

Cooperative Education Undergraduate Program Directory: National Commission for Cooperative Education: Boston, MA (1993).

Encyclopedia of Associations (29th ed.). (1995). Detroit: Gale Research. Co.

Engineering Index. (1995). New York: Engineering Index Inc. 7. LEXIS -NEXIS. (1995) London: Reed Elsevier.

Journal of Construction Education
Summer 1996, Vol. 1, No. 1, pp. 50 - 58
Copyright 1996 by the Associated Schools of Construction
1522-8150/96/$3.00/Educational Practice Manuscript

Enhancing Communication in the Design and Construction Industry through Multi-Disciplinary Education

Kenneth F. Robson, Mack Caldwell, and Jerlene Reynolds
The University of Oklahoma
Norman, Oklahoma

The Architecture and Construction Industries are struggling in their attempts to work as a team in the successful delivery of projects. To a large degree this is the result of a lack of understanding of the needs and processes required by each respective industry. Attempting to address this situation early in their "careers" and to promote better understanding and communication between Architecture and Construction, the College of Architecture at South Central university brought together four disciplines to collaborate in a multi-disciplinary team approach to develop schematic design alternatives and construction budgets for a high-rise office building. Students from Architecture, Construction Science, Interior Design, and Landscape Architecture worked together to deal with issues of building design, site design, interior design, presentation, project management, construction estimates and construction scheduling. This initiative enriched learning beyond the confines of a single course or discipline. More reflective of a real-life situation than the typical University classroom experience, it exposed students to the necessities and complexities of working as a team, along with the achievements teamwork makes possible. Such a foundation is vital to success in the Architecture and Construction Industry as increasing emphasis is placed upon alternative project delivery systems.

Key Words: Multi-disciplinary Education, Teamwork, Construction Education, Construction Industry Cooperation

Introduction

Seeking to understand and to be understood, four disciplines in the College of Architecture brought together students to collaborate in a multi-disciplinary team approach to develop schematic design alternatives for an Edge-City Tall Building project. Students from Architecture, Construction Science, Interior Design and Landscape Architecture worked together to deal with issues of building design, site design, interior design, presentation, project management, construction estimates, and construction scheduling. The decision to attempt such a complex project was based on the instructors' mutually shared perceptions about the lack of understanding among the four disciplines in both the College and Industry. The instructors saw this approach to collaborative learning as an opportunity to foster better understanding, communication and teamwork that would better prepare students to meet the demands of the rapidly changing architecture, interior design and construction industry. This initiative enriched learning beyond the confines of a single course or discipline. More reflective of a practice experience than a University experience, it exposed students to the necessities, rigors, and achievements possible through cooperation. Such a foundation is vital to success in creating the built environment.

Course Objectives

In addition to the specific goals of each individual course, the following joint objectives were established:

1. To create a cooperative learning experience for all disciplines involved.
2. To require students to communicate outside their disciplines, to work in teams and to adhere to schedules set to assure success for the total project.
3. To develop a sense of the roles and responsibilities of the various disciplines.
4. And finally, through the shared use of an assigned project, to familiarize students with the level of detail required to accomplish the work of different disciplines.

Disciplines Involved

Architecture

The architecture students participating in this project were all fifth year students. They were in their last semester design studio that is a capstone course for their Bachelor of Architecture degree. The Tall Building Project lasted the entire semester. Eleven students enrolled in the course. In addition to the final review, their semester grade was based on interim evaluations of various subsystems designed for the project. Each student was required to prepare a Project Manual recording work plans, schedules, and the design process. They met on Monday, Wednesday and Friday from 1:30-5:30 PM.

Construction Science

The thirteen Construction Science students were enrolled in a graduate level estimating course. The Tall Building Project represented approximately fifty percent of their semester grade. That portion was broken down into twenty percent for a feasibility estimate and thirty percent for a conceptual design estimate. The latter required a formal presentation to the Architecture and Interior Design students who then selected the best team proposal. Scheduled class times were Tuesday and Thursday from 4:30 to 5:45 PM.

Interior Design

The Interior Design students were all fourth year students in their last semester design studio that is the capstone course for the Bachelor of Interior Design degree. Nineteen students were enrolled. The Tall Building Project represented approximately twenty-five percent of their final grade and was one of three projects completed during the semester. This project was assigned at the beginning of the semester so that the Interior Designers could have input as the architects developed their designs. Only during the last four weeks of the semester did they concentrate fully on the Tall Building Project. Their high-rise designs culminated in a formal joint presentation with the architects. The Interior Design studio met at the same time as the Architecture studio, but in a different location.

Landscape Architecture

The Landscape Architecture students were second year graduate students. The Tall Building Project was assigned at the beginning of the semester and represented approximately fifteen percent of their final grade. Five students were enrolled in the class. As a group, they were required to conduct a site analysis. Periodically throughout the semester, each student was required to consult with two different architecture students on site design issues. In addition, group critiques of each design occurred at mid-semester and again near the end of the semester. This studio met at the same time as the Interior Design and Architecture studios, but in a third location.

Project Requirements

The project involved the design of a fifty to sixty story building. Located on a twenty-acre site at the periphery of a metropolitan area next to a major mall on a main highway, the skyscraper was to house a hotel, a corporate office complex, and tenant office space. The respective areas broke down into roughly one third of the total for each. Design criteria are listed below:

1. The maximum gross square footage was to be 900,000 square feet.
2. The net usable square footage was to be at least seventy-five percent of the total gross square footage.
3. The minimum floor plate size was limited to 15,000 square feet, while the maximum floor plate size was limited to 24,000 square feet.
4. Office space was to be within 40 feet of an exterior window.
5. Office parking required 1,285 spaces and hotel parking 450 spaces.
6. Elevator banks were to be separate for hotel and office functions.
7. The building was to conform to the 1991 BOCA Building Code.

The hotel was to provide 300 rooms and 150 suites for guest accommodations. Additional space requirements included a lobby, reception, administration, housekeeping, Laundromat, lounge and restaurant, shops, and banquet and meeting rooms.

Team Responsibilities

Architecture Students

The architecture students were given the role of Architect in the service of the Developer for the Tall Building. They were required to produce a set of schematic design documents to include floor plans, elevations, sections, structural diagrams, elevator operation diagrams, and a model. Along with these requirements, they were responsible for maintaining a Project Manual that recorded the design process. This included library searches into the history and style of tall buildings, structural and mechanical information, code checks, sketches, photos and notes from field trips, calculations, interim review notes and evaluations, and a work plan logging time spent on each task. Additionally, the architecture students were responsible for the coordination of efforts by other disciplines. This included the receipt and distribution of information and drawings, scheduling meetings and work sessions, devising compromises to resolve misunderstandings and conflicts, and integrating the opinions of others into their design. This last requirement was particularly important because the interior design students were the designated representatives for the two major tenants whom the Developer had agreed to accommodate.

Construction Science Students

The construction science students were given the role of General Contractor. Their first assignment was to work in teams of four to produce three feasibility estimates based on low, medium, and high quality standards of construction. These estimates were presented to the architecture students in three formal packages. Each written proposal included a cover letter, all inclusions and exclusions, and a breakdown of the estimate into foundations, substructure, superstructure, exterior closure, roofing, interior construction, conveying systems, mechanical and electrical systems, any special construction, site work and general conditions. Based on the estimates and in conjunction with the architecture students, the construction students were then to select three designs, which they would monitor as the Architects, developed them. Lastly, they were to choose one of the three fully developed designs for the final schematic design estimate. Along with this final estimate, they were to develop "company" marketing materials and give a formal presentation to the architecture and interior design students. Staged as an interview with representatives of the Owner (Architecture, Interior Design and Construction Science faculty), the students were to demonstrate their qualifications in order to be selected to join a partnering venture with the Developer's team. This scenario was chosen to reflect the increasing popularity of alternative delivery methods in today's industry.

Landscape Architecture Students

The landscape architecture students acted as Consultants to the architecture students and were responsible for collecting initial site data related to environmental factors (sun, wind and the elements), transportation and access, detention and retention of water, earth formations, and parking. Periodically they met with the architects to review site plan development, providing input and critiques related to opportunities and constraints for each design. Originally assigned to consult with two architects each, the landscape students soon initiated group critiques for each architect. They were not required to prepare any presentation documents.

Interior Design Students

The interior design students were assigned the role of Interior Designer, but acted more like joint venture partners than consultants because they functioned as sole agents for the Corporate and Hotel Clients upon whom the Developer was dependent if the project were to succeed. They provided the architecture students with their Corporate Client's preferred spatial organization. The architecture students were required to insert these requirements into their skyscraper design. In addition, the Interior Design students were responsible for developing detailed floor plans, interior elevations and perspectives, and selecting materials, finishes, fixtures and furniture for the Hotel portion of the project. They also acted as Consultants to the architecture students throughout the semester to provide input on space allocation, accessibility and circulation, core and room layouts, materials selection, and color choices. Finally, they shared responsibility with the architecture students for the formal presentation.

Consultants And Field Trips

Besides the usual responsibilities of coaching students on how to achieve their design goals, the studio faculty (Architecture and Interior Design) responded to requests for information and clarifications in much the same way as would representatives for the Developer. Other faculty, who teach structures and controls, agreed to act as engineering consultants. Industry volunteers (Kawneer, Montgomery Elevators, etc.) agreed to cooperate with students as manufacturers' representatives. They lectured, provided technical manuals and analysis, sponsored field trips, and gave the students samples of their products.

A Dallas based architectural firm (HKS) with tall building experience arranged for the students to visit I.M. Pei's Fountain Place, along with two other high-rise projects. Students toured behind the scenes facilities of each. HKS also presented a general overview of tall building design for the students before the site visits. After the tours, HKS was host to a question and answer session. Students then formed discipline specific groups to talk with experienced architects, engineers, interior designers and cost estimators.

Other field trips included visits to the site, to a curtain wall installation under construction, and to a glass supplier's fabrication shop.

Process

Preparation

Throughout the semester prior to this class, faculty and consultants brainstormed and strategize to create a syllabus and to integrate the project into the spring 1995 semester workload. Sabbatical leave for one of the architecture instructors greatly reduced the formal project management component. A standard hypothetical high-rise project was selected for use in this class.

Execution

During the first week of the semester, the Landscape Architects and Architects visited the site. The Interior Designers were teamed with the Architects and began research into plan types for the corporate office space and the hotel. While the Landscape Architects performed their site investigations, the Architects began the first of two intensive design charettes. By the end of the fourth week, they had each completed concept models for two alternative schemes. Meanwhile, the General Contractors formed three teams and began their feasibility estimates based on generic information and assumptions that would yield low, medium, and high results. At the end of the sixth week, they presented their results to the Architects.

Concurrently, the Architects selected the alternative each wished to develop and began work on the core. The Landscape Architects distributed their site report and pulled off to do a project for another "client". Likewise, the Interior Designers were involved with another project, but kept abreast of developments and provided input on their own initiative. During the third week of the semester, Architects, Interior Designers and Contractors made the Dallas field trip to tour skyscrapers and the HKS office.

After the feasibility study presentations, the Architects selected three projects out of the eleven under development that seemed to best represent the low, medium, and high categories. Each designer was to be responsible for maintaining the flow of information to the Contractors so that by week ten a decision could be made as to which of the three would be chosen for the final estimate. As discussed later in this paper, this process did not work as well as had been envisioned by the instructors.

Outside consultants dominated the middle period (weeks 6-12) of the schedule. Montgomery Elevator representatives presented their vertical circulation analysis. Kawneer presented their curtain-wall system and donated technical manuals. A mechanical engineer explained HVAC systems for high-rise buildings. The structures faculty consulted individually with each team. A glass supply house, an authorized Kawneer fabricator and installer, sponsored a construction site visit and donated samples of glass.

Also, during this period, the Landscape Architects reviewed the site development progress once officially, and several more times on their own initiative. The Interior Designers followed a similar pattern of self-initiated work sessions with their respective teams. The greatest burden of responsibility fell on the shoulders of the three teams interfacing with the General Contractors. The instructors had hoped these three teams would take the lead in making choices and documenting their design decisions. Unfortunately, this did not happen which forced the Contractors to select the project for their final estimate based on which team demonstrated the most earnest response to their requests for information and documentation. Even so, a series of deadlines were not met which compromised the optimum learning potential the instructors hoped to achieve.

By the eleventh week, the Interior Designers were back on the Tall Building Project full time. During the twelfth week the Landscape Architects concluded their participation with a group critique of all eleven-site designs. The thirteenth and fourteenth weeks were given over to preparations for the final review. During this period the General Contractors were completing their estimating and scheduling packages for formal presentation at the end of the semester.

The final review was held during the final week of the semester with eleven teams of one Architect and two Interior designers presenting their proposals to a review panel consisting of three practitioners and the two design studio faculty. The General Contractors presented their proposals to the Construction Science instructor, the two design studio faculty and the Architects during their final class session.

Results

Each discipline became much more aware of the various roles, responsibilities, benefits, and constraints of the other disciplines. The architecture students recorded this information and many more aspects in their Project Manuals. The interdependence of each discipline in completing the total project led to a clearer understanding of the need for cooperation. With eleven design teams and three estimating teams working on the same project, differences in the way people learn and at what speeds had to be accommodated. When drawings were incomplete or decisions vague, other disciplines were adversely affected. Peer pressure and the effects of interdependence served to motivate students in a way more characteristic of the work-place environment than the usual classroom setting. Every student who participated learned what it means to work as a team toward shared goals, to perform tasks based upon a schedule, and to effectively deal with the complexities of collaboration through communication and cooperation in an atmosphere of mutual respect.

The tangible products that resulted from this effort were not as impressive as student work in previous years when the team approach across discipline lines was not attempted. As with all explorations, the element of risk is very high and acts as an inhibition to creativity. This effect will surely diminish with repeated attempts and associated refinements. Any project in which four disciplines collaborate requires an enormous amount of extra coordination and planning. The Architecture Design studio instructor assumed the responsibility for these tasks. With repetition, the time required to meet this responsibility effectively will also diminish, freeing the instructor to more actively coach the architecture students to produce more creatively. Because of the inherent complexity in the Tall Building Project and its rarity in the building industry in this country, another building type may be better suited to this kind of team approach. Indeed, it may be more desirable to introduce this type of collaborative learning at an intermediate level in the respective curricula. This would give students a more accurate understanding of how work is accomplished in the professional world and would allow them time to reflect on what skills they need to develop during the balance of their education.

This class was particularly enlightening for the construction class, the Architect and the two Interior Designers whose project was selected by the Contractors for their final conceptual estimate, schedule and formal presentation. With so much of their "profits" (grades) depending upon the work of others, the Contractors soon realized that they were not in control of their own destiny. The final deadline for their presentation could not change, while everything else in between the beginning of the semester and their final presentation could and did slip, leaving them less and less time to accomplish their tasks. With only four weeks remaining in the semester, the Contractors took charge of the entire situation. On their own they sought out the Architects, determined which Team could provide the most information, along with their Interior Designers, and began to schedule meetings and to give the Architects the information required by the Contractors along with deadlines for this information. By the time the contractors had received enough information to accomplish their work, there were only one and one-half weeks left before their final project was due. The Architects and the Interior Designers were amazed at the amount of detail required by the Contractors. Even more amazing to them was the fact that they agreed that the Contractors needed this information in order to prepare budgetary estimates. Much as owners have come to realize, these students came to realize the benefits of alternative project delivery methods that require the various disciplines to work as a team. However, even more importantly, the Contractors, Architects and Interior Designers that were fortunate enough to work together during the final four weeks, began to understand the processes involved, needs, and requirements of the other Disciplines and to understand the interdependence of the various disciplines in the Construction Industry.

Suggested Improvements

This was the Division of Construction Science's first attempt at a multi-disciplinary class. The Architecture Division took the lead in developing this class and in making the necessary arrangements, while Construction Science, Interior Design, and Landscape Architecture brainstormed with Architecture in developing schedules, required field trips and assignments. In order for this class to be of the most benefit for all parties, especially in its relevance to a real world experience, the following improvements need to be implemented.

The project should be much more realistic than a high-rise project. Even the Architects in their discussion with the Contractors felt that a project, which they were more likely to encounter, would have been of greater benefit. Today's students want realism.

All deadlines should be strictly enforced. This is an attempt to emulate a real world experience. In a Team approach such as this, if one Team member falters it creates a chain reaction. When the Architects failed to provide schematic drawings on the required dates all of the other disciplines had to adjust until there was very little time left for them to accomplish their work.

The project should not be based on the standard method of project delivery; i.e., make it a design-build or Construction Management method of delivery in lieu of the standard design, bid, build type of project.

Although this was a graduate class for the Construction Science Division, for the maximum benefit of all participants, consideration should be given to making this an undergraduate class.

Strong consideration should be given to joining with an industry partner on a real-life project. This not only increases the realism of the project but it also strengthens academic and industry relationships. Additionally, students are given added incentive to create a more professional product if they know that industry is involved.

These suggestions, when incorporated into the existing multi-disciplinary class will enhance the learning potential for all students involved.

Conclusion

By bringing together four disciplines, Architecture, Construction, Interiors and Landscape Architecture, and focusing their efforts on a common project, The College of Architecture, is preparing their graduates to better meet the needs of industry. A common project such as the Tall

Building project forced the students to work together to finish their assignments and thus they became aware of the interdependence of each discipline. Additionally, as the students began to understand the roles and responsibilities of each discipline, they realized that by working together, by becoming a team, they could more quickly and efficiently accomplish the assigned tasks. This multi -disciplinary class emphasized the unique requirements and responsibilities of each discipline. Thus, the students also became aware of the importance of effective communication skills and the needs of each discipline. Teamwork, communication skills and understanding the needs and responsibilities of the various disciplines are integral elements to successful project delivery in today's industry. The need for these s kills is more clearly defined in a multi -disciplinary setting and becomes more readily apparent to both students and faculty when they are required to work together. Additionally, by emphasizing these skills through the use of a multi-disciplinary class su ch as the one at this university, students will be better prepared to begin their careers in industry in addition to potentially being more productive and of greater benefit to industry earlier in their careers.

Contributing Reviewers

Dr. Joe Huber, *Indiana State University*
Dr. Mark O. Federle, *Iowa State University*
Mr. Jim Carr, *Ohio State University - Wooster*
Dr. Alex Aswad, *Pennsilvania State - Harrisburg*
Dr. Joseph J Cecere, *Pennsilvania State - Harrisburg*
Dr. Yohchia Chen, *Pennsilvania State - Harrisburg*
Mr. Lin Harley, *Pennsilvania State - Harrisburg*
Mr. D. Perry Achor, *Purdue University - BCM*
Dr. Philip D Udo-Inyang, *Temple University*
Dr. Nancy L. Holland, *Texas A&M University*
Mr. Albert Pedulla, *Texas A&M University*
Dr. David Lickteig, *University of Arkansas - Pine Bluff*
Dr. Michael D. Nobe, *University of Nebraska - Kearney*
Ms. Linda Swoboda, *University of Nebraska - Lincoln*
Mr. Eugene H. Wright, *University of Nebraska - Lincoln*
Mr. David A Marchman, *University of Southern Mississippi*

Acknowledgement

The Editor wishes to thank the Department of Industrial Technology and the College of Applied Science and Technology of Illinois State University for their support of the *Journal* creation and operations. Thanks are also due to the Editorial Advisory Board whose names appear on the second page; and to those serving on the Review Board listed above.

Membership Applications

Inquiries should be send to: Associated Schools of Construction, Hendrick D. Mol., Executive Director, Building Science Department, 119 Dudley Hall, Auburn University, Auburn, AL 36849 -5315, Tel: 334.844.4518, E-mail: molhend@mail.auburn.edu

Organizations eligible for membership may fill out one of the application f orms at: (http://ascweb.org). Please read the following membership grouping information, pick or enter the hyperlink into your web browser for the type of membership that fits your organization and submit the completed for m.

- Institutional Members: shall be those institutions having at least one baccalaureate or higher degree construction program. Annual member dues are $400.00.
- Associate Members: shall be institutions of higher education, including junior and community col leges, not meeting institutional member requirements (two year programs). Annual member dues are $250.00.
- Industrial Members: shall be industrial organizations demonstrating a constructive interest in construction education. Annual member dues are $400.00 base membership or $650, which includes $250 for advertising industry, positions on the ASC web site. This service (http://ascweb.org/internet/positions/industry/main.asp) includes full-time, part-time, summer internship, and co -op program listings.

National Office Staff

Executive Director
Mr. Hendrick D. Mol
Auburn University
Tel: 334.844.4518
E-mail: molhend@mail.auburn.edu

Webmaster
Dr. K. C. Williamson III
Illinois State University
Tel: 309.438. 2633
E-mail: kcwilli@ilstu.edu

Journal Editor/Publisher
Dr. K. C. Williamson III
Illinois State University
Tel: 309.438. 2633
E-mail: kcwilli@ilstu.edu

Proceedings Editor/Publisher
Mr. Dale J. Koehler
Purdue University
Tel: 765.494.2457
E-mail: djkoehler@tech.purdue.edu

Officers 1996-1997

President
Mr. Bill McManus
University of Oklahoma
Tel: 405.325.6404
E-mail: bill-mcmanus@ou.edu

First Vice President
Mr. John Mouton
Auburn University
Tel: 334.844.4518
E-mail: moutojo@mail.auburn.edu

First Past President
Dr. Larry Grosse
Colorado State University
Tel: 970.491.7958
E-mail: drfire107@aol.com

Secretary/Treasurer
Dr. Larry Grosse
Colorado State University
Tel: 970.491.7958
E-mail: drfire107@aol.com

Assistant Secretary Treasurer
Mr. F. Eugene Rebholz
Bradley University
Tel: 309.677.2942
E-mail: fer@bradley.edu

Directors 1996-1997

Northeast Director
Mr. Joseph F. Keuler
State University of New York/ESF
Tel: 315.470.6834
E-mail: jfkeuler@mailbox.syr.edu

Southeast Director
Dr. Arlan Toy
Southern Polytechnic State University
Tel: 770.528.7221
E-mail: gtoy@spsu.edu

Great Lakes Director
Mr. L. Travis Chapin
Bowling Green State University
Tel: 419.372.2837
E-mail: tchapin@bgnet.bgsu.edu

North Central Director
Mr. Eugene H. Wright
University of Nebraska – Lincoln
Tel: 402.472.3739
E-mail: ewright@unlinfo.unl.edu

South Central Director
Mr. Kenneth F. Robson
University of Oklahoma
Tel: 405.325.6404
E-mail: krobson@ou.edu

Far West Director
Mr. James A Rodger
California Polytechnic State University
Tel: 805.756.1323
E-mail: jrodger@calpoly.edu