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Curriculum Development and Continuing Education in Project Management for the Specialty Subcontracting Industry

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The construction industry possesses no dearth of training programs, and academia is seldom reluctant to offer its services when called upon to assist in developing educational programs for industry. Often, though, academia is unaware of the specific and separate training needs of the non-general-contracting members of the contracting community, as well as being unaware of the opportunities that lie therein. Further, most industry training programs are terminal in nature, failing to measure success in terms of the financial impact to the firms sponsoring the students. Finally, as is possible with any curriculum, many industry training programs become stagnant and dated over time because of a failure to view industry training as a highly dynamic process which must be prepared to change rapidly with changes in technology, information, and resources. The following case is a study in partnering to achieve the goals of trade-specific project management training, measurability of success, and accountability in industry education programs among the National Association of Plumbing-Heating-Cooling Contractors and a large Northeastern university.

Key Words: Continuing Education, Industry Training Programs, Partnering, Subcontractor Training Program, Trade-specific Project Management Training

Introduction

The Curriculum Committee of the National Association of Plumbing-Heating-Cooling Contractors (NAPHCC) Education Foundation agreed in the spring of 1995 to pursue implementing a Project Management course for contractor members' employees. The original intent was to provide on-site courses at a selected university, and a continuing education program in the form of a home study course. To that end, they selected five universities as potential candidates and mailed them an initial Request For Proposal (RFP) form. The universities initially queried were Purdue University, Arizona State University, Pennsylvania State University, Kutztown University of Pennsylvania, and the University of Florida. Only three elected to respond: Purdue, Arizona State, and Penn State. At the NAPHCC meeting in Minneapolis on June 7, 1995, Purdue University and Arizona State were selected as finalists.

Based upon discussions at the Minneapolis meeting, a consensus was reached regarding sending the two finalists a revised RFP which expanded the set of guidelines to be addressed in the final proposals. Both universities responded expeditiously, and an NAPHCC Task Force was created to visit both facilities. Prior to these campus visits, all NAPHCC Curriculum Committee

members received copies of the final proposals and were asked to submit written comments to be used during the on-site evaluations.

The Task Force visited this university on August 22, 1995, and Arizona State on August 29, 1995. Since both universities indicated that preparing a home-study course prior to the start of the in-residence portion of the program (as called for in the Revised RFP) would delay the start of the program until Fall 1996, it was decided by the Task Force to restructure the program requirements of the Revised RFP as follows:

- ?? Self Examination and Evaluation by Employer for participant inclusion to initial class to be held in Early 1996.
- ?? Intensive on-campus instruction and team participation for 24 (maximum) attendees. Minimum of one-week course instruction, with follow-up, evaluation, and inclusion of a continuing education component post-instruction. The consensus of the Task Force was that, with the amount of initial course study, two weeks of on-campus instruction would be required, and that the best format to follow would be two one-week in-residence sessions separated by 3-4 months.
- ?? Continuing education program with inclusion of a Project Management Reference Manual, updated annually (mid-September).

Using these guidelines, both schools provided tours of their facilities, introduced faculty and staff members, and discussed their proposals including proposed budgets.

On August 30, 1995 the Department of Building Construction and Contracting was notified that it had been selected as the successful candidate, and was awarded a letter of intent.

Following the award, and to maintain the momentum of the process, a Foundation Project Management Techniques Symposium was scheduled and held at the Falls Church, Virginia, NAPHCC headquarters September 29 - October, 1, 1995. The Foundation provided an independent facilitator to lead the conference of a representative group of NAPHCC Contractor chief executive officers and chief operating officers (CEOs/COOs), and key selected personnel from the university. The purposes of the symposium were to brainstorm course topics and identify the format and content of the course of study and the course manual.

At that meeting, the Board of Governors agreed to utilize the partnering process to specifically design and implement a program of instruction to aid, assist, and upgrade the plumbing, heating, and cooling contracting industry in the area of the Process of Project Management. The collaboration of contractors and educators committed themselves to provide an intensive course of study to include the following proposed approach:

- ?? 80 hours of on-campus instruction comprised of two, 40-hour sessions (Mid-February 1996 and May 1996)-- each consisting of 16 modules of instruction (Appendix A)
- ?? Project Management reference manual/text (available September 1996)

Serving the Needs of the Non-General Contracting Members of the Contracting Community

The National Association of Plumbing-Heating-Cooling Contractors (NAPHCC) Association has over three thousand members and takes a proactive approach to improving the knowledge and quality of their industry. They have a well-funded Education Foundation and a long-term commitment to both their members and their industry. They are committed to industry education for the following reasons:

1. Education has a positive financial impact on the bottom line. See Table 1 for an example of an abbreviated sample financial statement for a PHCC contractor indicating the economic impact of an effective training program.
2. On-the-job training has its merits, but distractions and responsibilities limit the ability of employees to learn new techniques in their everyday work environment.
3. Today's clients expect continuous employee education of all employees
4. Long-term employee productivity is enhanced through education in spite of short-term productivity losses incurred during off-site educational experiences.
5. If contractors don't train their employees, their competition will.
6. Changing industry technology, business methods, and customer demands mean that contractors must consider continuous training as a part of doing business.
7. Managers of Projects are responsible for most of the costs of a construction project and will benefit most from effective training.
8. Training managers during slow times prepares both the employees and the company for the inevitable upturn in the business cycle.
9. Training managers during busy times provides instant feedback on new techniques learned during a training program.
10. Not providing training for managers is too expensive in a construction climate with thin profit margins, increased competition, and reduced opportunities for additional work. The cost of rework on one job could easily amount to ten times the cost of a full training program.

Role of Construction Academia as Partners with Specialty Contractors

Partnering can be described as the conducting of a cooperative enterprise between two or more parties dedicated to achieving a common goal for mutual benefit with a minimum of dispute and conflict. Benefits of partnering include improved efficiency and cost effectiveness, improved communications, timely problem identification and resolution, improved scheduling, better relationships, increased opportunity for innovation, and improvement of products and services. The underlying hallmarks of this relationship are trust, cooperation, teamwork, shared vision, and the attainment of mutual objectives. It is a change of attitude rather than a formally contractual agreement that characterizes partnering.

For academia, preparation for designing a curriculum for industry education programs rather than college programs requires learning as quickly and as inexpensively as possible about the precise nature of industry customer demand, the suitability of the new curricula or delivery concept, and determining the necessary adjustments in market strategy from academia to

industry. These objectives can be accomplished by involving key industry customers early in the development phase, by regularly testing appropriateness and effectiveness of training techniques with customers in small-scale experiments, and by working with a partner to gain insights into a new and unfamiliar class of customers.

NAPHCC and this university have undertaken this type of partnering process that provides a new value creation model for construction educators. Whereas most construction education programs extant have created value in being directed towards educating future employees of general contracting firms, the NAPHCC and this university partnership has created value by entering into a joint venture to create *appropriate and specific* education for managers in their industry in a climate where *demand* for continuous education is high, and where the *availability* of high-quality construction education specifically oriented to Specialty Contractors is scarce (Figure 1).

Table 1

Abbreviated sample financial statement for a PHCC contractor indicating the economic impact of an effective training program

Abbreviated Sample Financial Statement for an NAPHCC Contractor			
Revenue (Annual Sales)	\$15,000,000		
Direct Costs:		% of Annual Sales	
Material	\$5,250,000	35%	
Labor	\$4,050,000	27%	
Subcontractors	\$1,500,000	10%	
Other Direct Costs	\$600,000	4%	
Total Direct Costs	\$11,400,000	76%	
Gross Profit	\$3,600,000	24%	
Overhead	\$3,300,000	22%	
NET PROFIT PRE-TAX	\$300,000	2%	
Assume 5% increase in productivity through an effective training program.			
Labor Savings	\$202,000		
Payroll/Ins. Savings (20%)	\$40,500		
New Profit	\$543,000	or 3.62%	
% Profit Increase		81%	
The Net Result of this example would have the SAME EFFECT as increasing sales by \$12,150,000!			

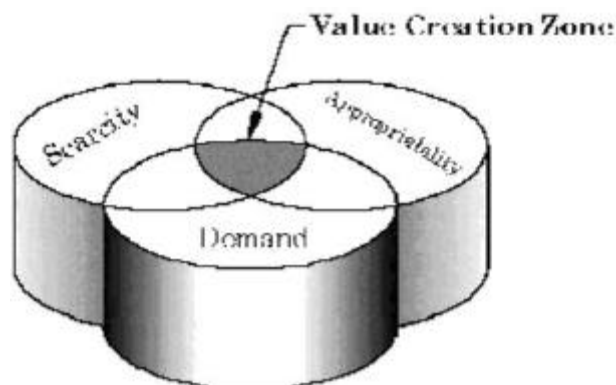


Figure 1. What makes construction education valuable to specialty contractors?

This value creation model reaps rewards for both the specialty contracting industry and the construction academia. The foresight of the NAPHCC will not only lead to better educated employees who will help to improve the financial returns on their firms' investments in human capital, but will also help to build a better educated plumbing, heating, and cooling industry, and lessen the number of contractors doing business at unacceptable margins. For construction educators, the rewards include a new target market where demand for education, instructional materials, and research is high, and opportunities for funded research are highly probable.

Mitigating the Terminal Nature of Training Programs

There are several training programs currently in existence that offer project management education to individuals employed in the construction industry. The Associated General Contractors (AGC) offer a *Construction Project Manager Course*; the Associated Builders and Contractors, Inc. (ABC) through their academy approach, offer project management training; the National Association of Home Builders (NAHB) offers a *Graduate Builders Institute*, and the Mechanical Contractors Association of America, Inc. (MCAA), through their Institute for Project Management, offers a *Managing for Profit* program oriented towards teaching project management skills to mechanical project managers.

While not exhaustive, the list of programs above is representative of the educational opportunities for project management training for industry available today. Certainly there are differences in these and other project management programs, yet for the most part, each of these programs utilizes similar pedagogical approaches. They are usually offered as intensive one-week sessions, with the MCAA program offered as two, one-week sessions held several months apart to "make the course easy on your project schedule." Generally, the course structure in these programs is topically organized, is taught by multiple instructors, and bears the risk of presenting project management as a series of steps (or topics) to master rather than as an integrated process which is constantly in flux.

The experiential learning model of Kolb provides us with a framework for examining the current project management approach, and suggests ways in which greater success in project management courses may be achieved. Kolb has postulated that learning involves a cycle of four processes, each of which must be present for learning to occur most completely (see Figure 3).

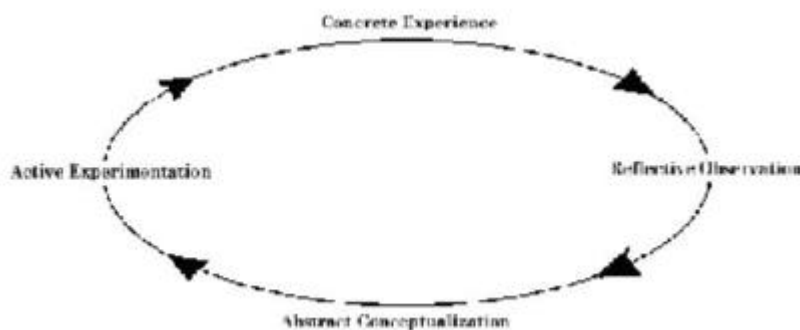


Figure 2. The Experiential (Kolb) Learning Cycle

First, the cycle begins with Concrete Experience, the learner's personal involvement in a specific experience. In the case of individuals employed in the construction industry who are sent to project management seminars, this is their existing knowledge about the project management and construction process.

Second, the learner reflects (Reflective Observation) on this personal involvement in a specific experience from many viewpoints, seeking to find its meaning. CEOs/COOs of construction companies typically tend to send only those employees who show some promise of future success to these not inexpensive programs that seems to suggest that the learner has already reflected to some degree upon the project management process.

Third, out of this reflection, the learner draws logical conclusions (Abstract Conceptualization), and may add to his or her own conclusions the theoretical constructs of others. This is where existing project management programs begin, instructing the learner using lectures, papers, case studies, projects, and assignments in very brief but intensive training sessions (see Figure 4). Finally, the conclusions and constructs gained by the learner in the third stage (Abstract Conceptualization) guide decisions and actions (Active Experimentation) that lead to new concrete experiences. This is the goal of both the CEOs/COOs and the instructional entities that newly educated individuals will take what they have learned in the classroom back to the workplace and apply it.

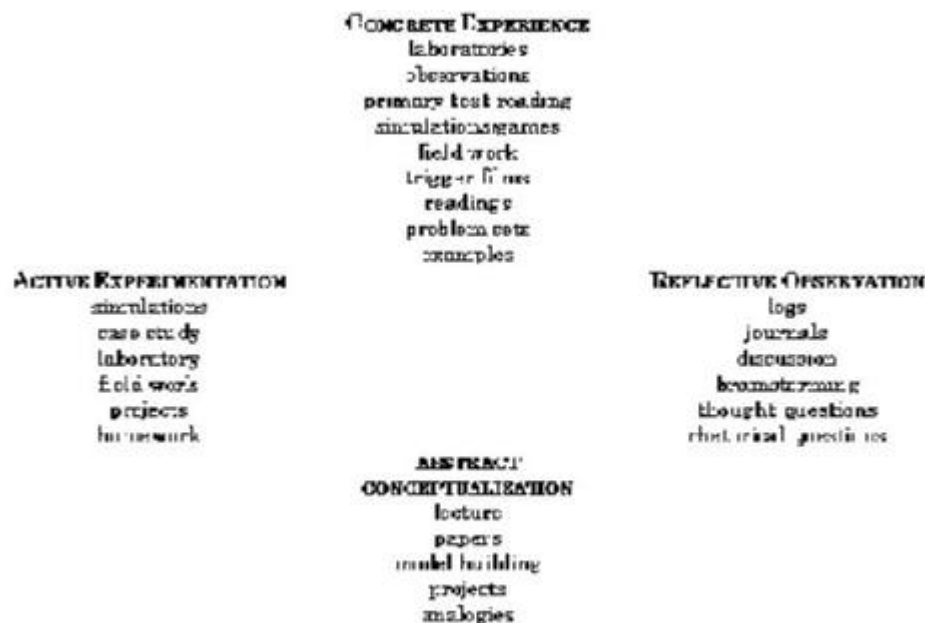


Figure 4. Instructional activities that may support various aspects of the learning cycle

Problems arise, however, when training programs truncate at the end of Stage Four (Active Experimentation), because even if the knowledge conveyed during the third stage (Abstract Conceptualization) was fully understood, and the learner eagerly committed to taking the learned material back to the workplace and implementing change into the project management process

(Active Experimentation to Concrete Experience), usually success will be minimal without a specific and directed mechanism to force the application of newly acquired knowledge. Much, if not most, of the gained knowledge will be lost rapidly as a result of a compressed instructional delivery design.

While compressed course schedule design may be inviolate due to the nature of both the industry and the student, greater retention of the fundamental concepts and practices may be accomplished by modifying the instructional approach to present a cross-curricular, thematic approach to educating the learner in the process of project management when accompanied by applications which lead to a second revolution around the Experiential Learning Cycle. Additionally, if such applications are accompanied by mandatory reporting, follow-up, and a demonstration of economic value added for a period of one year post-completion of the training, then greater success may be achieved.

The NAPHCC and this university joint venture includes a major emphasis on the application phase, which forces the learner to make the transition from Active Experimentation to Concrete Experience, and to report to both employer and educational consultant at this university on the economic value that the learner is personally adding to the firm's effort as a result of newly gained knowledge.

Measuring Program Success

In the long run, the NAPHCC this university program will be a success if the contractor members who send students to the program gain improved economic results in real terms on those projects that are managed by individuals who have graduated from the program. Integrated application assignments created to provide every individual with at least one useable tool, method, or technique that the individual may directly apply and put to use immediately in the company is a critical element of the program. Application assignments occur during the inter-session between the two in-residence sessions, and post-completion of the second in-residence.

The first application assignment is returned, evaluated, and measured for economic impact by the student, the educational consultant, and the CEO or COO who enrolled the student. If because of the nature of the individual's job, or the firm's financial reporting system, the student is unable to report actual economic value added, the student will be required to make an accurate projection of *expected value added* in the near future. This projection will be evaluated by both the educational consultant and the CEO/COO of the partner firm to assess the expected accuracy of the projection.

The second application assignment is monitored and evaluated on a quarterly basis for the period of one year post-completion of the program by the student, the educational consultant, and the CEO/COO, with site visits and consultation by the instructor as needed by the firm to demonstrate and substantiate real economic value added. If after one year, the CEO/COO of the firm cannot readily attribute specific economic gains to the knowledge or processes gained by the student in the program, the program will have failed for that firm.

Methods for Keeping Industry Education Programs Current

One of the most severe criticisms by the NAPHCC of existing programs, and impetus for choosing to sponsor the development of a training program specific to their needs, originated from their perception that over time, existing programs become stagnant, outdated, and outmoded. They attributed this to a lack of an institutionalized and methodical approach to constantly monitoring, evaluating, and revising the programs. With the rapidly evolving technology changes in software, communications, and information collection and management, it was felt that industry education programs must constantly change in order to meet the needs of a dynamically changing business environment.

To that end, they have institutionalized several mechanisms to ensure that their program stays not only current, but on the cutting edge of the industry.

First, they have created a formal Audit Committee that will continuously monitor NAPHCC and this university program efficacy. This committee will enroll at least four members in every class, and will provide feedback to both the industry and educational entities.

Second, each instructional module development and maintenance team will be composed of both educators and industry leaders. This composition is intended to create an environment whereby changes in industry practices or requirements are rapidly incorporated into the curriculum.

Finally, the application and economic evaluation methodologies will provide constant feedback of the effectiveness of the educational experience, and act as a trigger-point in bringing the program back on target if required.

Conclusion

As changes in technology, information management, and resource allocation provide opportunities and challenges for specialty contractors in the construction industry, the role of educators as partners with industry becomes crucial. While most, if not all, of the topics of construction project management are similar regardless of the type of construction performed by a firm, it is important that educators be able to provide industry training programs which are designed specifically for subcontractors and specialty contractors. The lens through which subcontractors and specialty contractors view the construction process is significantly different than that of the general contractors. This, coupled with the fact that subcontractors perform close to 90 percent of all construction labor on projects today, gives one pause when contemplating that most project management programs are oriented towards general contractors.

The pedagogy of intensive training over short intervals is also troublesome, and should lead educators to find appropriate methodologies to compensate for the apparent necessity for condensed class time. Some methods examined herein included collaboration with industry to develop educational goals and objectives, systematic measurement of actual economic results of the training, accountability of all parties including students, educators, and CEOs/COOs, and the

implementation of multiple application phases to foster the transition from Active Experimentation to Concrete Experience.

Recommendation

Considering that students in the program will be entering with various and diverse skill levels, a recommendation is to take advantage of the notion of "contractor-to-contractor" education and produce a pre-session Skills Assessment Form. This form would gauge the levels of experience and expertise of the incoming students in the areas of computer literacy, formal education, age, trade experience, management experience, office experience, industry experience, primary focus of firm, job title, and size of the organization in volume, in order to develop heterogeneous work teams who will learn from each other, and compensate as a team for individual weaknesses.

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Appendix

Project Management Course Modules

Course Module 0 Course Introduction

(Estimated Instruction Time: 1.5 hours)

- Quality
- Planning
- Marketability
- Profitability
- Safety
- Technology
- Construction as a Process not a Product

Course Module 1 Business Management/Quality/Pre-Planning

(Estimated Instruction Time: 4 - 8 hours)

- Continuous Improvement Process
- Quality Assurance
- Quality Control
- Managing Uncertainty
- Business Failures
- Managing Change in the Organization
- Delegation
- Problem Solving & Decision Making
- Mastering Financial Statements

FOCUS ON TECHNOLOGY:

- Computerized Labor Tracking & Analysis

Course Module 2 Marketing

(Estimated Instruction Time: 1 - 2 hours)

- Proposal & Scope
- "Redlines", Design & Engineering
- Conceptual Estimating
- Design Team Liaison
- Manager Marketing - Controlling the Client, Selling Changes & Enforcing Contracts While Retaining the Good will and Confidence of the Client (*NOTE: Suggest 1 hour course time dedicated to this topic)

FOCUS ON TECHNOLOGY:

- New Markets - Using Technology to Capture Work and Increase Margins

Course Module 3 Mechanical Estimating in the 21st Century

(Estimated Instruction Time: 8 - 12 hours)

- Estimate Analysis (*NOTE: Suggest "Homework"/Personal Time)
- Overtime & Delay Impact
- Computers & Digitizers
- "It's Not a Takeoff! It's an Estimate!"
- Margin Analysis
- Bid Estimating Summary & "What if" scenarios
- Estimating Forms
- Estimate Review
- Takeoff Sheets & Audit Trail Data

FOCUS ON TECHNOLOGY:

- Digitizers
- Computerized Estimate Analysis
- Building a Computerized Historical Database

Course Module 4 Contracts/Claims/Construction Law

(Estimated Instruction Time: 4 - 8 hours)

- Guidelines for Contract Review
- Sales Proposal

- Scope of Work
- Contract Documents
- Contract Review
- Changes
- Scheduling
- Termination
- Liquidated Damages
- Warranty
- Construction Law Case Studies
- Avoiding Claims
- Request for Equitable Adjustment
- Claimable Cost Items
- Calculating the Amount of the Claim
- Preparing the Claim
- Different Methods of Resolving a Claim
- Bidding Private Work
- Bidding Public Work
- Breach of Contract by Owner
- Mechanic's Liens, Stop Notice, Payment Bond
- Litigation or Arbitration
- Labor & Cost Control

Course Module 5 Pre-Construction Planning and Profitability

(Estimated Instruction Time: 8 - 12 hours)

- General Contractor Qualifications
- Document Review
- Re-Estimates
- Shop-Drawings/CAD Awareness
- Project Team
- General Contractor Liaison Coordination
- Reimbursable Costs
- Scheduling for Maximum Productivity & Profit
- Partnering
- Pre-Fabs

FOCUS ON TECHNOLOGY:

- Computerized Scheduling
- Computerized Spreadsheet Analysis
- CAD for Mechanical Contractors

Course Module 6 Construction Plan

(Estimated Instruction Time: 6 - 10 hours)

- Project Turnover
- Preliminary Meeting
- Computerized Optimal Scheduling
- Materials Handling Plan & Expediting
- Construction Plan
- Construction Plan Format
- Construction Plan Meeting
- Commissioning Plan
- Schedule of Values & Front-loading

FOCUS ON TECHNOLOGY:

- Commissioning & the Mechanical Contractor
- Computerized Front-loading & SOV
- Using Historical Database to Predict Material Costs & Productivity

Course Module 7 Project Control

(Estimated Instruction Time: 20 - 24 hours)

- Communications
- Mobilizations

- Site Planning
- Staffing
- Labor Feedback
- Manpower Loading
- Schedule
- Spreadsheet & Other Computerized Management Techniques
- Tracking Equipment & Materials
- Computerized Schedule Updating & Maintenance - A Guide to Changes
- Short Interval Scheduling
- Managing Productivity
- Project Accounting
- Managing Cash Flow
- Forecasting
- Project Meetings
- Job Walks
- Project Safety & Controlling Workmen's Compensation
- General Contractor Control
- Change Order Procedures
- Conflict Management & The Art of Negotiating
- Managing the Labor Agreement: Two-gate Projects, Strikes, Crew-Mixes, and Optimizing Labor

FOCUS ON TECHNOLOGY:

- Computerized Scheduling & Adjustment
- Spreadsheet Analysis & Forecasting
- Cost Tracking with Computers

Course Module 8 Project Records

(Estimated Instruction Time: 4 hours)

- Tracking Costs
- Cost Control Logs
- Change Order Logs
- Purchase Order Logs
- Submittal/Delivery Logs
- Construction Schedule
- Construction Photographs & Videos
- Telephone Conversation Record
- Letter of Transmittal
- Project File Categories

FOCUS ON TECHNOLOGY:

- Using Integrated Project Management Software to Achieve a Well Documented Project

Course Module 9 Purchasing/Vendors

(Estimated Instruction Time: 2 hours)

- Purchasing Policies & Ethical Procedures
- Buyouts
- Purchase Order System
- Changing P.O.'s After Issuance
- Submittal Data Review
- Receiving
- Shop Receiving
- Job-site Receiving
- Bar-coding

FOCUS ON TECHNOLOGY:

- Bar-Coding
- Computerized Purchasing Control

Course Module 10 Subcontractor Management

(Estimated Instruction Time 2 - 4 hours)

- Subcontract Release
- Subcontract Billing

- On-site Management of Subcontractors
- Subcontract Change Orders
- Deductive Change Orders/Back Changes
- Subcontract Termination

Course Module 11 Fab Shops/Field and Warehouse

(Estimated Instruction Time 4 - 8 hours)

- Standardization of Fabrication & Installation Methods for Maximum Productivity
- Shop Construction Standards
- Field Construction Standards
- Spool Sheets
- Pre-Fab & Productivity
- Deliveries

FOCUS ON TECHNOLOGY:

- Spooling on CAD

Course Module 12 Personnel/Motivation/Leadership

(Estimated Instruction Time 8 - 12 hours)

- Hiring Procedure
- Alcohol/Substance Abuse
- New Employee Orientation
- Motivation & Leadership
- Management Styles
- Team Building & Team Dynamics
- Time Management

FOCUS ON TECHNOLOGY:

- Personality Profiles & Team Building

Course Module 13 Job Close-out

(Estimated Instruction Time 4 - 8 hours)

- Commissioning
- Start, Text & Balance
- Demobilization
- Final Payment
- Warranty
- Achieving Documentation

FOCUS ON TECHNOLOGY:

- Commissioning
- Archiving on CD-ROM

Course Module 14 Post-Job Analysis

(Estimated Instruction Time 4 - 8 hours)

- Formal Customer Interview by 3rd Party
- Post-Feedback Meeting
- Leap-frogging Completed Project to New Work
- Use Your Database to Make Decisions About Future Projects
- Feedback for Estimating
- Service After the Sale
- Service Agreements

FOCUS ON TECHNOLOGY:

- Computerized Database Building & Manipulation

Course Module 15 - Focus on Emerging Technology

(Estimated Instruction Time 4 - 6 hours)

- Maximizing Profit by Staying Current
- Computers
- Spreadsheets
- Digitizers
- Bar-Coding
- Multi-Media Presentations
- Photos & Videos

Improving an Existing Course in Mechanical Construction

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The Building Construction and Contracting Department required information for the development and improvement of its only required course in mechanical construction. A multi-part study was conducted to collect this information from students, placement records, construction educators, and construction industry professionals. Student career interests, and the department's last six years of placement records were studied to determine the area of industry focus for the class. Construction educators and construction industry professionals were surveyed to determine the importance of existing course topics, and to identify important course topics, which are not being covered in the class. The study indicates that the majority of students in the class are interested in general construction and construction management, and that the majority of graduates over the past six years have found employment with general construction and construction management firms. In addition, the study identifies scheduling and coordination as the only two topics which appear within the five most important topics of both construction educators and construction industry professionals. This paper provides results of the study and serves as a resource to other educators who are currently modifying their course in mechanical construction.

Key Words: Mechanical Construction, General Construction, Construction Management, Teaching, Survey, Graduates

Introduction

Depending upon the type of structure, the mechanical portion of a construction project is often a significant percentage of the total project cost. Because of this significance, it is imperative that we adequately educate our students in the area of mechanical construction. In Fall 1994, in a continuing effort to provide quality mechanical construction education, our department initiated the process of reviewing its only required course in mechanical construction to determine the most applicable topics and the overall course perspective.

The required course, BC 334 Mechanical Construction, is a three credit hour course and is taught each semester to approximately 50 to 70 students. It is an introductory course that provides a limited overview and exposure of the mechanical construction process. Course topics and expected outcomes are illustrated in Figures 1 and 2. In our efforts to improve the course, we established two objectives for the study. Our first objective was to determine the most important course topics. The second objective was to determine if our assumption on the course perspective was correct--that the course should be taught from the perspective of the general contractor/construction manager (GC/CM) rather than from the mechanical contractor.

We expected that the results of the studies would indicate the important topics to be scheduling, coordination, plan and specification interpretation, basic terminology, and methods and

materials, because they are more applicable to the perspective of a GC/CM. The perspective of the GC/CM is managing the mechanical construction work that is being performed by a subcontractor. The perspective of the mechanical contractor is one of a much higher proficiency that involves the actual performance of the work. We believed that the course should be taught from the general construction/construction manager perspective because it appeared that the majority of BC graduates have traditionally obtained such positions. According to the BC faculty "elders," the majority of our alumni over the past 25 years have traditionally entered the fields of general construction and construction management.

Table 1

BC 334 Mechanical Construction Topic Areas of Exposure

The student will be exposed to the following ten topic areas of mechanical construction:

1. The mechanical scope of work for a building construction project
2. Interpreting mechanical drawings and specifications
3. Application and quantity takeoff of piping, fittings, valves, and hangers
4. Basic plumbing codes and design principles
5. Various HVAC equipment and system configurations
6. Components and typical system configurations of hydronic systems
7. Basic ductwork methods and materials
8. Rectangular ductwork quantity takeoff
9. Computerized mechanical estimating
10. Career opportunities in mechanical construction

Table 2

BC 334 Mechanical Construction's Ten Expected Outcomes

Upon successful completion of the course, the student should have the skills to complete the following ten items:

1. Interpret and comprehend mechanical drawings and specifications
2. Explain and use the basic terminology of mechanical construction
3. Identify and describe the major components of plumbing, hydronic, and HVAC systems
4. Identify, describe, and apply the most common piping methods and materials used in mechanical construction
5. Perform a simple plumbing piping quantity takeoff
6. Perform a simple rectangular ductwork quantity takeoff
7. Perform a simple hydraulic piping quantity takeoff
8. List common coordination and scope of work problems encountered by the mechanical contractor
9. Describe the "typical" organization of a mechanical construction firm
10. Describe potential career opportunities in mechanical construction

Method

The study was conducted in four distinctive parts.

Part One

In fall 1994, eight construction educators at the ASC Region III Regional Meeting were surveyed to obtain their opinions regarding the most important topics to be taught in a mechanical

construction course. A roundtable presentation (Koontz, 1994) was conducted to state the problem to the audience who then provided verbal feedback and completed a survey instrument (see Appendix A).

Part Two

In Spring 1995, resulting from the input provided by the construction educators in Fall 1994, a telephone survey was conducted of construction industry professionals to collect their opinions regarding what should be taught in a mechanical construction course. Forty-one survey participants were selected randomly from among BC alumni who work for general contracting or construction management firms. These randomly selected alumni were chosen specifically from general contracting or construction management firms because at this point it was hypothesized that the general contracting or construction management firms typically employ the majority of BC graduates. The average industry experience was eight years. Alumni graduation dates ranged from the years 1975 to 1994.

A survey instrument was developed (Appendix B) that included a list of twenty-four topics which required a rating of DK for don't know or no opinion, or a rating of 1 through 5 for not important through *important*. The instrument topics were created from the course syllabus for BC 334 Mechanical Construction, and from telephone interviews with four alumni who are employed by three Lafayette, Indiana, general contractors.

Part Three

In Fall 1995, an informal poll of students enrolled in BC 334 was conducted to determine the number of students interested in careers in General Contractor/CM, Residential, Mechanical/Industrial, Electrical, Heavy Highway/Excavating, Government/Municipal, Lumber/Building Materials, and Other (Figure 3). It was believed that this informal study of student career interests, although relatively insignificant, would help to develop the course perspective.

Part Four

In fall 1995, 448 BC department student placement records from 1990-1995 were studied to identify types of entry-level positions obtained by BC graduates. Entry-level positions were identified as General Contractor/CM, Residential, Mechanical/Industrial, Electrical, Heavy Highway/Excavating, Government/Municipal, Lumber/Building Materials, and Other (Figure 4). It was believed that this study would support or refute the hypothesis that the majority of our students are typically employed by general construction or construction management firms, thereby determining the perspective of course instruction. Should the course be from the perspective of future mechanical contractors, or from the perspective of future general contractors/construction managers?

Results

The first part of the study was the collection of opinions from the eight construction educators at the ASC Region III Regional Meeting. The educators were asked their opinions on the importance of 17 mechanical construction topics. They were asked to assign a value from 1 to 10 for each topic with 1 = unnecessary and 10 = mandatory. The mean ratings for the top 15 topics are presented in Figure 3.

Upon review of the data from the two surveys, illustrated in Figures 3 and 4, two observations of interest can be made. Industry professionals rated scope of work issues as the most important topic (#1), while educators, on the other hand, rated scope of work issues as the least important topic (#15). Industry rated piping materials as a relatively unimportant topic (#13), and educators rated piping materials as their most important topic (#1). Both topics, scope of work issues and piping materials, indicate a strong difference of opinion between industry and educators. The results of the second part of the study regarding the telephone survey of 41 industry professionals are represented in Figure 4. The results of the third part of the study, the Fall 1995 semester informal poll of student career interests, is displayed in Figure 5. The results of the fourth part of the study, as illustrated in Figure 6, consisted of a study of 448 BC graduate records regarding entry-level placement between the years of 1990 and 1995.

Discussion

Course Topics

Regarding our first objective, important course topics, we had expected that the results of the studies would indicate the five most important topics to be scheduling, coordination, plan and specification interpretation, basic terminology, and methods and materials, because they are more applicable to the perspective of a GC/CM.

Of the top five items in each list, only scheduling and coordination appear to be important mechanical construction topics to both educators and industry. Educators ranked scheduling as their second most important topic, and coordination as their third most important topic. Industry ranked coordination as #3 and scheduling as #4. Though considered to be an important item to both educators and industry, scheduling has not been covered in the BC 334 Mechanical Construction course. Coordination, on the other hand, has been taught and will continue to be taught in the course.

Regarding the remaining three items of the top five items, educators listed: #1 Piping Materials and Methods, #4 HVAC Equipment, and #5 Plumbing Systems. Industry, on the other hand, listed as the remaining 3 items of the top five items: #1 General Contractor/Mechanical Contractor Scope of Work Issues, #2 Mechanical Construction Terminology, and #5 Mechanical Shop Drawing Review and Understanding. Though those three items of the top five items were not the same for both educators and industry, all of the top five items listed for both educators and industry have been and continue to be taught in the course, with the exception of #5 Mechanical Shop Drawing Review and Understanding.

Table 3

ASC Region III Educator Mean Topic Ratings

Item Number	Topic	Mean Rating
1.	Piping Methods and Materials	7.88
2.	Scheduling	7.88
3.	Coordination Between Trades	7.88
4.	HVAC Equipment	7.50
5.	Plumbing Systems	7.39
6.	Labor and Material Costs	7.25
7.	Ductwork Systems	6.88
8.	Basic Code Requirements	6.75
9.	Plan and Specification Competency	6.63
10.	Fire Protection Systems	6.63
11.	Equipment Applications	6.63
12.	Hydronic Systems	6.00
13.	Basic Design Concepts	5.88
14.	Shop Drawings/Submittals	5.50
15.	Scope of Work Issues	5.38

Table 4

Industry Mean Topic Ratings

Item Number	Topic	Mean Rating
1.	General contractor/mechanical contractor scope of work issues	4.46
2.	Mechanical construction terminology	4.15
3.	Mechanical construction coordination issues	4.05
4.	Scheduling mechanical construction	3.95
5.	Mechanical shop drawing review and understanding	3.90
6.	Plumbing blueprint reading	3.76
7.	HVAC piping blueprint reading	3.63
8.	Sheet metal/ductwork blueprint reading	3.51
9.	Mechanical billings/schedule of values preparation	3.44
10.	Fire protection system types and applications	3.39
11.	Understanding basic mechanical code	3.34
12.	Basic principles of temperature control systems	3.32
13.	Recognition and application of various types of piping, valves, fittings, and hangers	3.24
14.	Understanding basic plumbing code	3.22
15.	HVAC equipment types and applications	3.05

Table 5

Career Interest of BC 334 Students, Fall 1995

BC 334 Student Career Interest, Fall 1995	
General Contractor/CM	56%
Residential	23%
Mechanical/Industrial	5%
Electrical	4%
Heavy Highway/Excavating	5%
Government/Municipal	0%
Lumber/Building Materials	0%
Other	7%

Table 6

Entry-level positions among types of employers, 1990-95

Entry-Level Placement of BC Graduates Among Types of Employers, 1990-95	
General Contractor/CM	55%
Residential	14%
Mechanical/Industrial	8%
Electrical	1%
Heavy Highway/Excavating	5%
Government/Municipal	4%
Lumber/Building Materials	2%
Other	11%

In Fall 1996, scheduling will be implemented to incorporate specific instruction for mechanical scheduling into the existing BC 334 course. In addition, due to strong industry response, mechanical shop drawing review and understanding will also be incorporated into the course.

Course Perspective

Regarding our second objective, course perspective, it was found that the course should be taught from the general construction/construction manager perspective. It appears from the information provided by Part Four of the study (Figure 6) that although our students enter several areas of construction, the GC/CM interest area has been the dominating area for the last six years. With such a large percentage of students indicating career interest in GC/CM (Figure 5), coupled with such a high percentage of alumni who have entered that particular career area (Figure 6), it appears most appropriate to present material and examples that are from the GC/CM perspective. It would serve well to maintain the focus of "what a general contractor or construction manager should know about mechanical construction."

In General

For the purposes of this initial study, the information provided was sufficient, however, future studies should involve the distribution of identical lists and rating scales to both educators and

industry. This study provided appropriate information for determining course content and teaching perspective which has been implemented into the BC 334 Mechanical Construction course.

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Appendix A

Survey Of Educators Regarding Mechanical Construction Course Content

Please complete and forward to the presenter

- 1) Please rate the value of the following topics for their importance as a part of the mechanical construction course content:
(use scale of 1 to 10, 1 = unnecessary and 10 = mandatory)

-Plumbing Systems	
-Fire Protection Systems	
-Ductwork Systems	
-Hydronic Systems	
-HVAC Equipment	
-Refrigeration Systems	
-Other _____	
-Other _____	
-Other _____	

- 2) Please rate the value of the following topics for their importance as a part of the mechanical construction course content:
(use scale of 1 to 10, 1 = unnecessary and 10 = mandatory)

-Piping Methods and Materials	
-Plan and Specification Competency	
-Basic Design Concepts	
-Basic Code Requirements	
-Equipment Applications	
-Labor and Material Costs	
-Scheduling	
-Labor Issues/Labor Jurisdiction	
-Shop Drawings/Submittals	
-Coordination Between Trades	
-Scope of Work Issues	
-Other _____	
-Other _____	
-Other _____	

Appendix B

Mechanical Construction Course Content: Input From General Contractors

COMPANY NAME: _____

CO. ADDRESS: _____

TELEPHONE: _____

ALUMNI NAME: _____

YEAR GRADUATED: _____

PURPOSE: To acquire industry input for determining course content of the BC334 Mechanical Construction course.

SUBJECTS: Purdue University Building Construction and Contracting alumni employed by general construction firms.

Please respond to each item using the following scale.

DK = don't know or no opinion, 1 = not important, 5 = important

1. Plumbing blue print reading.	_____
2. HVAC piping blueprint reading.	_____
3. Sheetmetal/cutwork blueprint reading.	_____
4. Recognition and application of various types of piping, valves, fittings and hangers.	_____
5. HVAC equipment types and applications.	_____
6. Fire protection system types and applications.	_____
7. Welding methods, processes, and applications.	_____
8. General contractor/mechanical contractor scope of work issues.	_____
9. Plumbing quantity take off and pricing.	_____
10. HVAC piping quantity take off and pricing.	_____
11. Sheetmetal/cutwork quantity take off and pricing.	_____
12. Understanding basic plumbing code.	_____
13. Understanding basic mechanical code.	_____
14. Basic principles of temperature control systems.	_____
15. Mechanical construction coordination issues.	_____
16. HVAC load calculations.	_____
17. HVAC testing and balancing procedures.	_____
18. Basic principles of commercial refrigeration.	_____
19. Evaporator types and applications.	_____
20. Chiller types and applications.	_____
21. Scheduling mechanical construction.	_____
22. Mechanical construction terminology.	_____
23. Mechanical shop drawing review and understanding.	_____
24. Mechanical billings/schedule of values preparation.	_____

The World Wide Web and Multimedia in Undergraduate Construction Education

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An undergraduate class in Microcomputer Applications in Construction at a large Southwestern university has traditionally focused on computer literacy. Higher levels of entrance competency allow the time spent on spreadsheet, word processing, and database training to be dramatically reduced. A new focus on the computer as a tool for success construction management has been developed, with emphasis on information exchange, and the first delivery of the revised course current the fall semester of 1995. The use of the Internet and the World Wide Web as tools for marketing and remote project control is presented, and the students develop competency in the creation of home pages. Multimedia authoring has also been added to the class. Working in groups, the students develop interactive demonstrations of construction processes incorporating video, graphics, sound, and text. A database wall is developed to provide access to these applications on a local network and on the Internet. In this way, the students in this sophomore level class can participate in education across the curriculum. In this paper the curriculum for this new class is described. The results of surveys monitoring student attitudes are presented and discussed. The lessons learned in the first delivery of the course are summarized.

Key Words: Collaborative Learning, Hypermedia, Information Technology, Microcomputer Applications Multimedia.

Introduction

In its efforts to provide cutting edge computer skills as part of its undergraduate curriculum, this university program has taught a microcomputer class since the middle 1980's. The course (CON 251), titled Microcomputer Applications in Construction, historically has focused on developing computer literacy in sophomore students. The educational tools were skill based and primarily centered on the use of the computer as an end, with exit competencies consisting of the ability to perform certain functions judged important by the instructor. These included spreadsheets, word processing, and database tools. The focus of the class has recently been altered, to provide an appreciation of the use of the computer as an information management and transfer tool to support the operations of a construction project or company.

The previous version of the course had developed in accord with the very low microcomputer entrance competency level that existed when this course was developed. However, by 1994 the entrance competency had changed dramatically in response to a number of pressures. The most obvious pressure was the modification of the prerequisite engineering core class, Introduction to Engineering, to incorporate spreadsheet modeling. A second and more gradual pressure was the overall increase in the availability and importance of computers in the high school curriculum and the general college atmosphere (Figure 1).

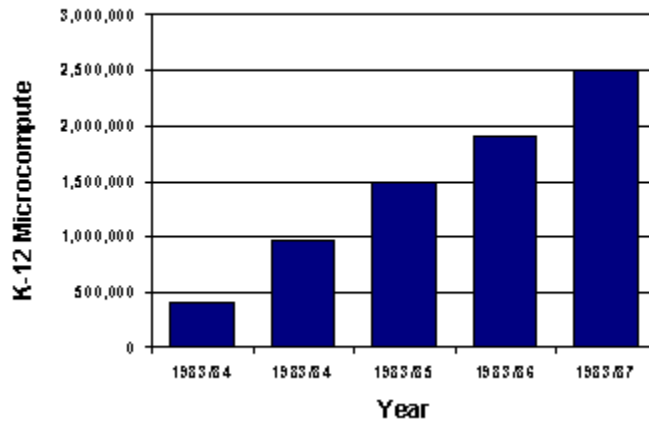


Figure 1: Installed microcomputers in grades K-12 in the United States (Data from Snyder and Hoffman, 1995)

During the 1994 academic year, the skill levels of students at the beginning of the class were checked through a series of interviews and a survey that asked the students to self-select their competency level in a number of software applications and in general. The results of this evaluation indicate that the student entering CON 251 in 1994 was relatively capable in word processing and spreadsheets, but less so in database management and graphics (Figure 2). Changes in the course were therefore needed to prevent boredom and perceived irrelevance based on entry competence.

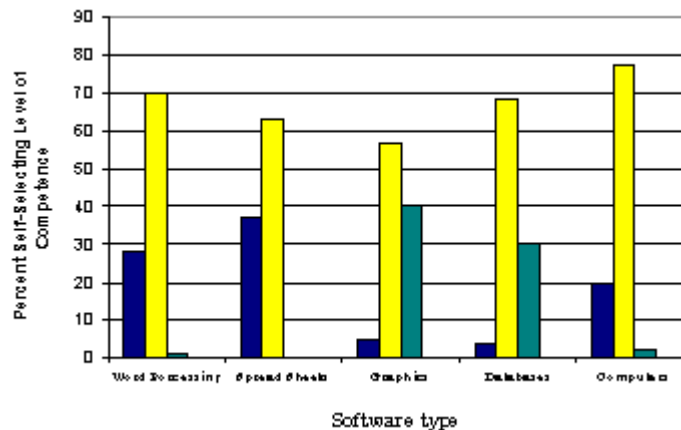


Figure 2: Self-selected entrance competency levels for CON 251 students, AY 1994

Furthermore, the cutting edge of technology had changed since the course was created. The skill-based approach had been acceptable for developing general literacy, but it did not demonstrate the capability of current information technology (Rebholz and George, 1993). Information transfer via multimedia tools is expected to increase significantly in construction in the area, expanding rapidly in the areas of presentations, mining, and reference (Aminmansour, 1994). Consequently, the strategic plan for the DEWSC curriculum called for a new focus of computer

usage, to be no longer on "computer literacy," but on the use of the computer to convert data to information, following trends observed in the industry (Martin, 1990; Bjork and Penttila, 1991).

To this end, CON 251 was changed to adopt a supporting role for the conversion of the approach from computer literacy to information management. For the purposes of this course, information management was loosely defined as the ability to use the computer to obtain, updates and communicate relevant information about the industry or project in order to more effectively manage or obtain construction projects, to communicate, or to train. The use of the course to encourage these skills meant that a natural path was created to incorporate the Internet and multimedia in the specific topics covered. Students were presented with various multimedia tools, first from a discovery standpoint and, finally, from a creation standpoint. That is, students were introduced to finished multimedia applications, including training tools, references, and even games, and taught how to use them. The students then used the tools to create their own projects.

Course Overview

The changes made in the course include a dramatic reduction of the time previously spent on skill-based training in spreadsheet and word processing software, to allow the incorporation of multimedia and the Internet into the classroom. A summary of the course syllabus containing a complete list of the subjects covered and the time spent on each is presented in Table 1. With the exception of Authorware, licenses were obtained for all software for each workstation in our laboratory. A single educational-use Authorware license was obtained, and the student teams were consequently required to schedule their time around sharing the license. A course in multimedia using Authorware is also taught in the College of Education and, in future semesters, a group license will be available on the campus-wide network.

Table 1

Summary of Revised Microcomputers in Construction Curriculum

Subject	Week	Specific Software
Microcomputers and Information	1	n/a
Presentation Software	1	Microsoft PowerPoint
World Wide Web	2	Netscape, Microsoft Word Internet Assistant
Advanced Word Processing Topics	2	Microsoft Word
Advanced Spreadsheet Topics	3	Microsoft Excel
Data Management	3	Paradox
Multimedia Components (Sound, Stills, Graphics)	2.5	Sound Blaster Wave Studio, Snappy, Adobe Photoshop, Adobe Illustrator, Microsoft Paintbrush
Multimedia Authoring	3	Macromedia Authorware Pro

For the first delivery of the course in the fall of 1995, the course was scheduled for a 1 hour and 15-minute class period two days a week. The course was presented in a regular classroom, using

a Pentium computer on a rolling cart and a Proxima™ display unit to project the computer monitor image onto the screen at the front of the room. During the fall of 1995, a new construction computer laboratory/classroom was underway (Figure 3), with scheduled completion in January 1996. This room will be used in future semesters, with students able to follow along at a computer (no more than two students per computer) as the in-class lessons and demonstrations progress.

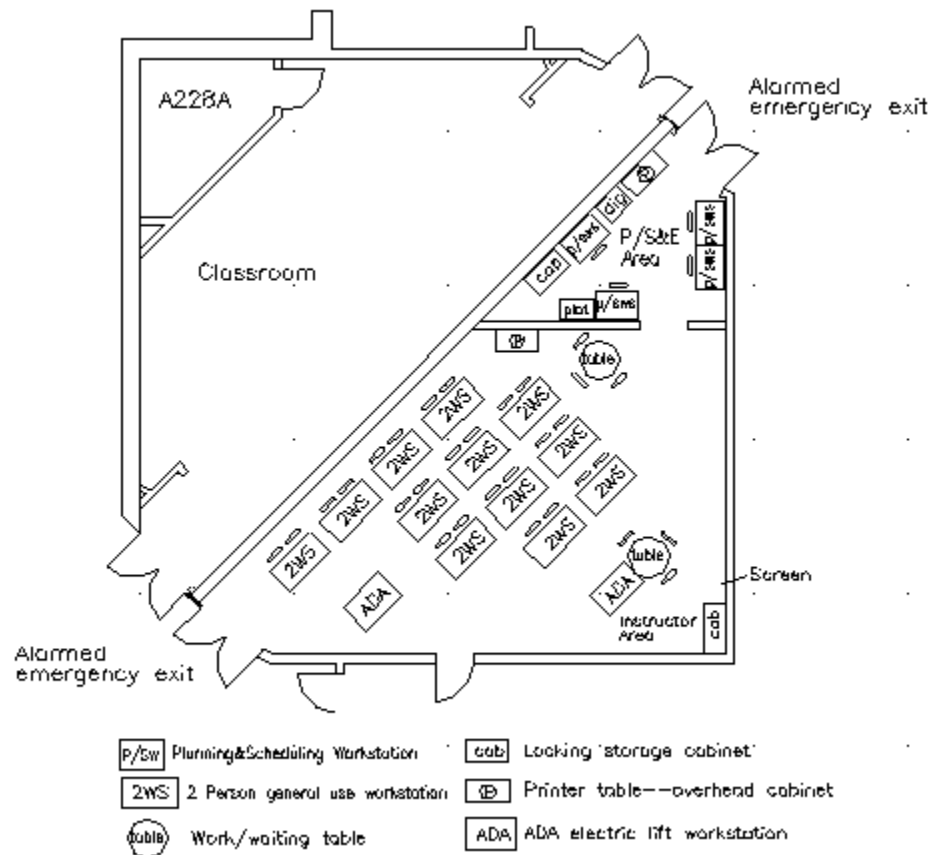


Figure 3: New Computer Classroom and Laboratory

The overall approach to all of the material presented in the course was modified, in addition to the changes in the actual material covered. Two underlying themes were stated or implied in every literature throughout the semester:

The computer is best viewed as a tool which can be used for successful construction project management (Paulson, 1995); and there is no more reason to be fearful of the computer than of hammer, meaning that the student should work to overcome fear of self-developing the skills they need throughout their careers.

In every lecture, construction-specific applications of the particular software were developed. The various skills required were demonstrated only incidentally to the final project, and it was stressed that the student needs to become proficient with the help utilities and to engage in self-directed learning to go beyond that level of skill taught in class. This implies that the help utilities were always demonstrated; it becomes rapidly apparent that they all work about the same

way. In the beginning of the course, emphasis was placed on the specifics of the processes, but as time went on, the emphasis shifted to the beginning and end course, the elements shifted to the beginning and end of development. The process in between was steadily, more and more often, left up to the students.

This shift is a very important part of the class, as it takes some effort to convince students that their developer-user student model will change upon graduation. Because the construction industry is dominated by small firms (Bashford, 1995), it is quite possible that the graduating student will become one of only a few computer-capable personnel at his/her first job. This means that graduates will often find themselves in a situation where they have to prepare an application for which they may not be the primary (or sole) user, a very different situation than they face during their education. Note that in this context the term "application" is not intended to denote a package developed from a primary language, but rather a spreadsheet, database, web page, etc., prepared for a specific purpose. The need for careful planning of the input requirements and locations, development of meaningful help messages and, especially, provision of complete documentation, were therefore stressed in the course. Students were required to use, and demonstrate evidence of, all three in the applications they created.

The class relied heavily upon collaborative learning techniques as part of the delivery method, which were in fact integral to the approach. Clearly, from these ambitious schedule of materials covered in the class presented in Table 1, methods for improving delivery efficiency were essential to the success of the course. This particular course is perhaps ideally suited to such an approach. First, computer learning is heavily interest-based; thus, different things. Further, each student in the group will have a different set of entrance competencies in the various software products. Both of these forces tend to create an atmosphere in the groups in which the students teach each other, which raises the delivery efficiency for all involved (National Training Laboratories).

Most assignments were collaborative in nature, although a few individual assignments were completed as well. Projects early in the semester were competency-based, focusing on skill development in specific software applications. As the course proceeded, the assignments became more results-based, and the projects developed became steadily more public, from the multimedia projects that will be used to generate teaching tools for use in other classes to the home page materials that will be used on the Internet. The most unusual portions of the curriculum for this class were the Internet and multimedia portions. Both will be covered in significant detail in later sections, but should be summarized in this overview. In the Internet portion, resources on the Internet geared to constructors were identified to students, both as a means of developing information sources and as a means of experiencing the global nature of the industry.

Students also learned about the simple multimedia tools of the World Wide Web, how to prepare hypertext markup language (HTML) pages. The students were thus able to learn how to obtain, use, and present information from the Internet. Also, the powerful features of multimedia as an education, training, and marketing tool were presented. A number of multimedia authoring packages were considered, with comparisons made based on apparent ease of use, cost, PC platform availability, and flexibility. A simple, flowline metaphor multimedia authoring tool

(Macromedia Authorware Pro) was used. The goal of this educational process was the switch from use of multimedia to creation of multimedia, a demonstrated means of improving information transfer abilities (Wilson, 1994). The requirement for both compelling presentation style and accurate information were stressed. The students developed multimedia demonstrations of construction processes (e.g. concrete slab construction). In order to facilitate the later use of these tools within other courses in the program, a multimedia information system is under development to catalog them, allowing the user to establish information bearing, content-based relationships between the multimedia objects (Grosky, 1994).

World Wide Web

The concept of systems that would allow readers to follow non-linear paths through documents dates back to 1945. Vannevar Bush proposed a sort of database machine called Memex that would allow readers to follow trails of information. It was not until 1987 that the first practical application of a hypertext system was created. The HyperCard package for Macintosh introduced many users to the concept of non-linear flows through databases (Wiggins, 1995). This system allowed links to sound and images, combining hypertext with multimedia. Hypertext systems with multimedia capabilities are sometimes called hypermedia systems.

The Web began at the European Particle Physics Laboratory, (CERN). In 1989, CERN physicist Tim Berners-Lee proposed the concept of the Web as a system for transferring; ideas and research among scientists in the high-energy-physics community. The proposal defined a system that would use hypertext to transmit documents and other types of communications through computer networks. This system was not intended to transmit images nor to include sound and video.

The end of 1990 introduced the first Web software introduced on Steven Job's NeXT computer system. The NeXT software provided the capability to view and transmit hypertext documents over the Internet and enabled users to edit hypertext documents. This system was presented to CERN committees and attendees at the Hypertext '91 conference. Over the next few years, the Web system expanded rapidly (Wiggins, 1995).

The Internet doubles in size every 10 months. The Web grows even faster, at an annual rate of 3,000 percent. In 1993, fewer than 100 Web servers existed; today, the Web has more than 10,000 servers. The term "World-Wide Web" comes from the notion that individual nodes of information are linked with hypertext, creating a "web" of information. It is "world—de" in that WWW browsers speak not one, but multiple protocols and retrieve information from distant machines around the globe over the Internet. The initial goal of the World Wide Web was to provide a single, unified means of accessing hypermedia documents from anywhere on the Internet.

A very common error is to think about the Web and the Internet as synonymous. The web is a collection of protocols and standards used to access the information available on the Internet. The Internet is the physical medium that is used to transport the data. Because common protocols and standards regardless of platform, and in a variety of media, the web represents a powerful vehicle

for information exchange. Remote project control (Schriener, June 1995), advertising (Schriener, August 1995), and materials data are already available on the Web, and the potential uses in construction expand every day.

Curriculum for the World Wide Web portion of the class followed an experience-then-develop approach. That is, the students learned first to use the resource and then to author it. Specifically, this part of the course was divided in two areas:

1. Show the students how to use the World Wide Web, and discuss its properties.
2. Help the students to develop home pages for the World Wide Web.

Netscape was used as a viewer for the first part of the World Wide Web curriculum. At first we focused on how the Web works, examining and understanding the features of Netscape, as well as the concept of hypertext links. In these early encounters, the students were asked to direct movements around the Web, choosing hypertext links to follow by acclamation. Materials of simple general interest, not related to construction, were used to stimulate students to understand the mechanics of the Web.

To continue with this level of appreciation, students were encouraged to simply hunt around on the Web and look for something of interest, and to bring back an address and a short description of a Web page. Eight percent of the 24 students returned these assignments. A summary of the topic areas they developed is presented in Table 2.

Table 2

Summary of Student-Selected Web Pages

Topic	Percentage presented
Hobbies	52
Sports	21
Different subjects	17
Movies	5
Music	5

While hyperlinks are a powerful method for conducting intuitive searches for data, information, or resources on the Web, the sheer magnitude of the Web can make hyperlink searching alone very inefficient. To improve the efficiency of information access, an important step in developing competence is to become familiar with means of searching for a specific topic through one of the many search engines available. Search engines are computer programs that search the Web on a periodic basis, collecting information about new Web documents and servers. Depending on the search engine, the information collected may contain only the name and address of home pages, or it may also include information about the contents of a page, the words in a text-based document, or information about multimedia files. To assist students in accessing and understanding these search engines, a number of the most commonly used were introduced in class (Table 3). Several of these engines were used during the class, but now were used specifically to identify resources relating to construction. Again, while asking for student

direction for topic areas, a number of construction-related resources were identified and accessed.

The limitations of the search engines available on the Web were stressed. First, not all are updated on a daily or even weekly basis, so recent resources can be missed. This oversight can be significant, given the rapid growth of the Web. Perhaps the biggest problem is that the search engines are based on indexes created by humans. Unless a home page title or URL address contains a word that fits the seal profile, or the creator of the page or document has indexed it with that word, it is possible to miss resources that might be important. Finally, it is absolutely critical that student understand that anyone, anywhere, can put whatever he or she want on the Web. Therefore, more than normal effort must be expended to verify information obtained. With a complete understanding these issues, one can effectively sear for information on the Web.

Once the search engines had been used to identify some construction-related Web pages, a few construction applications were reviewed. Mile many people believe that the only appropriate World Wide Web use is in advertising, other uses were demonstrated as well. Perhaps the most interesting is the Global Construction Network of Avatar Development Corporation (Schrieners Aug 1995). This page provides actual job site management and coordination support through links to the schedule of a project, photographs of job progress, and safety information regarding excavation planning. Meeting announcements are posted on the system, and the site also has an E-mail capability that allows communication about current issues at the job site between the contractor, subcontractors, and the architect. A public introduction to the concept can be viewed at <http://www.gcn.nets> and for this class we requested and received access to some of the active portions of the page. (Some portions of the site were not made available and are password protected in order to maintain the confidentiality of certain issues within the project). The students found this application very interesting, particularly the photographic images of the job site. Overall, this site contains much of the information about this project the students had been hearing about in other classes in the construction curriculum; thus, the page becomes a real-time "example."

Table 3

Addresses for Search Engines On The Web

ALIWEB	http://web.nexor.co.uk/aliweb/doc/aliweb.html
CUI Search Catalog	http://cui.www.unige.ch/w3catalog
EINET Galaxy-Search the World Wide Web	http://galaxy.einet.net/www/www.html
Global Network Academy Meta-Library	http://uu-gna.mit.edu:8001/uu-gna/meta-library/index.html
Lycos	http://www.lycos.com
Nomad Gateway	http://www.rns.com/cgi-bin/nomad
Webcrawler Search	http://www.bio.tech.washington.edu
WWW-The World Wide Web Worm	http://www.cs.colorado.edu/home/mcbryan/www.html
Yahoo	http://adeono.stanford.edu/yahoo

After the students were exposed to using the World Wide Web, methods for generating home pages were presented. Home pages are written in Hypertext markup language (HTML), a text-

based coding language combining text with codes that control presentation of the hyperlinks, graphics, and other media. The students were presented with a synopsis of the HTML codes, and shown examples of HTML coding for some of the pages previously presented. However, while one can prepare HTML in a simple text editor, it is not an intuitive process, and not people prefer to work in a simplified HTML authoring environment.

For the first delivery of the course, HTML authoring was done using Microsoft Word Internet Assistant that can be down loaded from <http://www.Microsoft.com>. To drive the student experience with HTML authoring, the students were given group assignments to develop home pages for faculty members. Each group was required to interview a faculty member to get information to include in the page. Each home page was to include at least one picture so that the students had to learn how to use the optical scanner.

The Microsoft Word Internet Assistant was used because the students were already familiar with Microsoft Word. Thus, the learning curve should have been shortened. However, for several reasons the Internet Assistant in actual application was less useful than expected. Some of the formats that are available in Word for Windows do not work well in the Internet Assistant. Furthermore, incorporation of images in the home page was extremely difficult and, in fact, the codes for the control of images had to be inserted using a text editor so that the document would appear on the Web as expected. System crashes were relatively common using the Internet Assistant. Word Internet Assistant is useful for writing text because the HTML tags needed to format the text can be inserted automatically and invisibly. For the same reason it is useful to create links to either local documents, or to documents that are already in the Web. However, the other difficulties were enough to cause us to reconsider this selection, and in future semesters this selection will be performed with another HTML editor.

Multimedia Applications

The first step in course development for this segment of the course was to identify software that could be used for authoring multimedia. This process required an evaluation of several packages (including Authorware Digital Chisel, Director, Toolbook, and others). Each was evaluated according to the following criteria:

1. Ease of use
2. Ability to produce a quality product
3. Cost

Platform availability was also an important consideration. Because the computer laboratory facility at the School is IBM-based, consideration of Macintosh-only software was not realistic, in spite of any other characteristics of such software. After an evaluation of several packages, Macromedia Authorware Pro was selected. While costly (a single educational use license is about \$1000), this program can be used to produce extremely high-quality applications incorporating text, graphics, animation, video, and sound. Interactivity including buttons, hypertext, monitored quizzing, and even more complicated forms such as drag-and drop are easy to incorporate. Multimedia objects are placed in a flowline, running from the top down, and

interactive branches and loops are shown on the flow chart. Because this flow chart is simple to conceive, students can begin to produce multimedia applications right away. Very complex applications can be created with just these simple tools, and ambitious students using programmable variables can introduce more complexity. The drawback of this program was that only one license could be purchased, requiring students to schedule their time at the licensed computer.

The actual curriculum for the multimedia portion of course was divided into five parts:

1. Introduction of multimedia concepts and applications
2. Creation of graphic images
3. Creation and manipulation of photographic images
4. Creation and editing of sound
5. Use of Authorware to connect multimedia elements

In order to convey the information in a realistic setting, the material was presented by example. A simple application was prepared by the graduate assistant to demonstrate the sampling and testing of concrete. The application included photographic images of concrete sapling and testing, text descriptions, explanatory drawings and narration. It was developed, from beginning to end, in front of the students, using the elements obtained in the field as raw materials. The process began with a day of using multimedia followed by two class discussions about techniques for effective multimedia, at the end of which the class worked out a simple storyboard of the application. Over the next few lectures, we demonstrated all of the techniques that were needed to prepare all of the elements.

For example, the explanatory drawings that were needed were first charted on the storyboard, and we went through the various development tools that could be used to create them. Some were produced in PowerPoint, with which the students were already familiar, and in Paintbrush. Complex drawing elements were completed in Illustrator. In every case, the actual process was performed in front of the students, and elements were provided in read-only files on the construction network for them to work with if they wanted to re-create what was done in class. This same process was completed with editing sound editing and photographic manipulation.

Software that was used in this segment was previously presented in Table 1. The hardware needed, including speakers, microphones, a scanner, a video camera, and the Snappy, were provided by check-out form the School to the students. This prevented placing an undue financial burden on the students. Computer facilities were available in the construction laboratory; in addition, every student group included at least one person who had adequate computer equipment of their own -- interestingly, this occurred by happenstance rather than by design.

The students were asked to develop their own storyboards after the in-class process for the concrete simulation, and similarly to work on each element of their application as it came up in the classroom. In this portion of the class, the Monday class was a lecture/demonstration, and the Wednesday class was a laboratory period in which the instructor and teaching assistant were available for assistance. The strength of this approach was that it kept the student groups moving

at a reasonable pace and seemed to be effective in transmitting the techniques that were needed at the time they were needed. The disadvantage, however, was that students (particularly the less ambitious students) tended to follow the model of the classroom application fairly closely, which had the effect of limiting the creativity that might have been displayed using some other approach.

After all of the elements were completed, the authoring process using Authorware was begun using the same approach; the development of the concrete sampling application was presented on Mondays, and the groups were allowed open laboratory access with help on Wednesdays. Their demands on the instructor and teaching assistant outside the regular class time increased dramatically during this time, averaging 25 hours per week in the final three weeks of the class. Interactive multimedia applications were developed by all student groups, and were demonstrated at the final examination period after the end of classes.

The student groups all successfully completed their applications, and of course showed varying levels of creativity and professionalism. The final products ranged from a very simple text-with-pictures application controlled by pushing on-screen buttons, to relatively advanced hypermedia productions. More advanced applications included different types of interactivity ranging from buttons to hypertext to hot objects, complex interactive graphics, and sound.

A number of lessons were learned for incorporation in future semesters. First, some of the students developed the applications on their own machines or on high-performance machines in the construction laboratory, but the demonstrations were delivered on a medium range Pentium machine. This difference introduced mismatches in timing of text with graphics and some slow graphic loading times that the students did not expect. In the future, the students will be encouraged to test their work on several machines, and the machine for use in the final period will be available several days in advance. The availability of a computer for the students to use during the classroom period was clearly demonstrated as a need, which will be addressed beginning in the Spring of 1996 in the new laboratory. Most important, student feedback indicated that the show-and-do style used for this portion was executive, but that the time dilation of compressing the curriculum into the end of the semester was difficult. This difficulty was plainly exacerbated by the single-license issue. Future deliveries will be modified to introduce the multimedia concepts early in the semester and then intersperse the various elements throughout the semester. In this way, students will be able to avoid time pressures if they choose and may be free to express more creativity in their application development.

Conclusion

The revised format for the Microcomputer Applications in Construction class resulted in a very ambitious schedule. A wide variety of information management and manipulation techniques were presented, including the use of the Internet and multimedia. This schedule and curriculum pushed the students to identify techniques to teach themselves features of the software very rapidly and to become comfortable with a variety of tools. This process of encouraging comfort with computer Eased tools is perhaps the single most important lesson the students were exposed to.

The very fast paced nature of the course, which had the positive impact of encouraging self-directed learning, also can lead to low retention of the specifics of the applications introduced. While this is potentially a problem in many subjects, in the microcomputer area retention of process specifics is not necessarily a serious cause for concern, because new versions and new packages bombard computer users constantly. Developing the ability to understand the underlying themes and use them with a changing set of specific processes is therefore critical.

The new portions of the curriculum introduced a number of important elements on their own, however. First, the use of the World Wide Web allowed the students to gain access to information about construction from around the globe. An ongoing project was brought into the class and followed there, allowing sophomore students an exciting look ahead. Multimedia application development forced students to become acquainted with a number of input and output methods, as well as away of seeing the computer as a direct and power means of conveying information in a compelling style. Student groups were successful in developing multimedia applications and in dealing with the many formats and software packages that were needed for the applications.

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Cross European Collaboration in Civil Engineering Education

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Over the past ten years the opportunities for students to gain experience of Academia and Industry in other European countries has grown apace, mostly financed through the European Union funded TEMPUS and ERASMUS schemes. Alongside these opportunities has been the acknowledgement that with the growing emphasis in the Construction Industry in Europe towards "Design and Build" there is a need for a Civil Engineer who can "Manage the Construction Process" from inception to completion. Thus the national and European awards in Civil Engineering Management recognize the need for an academic course of study providing not solely the traditional technology subject area but balanced combination of technology and management. This paper reports on the development of a national Civil engineering Management degree programme, which had led to the first joint award in European Civil Engineering Management concurrently, offered in six separate Institutions in six different European Countries.

Key Words: Civil engineering Education, Cross European Education, United Kingdom

Introduction

Historically the growth of built facilities in the United Kingdom stemmed from the rapid industrialization during the nineteenth century, particularly housing for the expanding population settling in the towns and factory premises as places of employment. Work of this nature required a variety of craftsmen who formed the basis of today's building sector.

Such rapid expansion clearly put pressure on the infrastructure causing canals, railways and roads to be constructed, together with a general requirement for public utilities. These areas of activity gradually coalesced into the Civil Engineering disciplines, which demanded sound engineering knowledge relating to structural analysis and design, fluid mechanics, water engineering, geotechnics and some aspects of mechanical and electrical engineering.

In contrast, the building disciplines were more concerned with the technology of buildings and the associated construction systems.

Educational Developments

The education of Civil Engineers in part developed in the late Victorian Universities, but a significant and possibly the greater proportion of Engineers attended various Institutes and Colleges studying on a part-time basis (one day and one evening per week or even evenings

only), courses approved by such bodies as the Institution of Civil Engineers (ICE) (founded in the 1820's) and the Institution of Structural Engineers (I Struct E).

The Universities in particular focused on theoretical aspects of Engineering in order to sustain academic credibility with the already established science disciplines. This emphasis was less marked in the Institute/College curricula and more applied subjects were taught. The Building disciplines however, were hardly represented at all in academia, other than for craft training, until well into the twentieth century. However, the development of more complicated buildings with complex building services requirements and the use of modern materials together with a range of procurement and contracting arrangements since the 1950's have called for much better prepared professional managers of the construction process. The education curriculum for these disciplines has largely been influenced by the major professional building Institutions, such as the Chartered Institute of Building (CIOB) and the Royal Institution of Chartered Surveyors (RICS) together with a sizable number of non chartered bodies like the Architects and Surveyors Institute (ASI), Institution of Civil Engineering Surveyors (ICES), Association of Building Engineers (ABE), Institute of Building Control (IBC), Institute of Clerks of Works (ICW), etc. The majority of courses for these disciplines are based in local Further Education Colleges and Higher Education Polytechnics, with little activity in the traditional Universities. Importantly, the changes to University status of the former Polytechnics has recently brought much of Built Environment education into a more elevated arena of prestige.

It should be made clear, of course, that Architecture, a companion to the Building discipline, has long been a well sought after profession to follow, and taught in the most prestigious Academic Institutions. Unfortunately little Architecture was needed in the formative stages in establishing the nations' industrial facilities, and as a consequence, separation rather than integration of Architects, Builders, Civil Engineers, etc. is still a disturbing feature of the present day industry.

The Current Scene

Unlike much of the rest of the developed world, professionals in the UK construction Industry generally need to qualify to practice through membership of one of the aforementioned professional societies. Most of these societies jealously try to guard their position in the market place and make membership difficult to achieve through a specifically accredited course of academic study and then controlled industrial training and experience requirements. This is then followed by recorded continuing professional development activities in order to retain professional membership. This system whilst laudable in itself in attempting to maintain and raise professional standards has, in practice, resulted in many aspects of their work overlapping.

Thus the opportunity now exists for a significant common programme of study in the Built Environment disciplines, which is the normal pattern in most of Continental Europe, with concentration either on practical engineering (usually termed Civil Engineering) and practical Architecture (Architecture being defined in its original meaning of master builder).

Accepting that UK traditional Civil Engineering and Architecture courses broadly cater for the demand for Design Engineers (including structural and architectural design) and /or research,

The School of Construction, Engineering and Technology at the university has concentrated on the " Master Builder" discipline, which as stated above presently covers a fragmented group of professionals including Architects, Builders, Civil Engineers, Quantity Surveyors, Building Surveyors, Construction and Project Managers, Building Control Officers, etc., that is all those involved in 'managing the construction process' from inception through to completion, working for clients, consultants, contracting firms and many others.

Construction Degree Awards

The School has introduced the portfolio of modules shown in Table 1 covering technology and management. Specific combinations of these modules studied at the correct academic level (3

Table 1

<i>School of Construction, Engineering and Technology_Construction Division</i>	
Module Portfolio	
<u>Level 1 (Year 1)</u>	
Civil Engineering Technology and Materials I	Planning Design and Conservation
Communication	Property Studies I
Construction Technology and Materials I	Quantity Surveying Practice I
Construction Technology and Materials II	Quantity Surveying Practice II
Contractual Procedures I	Statutory Control of Buildings
Environmental Engineering I	Structural Analysis I
European Language	Structural Design I
Geotechnics I	Surveying I
	Surveying and Geotechnics
<u>Level 2 (Year 2)</u>	
Building Surveying Practice and Procedure	European Language
Civil Engineering Construction (QS)	Hydraulics
Civil Engineering Technology II	Integrated Project
Civil Engineering Technology III	Law
Construction Economics	Office Organization and Administration
Construction Management I	Quantity Surveying Practice (Building)
Construction Technology III	Quantity Surveying Practice (Civils)
Environmental Engineering II	Structural Applications
Estimating	
<u>Level 3 (Year 3)</u>	
Advanced Construction IT	Engineering Control and Procedure
Civil Engineering Technology IV	European Building Studies
Construction Technology IV	European Language
Construction Management II	Facilities Management
Contractual Procedures II	Finance
Development Economics Project	Leadership Development
Development and Evaluation of Land and Property	Plant Management
Dissertation (Double length module)	Property Law
?? A total of 50 modules (17 level 1, 17 level 2 and 16 level 3) serve the 6 named degree awards.	
?? Each module is worth 15 credits except the Dissertation (30 credits)	
?? A 15 credit module involves 150 hours of student effort. Lecturer contact time (Lectures, tutorials, practicals etc.) is approximately 45 hours	
?? Students would normally expect to study 8/9 modules (120/135 credits) per academic year.	

levels basically equivalent to each of the 3 years of academic study) allow the award of a named degree.

A Bachelor of Science programme can be awarded at Ordinary level [BSc.] or at a graded advanced Honours level [BSc.(Hons)] depending on the number of credits successfully achieved, normally 280 credits for a BSc and 310 for a BSc Honours award. Most students would study for the Honours level award but depending on the quality of their module results may 'fall back' to an Ordinary award.

Taking two of the degrees offered Tables 2 and 3 illustrate how modules are combined to give named degree awards, and also highlight modules that are common between the two programmes.

Table 2

<i>School of Construction, Engineering and Technology Construction Division</i>	
BSc (Hons) BUILDING MANAGEMENT	
YEAR 1	
<u>Communication</u>	<u>Contractual Procedures I</u>
Construction Technology and Materials I	Environmental Engineering I
Construction Technology and Materials II	Statutory Control of Buildings
QS Practice I	Surveying and Geotechnics
YEAR 2	
<u>Construction Economics</u>	<u>Estimating</u>
<u>Construction Management I</u>	<u>Integrated Project</u>
Construction Technology III	<u>Law</u>
Environmental Engineering II	Structural Applications
YEAR 3	
<u>Construction Management II</u>	Optional Modules (minimum of 1 to be studied)
Construction Technology IV	<u>Advanced construction IT</u>
<u>Contractual Procedures II</u>	European Building Studies
<u>Development Economics Project</u>	<u>European Language</u>
<u>Finance</u>	Facilities Management
<u>Dissertation</u>	<u>Plant Management</u>
	<u>Leadership Development</u>
?? Modules in <u>Bold and underlined</u> indicate those studied in common with the BSc (Hons) in Civil Engineering Management.	
?? Modules in Bold only, are studied in common with other construction degree programmes.	

The School offers Bachelor of Science Honours Degree programmes in:

- ?? Building Management - (Table 2)
- ?? Building Surveying
- ?? Civil Engineering Management - (Table 3)
- ?? Civil Engineering Surveying (Quantities)
- ?? European Civil Engineering Management
- ?? Quantity Surveying

As can be seen, most of the degree awards (see Tables 2 and 3 as examples) share a broad core of modules, particularly at levels 2 and 3 (years 2 and 3). Indeed if the Industry was less

fragmented, a single degree title under the Construction umbrella would probably suffice, with perhaps options available to allow some specialization.

Table 3

<i>School of Construction, Engineering and Technology Construction Division</i>	
BSc (Hons) CIVIL ENGINEERING MANAGEMENT	
YEAR 1	
<u>Communication</u>	<u>Contractual Procedures I</u>
Civil Engineering Technology and Materials I	Structural Analysis I
Civil Engineering Technology II	Structural Design I
Surveying I	Geotechnics I
YEAR 2	
<u>Construction Economics</u>	QS Practice (Civils)
<u>Construction Management I</u>	Optional Modules (minimum of 1 to be studied)
Civil Engineering Technology III	Office Organization and Administration
<u>Integrated Project</u>	European Language
<u>Law</u>	Leadership Development
Hydraulics	
YEAR 3	
<u>Construction Management II</u>	Optional Modules (minimum of 1 to be studied)
Civil Engineering Technology IV	<u>Advanced construction IT</u>
Engineering Control and Procedure	<u>Contractual Procedures II</u>
<u>Development Economics Project</u>	<u>European Language</u>
<u>Finance</u>	<u>Plant Management</u>
<u>Dissertation</u>	<u>Leadership Development</u>
?? Modules in <u>Bold and Underlined</u> indicate those studied in common with the BSc (Hons) Building Management.	
?? Modules in Bold , only are studied in common with other degree programmes	

Another factor which has led us to believe that this university's approach towards educating professionals to 'manage the construction process' is the way forward in the development of 'Design and Build' contracts. Many major Civil Engineering projects in the UK are let on this basis such as The Channel Tunnel, the bridge over the River Thames at Dartford, the new bridge over the River Severn into Wales near Bristol and the Birmingham Northern Relief Road. These projects require the construction professionals to work together as a team to manage the complete construction project from inception to completion, rather than the traditional compartmentalizing of each of the professions inputting their expertise at various stages of the contract.

In no way do we advocate replacement of established traditional courses but we consider our courses are totally complimentary to the existing provision and provide an expertise in human resource management that is urgently required.

Graham Mackenzie the Director General of the Engineering Employers' Federation has recently stated to the Engineering Council that the education and training of Engineers is outdated and not strategically focused to suit Industry's needs. An overhaul of the process to ensure that Engineers and Technicians are multi-skilled, have business and finance skills and are good communicators is essential. We consider that the degree courses we offer at this university tackle this shortage of skills required by today's Engineers.

European Civil Engineering Management

In the rest of this paper we will specifically consider the provision within the area of Civil Engineering both with the national course and with its development onto the European Continent.

The BSc Civil Engineering Management (CEM) was introduced in 1990 and graduates from this course have gained specific employment because of their training in technology and management. For example, one Engineer was temporarily transferred from the Local Authority that he worked for to a national firm of Consulting Engineers to work in the Middle East to use his marketing and managing skills in developing a new regional office.

During the planning and implementation of the CEM programme we were in consultation with Institutions on the European Mainland, who, when they saw our proposals considered that such a programme was also directly relevant to the Construction Industry in their countries. This therefore led to the implementation of a BSc European Civil Engineering Management degree award, initially with partners in Germany, Holland and Poland commencing in October 1992. It now also includes partners in the Czech Republic and Hungary with Denmark, Greece and Ireland due to join in October 1995. The course is of 4 years duration with 3 years of academic study and 12 months industrial placement. The programme allows for study both at the home Institution and at one or more of the foreign Institutions (See table 4).

However whilst most of the continental students have a good command of English, the same does not usually hold for British students, although a foreign language is an essential element in the curriculum from the beginning. In fact the only difference in academic content between our national and European programmes is that in the national programmes foreign language study is an option whilst in the European programme it is essential. To help overcome this reluctance of the British to learn foreign languages, all students are required to undertake the 6 months of industrial placement in the foreign country before undertaking formal curriculum studies. Also, at the foreign Institution some subjects will initially be taught in English.

Table 4

European Civil Engineering Management Course Programme

YEAR 1		YEAR 2		YEAR 3		YEAR 4	
SEM	SEM	SEM	SEM	SEM	SEM	SEM	SEM
1	2	3	4	5	6	7	8
T	T	T	P	P	T	T	T
H	H	H	H	A	A	A	H

T = Taught Theory Semester

P = Industrial Period Semester

H = Based at Home Institution

A = Based at Foreign Institutio

SUMMARY

4 Year (48 Months) overall programme of study

30 Months based at Home Institution

(6 Months spent in Industry at Home)

18 Months based at Foreign Institution

(6 Months spent in Industry in Foreign Country)

At present Semester 8 must be completed in the home country in order to qualify for the degree award initially registered i.e. BSc European Civil Engineering Management for UK students or Dip Ing European Civil Engineering Management for Continental students.

Eventually dual qualifications might be possible but presently each Institution is constrained by the quality control systems operating for the validation of degree awards pertaining to that Institution. For instance at present this University has only validated the the modules taught at the foreign Institutions in Semesters 6 and 7 along with the Industrial placement in Semester 5 rather than the whole of the course in each Institution.

This university has gained registration to Part 1 BS EN ISO 9000, the British, European and International Standard for Quality Systems for the whole of its core business " the design and delivery of learning experiences with provision for research and consultancy services".

The host Institution in line with current European Union legislation on student mobility receives study fees. For European Union students' tuition fees are claimed back through Wolverhampton Metropolitan Borough Council, for non-European Union partners a reciprocal exchange scheme has to operate so that we do not charge them tuition fees and they do not charge our students. However subsistence grants are not generally available for the foreign students except through the European Union funded grant scheme called ERASMUS for European Union students and through the European Union funded grant scheme called TEMPUS for the Eastern European partners. Employers do make nominal payments towards subsistence expenses.

Despite the recession in the Construction Industry in the UK, we have managed to place, in Companies, the foreign students studying with us in 1994/5 (10 students from Germany, 5 from Poland and 2 from Czech Republic) and 1995/6 (15 students from Germany, 5 from Poland and 2 from Holland) These have and are working with Contractors, Consulting Engineers and Local Authorities.

With approximately 200 students studying on the ECEM programme in the 6 partner Institutions, each Institution has to plan and agree with all partners its intake each year to ensure that the students are able to study after the end of Year 2 at the foreign Institution of their choice. The host Institution is responsible for finding accommodation for visiting students and also for placing them in industry.

Formal meetings of the partner Institutions are held 3 times a year to consider all the problems that do arise from such an innovative study programme and to date things have run reasonably smoothly, but funding problems are likely to occur at the end of the next academic year when the European Union funded ERASMUS and TEMPUS schemes finish. However, it is intended to bid for support from the projected replacement schemes. Information on the replacement schemes suggests that support will be given to more flexible and wider based partnerships. This will fit in with our intention to expand our European course provision in Wolverhampton to include all the Construction professions represented by our degree programmes rather than just Civil Engineering.

Developing an Educational Interactive Multimedia Application for Construction Estimating

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The production process for an interactive multimedia application is discussed. The application allows students to perform a walkthrough of a wood frame residential project, with close-ups and explanations of selected items available upon user's action. A second set of features consists of watching video clips and pictures of related construction processes. The application is delivered in CD-ROM and works under the Microsoft Windows operating system. New multimedia projects can benefit from the ensuing discussion on this application's planning, and the hardware and software employed, since some of the design considerations could be reused in similar educational contexts.

Key Words: Interactive Multimedia, Construction Estimating, Curriculum Development

Introduction

The nature of construction is very visually oriented, and this is especially true for teaching estimating. Since estimating is heavily dependent on the visualization of the item being considered, a traditional lecture is at a great disadvantage compared to one that furnishes the student with additional sensorial information and actions. Estimating textbooks are generally limited in their explanation of construction items and procedures, concentrating more on the substantive issues of the subject. To supplement the course textbook and enrich their lectures, estimating instructors frequently display their own sets of pictures and slides. Although this approach is much better than having no visual connection at all with the estimated items, it still has some important flaws. The data is displayed at the discretion of the instructor, and each picture can have much more information than a student can assimilate in the few seconds it is shown. On the other hand, a growing percentage of construction students has some previous exposure to construction, which makes a detailed explanation of the pictures unnecessary and boring to them.

This paper summarizes the design and production process for an interactive educational multimedia application for construction estimating developed at a Southwestern university. The interdisciplinary nature of this project required several rounds of feature refinements, as a better understanding of its objectives and the capabilities of the technology was being achieved by the authors. This article presents the steps involved in developing this application, as well as its environment, features and operation.

Multimedia Applications

The terms "multimedia" and "multimedia application" require some discussion to understand their domain. The Microsoft Bookshelf™ dictionary defines multimedia as "the combined use of several media, such as movies, slides, music, and lighting, especially for the purpose of education or entertainment." As Burger (1993) notes, this definition suggests that a slide presentation combined with overhead transparencies is multimedia, which is not the current common understanding of the term. In fact, "multimedia," and especially "multimedia application," has come to imply the use of computers as their delivery system and a degree of interactivity. (Aindleigh & Thakrar, 1996). Callica & Newson (1996) present a timeline of the evolution of multimedia.

A substantial factor in associating multimedia with computers comes from the flexibility computers offer to develop and deliver complex applications (Rimmer, 1995; Fisher, 1994). At the high end, dedicated production systems are used to develop video games, television commercials, and virtual-reality training devices. Even more exciting for academia, many of the capabilities of these expensive production systems (easily costing hundreds of thousands of dollars) are now available for normal desktop computers, many times at a deeply discounted cost to educators ("Multimedia," 1996). To give some vivid examples of price levels at the end of 1995, a well-equipped desktop computer costs less than \$3,500. A video production system retails for \$1,300, including the necessary computer hardware and software. The authoring software detailed later in this article costs \$150 in its academic version, and a CD-ROM mastering drive can be purchased for \$1,000. Many construction programs could afford a system for multimedia production.

Educational multimedia applications have been extensively discussed in the literature. Aminmansour (1994) shows an interactive screen for concrete cylinder testing. Wartell (1994) and Senior et al. (1995) discuss the use of video applications. Vanegas and Baker (1995) present issues on the use of multimedia in civil engineering. Reisman and Carr (1991) and Reinhardt (1995) offer global perspectives on the use of multimedia in education. The best source of technical information in this rapidly evolving field, however, are specialized magazines such as *New Media*, *Multimedia Schools*, *Syllabus*, *Byte*, *Virtual Reality*, *Imaging Magazine*, and others.

The Estimating Multimedia Project

The estimating application detailed here is a self-paced learning tool, conceived as a solution to the dilemma of thoroughness versus expedience in the classroom. The application performs a walkthrough of a wood frame residential project, showing its components and, if requested by the user, a written explanation or video for selected items. The typical student at this university is relatively mature (with a mean age of about 28 years), and has had some construction experience. A minority of the students, however, is new to the myriad items and terms used in wood construction. This application allows for a better understanding of these items and terms, while more time can be devoted to estimating theory and practice in the classroom.

While the main purpose of this project was clear, its details were revised many times. There were available features in the development environment that were not clear to the estimating instructor

at first. On the other hand, more graphic material was collected than originally anticipated, and some modifications were necessary to include all the pictures and footage. In its final form, the student can perform a walkthrough of a residence construction project with all framework finished and the exterior wall sheathing in place. The student can also choose to view additional pictures and video of similar projects at other stages, which increase the information conveyed and provides more variety to the experience.



Figure 1: Main Screen

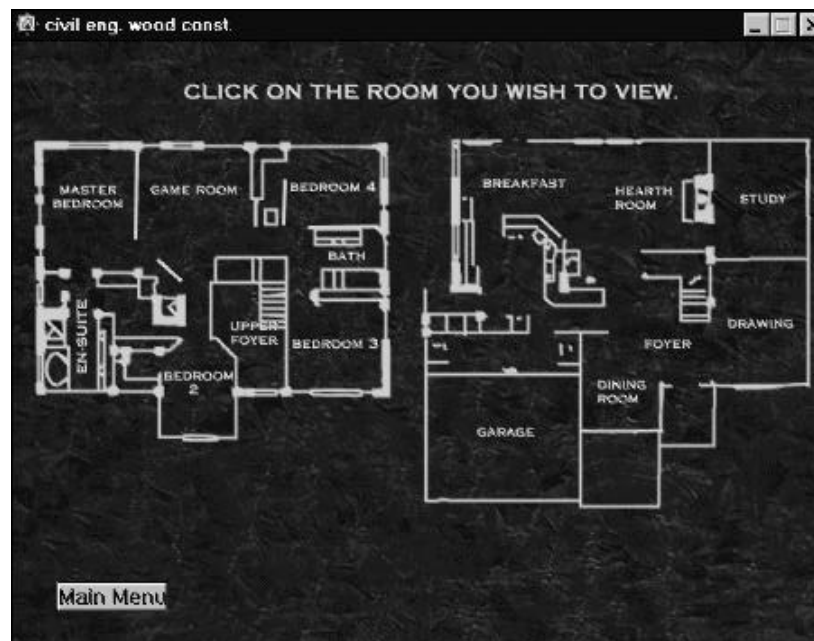


Figure 2: Floor Plan of Project

In its final form, the application is delivered in CD-ROM format under Microsoft Windows. After its opening screens and credits, it presents its two basic options to the user: a walkthrough of the project, or a series of supplemental activities (Figure 1). If the user chooses the walkthrough, it is presented with the floor plan of a two-story residence project (Figure 2). By clicking the mouse cursor over any room, the picture changes into a front view of one of the room's walls and warped views of the adjacent walls (Figure 3). At this point, the user can click over any of the two sidewalls, which then becomes the center picture; or he can click over visible doors and aisles in the center picture, which leads to the adjacent room. At any point, a reduced floor plan highlights the wall being observed. This floor plan is also used to point to any room and "fly" directly to it. Another function of the walkthrough is to provide additional information about specific wood items. If the mouse cursor changes shape when it passes over an item in a picture, it means that a close-up and textual information about the item is available, which is brought up by clicking on the item (Figure 4).

If the supplemental activities path is chosen in Figure 1, the nine "thumbnail" icons shown in Figure 5 are presented. Each one addresses a different aspect of the construction project not covered in the main walkthrough, either by showing the picture at a larger scale with a scrollable text window, as shown in Figure 6, or a video of the operation plus non-scrollable text. Clicking on its thumbnail icons activates the video or picture.

The user can stop the session at any time, and quickly re-enter at the point where it was left.



Figure 3: Walkthrough Screen



Figure 4: Details on Item Chosen from Walkthrough Screen

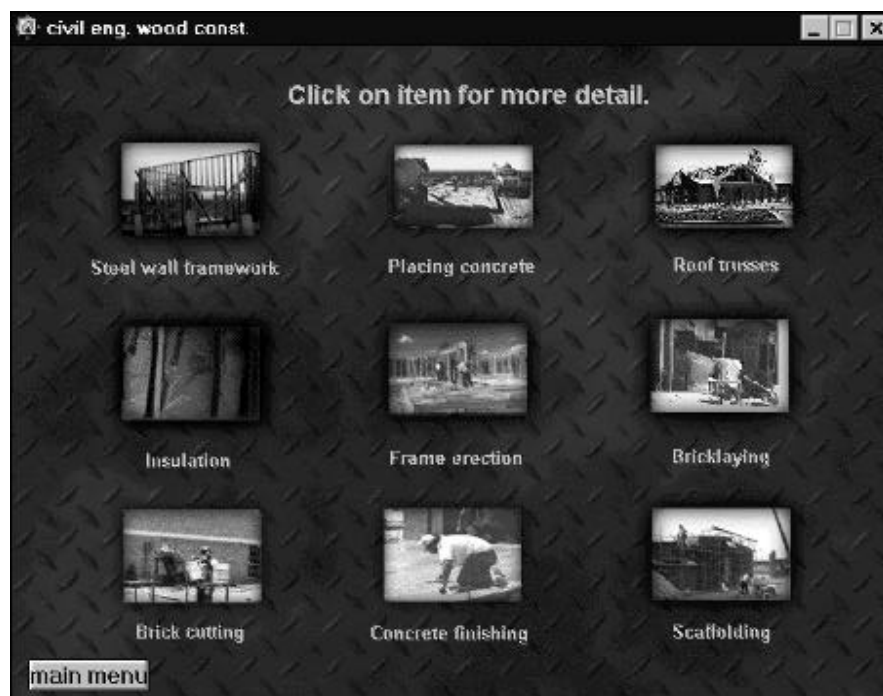


Figure 5: Thumbnail Icons of Videos and Pictures



Figure 6: Picture from Thumbnail Icon

Planning the Pictures and Video

There were many logistic issues that had to be addressed to plan and record the video and pictures composing the application. All walkthrough pictures had to be taken on the same day, and sequence had to be kept among them. To visualize potential problems, a complete preliminary run of pictures was taken and analyzed. From this run, it became apparent that the time of the day was critical, since late in the afternoon too much sunlight was entering directly through the windows, and in the middle of the day taking the pictures was too disruptive for the workers at the project. The most interesting wood items were targeted for close-ups, and the distance and zooming required to capture each wall were reviewed. With this information, the project was cleaned for a weekend photo session, and the pictures taken early in the afternoon using a 35-mm camera with zooming capabilities and 400 ASA film. The picture exposure was manually controlled, to assure uniformity in the lighting.

The supplemental pictures and videos were taken from residential projects around Albuquerque. The video camera used was a Hi-8mm, which provides a much better resolution than an 8-mm, C-VHS or VHS (Hone and Kuntz, 1994). This part of the project had a much freer format than the walkthrough, and the best footage was included.

The film was sent to a developing service that returned the pictures in digital format on CD-ROM. This service was inexpensive (at around \$21 plus posting for a roll of 24 exposures), and invaluable in enhancing the quality of the project. The video was digitized using the facilities of UNM's construction program, although there are digitizing services in the Albuquerque area.

Developing Environment

Integrating pictures and movies into a user-controllable production was a major task until recently. In the last few years, software tools like Gold Disk's Astound 2.0, Asymetrix Multimedia Toolbook 3.0, AT&T Multimedia Designer, and Macromedia Authorware have made assembling the various visual parts a relatively easy part of the production. These tools allow the application designer to concentrate on the layout and logical flow of the application, instead of its low-level programming details.

For this project, Macromedia Authorware was chosen as the implementation vehicle. Its paradigm is built around a flowchart with icons. Each icon represents a different action or function. Figure 7 pictures the initial section of the flowchart for the estimating application. The first icon tells the program to play a sound file; down in the flowchart, their icons indicate programmed pauses and titles. This (partial) flowchart ends with the choices of the main menu, which nests sub-levels for further action.

One major challenge in the design was to keep track of which picture should occupy the center position and which should be at its left and right sides. The flowchart was developed to keep a database of possible actions and direct jumps to different sections. As a consequence, the application runs relatively slowly compared to more linear designs.

Besides the pictures and video, much of the production required background, titles, and some picture manipulation. Adobe Photoshop 3.0 was used for this purpose. Some of its more sophisticated features, such as layers and alpha channels, were used here to maximize development expediency. Other less sophisticated programs (e.g., Fauve Software Matisse, Micrografx Windows Draw, Corel Photo Paint) can lead to the same results.

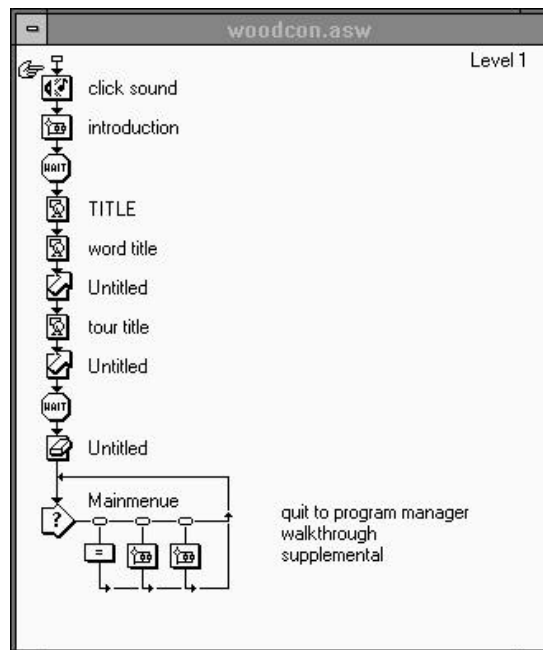


Figure 7: Developing Flowchart

The paradigm upon which this application was built is close to the virtual-reality environment offered by Apple QuickTime VR. During 1995, no consumer-oriented products integrated Quicktime VR, but this project could be entirely developed using virtual-reality in the future (all products mentioned in this section are registered trademarks of their owners).

Conclusion

This paper has discussed the production of one educational application of multimedia in particular. Other construction faculty interested in developing a similar application can benefit from these details, since there is much potential for the use of multimedia in construction. The sights and sounds of other construction settings could be integrated into applications similar to this one. Even more ambitious areas of application can be found in planning and contracting, since the consequences of a decision on the project's progress and appearance could be visualized immediately in a non-threatening environment. Such uses will require the extensive integration of video, sound and virtual graphic objects. The consumer-oriented products that will deliver these capabilities are either available for high-end desktop computers, or will be available in the near future.

In developing this estimating application, it was also evident that the required software and hardware is affordable to most construction programs. The main obstacle to the widespread use of multimedia productions in construction education is, therefore, the lack of dissemination about what such a project entails, more than any technical or financial consideration.

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