



# **Biomanufacturing Simulations Lessons Learned**

**for Emergent Learning Forum**

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# About the Simulations

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- Audience
  - New employees to biomanufacturing facility
  - College degree, but not necessarily in science
- More to introduce the concepts than to train details of procedures
- Total of 6 sims of various types
  - Each has leveraged different aspects of simulation design
  - Each provides different “Sim Wins”
  - Each has created its own challenges



# Type 1: Controlling multiple variables

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- Subject Matter:
  - Controlling cell growth in a bioreactor
- Instructional Flow:
  - Present each variable in isolation
  - Combine variables, add support and encourage exploration
  - Remove support to demonstrate mastery



# Type 1: Controlling multiple variables

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- Sim Wins:
  - Cost
  - Time compression: weeks → minutes
- Lessons:
  - Use the simplest possible model that meets the *instructional* goals
  - Tuning the model to make sim challenging but achievable is time consuming
  - Learners loved the gaming aspect



## Type 2: Step-by-Step Procedure

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- Subject Matter:
  - Cleaning a large reaction vessel (CIP)
- Instructional Flow :
  - Present overview of equipment
  - Present each step of the procedure
  - Allow learner to try process with support
  - Remove support to demonstrate mastery



## Type 2: Step-by-Step Procedure

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- Sim Wins:
  - Cost
  - Exploration of effects of parameters not controllable on real system
- Lessons:
  - Important to let people intentionally explore the consequences of mistakes
  - Adding even semi-gratuitous sound greatly enhances the learner's experience



# Type 3: Virtual Environment

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- Subject Matter:
  - Safety in handling high pressure in a manufacturing facility
- Instructional Flow:
  - Introduce safety concepts
  - Supervisor character walks learner through a virtual manufacturing area
  - Supervisor gives series of scenarios for the learner to complete
    - Learner is intentionally distracted during tasks
    - Later scenarios are set up counter to learner's expectations of "normal"
    - Supervisor provides feedback along the way



## Type 3: Virtual Environment

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- Sim Wins:
  - Learners can make potentially life-threatening mistakes without consequences
- Lessons:
  - Virtual supervisor is a great way to provide instruction and feedback
  - This level of reality is enough to get learners to react strongly to simulated danger and failures  
(see *The Media Equation*, Reeves and Nass)
  - Direct manipulation enhances the experience, but can confuse learners
  - Sound plays important role here, including background “system running” noise



# Project Management Lessons

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- Our traditional content development process quickly failed and was discarded in favor of small, fast iterations
- Important to get a working model in software ASAP
- Sim design is much more “tactile” than traditional e-learning; it takes a lot of time to get it to “feel right”
- Estimating time to accomplish even small specific tasks has been very difficult
- Set client expectation up front that this will be a longer, bumpier road than they’re used to (Think pioneer in a covered wagon without a map)
- Collaboration among a very experienced team has made these designs much stronger than if designed independently



# Development Lessons Learned

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- This requires both serious programming skills and serious Flash skills
- You can do really sophisticated simulations in Flash, partly due to its dynamic nature
- You will spend countless hours debugging your simulations in Flash, due to its dynamic nature
- A shared simulation code framework will cost in the short-run, but save time in the long-run
- Sometime you have to go “off framework” to save time and meet deadlines
- Real source code control is critical if you have more than one developer
  - try Subversion (<http://subversion.tigris.org>)