2006-981: RE-ENVISIONING CONSTRUCTION ENGINEERING AND MANAGEMENT EDUCATION THROUGH EXPERIENTIAL LEARNING

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Re-Envisioning Construction Engineering and Management Education through Experiential Learning

Introduction

One of the major challenges in construction engineering and management education is transferring knowledge from classroom environments to the field and practice of construction engineering and management. McCabe et al.[12] argue that much of civil engineering coursework teaches only theories of engineering and construction and that students may encounter difficulties when applying these theoretical constructs to real world situations. Sawhney et al.[18] maintain that many civil and construction engineering curricula do not allow the inclusion of issues of importance to industry, the participation of practitioners, or hands-on experience.

The University of Washington's Department of Construction Management has embarked on an ambitious project to develop a 28,000 sq. ft. research and education center, the Pacific Northwest Center for Construction Research and Education, to foster experiential learning and research in construction engineering and management. The Center is divided into three major functional areas: the Virtual Construction Laboratory, the Methods and Materials Laboratory, and the Construction Education Laboratory. Experiential learning has been introduced as a methodology that combines problem-solving skills with theoretical principles to redefine engineering education in order to meet the demands of the industry[14]. The University of Washington envisions the Pacific Northwest Center for Construction Research and Education as a place where learners will experience construction engineering and management theory and skills first hand, while researchers will study pedagogy and education methodologies related to engineering education.

Experiential learning can be defined as a constructivist pedagogical approach where learners build understanding through rich environments that encourage exploration and discovery. The teacher's role changes from that of a cognitive place holder to one that guides the actions in meaningful activities with practical and functional representations[2]. This paradigm is antagonistic to archetypal school activity and may be anathema to those accustomed to the didactic lecture-based models. However, it has been shown that students learn more effectively and permanently when they can actively participate in the learning process[4].

Experiential Learning and Construction Engineering and Management

Traditional construction engineering and management education follows the Cartesian view of mind-matter dualism where the learner and the learning context are detached. As a result, concepts are presented as fixed, well-structured, independent entities and classroom activities are disconnected from authentic context, resulting in fragmentation and specialization of courses and educational experiences. This fragmentation of knowledge has been identified in the construction domain[5,9] and is partially responsible for the polarization of learner and learning context. Under this paradigm, learners can recall concepts when they are explicitly required to, but even in relevant situations, students are unable to apply the concepts spontaneously.

In contrast to the traditional mode of education, learning through situational activity does not separate concepts from their application. Experiential learning presents concepts while clearly illustrating their relations to the decision-making environment. Barab et al.[2] studied student-resource and student-technology interactions in technology-rich, collaborative participatory environments. Some of their findings suggest that the ability to gain in-depth knowledge and skill with respect to a particular practice or concept is directly related to the availability of resources and the contextual demands. In a field such as construction engineering and management, where context-specific knowledge and awareness is imperative, experiential learning can support contextual learning and thereby improve the students' understanding of the concepts and their interrelations. However, in order to take full advantage of experiential learning in construction education, it is necessary to expose learners to realistic situations.

The challenge then is to create real-world contexts and examples in which students work through construction engineering and management problems. There are three main types of environments that can be utilized for experiential context learning: simulated environments, hands-on application laboratories, and computer application classrooms.

The aviation and medical industries, which face a similar dilemma of how to expose their professionals to realistic situations for acquiring and developing decision-making skills without endangering lives, are solving this problem by taking advantage of situational simulations in virtual environments. Flight simulators allow pilots to virtually execute and study different alternatives, while computer-aided surgery allows doctors to perform virtual operations. Therefore, one way of bringing experiential learning into the construction domain could be to develop situational simulations to provide construction managers and other decision-makers the opportunity of experiencing and responding to risky events without endangering the success of real projects.

Rojas and Mukherjee[16] have studied the use of situational simulations in construction engineering and management at the University of Washington. They argue that situational simulations can be effectively used in developing contextually rich educational environments to train decision makers in construction. They can emulate real construction management processes and provide temporally dynamic clinical exercises that expose participants to rapidly unfolding events and the pressures of decision-making. As the participant reacts to critical simulated situations, the simulated environment responds to their manipulations by challenging them to use their knowledge and skills to experiment and solve problems in a dynamic setting where conditions constantly change in response to their actions.

The use of situational simulation environments for learning is also supported by theories in situated cognition[20]. Such environments expose participants to clinical exercises that help them explore future consequences of present decisions and the sensitivity of their contexts to such decisions; over time, this exploration develops better decision-making skills. The Virtual Gorilla Project at the Atlanta Zoo[1], as well as the Virtual Puget Sound[19] and the Surgical Simulator[15] efforts at the Human Interface Technology Laboratory at the University of Washington are successful instances of such learning environments.

As a counter point to simulated environments, hand-on learning laboratories and computer classrooms allow students to practice and apply concepts throughout the construction engineering and management curriculum. For example, in a recent construction materials and methods course offered at the University of Washington, master masons were invited to the lecture hall to discuss masonry construction. They talked about quality, productivity and ergonomics. The students went home with lists of issues and a notion that masonry is a technically difficult skill to master and is physically demanding to perform. These same master masons invited the students to the International Masonry Institute learning center for a Saturday morning hands-on lesson. Twelve students out of one hundred attended the session and watched the masons lay brick and stone. The instructors not only showed examples and best practices (i.e., double buttering head joints), they were also able to illustrate the techniques and consequences with the material in hand. The students then tried their hand at laying brick. After an hour of wrestling with mortar that was heavier than they expected, bricks that were rough to the touch, and tools that felt foreign and awkward, the students reported aching wrists and a new found respect for the craftspeople that lay brick, stone and CMU block. When asked on a test what practices the master masons recommend for improved quality, the students who attended the hands-on session answered the question quickly and with confidence, whereas the other students struggled to remember what was said in the guest lecture. Therefore, hands-on experiences may also provide opportunities for incorporating experiential learning into the construction engineering and management domain.

Experiential learning can provide an environment to interact with materials, discuss design and construction issues and details, perform tests that illustrate the properties of materials, and practice techniques to gain an appreciation for the physical process of construction. For instance, hands-on experiences could include experiments and tests to fully understand the properties of materials, such as their strength, fire and weather resistance, acoustical characteristics, and expansion and friction coefficients. Students can then explore methods of construction by building assemblies, such as walls, slabs and finishes. Then students can test these assemblies for their performance requirements. Whether it is shaking a light wood frame in an earthquake simulation or exposing roofing tiles to alternating rain and sun in an accelerated weathering test, an experiential learning environment allows students to experience materials, means and methods that solidify their understanding of construction assemblies and processes.

Experience Learning Model at the Pacific Northwest Center for Construction Research and Education

In order to effectively and efficiently incorporate experiential learning into the construction engineering and management curriculum at the University of Washington, a model has been developed by the writers to take advantage of the new research and education facilities while building upon the body of knowledge in experiential learning in engineering education. The main objective of this model is to promote an environment that supports the development of the learner's creative potential by seeking stimulation and input from people who approach problems from multiple perspectives in a context of psychological safety and freedom while finding enjoyment, satisfaction, and challenge as motivators[10].

The proposed model is inspired by case learning methodology[11]. However, rather than developing case studies, the goal of this model is to develop "Experiences." For the purposes of this paper, an Experience is defined as an exercise where learners are actively engaged in executing projects, applying knowledge in problem situations, or both. The proposed model includes six sequential steps in designing and evaluating Experiences.

1. Definition of Learning Objectives
2. Definition of Scenario and Context
3. Identification of Resource Requirements
4. Execution of the Plan
5. Exercise and Post-Exercise Activities
6. Evaluation of Exercise

Throughout the development and execution of Experiences, educators should be cognizant of the following issues.

- <u>Learning Styles</u>: Finelli et al.[8] define learning styles as "…a biological and developmentally imposed set of personal characteristics that make some teaching (and learning) methods effective for certain students but ineffective for others …." There are several models of learning style preferences. However, the authors recommend Kolb's Experiential Learning Model[7] as a starting point to understand student differences. Experiences can be developed to teach around the Kolb's cycle by teaching for all four learning styles:

  Type 1 -- the diverger (concrete, reflective),
  Type 2 -- the assimilator (abstract, reflective),
  Type 3 -- the converger (abstract, active)
  Type 4 -- the accommodator (concrete, active)

  For example, Experiences in a lab setting can illustrate engineering concepts with the physical materials that perform or fail in real space and real time. Students not only see, but also hear, smell, feel and taste the materials' performance and failures. Those students who ask why (divergers) have their questions answered before their eyes; those who ask what (assimilators) can see and feel the concepts with the instructor as an expert to guide them through the Experience; those who ask how (convergers) can try the experiments themselves to discover through guided practice the means and methods; and those who ask what if (accommodators) can solve problem-based exercises that lead them to greater understanding of materials properties and limitations. To support these different learning styles, a mixture of teaching styles is important. Furthermore, different teaching styles require students to learn in a variety of environments. A balance between comfortable learning environments and challenging learning environments both encourages learning and forces students to stretch and grow to accommodate different and perhaps difficult learning conditions[7].

- <u>Approaches to Learning</u>: In addition to different learning styles, students also have different approaches to learning and orientations to studying. Felder and Brent[7] explain that students can approach learning from a superficial, deep, or strategic perspective. Those who apply a superficial approach are goal-oriented. They want to learn because they desire to pass a course, graduate, or get a job. Memorization of de-contextualized knowledge is the aim of these students. Students who have a deep approach are driven by intellectual curiosity. These students tend to be critical and analytical, and seek a true understanding of the material. Learners who have a strategic approach do whatever it takes to get a grade. Those students who apply this method prefer to memorize de-contextualized information rather than to learn concepts and understand their environment if they can get away with it. However, if the course requires deep understanding, they will do only what is necessary to obtain the desired outcome. From a pedagogical perspective, educators want to encourage a deep approach to learning. Felder and Brent[7] also summarize recommendations found in the literature that constructively align with the adoption of a deep approach; these include clearly-stated expectations and clear feedback on progress, assessment methods that prefer conceptual understanding over memorization, teaching methods that foster active student engagement, a reasonable workload, and consistency on the encouragement of a deep approach throughout the curriculum.

- Cognitive Levels of Activities: Catalano and Catalano[3] explore the transformation of teacher-centered to student-centered engineering education. One of their recommendations is to design activities at the proper cognitive level. Designing Experiences at a lower cognitive level than that of the students may create boredom, while designing Experiences at a significant higher level may create frustration. The objective should be to challenge students to work at a somewhat higher cognitive level by providing the tools and the environment to encourage intellectual growth. In construction engineering and management, lower cognitive levels include recognition and memorization, mid cognitive levels include solving problems and breaking down barriers, while high cognitive levels include drawing conclusions, evaluating pros and cons, and applying a system dynamics analysis approach.

- Psychological Safety and Freedom: Klukken et al.[10] argue that an environment where students are constantly guarding against any mistake discourages creativity. In addition, this critical environment diminishes active participation and engagement due to students' fear of failure. Who wants to participate in activities where their comments, questions, or suggestions are shot down or immediately reflected in grades? A safe environment where all comments are welcome and analyzed under the understanding that participation is most important, and problems or projects have the potential for multiple solutions, is more constructive to a participatory setting. It is also important to recognize that learning from mistakes is a valid pedagogical approach. After all, a student who makes a mistake but also learns from it gains a deeper understanding of the learning objective than a learner who happens to avoid mistakes by chance without an understanding of the concept. The attitude of an educator towards student mistakes can enhance or hinder psychological safety and freedom in an Experience. During a project management class at the University of Washington, a guest speaker from a local general contracting firm once said "if my project managers learn from their mistakes, I do not consider the cost of mistakes as waste, I consider it as tuition." This is the attitude that should be reflected in effective learning objectives.

We now turn to a detailed examination of the six sequential steps of the Experience Learning Model.

1) *Definition of Learning Objectives*

The first step towards the development of an Experience is to define the learning objectives. Proper learning objectives are paramount not only for an effective learning system, but also for effective assessment[6]. As discussed above, an understanding of different student learning styles, approaches to learning, orientation to studying, and varying levels of intellectual development is vital[7]. Consequently, there are several dimensions that must be addressed when defining learning objectives. The writers recommend a careful consideration of the following issues:

- <u>Knowledge Applicability vs. Knowledge Discovery</u>: When designing an Experience, educators should decide if they want to emphasize the application of a concept or the discovery of knowledge. Knowledge applicability refers to the process of applying known theories or principles to new situations. Knowledge discovery refers to the process of exposing learners who are ignorant of the underlying theory to new situations in order for them to explore and propose plausible explanations and theories, thereby discovering the concepts for themselves. These two approaches are not mutually exclusive, but an Experience will usually utilize one of these two approaches. The pedagogical implications of the selected dominant approach are significant. If knowledge applicability is the focus, then a series of pre-exercise activities, such as lectures, reading assignments, and knowledge assessment evaluations, should be incorporated into the design of the Experience. On the other hand, if knowledge discovery is the focus, then plenty of time should be allocated in the Experience for significant post-exercise activities, which may include lectures. Post-exercise activities are described later in this paper.

- <u>Building Appreciation vs. Making Decisions</u>: Educators should also decide if the Experience will focus on appreciation-building or decision-making. Appreciation-building refers to the process of drawing conclusions about a series of activities in order to gain appreciation of the difficulties and challenges involved in performing those activities. For example, once a student has spent a frustrating hour within the time restraints of a classroom exercise figuring out how to frame a wall, the lesson in productivity becomes tangible. They personally experience the pressure to finish the job, and understand on an immediate level what it means to cut corners to get it done. Then, the discussion of the consequences of cutting corners, or the pressure to increase productivity and how that affects the performance, the quality, and the workplace environment for the trade contractor becomes real to the student through this personal experience. In contrast to appreciation-building, decision-making refers to the process of evaluating alternatives and making decisions to optimize performance. For example, a student may encounter a test report from a concrete pour of several columns in which the experimental results from a 3-day compression test are 25% below the expected strength. The decision-maker can select among a variety of courses of action including disregarding the results, ordering new tests, waiting for the 7-day compression tests, or demolishing and re-building the columns. The specific action taken will have implications on project quality, cost, and schedule, as well as possible ethical implications. Analogous to the previous case, these approaches are not mutually exclusive. However, Experiences will tend to focus primarily on one or the other.

- Individual Work vs. Team-based Activities: Individual learning and team-based work are equally valuable skills for construction engineering and management students. Experiences can be designed for individuals or teams. Individual analysis and reflection is the basis for critical thinking, and the authors recommend that some type of individual work be incorporated into each learning Experience. Individual work can be reinforced by providing opportunities to present and argue their view with others in the class. Conversely, team-learning environments, such as working on projects in a lab, provide an opportunity for students to develop team building and interpersonal skills that will be invaluable in their professional lives. Leadership skills are often intangible and difficult to teach. By working in teams, students not only learn through doing, but they practice coordination, leadership, partnership, and patience. A cautionary note: working in groups and working in teams is not the same. Group work does not necessarily involve positive interdependence and collaboration. In a group environment, students usually divide a major task in subtasks and assign individuals to independently perform each subtask to later assemble a group response. In a team environment, members analyze, discuss, and solve problems together in a collaborative environment. Role playing is an excellent example of a team-based activity. By using role playing, educators can set up meetings where students play rolls such as contractor, subcontractor, design engineer, architect, owner, or user. Some exercise types might include planning and scheduling meetings (i.e. 4D schedule review), partnering meetings, community outreach, or alternatives evaluation meetings.

2) Definition of Scenario and Context

After defining the learning objectives, the next step in the model is to define the scenario and the context for the Experience. This step involves the identification of the activities and resources required for the implementation of the learning objectives. The scenario is the script that defines the activities students will perform and/or the decisions they will encounter. The context is the situational environment in which the scenario is being played. Several tools can be used to assist educators in defining the scenario and the context for an Experience.

Fig. 1 illustrates an example whereby decision diagrams are used as a planning tool for decision-making scenarios. Decision diagrams depict the logical thinking process required to solve a particular problem and the decisions that a reasonable person is most likely to make based on the circumstances and available information. Decision diagrams also identify the information that must be provided to support students' actions and define the variables that might be affected as a consequence of their decisions. The diagram shown in Fig. 1 was developed to explore the concept of schedule acceleration in a construction project. The scenario depicted in the figure is delay of material delivery. The boxes represent intermediate actions students are likely to make; the trapezoids indicate information needed to execute an action; the diamonds indicate decisions; while the ellipsoids are used to represent final actions. By reviewing this diagram, an educator realizes that this scenario requires, at a minimum, the availability of a CPM diagram, a bar chart

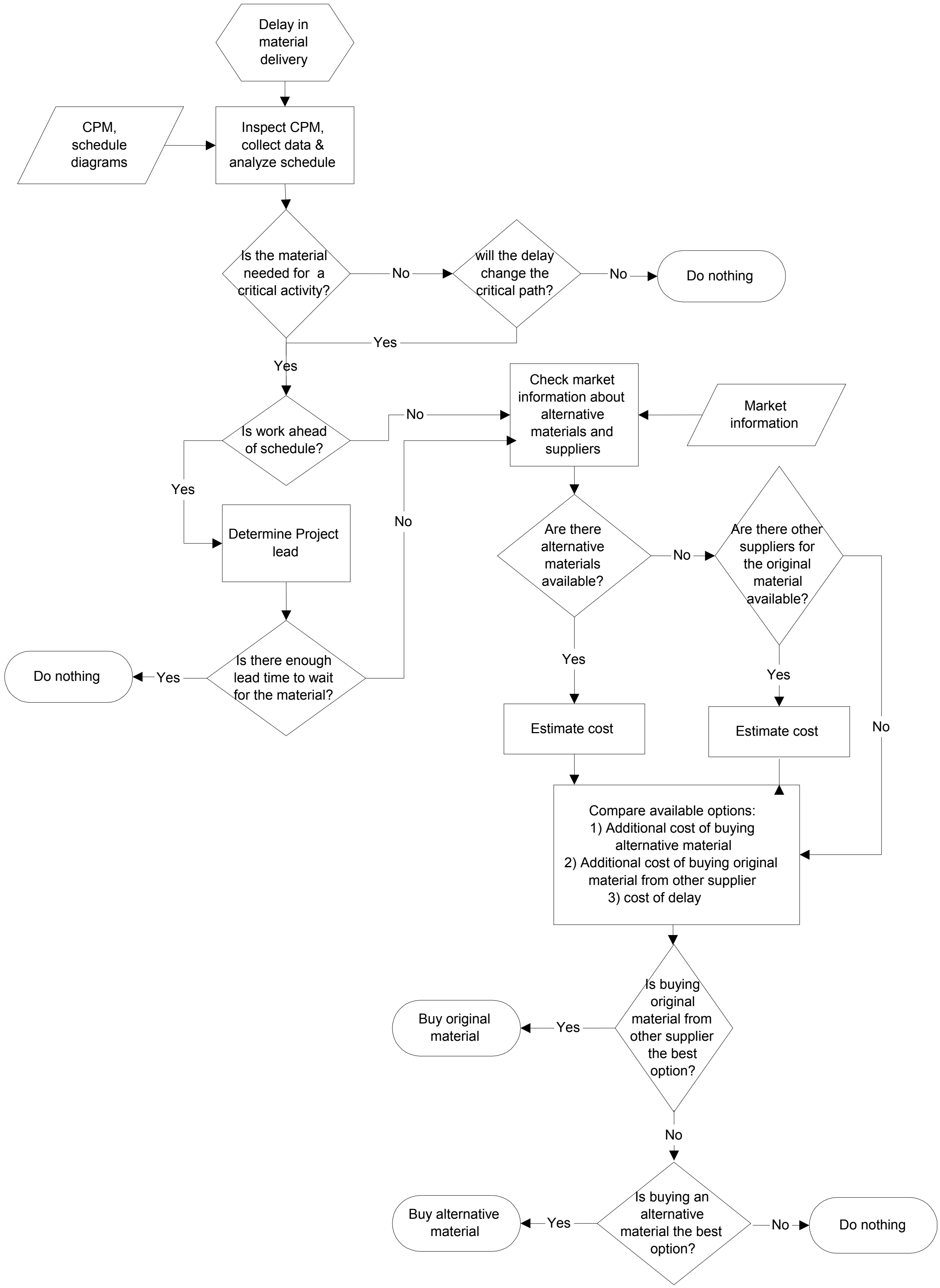

Fig. 1: Sample Decision Diagram

for as-planned and as-build schedules, market data on the cost of the specified material from multiple suppliers as well as the cost of alternative materials, and information about the amount of liquidated damages charged for every day the project is delayed.

The scenario depicted in Fig. 1 also helps in defining the context for the Experience. In order to properly contextualize this scenario, more detailed information about the construction project and the different stakeholders is needed. For instance, without any contextual information, decisions would likely be made based on minimum cost consideration only. However, if students also know that this is the first project this contractor is performing for a very important client with the potential of repeat business, some of them may decide to incur additional non-recoverable expenses in order to deliver the project on-time. These expenses could derive from buying the material at a higher price or accelerating a future critical activity. This is a valid strategy where the additional cost could be categorized as a marketing expense.

Students are likely to deviate from the very logical and organized analysis presented in a decision diagram. Mukherjee at al.[13] used a similar scenario during the evaluation of a simulated environment. During the study they noted how students were reacting to delays in the schedule. The most common reaction was to accelerate the activity at hand, without paying attention to where it was on the critical path diagram (i.e. it may not be a critical activity). Furthermore, it is important to recognize that decision diagrams may not include all possible permutations for a given scenario and that revisions may be necessary over time as new alternative actions are unveiled by creative students.

Regardless of the tools used to develop the scenario or context, this step establishes a script from which the educator communicates the exercise.

3) Identification of Resource Requirements

After defining the scenario and context for the Experience, it is necessary to identify resource requirements. Some of these resources are required only once to develop the Experience, while others may be needed in a recurring basis. Indirect resources related to planning activities, writing software applications, developing instructional guides, procuring instrumentation, and generating assessment tools are required only in the initial development of the Experience. Resources consumed during the execution of the Experience, such as building materials and assemblies, are recurring requirements.

Once resource requirements are assessed, educators can estimate the level of effort needed to develop and execute the Experience, in terms of both manpower and cost. The development of Experiences grounded in sound pedagogical practices requires a significant amount of resources and tend to be faculty-intensive. Institutional support is indispensable. By performing an inventory of resource requirements, educators are better equipped to write a proposal for the development of the Experience and negotiate the needed support, which may take the form of teaching assistants, release time, or even industry sponsorship.

4) Execution of the Plan

After approval of the proposal for the development of the Experience and allocation of the necessary resources, educators can focus their efforts on implementing their plan and taking care of all logistical issues involved in transforming their vision into a coherent and well-designed pedagogical exercise.

5) Exercise and Post-Exercise Activities

The next step in the model is to implement the Experience itself and perform post-exercise activities. Post-exercise activities include actions such as group analyses and debriefing sessions. In these activities, learners review and examine laboratory exercises. They describe the events that occurred, account for their actions, and discuss alternative strategies to solve the problems encountered. Post-exercise activities may generate a cognitive conflict within a group of learners because students may challenge the perceptions and decisions made by others during exercises. As a result of this cognitive conflict, learners begin to reorganize their way of thinking about a particular set of events. Time for reflection is as pedagogically important as executing the Experience itself.

6) Evaluation of Exercise

Evaluations are performed after post-exercise activities to help determine the extent to which the exercise fulfills its learning objectives. For example, if one of the learning objectives was an emphasis on decision-making, this evaluation should include mechanisms to answer the question: Are learners better decision-makers as a result of doing with the exercise?

In designing an Experience and evaluating its pedagogical effectiveness, the authors recommend blinded control studies. These studies usually include an experimental group and a control group. The experimental group consists of students who have experienced the exercise and the post-exercise activities, while the control group consists of students who have not. In the case of the decision-making example discussed in Step 2 above, the challenge of a longitudinal study is to quantify how good a decision-maker a subject actually is. The recommended approach is to assemble a panel of experts from the local construction industry to serve as judges. The panel interviews each one of the participating subjects before and after the exercise is executed to determine if their decision-making skills have changed. Members of the panel do not know the group to which each subject belongs (experimental or control). Panel members should receive proper training in order to make sure that they respond in a consistent and reliable manner. The decision-making skills of each subject can be evaluated through the introduction of a hypothetical situation in the same topical area as the exercise. They should be evaluated depending on how well they solve the problem. The evaluation criterion recommended is based on the work of Russo and Schoemaker[17]. These researchers described the following ten major barriers to successful decision-making:

- Not taking enough time to analyze the problem.
- Solving the wrong problem.
- Not looking at all sides of the problem.

- Being overconfident while predicting outcomes.
- Relying on easily available data.
- Not using a systematic procedure.
- Not managing the decision-process of a group.
- Failing to understand evidence from past outcomes.
- Failing to systematically record and track results.
- Not evaluating the decision-making process.

The hypothetical situation should present subjects with plenty of opportunities to make poor decisions by not successfully negotiating the barriers listed above. Each member of the judging panel assigns a grade for each one of the parameters depending on how well the subject was able to look beyond these barriers. Statistical data are gathered from the longitudinal study and comparisons among the experimental and the control groups are performed. This provides valuable knowledge about the efficacy of the exercise as a tool to improve the decision-making process of current and future construction engineers.

Finally, it is important to recognize that this process evaluates the effectives of the Experience rather than the performance of the subjects. Therefore, the authors do not recommend using the results of these evaluations as part of student grades.

The Pacific Northwest Center for Construction Research and Education

The Department of Construction Management at the University of Washington (UW) proposes to utilize the Experience methodology in a variety of ways at the Pacific Northwest Center for Construction Research and Education to redesign construction engineering and management education.

The Virtual Construction Laboratory (VCL):

The VCL focuses on modeling, simulation, and visualization of construction engineering and management processes. It houses a 1,200 sq. ft. Holosuite and a 120 degrees projection screen (30’ x 15’) for virtual and augmented reality applications. This lab is being developed in collaboration with UW’s Human Interface Technology Laboratory. The educational objectives of this lab include:

- Encourage a System Dynamics Perspective – Learners will gain an understanding that the construction engineering and management domain is a complex system that has multiple interacting components (schedule, cost, resource distribution and availability, safety, quality, etc.) with multiple feedback loops. System dynamics can be used to understand these interdependencies so that causal impact of changes can be traced throughout the system.

- Enhance Understanding of Construction Planning and Scheduling – Learners will broaden their awareness of the importance of planning for construction projects. Constructability reviews, productivity analyses, proper sequencing, temporary structures, job site layout, and material storage and handling are essential for a successful construction project. The use of 3D and 4D models, as well as virtual and augmented reality applications, greatly improves understanding of construction planning issues.

- Increase Awareness of Construction Safety – The simulation of dangerous operations, improper practices and risky behaviors will increase the consciousness regarding the role of safety in the construction engineering and management domain.

- Build Familiarity with Information, Simulation, and Visualization Technologies – Increasing interaction with state-of-the-art computing technologies will encourage future construction practitioners to apply these technologies in the field. One of the main barriers to adopting emerging technology is the exposure to and comfort level with new technology and how they support the planning and management functions on a project. Exposure to these technologies broadens the learner's horizons both at the learning institution and in professional practice.

The Methods and Materials Laboratory (MML):

The MML focuses on productivity, safety, and health education. It incorporates two primary components: a large high bay space in which construction systems can be used to work on specified building components or materials using standard or innovative techniques, and an integrated high-speed data acquisition system to capture multiple-feed digital video and instrument signals using high speed wireless telemetry. This space is being developed in collaboration with UW's Environmental and Occupational Health Sciences Department. The educational objectives of this lab include:

- Enhance Familiarity with Construction Methods and Materials – By providing hands-on experiences to learners, this laboratory will improve the understanding of method and materials. In laboratory experiments, for example, learners cannot only build walls, slabs and finishes, but also can test these assemblies for their performance requirements. In this environment, learners gain respect for the trades who perform the labor in the field, appreciation for productivity and coordination issues, as well as awareness of quality, safety, and management concerns.

- Understand Factors Affecting Labor Productivity – By performing construction activities under different conditions or constraints, learners and researchers will experiment with a variety of factors known to affect productivity values, providing a deeper understanding about labor productivity.

- Broaden Understanding of Environmental Health and Safety Issues – Scenarios will be developed and performed in this laboratory that will enhance awareness of the hazardous materials and conditions workers are typically exposed to in construction projects. A better understanding of health and safety risks encourages a more comprehensive consideration of these issues in the planning of construction projects and implementing health and safety programs for the benefit of workers and society in general.

The Construction Education Laboratory (CEL):

The CEL investigates different pedagogical approaches related to construction education. It houses a two-way teleconferencing classroom with experimental tele-observation and tele-operation capabilities. It also incorporates a state-of-the-art multimedia production facility to create a variety of educational materials. This lab is being developed in partnership with UW's College of Education. The objectives of this lab include:

- Encourage Post-Exercise Activities – Evaluation and reflection are important steps for experiential learning, and in the CEL instructors will develop practices such as group analyses and debriefing sessions. In these activities, learners review and examine laboratory exercises. They describe the events that occurred, account for their actions, and discuss alternative strategies to solve the problems encountered. Post-exercise activities may generate a cognitive conflict within a group of learners because students may challenge the perceptions and decisions made by others during exercises. As a result of this cognitive conflict, learners begin to reorganize their way of thinking about a particular set of events and how various perspectives contribute to a more complex understanding of the processes and projects they will work on throughout their career.

- Evaluate Pedagogical Activities – Learners and researchers will examine the effectiveness of different pedagogical approaches by conducting experiments in the classroom setting. This will enhance our understanding of the relationship among pedagogy and students learning styles, approaches to learning, and intellectual development.

- Disseminate Knowledge – The CEL will allow the University of Washington to provide education to a broader audience through the dissemination of on-line information, simulations, experiments, tele-observations, tele-operations, seminars, and other activities. Traditional classroom education is only available to those who can be present when and where the education is offered. Learners are usually restricted to the educational resources locally available. The CEL changes this traditional paradigm, as every student has access to a variety of learning opportunities across the globe.

- Build Partnerships – The CEL facilitates partnering among institutions of higher education and between the academic community and the industry to leverage resources and expertise in order to generate a richer educational environment for the learner. Educational programs at different institutions exhibit different competencies. Sharing these competencies and other resources through on-line collaborations broadens the learner's horizons.

- Build Repositories of Educational-Oriented Simulations – The CEL will allow educators to establish formal simulations as "educational exercises" to be used throughout the higher-education community as well as the industry. The CEL will provide certification of these simulations to maintain academic integrity standards and protocol. For example, to be considered an "educational exercise", a simulation should properly identify authorship, supported decision-making skills, intended audience, and other relevant characteristics, including the disposition of the authors to allow postings of third party evaluations of their exercises. Certification will not be required to register a simulation with the CEL, but it will provide educators and learners with the assurance that those simulations that are certified comply with a minimum set of standards.

Conclusions

Throughout this paper, the authors have presented means and methods of applying experiential pedagogical approaches to Construction Engineering and Management education and curriculum. A pedagogical model is presented whereby educators develop “Experiences” to facilitate active learning in the context of real-world applications and problems. This model includes the following six steps:

1. Definition of Learning Objectives
2. Definition of Scenario and Context
3. Identification of Resource Requirements
4. Execution of the Plan
5. Exercise and Post-Exercise Activities
6. Evaluation of Exercise

Illustrative examples are presented to discuss how the University of Washington’s Department of Construction Management envisions experiential learning curriculum at the Pacific Northwest Center for Construction Research and Education.

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