

# Using Simulations to Better Train Future Construction Management Personnel



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# INTRODUCTION AND BACKGROUND

Managing construction involves being able to make decisions that involve balancing time, cost, quality, resources, and identifying and solving a variety of issues related to the selection of equipment, labor, and tools.

The skills required of today's construction engineering and management professionals are a combination of management skills and technical knowledge.

# INTRODUCTION AND BACKGROUND

millennium generation enters the higher education system many have spent hours playing computer games as they have in the classroom during their lifetime; therefore, a natural transition is for our learning environments to begin to use techniques from the gaming world.

In the effort to enhance the education experience for construction engineering and management students, a COnstruction INdustry Simulation (COINS) was designed and developed at California Polytechnic State University, San Luis Obispo (Cal Poly) to prepare construction engineering and management students for the real world.

# DESIGN AND DEVELOPMENT OF COINS

The first version of COINS was Building Industry Game (BIG) and was originally developed to enhance student learning in construction management departments.

BIG originated out of an idea by Hal Johnston, Professor in Construction Management Department and Emeritus Faculty Jim Borland at Cal Poly.

The BIG simulation game focused on the commercial building sector of the construction industry.

It was their goal that BIG would become part of a larger integrated construction company simulation that incorporated more sectors of the construction industry; COINS incorporates their vision.

# DESIGN AND DEVELOPMENT OF COINS

COINS was developed into a web based simulation written with a in JAVA front-end and using PostgreSQL database.

COINS was developed using open source software.

The intent of COINS was to develop a simulation beyond just an estimating game;

the goal was to produce a simulation required students to create a strategy for:

- human resources management,
- business development/procurement of work, and
- project management.

# DESIGN AND DEVELOPMENT OF COINS

COINS includes projects from two of the largest construction industry sectors: Commercial Buildings and Heavy Civil Infrastructure projects.

| Commercial Building Projects   | Heavy Civil Infrastructure Projects  |
|--|--|
| <ul style="list-style-type: none"><li>▪ Multi-family housing</li><li>▪ Educational facilities</li><li>▪ Hospitals and medical office buildings</li><li>▪ Commercial office buildings</li><li>▪ Industrial manufacturing facilities</li></ul> | <ul style="list-style-type: none"><li>▪ Highways projects</li><li>▪ Bridges</li><li>▪ Residential site development</li><li>▪ Mass excavation</li><li>▪ Underground utilities</li></ul> |

# DESIGN AND DEVELOPMENT OF COINS

Each project consists of nine (9) activities, which together comprise the project schedule. These are listed in the table below.

| Commercial building Projects   | Heavy Civil Infrastructure Projects   |
|--|---|
| <ul style="list-style-type: none"><li>▪ Excavation</li><li>▪ Foundation</li><li>▪ Basement</li><li>▪ Framing</li><li>▪ Closure</li><li>▪ Roofing</li><li>▪ Siding</li><li>▪ Finishing</li><li>▪ Mechanical, electrical, and plumbing</li></ul> | <ul style="list-style-type: none"><li>▪ Clear and grubbing</li><li>▪ Rough grading</li><li>▪ Excavation</li><li>▪ Underground utilities (water, sewer, storm drain)</li><li>▪ Concrete placing and finishing</li><li>▪ Backfilling and compaction</li><li>▪ Aggregate base placement and compaction</li><li>▪ Paving</li><li>▪ Finish grade</li></ul> |

# USE OF COINS IN THE EDUCATIONAL PROCESS

The typical use of COINS involves dividing a class into teams, who will form a virtual construction company.

Student teams are able to hire virtual staff as needed, deal with monthly problems, make choices, and experience the effects of their decisions.

During game play, participants gain experience and exposure to a cadre of real world scenarios, are provided with the opportunity to gain experience, learn from their mistakes, and experience the totality of management required of the construction professional.



# USE OF COINS IN THE EDUCATIONAL PROCESS

Each team is given an equal amount of capital at the beginning of the game.

Time is represented as "periods," each period represents two (2) months of real-time.

The period is advanced once or twice per week. Each period, new projects are available for the teams to propose on.

With the increasing number of awarded contracts, companies must recruit other overhead personnel or the companies must pay large additional sums for the employment of external consultants.

# USE OF COINS IN THE EDUCATIONAL PROCESS

Ultimately, the goal of the students during gameplay is to achieve the best possible outcome for their company by analyzing situations, gathering data, and making strategic decisions between time, cost and quality.

COINS allows the game administrator (instructor) to place the player or team into a situation or incident that could require a quick short term solution or possibly a long term change in the company.

Situations also take the form of cases that require ongoing management by the team over an extended period of time.

# HUMAN RESOURCES MANAGEMENT

The first order of business in game play involves students forming multiple teams and creating a virtual construction company.

They must develop a mission and value statement to define their company.

Student teams are given a username and password by instructor.

Teams register their team members and each student team member plays the role in the companies organization.

Teams are required to hire personnel, creating main office overhead, i.e. President, Marketing Director, Estimator, Student Intern, Scheduler, Accountant, etc. They are permitted to change personnel, as they need either for growth or other reasons.

# HUMAN RESOURCES MANAGEMENT

| Employee Type                                | Employee Pay per Period | # Currently Employed | Total for Employee Type | # to Hire/Layoff this Period |
|--|-------------------------|----------------------|-------------------------|------------------------------|
| <a href="#">Accounts Payable Clerk</a>       | \$5,000                 | 0                    | \$0                     | 0/0                          |
| <a href="#">Accounts Receivable Clerk</a>    | \$5,000                 | 0                    | \$0                     | 0/0                          |
| <a href="#">Administrative Assistant</a>     | \$6,500                 | 0                    | \$0                     | 0/0                          |
| <a href="#">Assistant Estimator</a>          | \$10,000                | 1                    | \$10,000                | 0/0                          |
| <a href="#">Assistant Project Manager</a>    | \$10,800                | 1                    | \$10,800                | 0/0                          |
| <a href="#">Blue Print Clerk</a>             | \$3,200                 | 0                    | \$0                     | 0/0                          |
| <a href="#">Business Development Manager</a> | \$15,000                | 0                    | \$0                     | 0/0                          |
| <a href="#">Cabinet Shop Manager</a>         | \$9,200                 | 0                    | \$0                     | 0/0                          |
| <a href="#">CEO</a>                          | \$25,000                | 1                    | \$25,000                | 0/0                          |
| <a href="#">Chief Accountant</a>             | \$15,000                | 1                    | \$15,000                | 0/0                          |
| <a href="#">Comptroller</a>                  | \$17,000                | 0                    | \$0                     | 0/0                          |
| <a href="#">Concrete Services Manager</a>    | \$10,800                | 0                    | \$0                     | 0/0                          |
| <a href="#">Contracts Coordinator</a>        | \$5,800                 | 0                    | \$0                     | 0/0                          |

## Companies in this game:

| Company Title         | Username   | Cash-on-hand  | Retained Earnings (Equity) |                      |
|-----------------------|------------|---------------|----------------------------|----------------------|
| AHT CONSTRUCTION      | adamthomas | \$126,501     | \$1,050,528                | <a href="#">View</a> |
| Freeloaders           | freeloader | \$450,383     | \$861,334                  | <a href="#">View</a> |
| Harmon CONSTRUCTION   | caleb1     | \$684,519     | \$806,519                  | <a href="#">View</a> |
| H & H Construction    | hayeshill  | (\$1,022,042) | \$1,128,049                | <a href="#">View</a> |
| MF DEVELOPMENT        | mattfroy   | \$742,513     | \$864,513                  | <a href="#">View</a> |
| OAKDALE CONSTRUCTION  | oakdale    | (\$511,669)   | \$1,120,740                | <a href="#">View</a> |
| Platypus Construction | keithryan  | \$759,661     | \$881,661                  | <a href="#">View</a> |
| POLY-BID              | poly-bid   | \$652,566     | \$1,185,046                | <a href="#">View</a> |
| RBTrust               | rbtrust    | \$991,466     | \$1,186,454                | <a href="#">View</a> |
| Smart Construction    | fire123    | \$142,884     | \$1,141,778                | <a href="#">View</a> |
| S & S Construction    | stowes     | \$273,978     | \$1,421,783                | <a href="#">View</a> |
| T Square Construction | winter     | \$594,901     | \$844,362                  | <a href="#">View</a> |

[Add a new company to this game](#)

# **BUSINESS DEVELOPMENT/PROCUREMENT OF WORK**

Teams are given quantities, expected production, and costs for each activity on every job available for each project.

The student teams must decide which project to propose on, select a method for each activity, determine their direct cost, and then finalize their cost estimate by adding cost for indirect jobsite cost, construction contingencies, and project margins.

COINS also generates an estimate internally for every project in effort to check the teams estimates within reason. Teams evaluate the results and attempt to interpret their competitor's strategies as the game progresses

# PROJECT MANAGEMENT

Players must monitor their financial position as work progresses, and submit request for payment for their work to date. Also, teams must create strategies to improve their bonding limits. A record of successful projects creates an opportunity to obtain negotiated work. At the end of every period, each team receives a:

- Progress Report
- Complete Dynamic Financial Report
- Analysis Report of the work accomplished, and
- financial result to date.

# PROJECT MANAGEMENT

The amount of work completed during a period depends on: the production rate for the work packages selected on each activity and the uncertainty factors, including - weather conditions, labor availability, and fluctuating cost of materials.

The end-of-period financial reports show expenses incurred for:

- Direct construction costs
- Bidding costs
- Consulting services
- Liquidated damages, and
- Interest on borrowed money



### Bill for Job 180

| Activity                | Percent Complete | Current Cost Incurred (\$) | Amount to Bill (\$)            |
|-------------------------|------------------|----------------------------|--------------------------------|
| Excavation              | 100.00%          | 0                          | <input type="text" value="0"/> |
| Foundation              | 100.00%          | 0                          | <input type="text" value="0"/> |
| Basement                | 100.00%          | 107,456                    | <input type="text" value="0"/> |
| Framing                 | 100.00%          | 0                          | <input type="text" value="0"/> |
| Closure                 | 100.00%          | 232,200                    | <input type="text" value="0"/> |
| Roof                    | 100.00%          | 707,370                    | <input type="text" value="0"/> |
| Siding                  | 54.29%           | 308,728                    | <input type="text" value="0"/> |
| Finishing               | 29.51%           | 220,224                    | <input type="text" value="0"/> |
| Mechanical & Electrical | 30.82%           | 6,000                      | <input type="text" value="0"/> |

**Total Amount to Bill:**

#### Summary of Revenue Info from Other Reports:

Contract Amount

\$5,958,552

Billed to date:

\$2,760,840

**S & S Construction**  
**Ratios Report**

Period: 5, September & October 2005

| Ratio                           | Average Over Past 4 Periods | Period 5 (Current) | Period 4 | Period 3 | Period 2 | Formula                                     |
|---------------------------------|-----------------------------|--------------------|----------|----------|----------|---|
| <b>Liquidity Ratios</b>         |                             |                    |          |          |          |   |
| Current Ratio                   | 5.19                        | 3.64               | 4.14     | 4.99     | 7.99     | Current Assets / Current Liabilities        |
| Receivable Turns                | 3.04                        | 8.63               | 0.62     | 1.51     | 1.40     | Revenue / Accounts Receivable               |
| Payable Turns                   | 2.57                        | 3.07               | 2.25     | 2.32     | 2.64     | Cost of Construction / Accounts Payable     |
| Working Capital Turns           | 3.89                        | 4.97               | 7.80     | 2.12     | 0.68     | Revenue / Cash-on-hand                      |
| Working Capital to WIP          | 8.4%                        | 2.2%               | 2.8%     | 8.5%     | 20.0%    | Cash-on-hand / Work-in-Progress             |
| <b>Debt Ratios</b>              |                             |                    |          |          |          |   |
| Earnings Coverage Over Interest | -                           | -                  | -        | -        | -        | Earnings from Operations / Interest Expense |
| Debt to Net Worth               | 0.25                        | 0.35               | 0.29     | 0.22     | 0.13     | Total Liabilities / Equity                  |
| <b>Operating Ratios</b>         |                             |                    |          |          |          |   |
| Gross Profit                    | 23.1%                       | 25.3%              | 28.5%    | 24.7%    | 13.9%    | Gross Profit / Revenue                      |
| Net Profit                      | 7.9%                        | 9.7%               | 14.5%    | 12.1%    | -4.6%    | Net Earnings / Revenue                      |
| Return on Net Worth             | 9.4%                        | 14.3%              | 15.4%    | 9.5%     | -1.8%    | Profit before Tax / Equity                  |
| Return on Assets                | 7.2%                        | 10.6%              | 11.9%    | 7.8%     | -1.6%    | Profit before Tax / Total Assets            |
| <b>Cost Ratios</b>              |                             |                    |          |          |          |   |
| Cost of Construction to Sales   | 76.9%                       | 74.7%              | 71.5%    | 75.3%    | 86.1%    | Cost of Construction / Revenue              |
| G&A Expense to Sales            | 11.2%                       | 10.3%              | 6.3%     | 9.8%     | 18.5%    | G&A Expense / Revenue                       |
| Operating Expense to Sales      | 88.1%                       | 85.0%              | 77.7%    | 85.0%    | 104.6%   | (Cost of Construction + G&A) / Revenue      |

# PROJECT MANAGEMENT

Student teams must monitor their financial position as work progresses, and bill for their progress payments.

Changes in company's financial position will change ratios and are also logged along with changes to the company's appraisal metrics:

- Financial liquidity
- Financial success
- Responsibility
- Pace
- Ethics
- Name recognition

# PROJECT MANAGEMENT

As gameplay progresses, teams have the following options:

- Pay a consulting fee to receive information on weather forecasts, material prices, labor and material availability, and market projections for future periods.

- Apply for loans.

Make a change and specify a different method for the following periods.

Use overtime to speed up certain activities (greatly increasing the labor costs).



**THANK YOU**

