Modeling and Simulation

A Model High School Curriculum
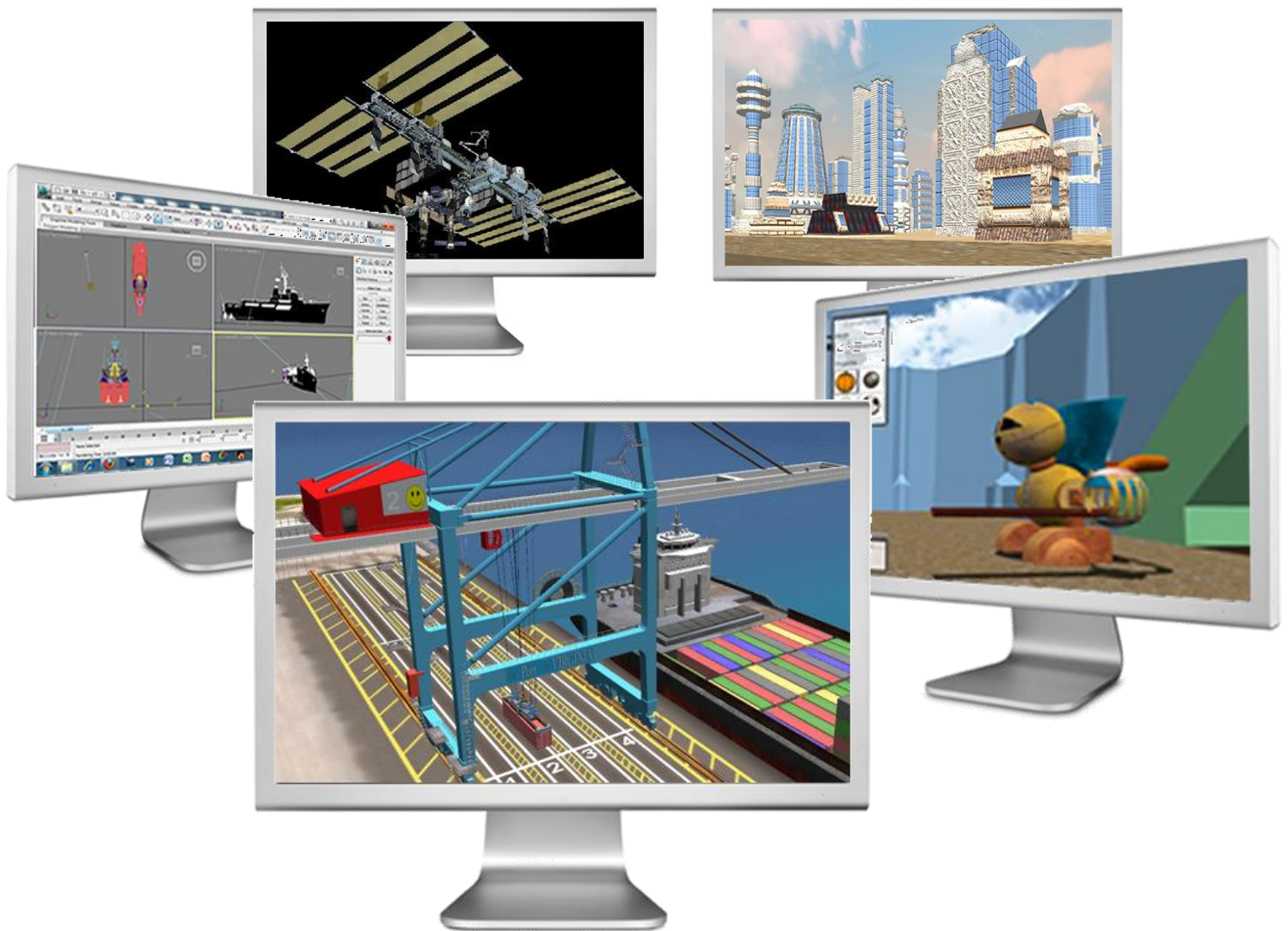
Curriculum Sponsors

This curriculum is the product of the combined efforts of the following organizations:

Opportunity Inc. of Hampton Roads

500 E. Plume St. Suite 700
Norfolk, VA 23510

The Cognition and Learning Laboratory

Old Dominion University

Department of STEM Education and Professional Studies

Old Dominion University

The Virginia Modeling, Analysis and Simulation Center (VMASC)

Old Dominion University

Old Dominion University

Contents

Introduction

Modeling and simulation is a dynamic field that is utilized in engineering, science, health science, business, education, and many other disciplines. Due to its dynamic nature, the modeling and simulation (M & S) field has tremendous potential for creating student interest in science, technology, engineering, and mathematics (STEM) disciplines. Content includes, but is not limited to geospatial technologies (i.e. GPS, GIS, remote sensing), gaming, medical and scientific imaging, animation, engineering drawing, transportation, distribution, warehousing, and architectural drawing.

Course Description

In *Modeling and Simulation*, students will develop an understanding of the systems, processes, tools, and implications of this field. Individual and group activities are designed to help students understand, use, manage, and assess historical, current, and emerging developments.

How to Use This Guide

The materials contained in this instructional framework guide have undergone a rigorous developmental process. A straw list of competencies was initially created by a group of secondary and post-secondary instructors based on the professional literature. A survey was then sent to modeling and simulation professionals in southeastern Virginia to validate the competencies and provide guidance on curriculum content and student experiences. Instructional materials were created by secondary and post-secondary instructors using the survey responses. Finally, independent reviewers provided feedback and revisions were made based on these responses as well as data obtained during field testing. The following participants have contributed as writers, reviewers, or field testers.

Mr. William Jackson
Advanced Technology Center
Virginia Beach, VA

Dr. Philip A. Reed
Old Dominion University
Norfolk, Virginia

Mr. Jody Strausser
Tidewater Community College
Suffolk, Virginia

Dr. Ginger Watson
Old Dominion University
Norfolk, Virginia

Each Duty Area section starts with a list of the Tasks/Competencies that pertain to that particular area. Tasks/Competencies define what students should know and be able to do after studying the Duty Area. Each task/competency is further defined by a rationale and objectives. In addition, the *Suggested Assessment Method* section lists activities for analyzing student achievement. Design briefs, problem solving, design portfolios, and technology assessment are all encouraged assessment strategies (see the *Instructional Delivery* section). At least one design brief is included in each unit and several case studies have been added to help meet tasks/competencies.

Task/Competency correlations to the Virginia Standards of Learning (SOL's) have been identified for English, Mathematics, Science, History, and Computers/Technology (See Appendix A for a complete list of related SOLs). Additional correlations have been made to the Virginia Workplace Readiness Skills.

Instructional Delivery

The technological method is central to the high school technology education curriculum. Using the technological method, students recognize technological problems and follow logical procedures to find solutions. The technological method enables students to create new opportunities, effectively communicate ideas and solutions, and analyze the technological benefits and consequences.

Teachers may use four instructional approaches to help students understand and use the technological method:

The Design Brief – Recognizing technological problems: A design brief helps students learn to recognize technological problems within a context or situation from the real world. Using critical thinking, students first clarify the problem and state it in written form before they follow the other steps in problem solving. Effective design briefs stimulate the application of math, science, and other disciplines to technological solutions. Teachers can use design briefs to focus learning on the specific content, materials, or processes that students need to study.

Problem Solving – Following logical procedures: Teachers who use this approach challenge students to find creative solutions to practical problems. The steps of problem solving are flexible; however, each step (analyze the problem, consider alternatives, make solutions, evaluate results) engages students in thinking, planning, and using various resources. Teams of students work cooperatively to solve problems and present solutions with models, products, displays, and/or graphic illustrations.

Design Portfolio – Communicating ideas and solutions: The portfolio documents the thinking process, serving as a graphic and written record of student work and accomplishment. Students benefit from presenting their ideas for others to consider. Portfolios allow students to record their progress, recycle ideas, and communicate with team members, teachers, and parents. In addition, a well-done portfolio is a resource for job and college interviews, bringing to light otherwise hidden skills.

Technology Assessment – Analyzing impacts: Technological knowledge and application are incomplete until the appropriateness of technology to society, the environment, and economic systems is determined. Using techniques of assessment, students learn to analyze the impacts of technology and make decisions based on their findings. Assessment ensures that new designs are appropriate solutions for today and tomorrow.

Competency List

Modeling and Simulation - 36 Weeks

Exploring Modeling and Simulation (1 Week)
    1.1 Use appropriate modeling and simulation terminology.
    1.2 Identify disciplines related to modeling and simulation.
    1.3 Explain modeling and simulation paradigms.
    1.4 Explain the history of modeling and simulation.
    1.5 Research information on the internet and print sources.
Demonstrating Computer Skills (1 Week)
    2.1 Perform basic computer operations.
    2.2 Demonstrate basic keyboarding and word processing.
    2.3 Manipulate file structures.
    2.4 Explain network components.
    2.5 Analyze ethical issues.
    2.6 Create basic spreadsheets.
Exhibiting Mathematical Skills (6 Weeks)
    3.1 Describe the methods of data collection in a census, sample survey, experiment, and observational study and identify an appropriate method of solution for a given problem setting.
    3.2 Analyze graphical displays of data.
    3.3 Analyze numerical characteristics of univariate data sets to describe patterns and departure from patterns, using mean, median, and mode.
    3.4 Identify and describe two or more events as complementary, dependent, independent, and/or mutually exclusive.
    3.5 Find probabilities (relative frequency and theoretical), including conditional probabilities for events that are either dependent or independent, by applying the "law of large numbers" concept, the addition rule, and the multiplication rule.
    3.6 Compute and distinguish between permutations and combinations and use technology for applications.
    3.7 Plan and conduct an experiment that will address control, randomization, and measurement of experimental error.
    3.8 Perform basic mathematical calculations as needed in software applications.
Understanding Problem Analysis (3 Weeks)
    4.1 Demonstrate the experimental design process.
    4.2 Explain discrete event simulation.
    4.3 Apply numerical analysis techniques.
    4.4 Select appropriate level of fidelity for a model.
Demonstrating Programming (6 Weeks)
    5.1 Examine computer programming factors that influence design.
    5.2 Explain object models.
    5.3 Explain agent-based simulation.
    5.4 Explore software evolution and lifecycle.
    5.5 Apply simple gaming concepts

Investigating Modeling and Simulation (11 Weeks)

6.1 Use modeling and simulation software.

6.2 Explain distributed simulation.

6.3 Explain visual simulation.

6.4 Explain human behavior models.

6.5 Explain intelligent systems.

6.6 Explain environmental models.

6.7 Build a scenario for experimentation or training.

Demonstrating Visualization (8 Weeks)

7.1 Build a visual model.

7.2 Render basic 3-D models.

Exhibiting Workplace Readiness Skills (Embedded Throughout)

8.1 Demonstrate reading skills on a level required for employment in a chosen career field.

8.2 Demonstrate math skills on a level required for employment in a chosen career field.

8.3 Demonstrate writing skills on a level required for employment in a chosen career field.

8.4 Demonstrate speaking and listening skills on a level required for employment in a chosen career field.

8.5 Demonstrate computer literacy on a level required for employment in a chosen career field.

8.6 Demonstrate reasoning, problem-solving, and decision-making skills.

8.7 Demonstrate understanding of the "big picture."

8.8 Demonstrate a strong work ethic.

8.9 Demonstrate a positive attitude.

8.10 Demonstrate independence and initiative.

8.11 Demonstrate self-presentation skills.

8.12 Maintain satisfactory attendance.

8.13 Participate as a team member to accomplish goals.

Resources

NOTE: Each Duty Area section starts with a list of resources for that particular area. The resources contained below pertain to multiple duty areas.

Print

Defense Modeling and Simulation Office Education Consortium. (2004) *Defense Modeling and Simulation Body of Knowledge* (Version 5b). Department of Defense Modeling and Simulation Coordinating Office.

Jackson, W.S. (2007). *Modeling and Simulation Curriculum Guide*. Virginia Beach, VA: Virginia Beach City Public Schools.

Mielke, R.R. (2007). *An Undergraduate Modeling and Simulation Engineering Program*. Proceedings of the Huntsville Simulation Conference, Huntsville, AL.

Mielke, R.R., Scerbo, M.W., Gaubatz, K.T., & Watson, G.S. (2007). *A Multidisciplinary Model For M&S Graduate Education*. Norfolk, VA: Old Dominion University.

Pruden Center for Industry and Technology. (2008). *Proposed Curriculum for Modeling and Simulation Support Specialist*. Suffolk, VA: Suffolk Public Schools.

Electronic

Clark, A. (2007). VisTE: Visualization in Technology Education. Retrieved December 8, 2007 from http://www.ncsu.edu/viste/.

Virginia's CTE Resource Center. (2011). *Virginia's Workplace Readiness Skills*. Retrieved April 8, 2011 from http://www.cteresource.org/attachments/wrs2010.pdf

Unit 1: Exploring Modeling and Simulation (M&S)

<u>Unit Length</u>:

This unit will last approximately one week.

<u>Goals</u>:

     1.1. Use appropriate modeling & simulation terminology.
     1.2. Identify disciplines related to modeling, analysis, and simulation.
     1.3. Explain modeling, analysis, and simulation paradigms.
     1.4. Explain the history of modeling, analysis, and simulation.
     1.5. Research information on the internet and print courses.

<u>Rationale</u>:

Modeling and simulation (M&S) has been described as one of the key enabling technologies of the 21st century. Modeling and simulation techniques have applications in fields as diverse as physics, chemistry, biology, economics, medicine, computer science, training and engineering. It is imperative that the student receive a well rounded overview of M&S history, terminology, and related disciplines in order to have a successful understanding of M&S technology.

Given a precisely defined model of a system, it is possible to produce computer programs that implement the model and allow the system to be simulated. Modeling and simulation (M&S) work hand-in-hand. The term "simulation" is normally used to describe the process of executing such a program with user-selected parameters and input data so as to simulate the system under prescribed conditions.

Unit 1.1: Modeling and Simulation Terminology

Unit Length:

This unit will last approximately one day but objectives will continue throughout the course.

Goals:

Use appropriate modeling and simulation terminology.

Rationale:

Read, Read, Read! Most vocabulary words are learned from context. The more words one is exposed to, the better vocabulary one will have. Learning a word won't help very much if you promptly forget it. Research shows that it takes from 10 to 20 repetitions to really make a word part of your vocabulary.
A good vocabulary will make a difference on the standardized tests, like the SAT or certification exams, which could determine the college you attend or the job you get. It will also determine the quality of your communication. So be in it for the long haul. Let building your vocabulary be a lifelong ambition.

Objectives:

1. Define modeling and simulation terms.
2. Use appropriate modeling and simulation terms in context.

Related Standards of Learning (SOLs):

Art: AII.12; English: 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, and 12.4; Computer/Technology: C/T 9-12.1 - C/T 9-12.9; History: USII.5

Recommended Instructional Activities:

1. Daily Context Vocabulary Quiz – List selected words on overhead or white board and allow teams of students to define words and earn benefit points for correct answers.
2. Use mnemonics (memory tricks)**.** For example, consider the word EGREGIOUS (extremely bad). Think, EGG REACH US - imagine we've made a mistake so bad that they are throwing eggs at us and a rotten EGG REACHes US.
3. Choose 5 words daily that are unknown to you from the list provided. Look up and write down the definition, part of speech and use the new word in a sentence of more than 6 words. Practice using the new word.
4. Write a story, postcard, letter or create a journal entry using 5-15 words in context.

Sample vocabulary terms:
Across, Action, Activation, Algebraic, Allocated, Ambient light, Animation, Antithetic, Arbitrary, Argument, Array, Artificial, Attached, Auxiliary, Behavior, Binary, Boolean, Bounded, Class, Clone, Constrained, Continuous, Continuous-change, Controlled, Coordination, Correlated, Decision, Declared, Declared Random, Deformation, Dependent, Descriptive, Deterministic, Diffuse, Discrete, Discrete-change, Discrete-time, Discriminate, Dual, Dummy, Editing, Ellipse, Endogenous, Essential, Exogenous, Experimental, Experimentation, External, externally generated, Flow, Formal, Free, Fuzzy, Gaussian, Geometry, Gizmo, Global, Goal, Helix, Hierarchy, Holistic, Independent, Inheritance, Initialized, Input, Instance, Instantiated, Instrumentable, Instrumental, Instrumented, Intermodal, Internal, Internally generated, Interpolated, Irrelevant, Key, Keyframe, Lag, Lagged, Latent, Lattice, Lead, Level, Linguistic, Linking, Local, Logical, Mapping, Materials, Mesh, Modifiers, Monitored, Nonnumeric, Nonobservable, Numerical, Observable, Output, Panning, Parametric, Qualified, Qualitative, Quantified, Quantitative, Random, Rate, Relevant, Reflection, Refraction, Render, Run control, Simple, Slack, Specular light, Spline, Stabilized, State, Statistical, Stevedores, Stochastic, Storyboard, Subscripted, Temporal, Temporary, Through, Time, Transform, Transparency, Transition, Uncontrollable, Uninitialized, Vortex, Yoked.

Workplace Readiness Skills: 1, 3, 5, 10, and 11

References:

A Glossary of DOE Terminology -
http://www.itl.nist.gov/div898/handbook/pri/section7/pri7.htm

Computer terms interactive quiz - http://www.quia.com/quiz/255345.html

Engineering Statistics Handbook Glossary -
http://www.itl.nist.gov/div898/handbook/glossary.htm#B

IEEE standard glossary of modeling and simulation terminology
An Introduction to Computer Simulation" by M. M. Woolfson and G. J. Pert, Oxford University Press, 1999

Simulation games and activities - http://www.youdagames.com/online-simulation-games/

M&S Dictionaries - http://www.site.uottawa.ca/~oren/SCS_MSNet/MSdictionaries.htm

The Fun Way to Build Vocabulary Skills! - http://www.vocabulary.co.il/

Use these links to practice for the Computer Skills test. -
http://www.ctdlc.org/remediation/indexComputer.html

Unit 1.2: Disciplines Related to Modeling and Simulation

Unit Length:

This unit will last approximately 1 day.

Goals:

Identify disciplines related to modeling and simulation.

Rationale:

The work world revolves about many varied systems, some small and some extremely large and complex. Manipulating these systems can provide for more efficient and effective operations. Modeling and Simulation is a discipline for developing a level of understanding of the interaction of the parts of a system, and of the system as a whole. Such an understanding is required in Industrial and Mechanical engineering, as well as in other engineering disciplines, including civil, electrical, and chemical engineering. Other professions that use M&S extensively include transportation, acquisition, testing, weather forecasting, education / training, scientific research, industrial management, quality control assurance, geographical information systems (GIS), psychology, social sciences, and medical, among others.
Mathematical models are widely used, for example, in engineering. The dynamic, time-dependent changes in many engineering systems can be described using differential equations. Business systems are more likely to be based on queuing theory and discrete-event modeling. In a discrete-event model, the state of a system is assumed to remain unchanged with time until an event occurs that changes the state of the system. As you can see M&S is involved in many different disciplines therefore employment opportunities are numerous.

Objectives:

1. Identify disciplines which use modeling and simulation tools.
2. Identify modeling and simulation related careers.
3. Discuss educational requirements to enter the modeling and simulation career field.
4. List personal characteristics of modeling and simulation professionals.

Related Standards of Learning (SOLs):

Art: AII.12; English: 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, and 12.4; Computer/Technology: C/T 9-12.1 - C/T 9-12.9; History: USII.5

Recommended Instructional Activities:

1. Invite guest speakers to share M & S professional experiences with students. Examples:

(City or school GIS coordinator, School Improvement Coordinator, Military M&S technician, Computer Science Instructor, Flight simulator users, Law enforcement simulator users, etc)
2. Arrange a guided tour of local M&S facilities. Write a summary critique of the experience and include in your ePortfolio.
3. List five career professionals who use modeling and simulation techniques. Write a two page synopsis of one of these career professionals. Be sure to include personal characteristic traits, education and training, unique skill set, and successes resulting from using M&S techniques.
4. Explain in 3 paragraphs how any of the following disciplines would use M&S to solve a problem. Examples are, but are not limited to: interior design, emergency medical technology, material handling, law enforcement, aviation, medicine, architecture, enterprise decision support, optimization, product design, testing, life cycle support, experimentation and prototyping, gaming technology in education and training.

Workplace Readiness Skills: 1, 3, 4, 5, 7, 8, 9, 10, and 11

References:

Doron trucking simulators - http://www.doronprecision.com/450truck.html

Helbing, D., Molnar, P. (1995). Social force model for pedestrian dynamics. *Physical Review E, 51*(5), pp. 4282-4286.

Integrated Land Use, Transportation, Environment (Ilute) Modeling System - http://www.civ.utoronto.ca/sect/traeng/ilute/ilute_the_model.htm

Java Simulation of road traffic - http://www.traffic-simulation.de/

Marsella, S. C., Pynadath, D. V., Read, S. J. (2004) PsychSim: Agent-based modeling of social interactions and influence, 6th International Conference on Cognitive Modeling, July 30-Aug 1, Pittsburg, PA.

Near real time visualizations of recent significant seismic events in the Southern California Region - http://shakemovie.caltech.edu/

Old Dominion University VMASC overview of graduate programs in M&S - http://www.vmasc.odu.edu/ACADEMICS/academics.html

SCS Simulation News - http://www.scs.org/newsletter/

Sokolowski, J. A., Banks C. M. (2008). Modeling global events: A focus on insurgencies. Proceedings of the Huntsville Simulation Conference HSC 2008. October 21-23, Huntsville, AL. pp. 235-240.

The Military Operations Research Society (MORS) - http://www.mors.org/

The Modeling and Simulation Information Analysis Center (MSIAC) web site - http://www.dod-msiac.org/resources.html

The MOVES Institute Defense Modeling and Simulation - http://www.movesinstitute.org/

US Department of Transportation, Federal Highway Administration traffic simulations - http://www.tfhrc.gov/safety/pubs/03050/04.htm

What makes a Modeling and Simulation Professional - http://www.informs-sim.org/wsc97papers/1375.PDF

Unit 1.3: Modeling and Simulation Paradigms

Unit Length:

This unit will last approximately one day.

Goals:

Explain modeling and simulation paradigms.

Rationale:

A paradigm is analogous to a philosophy, e.g. metaphysics or existentialism. Paradigms - like philosophies - may differ widely. Each seeks to explain the same universe; but each may differ in its underlying axioms and thus may yield substantially different descriptions of equivalent concepts. The following paradigms of M& S should be considered:

Discrete-event and *continuous-time modeling* – Discrete-event models assume the fundamental underlying model revolves around occurrences of specific events; for example, arrival of a customer, completion of a transaction, etc. Continuous-time simulation, on the other hand, calculates the state of the system in continuous time intervals; for example, the velocity of an accelerating vehicle over time. These paradigms are covered in more detail later in the course.

It is also important to understand how the following simulations are used as tools.
Live simulations involve real humans and/or equipment and activity in an actual setting. For example, soldiers practicing in the field as part of an exercise. Time is continuous, as in the real world. Another example of live simulation is a disaster response team responding to mock emergency. In this scenario the people and equipment are real but the situation is simulated.
Virtual simulations involve real humans with equipment that is partially, or completely, simulated. Examples include, a human operating a flight simulator, driving simulator, or nuclear power-plant simulator.
Constructive simulations involve humans and equipment that are both simulated. Most military strategic simulations are constructive. Other examples include crowd evacuation, disease spread, and weather predictions models.   A constructive simulation for weather could anticipate the path of a hurricane using variables such as current and changing temperature, pressure, wind current and other weather factors.

In summary, the differences among live, virtual, and constructive can be summarized as follows:

Live: real people – real equipment
Virtual: real people – simulated equipment
Constructive: simulated people – simulated equipment

<u>Objectives</u>:

1. Define the major M&S paradigms.
2. Identify differences between M&S paradigms.
3. Explain the usage of different M&S paradigms.

<u>Related Standards of Learning (SOLs)</u>:

Computer/Technology: C/T 9-12.1 - C/T 9-12.6; English: 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, 12.4; Math: G1, G2, COM.4, COM.8, and COM.16

Recommended Instructional Activities:

1. Provide students with a reading highlighting the different M&S philosophies and their utility. After students have read the selection, have them form into groups related to the different philosophies. Each group will then discuss their philosophy and present to the class their findings outlining important considerations.
2. List 3 types of each modeling and simulation paradigm: constructive, discrete, continuous, virtual, live, etc.

Workplace Readiness Skills: 1, 3, 5, 7, and 11

References:

A Library of Materials, most freely downloadable, created by classroom teachers and other educators, that addresses diverse curricular and organizational topics of interest to K-12 educators - http://www.clexchange.org/

Checkland, P. 1981. Systems Thinking, Systems Practice. New York: John Wiley & Sons. Descartes, R. 1927. Discourse on the Method of Rightly

Conducting the Reason and Seeking for Truth in the Sciences. In Descartes Selections, R.M. Eaton (ed). New York: Charles Scribner's Sons. Flood, F.L. and E.R. Carson. 1988.

Dealing with Complexity: An Introduction to the Theory and Application of Systems Science. New York: Plenum Press.

Just what is "simulation" anyway **-** http://www.ist.ucf.edu/background.htm

ProModel is a of simulation-based, decision making tool - http://www.promodel.com/

The Modeling and Simulation Information Analysis Center (MSIAC) web site - http://www.dod-msiac.org/resources.html

University of Central Florida - http://www.ist.ucf.edu/background.htm

Unit 1.4: History of Modeling and Simulation

Unit Length:

This unit will last approximately 1 day.

Goals:

Explain the history of modeling, analysis, and simulation.

Rationale:

Did you know the first model simulator, the Sanders Teacher, was a complete aircraft mounted on a universal joint and facing into the wind; it was able to rotate and tilt freely. Another early flight simulator of about 1910 was built using a section of a barrel mounted on a hoop. Computer simulation was developed hand-in-hand with the rapid growth of the computer, following its first large-scale deployment during the Manhattan Project in World War II to model the process of nuclear detonation. It was a simulation of 12 hard spheres using a Monte Carlo algorithm.

It's been said time and time again that if you don't know where you have been, you can't know where you are going. Hence, it's imperative to know the history of M&S to round out your knowledge in the field.

Objectives:

1. Identify early developments in modeling and simulation.
2. Discuss issues which led to the development of early simulators.

Related Standards of Learning (SOLs):

Art: AII.12; English: 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, and 12.4; Computer/Technology: C/T 9-12.1 - C/T 9-12.9; History: USII.5

Recommended Instructional Activities:

1. Use graphic technology to make a Visualization of a historic simulator or synthetic environment.
2. Discuss physical models created by Leonardo da Vinci in response to the challenges of siege warfare.
3. Write a report on Christopher Weikmann or Koenigspiel (1644) considered the birth of modern M&S.
4. With a partner or individually research and present to the class using PowerPoint on any of the following topics: Lanchester equations which codified firepower relationships (1916), ENIAC computer, The Sanders Teacher, First pilot trainer of Link (1929), Celestial Navigator Trainer, Manhattan Project, SAGE System air defense simulation (1959), DARPA (1958), ARPANET (1969), SIMNET (1982), Man Space flight simulations

Workplace Readiness Skills: 1, 3, 4, 5, 7, 9, 10, 11, 12 and 13

References:

A brief look at the history of flight simulation -
http://www.acecombatsix.com/flight_Simulations/index.html

Adorian, P., W.N. Staynes, and M. Bolton. The Evolution of Flight Simulators. Presented at the Royal Aeronautical Society Conference 23-25 April 1979

Brief History of Flight Simulation by Ray *L. Page* – **History of Flight**

Cutler, A.E. Environmental Realism in Flight Simulators. The Radio and Electronic Engineer, January 1966, pp 1-12.

Drummer, G.W.A. Aids to Training - The Design of Radar Synthetic Training Devices for the RAAF. IEE Journal, Vol 96, Pt. III March 1949, pp 101-116.

Dunn, W.H., C. Eldert, and P.V. Levonian. A Digital Computer for use in an Operational Flight Trainer. IRE Transactions on Electronic Computers, June 1955, pp 55-63.

Haward, D.M. The Sanders Teacher. Flight Vol 2 No. 50 December 10, 1910 pp 1006-1007.

Hellings, G. and E.T. Emms. A Visual System for Flight Simulators. British Communications and Electronics Vol 7 No. 5 May 1960 pp. 334-337.

Kelly, L.L. The Pilot Maker. (Grosset & Dunlap, 1970, New York).

Notes on History of RAAF Training 1939-44 Air Ministry, Air Member for Training (Public Record Office Reference AIR 20/1347).

Piper, Roger. The Story of Computers; Harcourt, Brace, and World, Inc., New York, 1964; Comprehensive study of computers, their history and its applications to possible careers

Ringham, G.B. and A.E. Cutler. Flight Simulators; The Journal of the Royal Aeronautical Society Vol 58, No. 519, March 1954, pp 153-172.

Wikipedia: History of Modeling and Simulation
http://en.wikipedia.org/wiki/Computer_model#History

Unit 1.5: Research

Unit Length:

This unit will last approximately one day but objectives will be reinforced throughout the course.

Goals:

Research information on the internet and print sources.

Rationale:

Given the connectivity of the modern global Internet, human connections can be more powerful than ever before. It is an essential workplace skill to be able to find reliable information on a topic competently and at a moment's notice. Never before in human history have learners had access to global knowledge that they have today. Powerful software on the Internet referred to as search engines can search millions of resources for very specific information in seconds and are very easy to learn and use. With such access to information, students must understand and respond appropriately to the ethical, legal and limitation issues they might be confronted with. Students must learn how to make a difference in the world and in the lives of others locally and at a distance.

Objectives:

1. Identify Internet safety issues and procedures for complying with acceptable use standards.
2. Use technology tools to collaborate and publish student work.
3. Develop a digital presentation.
4. Develop an Electronic Portfolio (ePortfolio).
5. Demonstrate research skills using browsers, search engines, directories, and databases.
6. Evaluate materials found online for relevance, appropriateness and bias.
7. Demonstrate appropriate use of online library catalog.
8. Present a multimedia presentation, including text, sound, and graphics, based on content from class work.

Related Standards of Learning (SOLs):

Art: AII.12; English: 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, and 12.4; Computer/Technology: C/T 9-12.1 - C/T 9-12.9; History: USII.5

Recommended Instructional Activities:

1. Read, Pair, and Share Activity - With a partner read portions of the acceptable use policy in your school. Each person reads a section while the other person relates back what he/she understood. This would be repeated in reverse throughout the reading.

2. Use the Internet to identify the skills and education required for employment in the modeling and simulation field.
3. Use the Internet to find three jobs in M&S located in your geographical area and present your findings in a PowerPoint presentation to the class.
4. Develop an Electronic Portfolio (ePortfolio) of your best work as you proceed through the course. Students will periodically evaluate the content of their ePortfolio by sharing with teacher and classmates.
5. Take Internet Basics Quiz and report results to teacher. *

Workplace Readiness Skills: 1, 3, 4, 5, 6, 7, 8, 10, 11, 12, and 13

References:

* Internet Basics Quiz -
http://www.classzone.com/books/research_guide/page_build.cfm?content=prequiz&state=none

Internet Research guide - http://www.vickiblackwell.com/shelter.html

Online seminar on Internet Research Skills -
http://www.virtualchase.com/researchskills/intro.html

Online lessons on Doing Research on the Web -
http://www.classzone.com/books/research_guide/page_build.cfm?content=web_research&state=none

SCS Simulation News - http://www.scs.org/newsletter/

Search Engines, Tools and Strategies: Make the most of your time online -
http://www.teachers.ash.org.au/researchskills/resources.htm

Simulation job postings - http://www.job-search-engine.com/keyword/modeling-simulation/

The Modeling and Simulation Information Analysis Center (MSIAC) web site - http://www.dod-msiac.org/resources.html

The Seven Steps of the Research Process -
http://olinuris.library.cornell.edu/ref/research/skill1.htm

Virginia Department of Education Guidelines and resources for internet safety in schools -
http://www.doe.virginia.gov/support/safety_crisis_management/internet_safety/guidelines_resources.pdf

All about ePortfolio - http://www.ehow.com/how_4425510_create-eportfolio-using-powerpoint.html

How to Create an ePortfolio using Sharepoint template -
http://www.teachertube.com/viewVideo.php?video_id=35003&title=How_to_create_an_ePortfol
io_site_using_a_Sharepoint_template

How To Create an ePortfolio with Google Pages -
http://electronicportfolios.com/google/handout.pdf

Design Brief: Create an ePortfolio

Create an ePortfolio

Context

The ePortfolio is a learner-centered collection designed to empower students to acquire the self-organizational skills needed to succeed in today's workplace and to become self-confident and competent citizens.

The ePortfolio is a means of sharing an array of skills and interests that you have gained both in and out of school with peers, teachers and prospective employers as it encourages the celebration of these achievements.

In short the ePortfolio provides a forum for developing personal competencies, such as goal setting and accomplishment, self-organization, self-confidence, and developing a vision of professional life.

Challenge

Each student will demonstrate an understanding of creating an ePortfolio. There are numerous software programs you can use to create an electronic portfolio, such as FrontPage, Dreamweaver, Word, or PowerPoint. To begin, create a list of the attributes/skills/competencies that you and your teacher want to highlight. Identify supporting documents (artifacts) that demonstrate those competencies. Artifacts can include: Word documents, Excel files, assignments, research papers, digital images, audio files, scanned letters of recognition, etc. Create an ePortfolio which will:

- Show participation in activities
- Demonstrate internship/work experiences
- Announce professional memberships
- Explain contributions to community - community service projects
- Create a plan of study
- Maintain a dynamic resume of your experiences in life, work, study, and at play
- Store examples of your achievements (documents, photos, graphics, spreadsheets, web pages)
- Create media rich information to share with family, friends, employers, faculty, and others
- Showcase your accomplishments!

Objectives

Upon completion of the design brief, students will be able to do the following:

- Identify Internet safety issues and procedures for complying with acceptable use standards.
- Apply information literacy skills (including searching and evaluation strategies) while using electronic resources.
- Use technology tools to collaborate and publish student work.

- Develop a digital presentation.
- Develop an Electronic Portfolio (ePortfolio).
- Demonstrate appropriate use of online library catalog.
- Present a multimedia presentation, including text, sound, and graphics, based on content from class work.

Materials
- Internet
- Computer and printer with appropriate software
- Digital storage device
- Notebook with dividers
- Pencil and paper
- ePortfolio

References
- All about ePortfolio - http://www.ehow.com/how_4425510_create-eportfolio-using-powerpoint.html
- Electronicportfolio.org by Dr Helen Barrett- http://electronicportfolios.org/
- Dr. Helen Barrett's Professional Portfolio - http://electronicportfolios.com/google/handout.pdf
- How to Create an ePortfolio using Sharepoint template - http://www.teachertube.com/viewVideo.php?video_id=35003&title=How_to_create_an_ePortfolio_site_using_a_Sharepoint_template
- How To Create an ePortfolio with Google Pages - http://sites.google.com/site/eportfolios/How-To-Create-ePortfolios-with-GoogleApps
- http://www.teachers.ash.org.au/researchskills/resources.htm
- Simulation job postings - http://www.job-search-engine.com/keyword/modeling-simulation/
- The Modeling and Simulation Information Analysis Center (MSIAC) web site - http://www.dod-msiac.org/resources.html
- The Seven Steps of the Research Process - http://faculty.dccc.edu/~jroberts/Guide%20to%20Writing%20Research%20Paper.doc

Evaluation

- What is an ePortfolio?
- List information that could be placed in an ePortfolio.
- Explain the benefits of having an ePortfolio.

Unit 2: Computer Skills

<u>Unit Length</u>:

This unit will last approximately one week but objectives will be reinforced throughout the course.

<u>Goals</u>:

    2.1.Perform basic computer operations.
    2.2.Demonstrate basic keyboarding and word processing.
    2.3.Manipulate file structures.
    2.4.Explain network components.
    2.5.Analyze ethical issues.
    2.6.Create basic spreadsheets.

<u>Rationale</u>:
Computer skills are a basic fact of life for most workers. Even if you don't work with computers in order to complete your primary work duties, it is likely that you run into them from time to time. In fact, most jobs, from supermarket management to restaurant service, require basic computer knowledge. And more and more jobs are demanding that workers become increasingly familiar with and comfortable using a wide range of computer applications.

Unit 2.1: Basic Computer Operations

Unit Length:

This unit will last approximately two days.

Goals:

Perform basic computer operations.

Rationale:
If you are longing to move up in your future job or if you are interested in moving into a new career, you may be wondering what computer skills you will need to accomplish these goals. Well, as computers become more and more important in most workplaces, computer skills are often the greatest asset a worker can possess. And though you may be able to get your work done with basic computer know-how, in order to really succeed in the workforce it is important to have some complex computer skills. Reaching complex computer skills requires that you have exceptional basic computer skills.

Objectives:

1. Maintain a clean and safe work environment.
2. Identify the parts of the user interface and of a window.
3. Manipulate software interface.
4. Use Help functions for different application programs.
5. Demonstrate the correct handling and operation of storage media.
6. Identify acceptable methods for backing up data.
7. Identify computer system components.
8. Demonstrate proper care of equipment and disks.
9. Demonstrate a working knowledge of software.
10. Discuss different operating systems (OS).

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.7

Recommended Instructional Activities:

1. Review computer history timeline.*
2. Have students clean and secure their workspace daily. Other students should be required to supervise this activity providing students the opportunity to lead and be led.
3. Open, edit, and save a word and other application files.
4. Locate and print to a remote printer. Allow students to load the printer with paper and toner when necessary. Allow students to trouble shoot minor printer errors.
5. Require students to backup data daily using a systematic approach.

---

6. Read, Pair, and Share Activity - With a partner read portions of the acceptable use policy in your school. Each person reads a section while the other person relates back what he/she understood. This would be repeated in reverse throughout the reading.

Workplace Readiness Skills: 1, 3, 4, 5, 7, 9, 10, 11, 12, and 13

References:

Basic online computer skills activity - http://www.catawba.k12.nc.us/pages/sites/edwebsites/computerskills/onlineactivities.htm

*Computer History Timeline - http://www.computerhistory.org/internet_history/

Computer skills test your knowledge online - http://www.catawba.k12.nc.us/pages/its/blalock/summerschool01/csmctest.htm

Critique of AUP's - http://www.io.com/~kinnaman/aupessay.html#scene

Papert, Seymout. Mindstorm: Children, Computers and Powerful Ideas. Basic Books, Inc., Publishers/New York, 1980; Interesting concepts are explored concerning learning, computers as a form of learning, and development of learning skills in all children.

Unit 2.2: Basic Keyboarding and Word Processing

Unit Length:

This unit will last approximately two days but objectives will be reinforced throughout the course.

Goals:

Demonstrate basic keyboarding and word processing.

Rationale:
Without the basic ability to type quickly and accurately, getting your ideas and data into a computer can take a lot of time and can be frustrating. Who really wants to use the hunt-and-peck method of inputting data for the rest of their lives? Keyboarding and word processing are skills needed in most every job in today's marketplace; it is a vital means of communicating. Excellent keyboarding skills will also make your general computing skills more effective. Gamers, programmers, and all individuals who use computers to help them perform their jobs require excellent keyboarding skills.

Objectives:

1. Demonstrate proper keyboarding techniques.
2. Edit text copy.
3. Apply keyboarding skills to create basic business documents.
4. Analyze data in electronic form.
5. Apply technology to communicate and collaborate.
6. Develop a digital presentation.
7. Demonstrate software functions and editing capabilities.

Related Standards of Learning (SOLs):

English 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, 12.4, Computer/Technology C/T 9-12.1 - C/T 9-12.6

Recommended Instructional Activities:

1. Require students to type <u>all</u> assignments to improve their word processing skills. Reinforce using proper spacing, page numbering, punctuation, capitalization, headers and footers, and tables etc.
2. Have students practice typing at online typing tutorial sites or use typing software.
3. Have students complete a typing speed test to get an official certificate of speed. This is an excellent portfolio addition.*
4. Develop a professional resume for inclusion in the ePortfolio. Have students exchange resumes then proof and edit accordingly.

---

5. Have students strive to acquire Brainbench free certifications in IT.
   http://www.brainbench.com/xml/bb/common/testcenter/freetests.xml#sponsored

<u>Workplace Readiness Skills:</u> 1, 3, 4, 5, 7, 9, 10, 11, 12, and 13

<u>References:</u>

Free online Typing course - http://www.goodtyping.com/

Free online Typing tutorial - http://www.nimblefingers.com/

*Get your Typing Certification now - http://www.learn2type.com/TypingCertificate

goodtyping.com - Typing speed test - http://www.goodtyping.com/test.php

Resume Writing 101 Get Your Resume in Shape for Jobs and Internships - http://www.collegeboard.com/student/plan/high-school/36957.html

Unit 2.3: Using File Structures

Unit Length:

This unit will last approximately one day.

Goals:

Manipulate file structures.

Rationale:
When using computers, nearly everything you do involves files in some way. Files of different types are created by different types of software programs and contain different types of information: text, images, web pages, etc. In the Modeling and Simulation career field you will be creating, editing, moving, sending, or receiving files of one kind or another. Most software programs have similar interface menus, so once you learn to use files related to a specific program, you will have mastered the basics of most programs regardless of the different types of files used. Understanding file structures and using them effectively can increase your productivity greatly.

Objectives:

1. Know parts of the windows that show files and folders.
2. Understand the folder tree and file naming conventions.
3. Manipulate files and folders.
4. Open an application using a shortcut or from the display of folders and files.
5. Save a file with a proper naming convention.
6. Use removable media properly.
7. Create backup files.
8. Use *Search* to locate a file.

Related Standards of Learning (SOLs):
Computer/Technology C/T 9-12.1 - C/T 9-12.6

Recommended Instructional Activities:

1. Make selected folders on your storage device to keep your assignments in order. Use a naming convention that is functional.
2. Create a file backup system and routinely backup your work.
3. Practice using * wildcard symbol to find a file.
4. Practice converting one file type as another e.g. bmp to jpg
5. Search for specific files on a classmates jump drive based on partial information.

Workplace Readiness Skills: 1, 3, 4, 5, 6, 8, 10, 12 and 13

References:

Microsoft Developer Network (MSDN): Naming a File - http://msdn.microsoft.com/en-us/library/aa365247.aspx

How File Systems Work - http://ezinearticles.com/?How-an-Operating-Systems-File-System-Works&id=980216

File system Hierarchy Standard - http://en.wikipedia.org/wiki/Filesystem_Hierarchy_Standard

Working with Files and Folders - http://www.jegsworks.com/Lessons/win/filesandfolders/index.html

Unit 2.4: Network Components

Unit Length:

This unit will last approximately three days.

Goals:

Explain network components.

Rationale:

A network is a set of computers which are linked together on a permanent basis. This can mean two computers cabled together on the same desk or thousands of computers across the world. Coworkers thousands of miles apart can share information instantaneously, just as hundreds of workers in a single location can simultaneously review research data maintained online. Computer networking technologies are the glue that binds these elements together. The public Internet allows businesses around the world to share information with each other and their customers. The World Wide Web provides services that let consumers buy books, clothes, and even cars online, or auction those same items off when no longer wanted.

Objectives:

1. Identify computer network components.
2. Identify basic types of topologies.
3. Apply technology to communicate and collaborate.
4. Describe a LAN and WAN.
5. Discuss the differences between an Internet and Intranet.

Related Standards of Learning (SOLs):

Computer/Technology C/T 9-12.1 - C/T 9-12.6

Recommended Instructional Activities:

1. Post a brief biography of yourself to the intranet to let other students get to know you. Using the discussion board, respond to at least two other students. Read something interesting about them and have questions you would like to ask them. Get to know your classmates.
2. Email the course instructor and attach file.
3. Visit a computer network closet of room in your building.
4. Invite a computer network professional or network instructor into your classroom as a guest speaker.
5. Prepare a schematic of various network topologies using PowerPoint, Visio or similar software.

<u>Workplace Readiness Skills</u>: 1, 3, 4, 5, 7, 11, 12, and 13

<u>References</u>:

An introduction to Computer networks - http://www.boloji.com/computing/networking/n001.htm

Basics of computer networks Sanford University PPT - http://www.stanford.edu/class/cs244a/

Critique AUP's - http://www.io.com/~kinnaman/aupessay.html#scene

How Ethernet Works - http://computer.howstuffworks.com/ethernet2.htm

Introduction to Computer Networks - http://functionx.com/networking/Lesson01.htm

Introduction to Computer Networking - http://www.ncte.ie/documents/networking/Introduction_Computer_Networking.doc

Unit 2.5: Ethical Issues

Unit Length:

This unit will last approximately two days but objectives will be reinforced throughout the course.

Goals:

Analyze ethical issues.

Rationale:
Ethical integrity and character development are grounded in high expectations and fostering relationships, these must embody all that we as teachers, leaders, and role models do every day. As a professional with access to confidential information, you must understand and respond appropriately to the ethical, legal and limitation issues they might be confronted with as students and later as career professionals.

Objectives:
1. Apply ethical and legal issues (including copyright) with technology.
2. Develop understanding of professional and ethical responsibilities.
3. Perform ethical behavior.
4. Use accepted Netiquette
5. Describe polite and civil communication.
6. Discuss individual integrity and honesty.
7. Explain the purposes of copyrights, trademarks, and patents.
8. Practice ethical behaviors regarding copyright, citation, and plagiarism.

Related Standards of Learning (SOLs):

English 11.1, 11.4, 11.8, 11.10, 12.1, 12.2, 12.4, Computer/Technology C/T 9-12.1 - C/T 9-12.6

Recommended Instructional Activities:

1. Complete the Design brief "Dealing with Ethical Issues"
2. Read, Pair, and Share activity - Read the code of ethics for simulationists and share your thoughts with your partner.
3. Post words such as these around the classroom as a constant reminder of ethics: Support, encourage, fair treatment, thorough, unbiased, trustworthiness, honesty, honor, truthfulness, integrity etc.
4. Take the work ethic inventory to determine your work ethic ability - http://www.coe.uga.edu/cgi-bin/cgiwrap/%7Erhill/new_owei/owei.pl

Workplace Readiness Skills: 1, 3, 4, 5, 7, 8, 9, 10, 11, 12 and 13

References:

Code of Professional Ethics for Simulationists -
http://www.site.uottawa.ca/~oren/pubs/D81_Code.pdf

Critiquing Acceptable Use Policies - http://www.io.com/~kinnaman/aupessay.html#scene
Elzas, M.S. 2000. "Why Should We Consider Ethical Issues To Be Relevant to Modeling and
Simulation?" Special Issue of Transactions of the SCS on Ethical Issues in Modeling and
Simulation. 17:4 (Dec.), 164.

E-mail netiquette guidelines - http://eleccomm.ieee.org/email-netiquette.shtml

Ethical issues online quiz -
http://www.catawba.k12.nc.us/pages/sites/edwebsites/computerskills/quizzes/ethics_integrity.ht
m

Exploring Ethical Issues lesson plan -
http://www.highschooljournalism.org/Teachers/Lesson_Plans/Detail.cfm?lessonplanid=197

IEEE Code of Ethics - http://www.ieee.org/portal/cms_docs/about/CoE_poster.pdf

Kettenis, D.L. (ed.) 2000. Special Issue of Transactions of the SCS on Ethical Issues in Modeling
and Simulation 17:4 (Dec.).

Lesson plans for teaching Ethical Computer issues -
http://www.cyberspacers.com/learn/learn2.html

Netiquette definition from Wikipedia - http://en.wikipedia.org/wiki/Netiquette
Ören, T.I. 2000a. "Responsibility, Ethics, and Simulation." Special Issue of Transactions of the
SCS on Ethical Issues in Modeling and Simulation 17:4 (Dec.), 165-170.

Ören, T.I. 2000b. "Educating the Simulationists." In Conception of Curriculum for Simulation
Education, (H. Szczerbicka, ed.) http://www.informs-cs.org/wsc00papers/225.PDF Proceedings
of the 2000 Winter Simulation Conference (Orlando, FL., Dec. 10-13), 1635-1644.

Ören, T.I. 2002. "Rationale for a Code of Professional Ethics for Simulationists." In Proceedings
of the 2002 Summer Computer Simulation Conference (San Diego, CA, July 13-18).

The impact of plagiarism -
http://www.gananda.org/webpages/hslibrary/index.cfm?subpage=303665

Whiteside, Thomas. Computer Capers. Thomas Y. Crowell Company, New York, 1978. Tales of
electronic thievery, and white collar crime.

Design Brief: Dealing with Ethical Issues

Dealing with Ethical Issues

Context

Ethical standards are what it means to be a good person, the social rules that govern our behavior. Ethics in business is essentially the study of what constitutes the right and wrong behavior in the workplace environment. A business is an organization whose objective is to provide goods or services for profit. The organization has a group of people that work together to achieve a common purpose. The moral challenges that these men and women face each day along with a whole range of problems that could occur, are why ethics plays such an important role in business. Most large businesses have a written code of ethics, sometimes called a code of conduct to set the standards that employees are to follow. In summary a good M&S professional should refrain from engaging in or supporting any activity that would discredit the profession.

Challenge

Each student will demonstrate an understanding of dealing correctly with ethical issues in the workplace. Read and answer the following questions as an individual, then as a team, and lastly, as a team come to a consensus and present your answers to the class.

Workplace Integrity Situations

Read the following situations carefully and give your answers and explanations as directed by your teacher. Be prepared to discuss your explanation.

1. Your boss is working up a bank deposit. He drops a $20 bill on the floor. He goes off to the bank. Do you keep the $20?

2. You're reviewing your payroll records and you find out that you've shorted one of your employees $20 in pay. He hasn't noticed it yet. Do you pay him the money?

3. Your company is giving an aptitude test for its employees that are going to be considered for promotion. A former employee offers to sell you the answers to the test for $20. Do you buy them?

4. Your boss finds a terrible mistake you've made. Do you lie and tell him that the employee that he fired last week was the one who made the mistake?

5. You accidentally give back too little change to a customer. He gave you a $50 and needed $30 in change. You gave him only $20. He didn't notice that he's been shorted. Do you keep the money?

6. A customer leaves his wallet on the counter one night. It has $100 in it. When he comes back the next day do you keep the $100 and tell him you found the wallet without the money in it?

7. Your boss asks you to carefully inspect the bottles you are packing for defects. You've got a date tonight and you know that if you do your job right you may have to work an extra half hour.

Do you rush through the work and claim that the bottles were inspected?

8. You catch a shoplifter with $10 of merchandise. He offers you $20 to ignore it. Do you take the money?

9. You know your friend and fellow employee is stealing from the cash drawer. After a year the owner makes you a manager. Do you fire your friend?

10. After another year the owner offers to make you a partner in the company. Now do you fire your friend?

11. Your boss is considering someone for a promotion. You know he is well qualified, but you dislike him strongly. Do you lie to your boss and say he won't do a good job?

12. Your company disparately needs a loan. If you fill out the loan application honestly you won't get the loan. Do you lie on the form?

13. Your boss asks you for a date. You don't like him/her, but she/he hints that it could help your career. Do you go?

14. No one knows that it was you who accidentally erased another department's computer disc. The employee in charge might be fired. Do you admit it and risk your job?

15. You've been buying paper bags from the same excellent salesman for the last ten years. A competitor offers you a 20% price break. Do you switch suppliers?

16. Other businesses are boycotting a supplier because the company refuses to give up its racist hiring policies. He offers you a substantial discount. Do you join the boycott?

17. (Explain "loss-leader sale.") Your lumber store is having a big two-week loss-leader sale on plywood sheets. After two days a hurricane is forecast. At the current rate your supply will run out in two days. Do you cancel the sale and raise your price?

18. Your friend helped get you a job at a stereo store. After three months you find out that he's been stealing from the cash drawer. Do you report him?

19. You're a plumber. You guarantee your work for thirty days. A client springs a leak in a pipe you fixed thirty-one days ago. Do you fix it for free?

20. A key employee has taken two weeks off due to the death of his mother. A crucial project in your department is overdue. Do you call him and ask him to come back three days early?

Objectives

Upon completion of the design brief, students will be able to do the following:
- Apply ethical and legal issues (including copyright) with technology.

- Develop understanding of professional and ethical responsibilities.
- Perform ethical behavior.
- Use accepted Netiquette
- Describe polite and civil communication.
- Discuss individual integrity and honesty.
- Practice ethical behaviors regarding copyright, citation, and plagiarism.

Materials
- Internet and researched information
- Computer with appropriate software
- Pencil and paper
- ePortfolio

References
- Code of Professional Ethics for Simulationists - http://www.site.uottawa.ca/~oren/pubs/D81_Code.pdf
- Critiquing Acceptable Use Policies - http://www.io.com/~kinnaman/aupessay.html#scene
- Elzas, M.S. 2000. "Why Should We Consider Ethical Issues To Be Relevant to Modeling and Simulation?" Special Issue of Transactions of the SCS on Ethical Issues in Modeling and Simulation. 17:4 (Dec.), 164.

- E-mail netiquette guidelines - http://eleccomm.ieee.org/email-netiquette.shtml

- Ethical issues online quiz - http://www.catawba.k12.nc.us/pages/sites/edwebsites/computerskills/quizzes/ethics_integrity.htm

- Exploring Ethical Issues lesson plan - http://www.highschooljournalism.org/Teachers/Lesson_Plans/Detail.cfm?lessonplanid=197

- Kettenis, D.L. (ed.) 2000. Special Issue of Transactions of the SCS on Ethical Issues in Modeling and Simulation 17:4 (Dec.).

Evaluation
- Evaluate student behavior daily and provide feedback.
- Provide peer evaluations to determine how students are viewed by peers.
- Observe students in team interactions and access the team dynamics.

Design Brief: Design a computer network

Design a computer network

Context

A network is a set of computers which are linked together on a permanent basis. This can mean two computers cabled together on the same desk or thousands of computers across the world. Coworkers thousands of miles apart can share information instantaneously, just as hundreds of workers in a single location can simultaneously review research data maintained online.

Creating a basic network diagram is an effective way to design and document a simple network. A basic network diagram can help you show logically how different devices will be installed to meet business needs.

Managing a computer network today is no small task. In addition to controlling access to printers and files over the network, most administrators must also manage security and access, optimize traffic flow across Local Area Networks (LANs) and Wide Area Networks (WANs), coordinate repair and maintenance of network equipment, and oversee data backup, storage, and recovery.
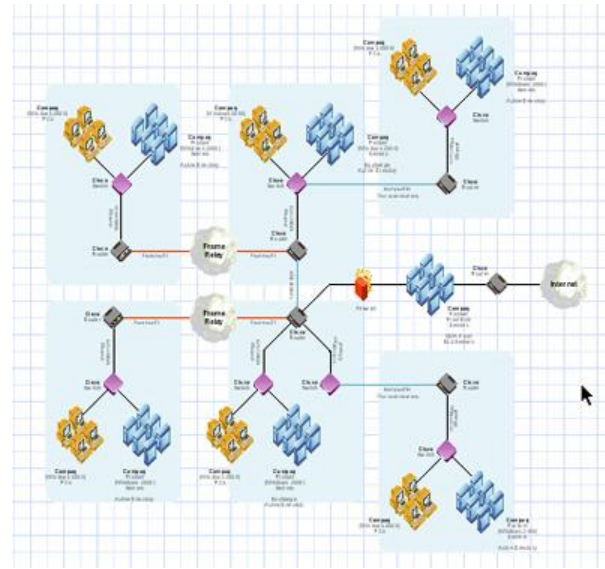
Challenge

Each student will demonstrate an understanding of a simple computer network by using a graphical diagramming program or pencil and paper to graphically show the arrangement of simple network components. Basic network diagrams must show the primary pieces of your network and how those pieces are connected. When choosing a network type (topology) four things should be considered: Cost, expandability, location of PC's, and speed

Objectives

Upon completion of the design brief, students will be able to do the following:

- Identify computer network components.
- Identify basic types of topologies.
- Apply technology to communicate and collaborate.
- Describe a LAN and WAN.
- Discuss the differences between an Internet and Intranet.

Materials

- Internet and researched information
- Computer with appropriate graphical software
- Pencil and paper
- ePortfolio

References

- Easy Home Networking Tutorial - http://www.homenethelp.com/web/howto/HomeNet-start.asp
- How Stuff Works: How Home Networking Works - http://www.howstuffworks.com/home-network.htm
- Basics of computer networks Sanford University PPT - http://www.stanford.edu/class/cs244a/
- How Ethernet Works - http://computer.howstuffworks.com/ethernet2.htm
- Introduction to Computer Networks - http://functionx.com/networking/Lesson01.htm
- Introduction to Computer Networking - http://www.ncte.ie/documents/networking/Introduction_Computer_Networking.doc

Evaluation

- You have two or more computers. How do you connect them to share files and printers? You need a home network. *First start by selecting a cabling method - Ethernet, wireless, PhoneLine, etc.*
- What is the most popular network type for both home and business? *The Ethernet.*
- Ethernet can operate at 10Mbps or 100Mbps. *T/F*
- What is Bandwidth? *Every line has an upper limit and a lower limit on the frequency of signals it can carry. This limited range is called the bandwidth.*
- What is MAC address? *The address for a device as it is identified at the Media Access Control (MAC) layer in the network architecture. MAC address is usually stored in ROM on the network adapter card and is unique.*

Unit 2.6: Create Basic Spreadsheets

Unit Length:

This unit will last approximately three days.

Goals:

Create basic spreadsheets.

Rationale:

A spreadsheet is the computer equivalent of a paper ledger sheet. It consists of a grid made from columns and rows. It is an environment that can make number manipulation easy and painless. Computer spreadsheets are widely used for a variety of analysis and provide an interface that is useful for modeling and simulation development. Sports statisticians' use spreadsheets, an inventory of the computers in the classroom are kept on spreadsheets and the grades you earn in school are computed on spreadsheets.

Objectives:

1. Use proper spreadsheet terminology.
2. Demonstrate use of a spreadsheet to organize and analyze data.
3. Enter text and labels into cells.
4. Format a cell and/or its contents.
5. Create a formula using arithmetic or functions.
6. Edit a formula using the formula bar.
7. Fill formulas down the spreadsheet
8. Create a variety of graphs using data from a spreadsheet.
9. Edit details on a chart.
10. Select data that are either contiguous or separate from each other.
11. Explain the difference between relative and absolute addresses.
12. Perform calculations between cells on different worksheets.
13. Analyze output data using spreadsheet program.
14. Print a designated portion of a spreadsheet.
15. Print an image of a chart.
16. Identify possible misuses of statistical data.

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, COM.1, COM.4, COM.8, COM.16, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Pair students to review Microsoft Excel website for new releases and information vital to novice users - http://office.microsoft.com/en-us/excel/default.aspx
2. Discuss this introduction to spreadsheets with students - www.armytoolbag.com/Tools/ComputerTng/Excel1.ppt
3. Complete Microsoft Excel tutorials as needed from introduction to remediation.
4. Complete spreadsheet vocabulary activity - http://www.ncwiseowl.org/kscope/techknowpark/MiniPosters/Poster14.html
5. Complete Webquest activity - Creating Charts and Graphs WebQuest - This WebQuest is an activity that can improve your student's skills in being able to read and interpret graphs.
6. Complete spreadsheet word search - http://www.ncwiseowl.org/kscope/techknowpark/MiniPosters/Poster18.html
7. Complete spreadsheet analysis - http://www.ncwiseowl.org/kscope/techknowpark/MiniPosters/Poster17.html
8. Crazy questions for spreadsheet graphing - http://www.ncwiseowl.org/kscope/techknowpark/FreeFall/Graphing.html
9. WebQuest: Digital Camera Selection - http://fp.ainet.com/edit4710/
10. Review the following excel introduction - Spreadsheets in the Classroom Using Excel - Easy Quick Tips to follow to learn how to use Excel with students.
11. Complete spreadsheet quiz - Retrieve, Edit, Print Spreadsheet Quiz
12. Create a monthly living budget, and invest wisely in the stock market with this challenging webquest - http://teachersnetwork.org/dcs/math/BasicMath/Millionaire/index.htm
13. Complete this fun spreadsheet activity - Fast Food Fun - This site is a great way to get students to realize nutrition facts by using spreadsheet calculations for analyzing fat calories and their eating habits.
14. Discuss Bar graph analysis - Bar Graph Analysis and Creation - Check this site out to help students learn to 'picture' the data and interpret its results.
15. Divide students into teams of two to complete the crossword puzzle - Spreadsheet Crossword Puzzle - An interactive site for students to test their understanding of spreadsheets.

Workplace Readiness Skills: 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, and 13

References:

Excel introduction - http://home.ubalt.edu/ntsbarsh/excel/excel.htm#rintro

Excel online computer skills activity - http://www.catawba.k12.nc.us/pages/sites/edwebsites/computerskills/onlineactivities.htm

Microsoft Excel tutorials - http://office.microsoft.com/en-us/training/CR100479681033.aspx

Spreadsheet Fast Food Activity -
http://www.ncwiseowl.org/kscope/techknowpark/Kiosk/index.html#

Center for Technology and Teacher Education - Microsoft Excel Interactive Projects

Classrooms That Excel Resources - Guides, Tutorials, Applications and Lesson Plans

Integrating Spreadsheets in the Classroom - Tutorials, Assessment, Charting & Graphing, Real-time data, Lesson Plans and WebQuests

Internet4Classrooms - Excel learning modules on a variety of topics; other Excel links

Integrating Spreadsheets in the Classroom - Get students to see data represented in graphs often.

Classroom Resources for Spreadsheets - How to use spreadsheets is explored through these many links.

Developers Guide to Excelets - Mathematical samples of interactive Excel are linked to this page.

Downloadable examples of interactive Excel can be found on this page -
http://academic.pgcc.edu/~ssinex/excelets/

Spreadsheet Basics - This online tutorial helps understand and visualize the vocabulary associated with spreadsheets while you have an Excel file open.

A Viewlet for Learning Excel Basics - This site runs a program to view how to set up a spreadsheet which analyzes temperatures.

Online Training with Excel - This site has the basics of Excel broken down into sections with Quicktime video used to explain each section. This site is great for the audio and visual learner.

Analyzing Time Management Choices - This website can be used with students to analyze how students choose to spend their time. As an activity, you could have students spend a week recording the choices they make and graph them as a class.

A Day in the Life of a Meteorologist - Based on the weather maps and data students collect over a period of two weeks, they create a PowerPoint

Spreadsheet Terms Quiz - Interactive webpage quizzing students on spreadsheet terms

Advantages and Uses of Spreadsheets - An interactive site using questions related to spreadsheet uses.

Charting Using Spreadsheets – This is an interactive quiz-site to analyze your charting capabilities.

Using Data and Statistics - This site would be useful in helping students understand what types of charts and graphs to use and when. It also gives some excellent class project ideas.

Tutorial on Graphs - Gives advantages and disadvantages and purposes of using graphs. This site covers the types of charts and graphs and helps students know how to choose the right one for a task - http://spreadsheets.about.com/od/excelcharts/ss/Chart_wiz_step.htm

Internet 4 Classrooms Excel Tutorial - Microsoft Excel Modules - A very easy to understand tutorial for MS Excel and sample workbooks to download.

Tech Train: Overview of Microsoft Excel - A great online tutorial.

National Council of Teachers of Mathematics - http://www.nctm.org/

Using Spreadsheets in the Classroom - A complete list of sites on how to use Excel as well as many lesson plan ideas - http://www.amphi.com/~psteffen/excel.html

Excel in the Classroom - Link to more links on rubrics, charting, lesson plans.

Almost Everything You Need for Using Spreadsheets - This site includes links for learning about and using spreadsheets, student lessons, and much more.

Comparing Graphs
Three different sets of data (earnings, votes, heights) are shown with three different types of graphs (line, bar, circle). The student is to compare the different graphs to determine which is best.
Comparing Data
The student enters data and then the spreadsheet generates several measures of that data such as mean, median, mode, quartiles, and range, which the user can investigate and compare.

Effects of Parentheses
The user inputs a mathematical expression, and then alters it with parentheses to see how many different answers can be generated. Great site for teaching order of operations.

Exploring Slope
Students learn about slope by experimenting with different values for "m" in the slope-intercept equation, then looking for patterns, relationships, and generalizations.

Scatter plots
As the user enters ordered pairs; the spreadsheet graphs a scatter plot, creates a line of best fit, and displays its equation (in linear or polynomial form).

Unit 3: Exhibiting Mathematical Skills

Unit Length:

This unit will last approximately six weeks.

Goals:

    3.1. Describe the methods of data collection in a census, sample survey, experiment, and observational study and identify an appropriate method of solution for a given problem setting.

    3.2. Analyze graphical displays of data.

    3.3. Analyze numerical characteristics of univariate data sets to describe patterns and departure from patterns, using mean, median, and mode.

    3.4. Plan and conduct an experiment that will address control, randomization, and measurement of experimental error.

    3.5. Compute and distinguish between permutations and combinations and use technology for applications.

    3.6. Identify and describe two or more events as complementary, dependent, independent, and/or mutually exclusive.

    3.7. Find probabilities (relative frequency and theoretical), including conditional probabilities for events that are either dependent or independent, by applying the "law of large numbers" concept, the addition rule, and the multiplication rule..

    3.8. Perform basic mathematical calculations as needed in software applications.

Rationale:

One aspect of modeling and simulation is the need to perform analysis on given or generated data sets. In order to effectively conduct analysis on data, basic probability and statistical analytical methodologies are required. Probability and statistics provide the foundation for simulations and cover methods used for incorporating randomness into models and estimating the unknown model parameters using observed data. The math review unit provides a review of the overall skills necessary to create and analyze simulation models.

Unit 3.1: Data Collection

Unit Length:

This unit will last approximately one week.

Goals:

Describe the methods of data collection in a census, sample survey, experiment, and observational study and identify an appropriate method of solution for a given problem setting.

Rationale:

Although it is very important to have two dimensional and three dimensional visualizations for simulations, without realistic data, the visualizations have little value. Although many simulations may have unknown variables being studied, in order to make the simulation realistic, collected data is required as input. In this section, students will learn how to collect data via a variety of methods as well as begin to understand bias in data collection and statistics in general.

Objectives:

1. Define terminology associated with data collection.
2. Differentiate between the various methods of data collection.
3. Explain the uses of random number generators.
4. Recognize various sources of bias in data collection.
5. Prepare a sample data collection.

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Explain to students that roughly a day cannot go by without the bombardment of data and statistics. Ask students if they think they should always trust data? Come up with a few examples of when data might have been incorrectly presented and relate them to the students.
2. Define the following terms: *population, data, variables,* and *sampling.*
3. Define the following terms: *census, experiment*, and *observational study* (*Sample Survey*).
4. Discuss the use of data and statistics and bias in the use of data collection and statistics. Define the following terms: *nonresponse bias, convenience samples ,response bias, and undercoverage bias.*

5. Class Survey: What do you have in common with your classmates? Students create a survey of 5-10 questions. The questions can be anything from food likes and dislikes to political issues. Allow students to survey the class on their likes and dislikes. Ask students to write a paragraph summarizing their results, making sure to list any biases. Students should also explain if they could make broad conclusions about their results and explain why or why not.

6. Provide students with a variety of scenarios and have them determine and explain whether the scenario was an observational study, experiment, or survey.

Workplace Readiness Skills: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

References:

Australian Bureau of Statistics --
http://www.abs.gov.au/Websitedbs/cashome.nsf/51c9a3d36edfd0dfca256acb00118404/9bf24b731daf6144ca2572fe001e2ad7!OpenDocument

Canada's National Statistics Agency -- Includes lesson plans --
http://www.statcan.ca/english/edu/power/ch2/types/types.htm

Glossary of statistical terminology --
http://www.stats.gla.ac.uk/steps/glossary/basic_definitions.html

Information about creating and collecting data from a survey --
http://www.webpages.uidaho.edu/~redgeman/Sampling%20PDF%20Files/SurveyData.pdf

Moore, David S
    Statistics: Concepts and Controversies –5th ed.
    W.H Freeman and Company, New York, 2001.

New York Times Lesson plans on the Scientific method --
http://www.nytimes.com/learning/teachers/lessons/scimethod.html

Super Survey Knowledge Base – "How to prevent bias in a survey?" -- http://knowledge-base.supersurvey.com/response-bias.htm

Using observation to determine an understanding of the Milky Way galaxy --
http://www.gb.nrao.edu/~glangsto/lessons/lessonHISTORY.html

Unit 3.2: Analyze Graphs

Unit Length:

This unit will last approximately three days but objectives will be reinforced throughout course.

Goal: Analyze graphical displays of data.

Rationale:

After designing your survey, experiment, or observational study, the next logical step is to analyze the data. Graphical displays are commonly used for to perform this activity.

Objectives:

1. Define graphical terminology.
2. Interpret tables of statistics.
3. Create bar charts and pie graphs with appropriate software.
4. Analyze the data to solve a presented problem

Related Standards of Learning (SOLs):
Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:
1. Describe what makes a clear representation data and potentially what makes a misleading representation of data. Provide examples of good and bad histograms.
2. Explain the following terms: *frequency table*, *histogram, bar charts, shape, and outliers*, *labels, legends.* as they relate to graphical representations of data.
3. Students take the data from a completed survey place it in a table in a spreadsheet program and present a graphical representation of the data. (See Unit 3.1).
4. Form the graphical representation of the data, determine what conclusions could be formed. Ask students what was easier to understand, the table or the chart?
5. Provide students with a series of data in a spreadsheet. Students examine the data, chart it using a graphical display of their choice. Type a paragraph summarizing the data, describing why they chose that particular type of chart and what conclusions they can make from the data and the associated chart.

Workplace Readiness Skills: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

References:

Exploratory Data Analysis -- This chapter presents the assumptions, principles, and techniques necessary to gain insight into data via EDA--exploratory data analysis.
http://www.itl.nist.gov/div898/handbook/eda/eda.htm

Gary Klass, *Just Plain Data Analysis: Finding, Presenting, and Interpreting Social Science Data* (New York: Rowman and Littlefield Publishers, 2008)
ISBN: 978-0-7425-6053-6

Just Plain Data Analysis Companion Website -- http://lilt.ilstu.edu/jpda/

Making Sense of the 2000 Census Lesson Plan --
http://www.create.cett.msstate.edu/create/classroom/lplan_view.asp?articleID=78

Statistics: Collecting and Organizing data lesson plan. --
http://regentsprep.org/regents/biology/units/organization/index.cfm

Types of statistical graphs. http://math.youngzones.org/stat_graph.html

Unit 3.3: Describe Statistical Patterns

<u>Unit Length</u>:

This unit will last approximately three days but objectives will be reinforced throughout course.

<u>Goal</u>: Analyze numerical characteristics of univariate data sets to describe patterns and departure from patterns, using mean, median, and mode.

<u>Rationale</u>:
Every M&S professional is required to analyze the results of a simulation model to determine (1) if the simulation is operating correctly and (2) if the results of the simulation model with theoretical data is correct. Fortunately, statistics provides a variety of methods to describe patterns and variations in data.

In this section, we explore the several of the numerical characteristics of statistics.

<u>Objectives</u>:
1. Define statistical terminology.
2. Determine the numerical characteristics of a data set.

<u>Related Standards of Learning (SOLs)</u>:
Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

<u>Recommended Instructional Activities</u>:
1. Explain that *statistics* is the branch of mathematics that uses observations and measurements to analyze and summarize data gathered.
2. Identify the terms: *mean, median, mode, range,* and *standard deviation* and how they relate to the study of statistics.
3. Explain that variability is required to study data. For example, you might use an example of standard temperatures for the month of the year in which this section is being taught, measure the actual temperature and explain the idea that one can measure the variability from the average temperature.
4. Calculate the *mean, median*, *mode, range,* and *standard deviation* from a data set.
5. Using interactive software, students can compare and contrast properties of measures of central tendency, specifically the influence of changes in data values on the mean and median. For example, using the census database online (www.census.gov) . Find information about the Income in the United States. Compare the behavior of mean and mea

<u>Workplace Readiness Skills</u>: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

<u>References</u>:

Exploring and Comparing Mean Median and Mode
http://math.elon.edu/statistics112/exploring.html

Mean and Median Applets : http://www.ruf.rice.edu/~lane/stat_sim/descriptive/index.html

Practical uses of mean, median, and mode:
http://www.teachersnetwork.org/powertolearn/web/ludwig/outline.htm

Research Methods Knowledge Base http://www.socialresearchmethods.net/kb/statdesc.php

Standard Deviation and Explanation: http://www.childrensmercy.org/stats/definitions/stdev.htm

Statistics, Concepts and Controversies Associated Web site:
http://bcs.whfreeman.com/scc/default.asp?s=&n=&i=&v=&o=&ns=0&uid=0&rau=0

Statistics Definition web site: http://www.ltcconline.net/greenl/courses/201/descstat/mean.htm
Statistics Worksheets: http://edhelper.com/statistics.htm

Unit 3.4: Identify the Relationship Between Events

Unit Length:

This unit will last approximately two days but objectives will be reinforced throughout course.

Goal: Identify and describe two or more events as complementary, dependent, independent, and/or mutually exclusive.

Rationale:
Probability requires understanding of the various types of events that can occur. Very often the occurrence of one event is dependent upon a sequence or the occurrence of the first event. In order to accurately simulate random events, it is necessary to understand the way probabilities can change based on order or dependence.

Objectives:
1. Define probability event terminology.
2. Identify events as complementary, dependent, or independent.
3. Identify events as mutually exclusive or not mutually exclusive.

Related Standards of Learning (SOLs):
Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:
1. Define the terms: *complementary, dependent, and independent*.
2. Provide examples of dependent and independent events.
3. Define the terms: mutually exclusive, complementary, dependent, and independent.
4. Provide students with a series of examples that can be categorized as mutually exclusive, complementary, dependent, and independent.
5. Ask students to provide examples of events for each of the categories and explain why they meet criteria for each group.
6. Explain that the students will need to know how to identify these events because in the next section they will be calculating the probability for these types of events.

Workplace Readiness Skills: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

References:
Independent and Dependent Events:
http://www.learningwave.com/chapters/probability/dependent_independent.html

The Math Forum at Drexel: http://mathforum.org/library/drmath/view/56494.html

---

Interactive Mathematics: http://www.intmath.com/Counting-probability/8_Independent-dependent-events.php

SparkNotes, Complementary Events and Odds:
http://www.sparknotes.com/math/algebra1/probability/section2.rhtml

Online Math Learning: http://www.onlinemathlearning.com/complementary-events.html

Mrs. Glossars Math Goodies:
http://www.mathgoodies.com/lessons/vol6/mutually_exclusive.html

Regents Prep: http://www.regentsprep.org/

Probability Lesson Plan: http://www.cimt.plymouth.ac.uk/projects/mepres/book7/y7s21lp.pdf

Probability Simulations:
http://www.mathsonline.co.uk/nonmembers/resource/plans/tree_plan.html

Unit 3.5: Compute Probabilities

Unit Length:

This unit will last approximately ten days but objectives will be reinforced throughout course.

Goal: Find probabilities (relative frequency and theoretical), including conditional probabilities for events that are either dependent or independent, by applying the "law of large numbers" concept, the addition rule, and the multiplication rule.

Rationale:

Most people are familiar with probability, or the mathematics of chance, from playing lotteries or gambling games such as slot machines. There are many more applications of probability in business, weather forecasting, and in our day to lives. In fact, an entire area of study called Operations Research uses probability to assist business to run more efficiently. Modeling and simulation experts use probability in designing models that will occur at relative frequencies or to add randomness into a simulation.

Objectives:
1. Define probability terminology.
2. Explain probability rules.
3. Analyze categorical data using two-way tables to describe patterns and departure from patterns and to find marginal frequency and relative frequencies.
4. Distinguish between empirical and theoretical probability.
5. Calculate probabilities.
6. Explain the law of large numbers.
7. Calculate probabilities using addition rules.
8. Calculate probabilities using the multiplications rules.

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:
1. Define the following terms: probability, probability experiment, outcome, trial, sample space, and classical probability.
2. Explain and give examples of sample spaces. For example, the samples space for a coin is heads or tails. Ask students what the sample space is for two coins?
3. Explain the probability rules:
    a. The probability of any event will always be a number from zero to one.
    b. When an event cannot occur the probability is zero (0)
    c. When an event's certainty is 100%, the probability is 1
    d. The sum of all probabilities of a sample space are 1;
    e. The probability that an event will not occur is one minus the probability that the event will occur.

4. Provide students with an experimental probability exercise using dice or similar. For example, in a box, place pieces of paper to represent a $1, $5, $10, and $20 bills. Determine the probability that the bill is $10. Determine the probability n that the denomination of the bill selected is more than $2. The bill selected is of an odd denomination.
5. Provide students with the formula to calculate theoretical probability.
6. Ensure that probability notation is explained. For example, the probability of event A occurring is written: $P(A)$.
7. Explain to students that providing more trials on a particular probability experiment will lead to an experimental probability that is closer to the theoretical probability. Ensure students understand that this idea is the Law of Large Numbers.
8. Review the concepts of mutually exclusive and non-mutually exclusive while explaining the Addition Rules.
9. Provide students with the two probability addition rules:
    a. When two events are mutually exclusive: $P(A \text{ or } B) = P(A) + P(B)$
    b. When two events are not mutually exclusive: $P(A \text{ or } B) = P(A) + P(B) - P(A \text{ and } B)$
10. Provide students with the two multiplication rules:
    a. If two events are independent: $P(A \text{ and } B) = P(A) * P(B)$
    b. If two events are dependent: $P(A \text{ and } B) = P(A) P(B|A)$
11. One of the most difficult aspects for students is to determine when the various rules should be used. During class, provide students with a worksheet or class problem. Ask the students to try the problem on their own and then review their answers. Ask students to explain why they chose the rule they chose, even if they did not choose the correct rule as this assists other students from falling into a similar trap.

Workplace Readiness Skills: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

References:

Introduction to Probability Lesson Plans:
http://school.discoveryeducation.com/lessonplans/programs/probability/

Mrs. Glossar's Math Goodies http://www.mathgoodies.com/lessons/vol6/intro_probability.html

Rules of Probability: http://library.thinkquest.org/11506/prules.html

Probability Tutorials: http://www.probability.net/

Probability Web, The http://www.mathcs.carleton.edu/probweb/probweb.html

Statistics Glossary: http://mathforum.org/dr.math/faq/faq.prob.intro.html

Unit 3.6: Compute Permutations and Combinations

Unit Length:

This unit will last approximately ten days but objectives will be reinforced throughout course.

Goal: Compute and distinguish between permutations and combinations and use technology for applications.

Rationale:
You probably thought that you already knew how to count, but counting for probabilities involves some different mathematic counting skills. In order to calculate some probabilities, it is necessary to know the total number of ways an event can occur. This unit will provide the mechanisms for counting the various ways that events can occur given various situations. You will learn three rules, The Fundamental Counting Rule, Permutations, and Combinations.

Objectives:
1. Define the *Fundamental Counting Rule, Permutation,* and *Combination*.
2. Perform calculations using the Fundamental Counting Rule, Permutation and Combination
3. Distinguish when one would use a permutation and when one would use a combination.

Related Standards of Learning (SOLs):
Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:
1. Define the following terms: probability, probability experiment, outcome, trial, sample space, classical probability.
2. Explain and give examples of sample spaces. For example, the samples space for a coin is heads or tails. Ask students what the sample space is for two coins?
3. Explain the probability rules:
   a. The probability of any event will always be a number from zero to one.
   b. When an event cannot occur the probability is zero (0)
   c. When an event's certainty is 100%, the probability is 1
   d. The sum of all probabilities of a sample space are 1;
   e. The probability that an event will not occur is one minus the probability that the event will occur.
4. Provide students with an experimental probability exercise using dice or similar. For example: In a box, place pieces of paper to represent a $1, $5, $10, and $20 bills. Determine the probability that the bill is $10. Determine the probability n that the denomination of the bill selected is more than $2. The bill selected is of an odd denomination.
5. Provide students with the formula to calculate the theoretical probability.

6. Ensure that probability notation is explained. For example, the probability of event A occurring is written P(A).
7. Explain to students that providing more trials on a particular probability experiment will lead to an experimental probability that is closer to the theoretical probability. Ensure students understand that this idea is the Law of Large Numbers.
8. Review the concepts of mutually exclusive and non mutually exclusive while explaining the Addition Rules.
9. Provide students with the two probability addition rules:
    f. When two events are mutually exclusive: P(A or B) = P(A) + P(B)
    g. When two events are not mutually exclusive: P(A or B) = P(A) + P(B) − P(A and B)
10. Provide students with the two multiplication rules:
    h. If two events are independent: P(A and B) = P(A) * P(B)
    i. If two events are dependent: P(A and B) = P(A) P(B|A)
11. One of the most difficult aspects for students is to determine when the various rules should be used. During class, provide students with a worksheet or class problem. Ask the students to try the problem on their own and then review their answers. Ask students to explain why they chose the rule they chose, even if they did not choose the correct rule as this assists other students from falling into a similar trap.

Workplace Readiness Skills: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

References:

College Cram, Combinations: http://www.college-cram.com/study/algebra/presentations/245

Genius Maker Math Software for Permutations and Combinations:
http://www.goldenkstar.com/permutation-combination-software-school-mathematics.htm

InfoPlease.com Combinations and Permutations:
http://www.infoplease.com/ce6/sci/A0860531.html

Introduction to Probability Lesson Plans:
http://school.discoveryeducation.com/lessonplans/programs/probability/

Probability, Combinations and Permutations:
http://www.chem.qmul.ac.uk/software/download/qmc/ch5.pdf

Regent Prep: http://www.regentsprep.org/

Unit 3.7: Conduct an Experiment

<u>**Unit Length**</u>:

This unit will last approximately ten days but objectives will be reinforced throughout course.

<u>**Goal**</u>: Plan and conduct an experiment that will address control, randomization, and measurement of experimental error.

<u>**Rationale**</u>:
Now that you are familiar with a variety of probability and statistics basics, it is useful to see how these are applied in the real world. To complete this activity, you will develop an experiment and explore the ideas of experimental error.

<u>**Objectives**</u>:
1. Define experimental terminology.
2. Explain potential reasons for experimental error.
3. Conduct an experiment within the classroom.

<u>**Related Standards of Learning (SOLs)**</u>:
Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

<u>**Recommended Instructional Activities**</u>:

1. Review the following terms: *hypothesis, statistical significance, bias, placebo effect,* and *sampling error*.
2. Provide students with a series of experiments and hold a class discussion to understand what **might** be reasons for experimental error. Explain to students the importance of examining any experiment with these concepts in mind.
3. Brainstorm with students ideas for a **measurable** experiment that could be completed in the class room. For example, you might measure everyone in the class to determine what the average height of a person in the modeling and simulation program. Another idea would be to perform some form of a class survey.
4. Split the class into groups to perform the same experiment. Students then compare their data to see how it may differ and should explain why there are difference in the data.

<u>**Workplace Readiness Skills**</u>: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

<u>**References**</u>:

Introduction to Probability Lesson Plans:
http://school.discoveryeducation.com/lessonplans/programs/probability/

Mrs. Glossar's Math Goodies http://www.mathgoodies.com/lessons/vol6/intro_probability.html

---

Rules of Probability: http://library.thinkquest.org/11506/prules.html

Probability Tutorials: http://www.probability.net/

Probability Web, The http://www.mathcs.carleton.edu/probweb/probweb.html

Statistics Primer: http://mathforum.org/dr.math/faq/faq.prob.intro.html

Unit 3.8: Basic Mathematical Calculations

Unit Length:

This unit will last approximately eight days but objectives will be reinforced throughout course.

Goal: Perform basic mathematical calculations as needed in software applications.

Rationale:

It is important to understand probability distributions as these are commonly used in the models used in simulations. Probability distributions are critical to the study of discrete event simulations which are used in manufacturing, business, and other industries.

Software-based random number generation depends on formulas that given a seed, return sequences of numbers that conform to a specific probability distribution. These are called pseudo-random numbers because the same seed will return the exact same sequence of numbers. These sequences are finite in length which can become a problem when needing more random numbers than exist in a sequence; in such a case the sequence repeats and the statistical properties are no longer valid. This is not a problem for small experiments.

Objectives:

1. Define various probability distributions.
2. Calculate the probability from a distribution.
3. Perform discrete event simulations using probability distributions.
4. Understand random number generation and its limitations.

Related Standards of Learning (SOLs):

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Define the following terms: probability distribution, discrete, continuous, binomial distribution, triangular distribution, and normal distribution.
2. Introduce the binomial distribution and identify what types of problems in which it is most likely to be used.
3. Have students describe the outcome for tossing three coins at the same time and then calculate the probability by grouping the number of heads in each.
4. Design and perform a binomial experiment as a class activity.
5. Calculate the mean and standard deviation for the binomial distribution.
6. Introduce the triangular distribution and identify what types of problems in which it is most likely to be used.
7. Design and perform a triangular distribution experiment as a class activity.
8. Calculate the mean and standard deviation for the triangular distribution.

9. Explain that the normal distribution is the most common type of distribution.
10. Describe the characteristics of the normal distribution.
11. Explain how to calculate the probability from a normal distribution curve.
12. Explain how the shape of the curve affects the probability.
13. Calculate the mean and standard deviation for the normal distribution and use z scores.
14. Show students how to calculate the z score on a scientific calculator.
15. Explain the concept and uses of discrete event simulation.
16. Using appropriate software, determine what type of activity (manufacturing for example) might follow the normal distribution and determine where the bottlenecks may exist.
17. Use the random number generator of a calculator to generate a series of random numbers and compare the actual distribution with the intended distribution.

Workplace Readiness Skills: 1, 2, 5, 6, 7, 8, 9, 10, 11, and 13

References:

Discrete Probability Distributions:
http://www.dartmouth.edu/~chance/teaching_aids/books_articles/probability_book/Chapter1.pdf

Engineering and Statistics Handbook:
http://www.itl.nist.gov/div898/handbook/eda/section3/eda36.htm

Hyperstat Online, The Normal Distribution:
http://davidmlane.com/hyperstat/normal_distribution.html

Intervals and Probability Distributions: http://ifsc.ualr.edu/jdberleant/intprob/

Normal Distribution Calculator:
http://www.math.csusb.edu/faculty/stanton/m262/normal_distribution/normal_distribution.html

Rockwell Software, Arena Simulation Software: http://www.arenasimulation.com/

Probability distribution statistics tutorial:
http://stattrek.com/Lesson2/ProbabilityDistribution.aspx

Design Brief: Using Probability and Games

Simulation of a Forest Fire

Context

Wild fires are common in most ecosystems. Wildlife conservationists, local, state, and federal agencies work together to limit the negative effects of wildfires on resources and society. Most

wildlife fires must be suppressed to meet resource and social objectives. While it has been shown that wildfires serve important ecosystem functions, human involvement has played a significant role in the destruction of wildlife resources. The most common human related causes of wildfires are due to arson**,** campfires**,** discarding lit cigarettes, and improperly burning debris.

Fighting wildfires is a carefully planned and complex science. Many factors influence the method of fighting these fires. Activity participants can observe how properties like wind speed, wind direction, and forest density affect how the fire spreads.

Challenge

Each student will demonstrate an understanding of the application of probability and statistics as it relates to the spread of wildfires. Additionally, each student will identify the inputs and outputs of the simulation.

Objectives

Upon completion of the design brief, students will be able to do the following:

- Explain some techniques used in fighting wildfires.
- Understand experimental terminology.
- Apply randomness.
- Distinguish between empirical and theoretical probability.
- Calculate probabilities.
- Explain potential reasons for experimental error.
- Graph using a line plot
- Understand means
- Describe variance.
- Perform a hand simulation.

Materials

- Computer with Internet access and a web browser that is Java enabled.
- http://www.shodor.org/interactivate/activities/DirectableFire/
- Pencil and paper
- Dice
- Graph paper

References

- Fire and Aviation Management
  http://www.fs.fed.us/fire/
- Forest Fire Lesson Plan
  http://school.discoveryeducation.com/lessonplans/programs/forestfires/
- Forest Fires and Percolation: Managing Wildfires and Tree Growth
  http://polymer.bu.edu/java/java/blaze/blaze.html
- Forest Fire In the American Southwest -- Statistics
  http://forestfire.nau.edu/statistics.htm
- Java Applet allows the user to see the results of a fire if a forest is densely planted in a rectangular grid when directional probabilities are set
  http://www.shodor.org/interactivate/activities/DirectableFire/
- Modeling Forest Fires using Probability Modeling Tools to compare Forest Management practices of today versus Forest Management practices of the Past.
  http://serendip.brynmawr.edu/local/cci/lessons97/Abram.html
- National Interagency Fire Center
  http://www.nifc.gov/fire_info/nfn.htm
- Oregon Department of Forestry
  http://www.oregon.gov/ODF/FIRE/fire.shtml
- Plume rise model for Forest Fire Using ArcGIS Modeling Tool
  http://www.crwr.utexas.edu/gis/gishydro03/Classroom/trmproj/Nopmongcol/report.htm
- Simulating Fire Patterns in Heterogeneous Landscapes
  http://research.esd.ornl.gov/EMBYR/embyr.html

Evaluation

- Research the ecological benefits and dangers associated with wildfires. Provide a typed paragraph summarizing your finding.
- Perform the *Fire! Exploration* questions worksheet
  (http://www.shodor.org/interactivate/media/worksheets/29.pdf)
- Have students perform the hand simulation of the fire activity using graph paper and a die as stated on Shador.org site
  (http://www.shodor.org/interactivate/lessons/FireProbabilityChaos/).
- Describe the inputs and outputs to this simulation.
- Describe the variables in the simulation.
- Is this simulation realistic? Why or why not?
- Any simulation can be updated to increase its fidelity. Define fidelity and explain what could be modified in the simulation to improve the fidelity.

Unit 4: Understanding Problem Analysis

Unit Length:

This unit will last approximately three weeks.

Goals:

4.1. Demonstrate the experimental design process.
4.2. Explain discrete event simulation.
4.3. Apply numerical analysis techniques.
4.4. Select appropriate level of fidelity for a model

Rationale:

Computers and computer programming has become an integral part of today's society. The usage of computers appears in the educational and business as well as the scientific fields.
Computer literacy is needed by all students. Computer literacy implies a working knowledge of a math language, the language of programming, and an idea of what computers can and cannot do. Our students will enter a working world where computers will be used extensively. They will need to understand and use computers. Introducing the usage of computers, basic programming skills, and encouraging our children to think logically about solving problems will help them immensely when they enter the job market. The purpose of this unit is to act as an introduction to the thinking world of computers, to help students develop a math language and an alternative methodology that will enable them to solve all problems.

Unit 4.1: Experimental Design

<u>Unit Length</u>:

This unit will last approximately four days but objectives will be reinforced throughout course.

<u>Goals</u>:

Demonstrate the experimental design process.

<u>Rationale</u>:

Experimental design (ED) is a very powerful problem solving technique that assists engineers and other problem solvers in tackling quality control problems effectively and economically. It involves a strategy of planning, conducting, analyzing and interpreting experiments so that sound and valid conclusions can be drawn efficiently, effectively and economically. ED has proven to be very effective for improving the process yield, capability, performance and reducing variability in many business, engineering and scientific functions.

In this unit students will understand that a sequential process must be followed for a task to be completed. Also, when charting similar familiar tasks, they will learn to be very explicit in their directions. This explicit recitation of steps will help the student develop the directional thinking patterns that are so necessary in problem solving and ED.

Additionally, they will understand the basic principles of analysis of problems by identifying major problems and the main causal relationships between them.

<u>Objectives</u>:

1. Use proper attributes to develop flowchart.
2. Compare various types of studies (i.e. survey, observation, experiment).
3. Identify an experimental design.
4. Set objectives of the experiment.
5. Select the response or output.
6. Select process variables or design parameters (control factors), noise factors and the interactions among the process variables of interest.
7. Perform experimental design execution.
8. Check that the data are consistent with the experimental assumptions
9. Interpret the results.
10. Present the results.

<u>Related Standards of Learning (SOLs)</u>:

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, COM.4, COM.8, COM.16, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:
1. Experimental Design Vocabulary activity - http://mjksciteachingideas.com/pdf/ExpDesVocab.pdf
2. Experimental Design Practice - http://mjksciteachingideas.com/pdf/ExpDesPrac.pdf
3. Provide a brief overview of the three types of *t*-tests (two-sample, paired, and one-sample *t*-tests).
4. Write a 1-2 page paper that provides the following: Highlights of what you learned about experimental design; questions you might have; and ideas for how to design an experiment. Make specific recommendations for how you could improve on an experimental design format.
5. Play Computer Class. Assign groups of students to be INPUT DATA teams, OPERATIONS teams, DECISION teams, and OUTPUT teams. Each group has a set task to perform based on instructions given to them by another team. Watch how the transference of information is accomplished. Have students discuss the information processing involved.
6. Paper helicopter experiment - ED application for optimizing the time of flight of a paper helicopter which can be made from A4-size paper, scissors, ruler, paper clips and a measuring tape.*

Supporting Activities:

Students should eventually feel comfortable about designing flowcharts to complete tasks outside the realm of mathematics as they know it. Practice in the following activities will direct students to pay attention to the details and the order of events.

7. Use flowchart application program to develop and illustrate a flowchart identifying decision matrix to determine one of the following: what clothing to wear to school, what college to attend, what career field to pursue etc.
8. Write a flowchart to explain how one buys a can of soda from a soda machine.

Workplace Readiness Skills: 1, 2, 3, 4, 5, 6, 8, 10, 11, and 13

References:

Teaching Experimental Design - http://mjksciteachingideas.com/design.html

Experimental Design Reference - http://mjksciteachingideas.com/pdf/ExpDesRef.pdf

Aspects of Experimental Design with Real Live Examples - http://liutaiomottola.com/myth/expdesig.html

A Library of Materials, most freely downloadable, created by classroom teachers and other educators, that addresses diverse curricular and organizational topics of interest to K-12 educators - http://www.clexchange.org/

Article - Scientific inquiry training for high school students: Experimental evaluation of a model program, By Kenneth D. Peterson, School of Education, University of California, Berkeley, California 94720

Alcock, Donald. Illustrating BASIC: A Simple Programming Language... Cambridge University Press, Cambridge, 1977. Simple explanations of programming in the BASIC language. Clear enough for the general reader.

Engineering Statistics Handbook -
http://www.itl.nist.gov/div898/handbook/pri/section1/pri13.htm

Florida University High School's Global Technologies Magnet Program -
https://www.ocps.net/lc/east/hun/academics/programs/gt/Pages/default.aspx

Klienberg, Harry. How You Can Learn to Live With Computers. J.B..Lippincott Company, Philadelphia, 1977. An amusing book describing computer technology and its' basic usages in laymen terms. Good for those who have no experience with computers.

Modeling using STELLA, a powerful tool to explore systems as well as to generate a deep understanding of interconnections (see sample models) -
http://www.iseesystems.com/community/downloads/EducationDownloads.aspx

Schneider, Ben Ross Jr.. Travels in Computerland. Addison-Wesley Publishing Company, Inc., Reading, Mass., 1974. A humanist's impression of the potential for good and evil of computers in our society based on the authors' experience. Fun reading.

*Teaching Experimental Design Techniques to Industrial Engineers"
By Jiju Antony and Nick Capon
Portsmouth Business School, University of Portsmouth, Milton Site, Portsmouth, PO4 8JF, UK -
http://www.ijee.dit.ie/articles/Vol14-5/ijee1033.pdf

The Military Operations Research Society (MORS) - http://www.mors.org/

Wiebe, James H. "BASIC Programming for Gifted Elementary Students." Arithmetic Teacher, Vol.28, No.7 (March 1981) Report on the study of a group of children introduced to programming in BASIC during a summer school session.

Unit 4.2: Discrete Event Simulation

Unit Length:

This unit will last approximately one week.

Goals:

Explain discrete event simulation.

Rationale:

Discrete event simulation is an important system analysis technique. A discrete event simulation (DES) manages events in time. Most computer, logic-test, and fault-tree simulations are of this type. In this type of simulation, the simulator maintains a queue of events sorted by the simulated time they should occur. The simulator reads the queue and triggers new events as each event is processed. In this unit you will be able to access data produced by a simulation, understand the event relationships and to discover logic defects in the design, or the sequence of events.

Objectives:

1. Identify discrete event simulations.
2. Use simulation as an analysis tool.
3. Describe the output distribution.
4. Use historical/empirical data.
5. Correctly interpret summary statistics.
6. Correctly interpret confidence and prediction (certainty) intervals.
7. Identify sources of error in simulations.
8. Describe relationships among variables.
9. Describe the effect of correlation on simulation results.

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Read, Pair and Share reading activity: Read and discuss the various uses of DES in article: The Multiple Roles of Discrete Event Simulation in the Workplace – **The Multiple Roles of Discrete Events**
2. Read, Pair and Share reading activity: Read and discuss the uses of DES in automotive manufacturing. Article: Automotive applications of discrete event simulation Automotive Manufacturing & Production, July, 1997 - http://findarticles.com/p/articles/mi_m0FWH/is_n7_v109/ai_19785139/pg_1

---

3. Invite guest speaker to class to discuss the utility of numerical analysis. National Security Agency Mathematics Speakers Bureau is an excellent resource. http://www.nsa.gov/academia/early_opportunities/math_edu_partnership/index.shtml
4. List 5 samples of discrete event simulations and provide a paragraph synopsis of each one.
5. Develop basic discrete event simulation which provides summary percentile data statistics.
6. View video on queuing theory - http://hsor.org/videos/index.cfm?videos=arm-and-a-leg

Workplace Readiness Skills: 1, 2, 3, 5, 6, 8, 10, 11, and 13

References:

A philosophy of Modeling and Simulation (and more) - http://www.thesimguy.com/pubs.htm

A Library of Materials, most freely downloadable, created by classroom teachers and other educators, that addresses diverse curricular and organizational topics of interest to K-12 educators - http://www.clexchange.org/

Discrete-Event Simulation: Modeling, Programming, and Analysis by G. Fishman, 2001, *Discrete-Event Simulation*: A First Course - http://www.cs.wm.edu/~esmirni/Teaching/cs526/DESAFC-1.1.ppt

High School Operations Research Mathematics for Decision Making in Industry and Government – Welcome to HSOR.org (High School Operation Research): Home

Matt Rohrer, Bucky Strong. Article: Automotive applications of discrete event simulation Automotive Manufacturing & Production, July, 1997 - http://findarticles.com/p/articles/mi_m0FWH/is_n7_v109/ai_19785139/pg_1

Monte-Carlo *simulation*? Teach Discrete-Event simulation? *Teaching* (Monte-Carlo) Spreadsheet *Simulation* - http://meetings.informs.org/TMSWorkshop/TMS04/presentations/Grinde.ppt

Overview of Simulation - http://www.systems-thinking.org/modsim/modsim.htm

Peter J. Lawrence. Article: **The Multiple Roles of Discrete Event Simulation in the Workplace**

ProModel is a of simulation-based, decision making tool - http://www.promodel.com/

Unit 4.3: Numerical Analysis Techniques

Unit Length:

This unit will last approximately two days.

Goals:

Apply numerical analysis techniques.

Rationale:

Numerical analysis and mathematical modeling are essential in many areas of modern life. Sophisticated numerical analysis software is commonly embedded in popular software packages (e.g., spreadsheet programs) and allows fairly detailed models to be evaluated, even when the user is unaware of the underlying mathematics.

Numerical analysis and methods are applied to a very wide range of subject areas. Numerical analysis is an effective tool used by many researchers in many areas of engineering and science. For example, building modern structures makes major use of finite element methods for solving the partial differential equations associated with models of stress; and computational fluid mechanics is a fundamental tool in designing new airplanes, and so on.

Objectives:

1. Apply logical reasoning skills to solve real-world problems through the development of mathematical models.
2. Design a step-by-step plan (algorithm) to solve a given problem.
3. Write program specifications that define the constraints of a given problem.
4. Use a programmable calculator.
5. Write an algorithm to solve mathematical problems using formulas, equations, and functions.

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Invite guest speaker to class to discuss the utility of numerical analysis. National Security Agency Mathematics Speakers Bureau is an excellent resource. http://www.nsa.gov/academia/early_opportunities/math_edu_partnership/index.shtml
2. Read, Pair, and Share Article: Review and discuss interview with a pioneer in Numerical Analysis - http://history.siam.org/pdfs2/davis.pdf

---

3. Collaborate with a Physics class in a study of velocity and acceleration; consider using Hooke's Law.
4. View video and discuss application: Apply a variety of algorithms to solve a traveling salesman problem - http://hsor.org/videos/index.cfm?videos=outel_semiconductor
5. Design a step-by-step plan (algorithm) to solve a given problem. The plan will be in the form of a program flowchart, pseudo code, hierarchy chart, and/or data-flow diagram.
6. Complete this online programmable calculator activity -Velocity and the Bouncing Ball - http://education.ti.com/educationportal/activityexchange/activity_detail.do?cid=us&activityid=4084

Workplace Readiness Skills: 1, 2, 3, 5, 6, 8, 10, 11, and 13

References:

A Library of Materials, most freely downloadable, created by classroom teachers and other educators, that addresses diverse curricular and organizational topics of interest to K-12 educators - http://www.clexchange.org/

An interview with PHILIP J. DAVIS Conducted by William Kolata and Gail Corbett, 15 April, 2004, http://history.siam.org/pdfs2/davis.pdf

Floating-Point Number Tutorial - http://www.cs.utah.edu/~zachary/isp/applets/FP/FP.html

High School Operations Research Mathematics for Decision Making in Industry and Government – Welcome to HSOR.org (High School Operation Research): Home

Internet Resources for Numerical Analysis - http://mathforum.org/advanced/numerical.html

Kendall E. Atkinson, An Introduction to Numerical analysis - http://www.math.uiowa.edu/~atkinson/NA_Overview.pdf

Kendall E. Atkinson, Elementary Numerical Analysis (Paperback)

Numerical analysis from Wikipedia - http://en.wikipedia.org/wiki/Numerical_analysis

Schery, Stephen, Topics in Numerical Analysis for High School Mathematics, Math Teacher, 63, 4, 313-317, 70 Apr

NSA Concepts Curriculum - http://www.nsa.gov/academia/early_opportunities/math_edu_partnership/collected_learning/high_school/index.shtml

Steering Behaviors for Autonomous Characters - http://www.red3d.com/cwr/steer/

Unit 4.4: Select Model Fidelity

<u>Unit Length</u>:

This unit will last approximately one day.

<u>Goals</u>:

Select appropriate level of fidelity for a model

<u>Rationale</u>:
Fidelity in M&S is the degree to which a model or simulation reproduces the state and behavior of a real world object or the perception of a real world object, condition in a measurable manner. When developing a model simulation it is imperative to understand the importance of an efficient level of simulation fidelity, which will achieve acceptable output accuracy with minimum resources and thereby reduce model building effort and computation time. We have all heard the axiom that time is money and in the business world spending too much time on a simulation that only solves simply problems is not cost-effective.

<u>Objectives</u>:

1. Define fidelity.
2. Discuss model fidelity variation.
3. Select the proper level of fidelity to solve a given problem.
4. Identify the rationale for selecting fidelity level.

<u>Related Standards of Learning (SOLs)</u>:

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, COM.4, COM.8, COM.16, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

<u>Recommended Instructional Activities</u>:

1. Research the definition of model fidelity. Identify and illustrate (5) fidelity related concepts e.g. Listening to a portable radio vs. listening to a Bose radio.
2. Discuss and demonstrate model simulation fidelity levels.
3. Design a spreadsheet cost/benefit analysis of different fidelity level models. In your cost, consider construction time, money, storage capacity, and bandwidth, etc.

<u>Workplace Readiness Skills</u>: 1, 2, 3, 4, 5, 6, 11, and 13

References:

A [Library of Materials](), most freely downloadable, created by classroom teachers and other educators, that addresses diverse curricular and organizational topics of interest to K-12 educators - http://www.clexchange.org/

Characterization of Model Fidelity Uncertainty for Robust Design
Chandan Kumar Mozumder, D.Deg, 05, 63 pp

Fact Sheet dealing with military simulation fidelity level: What is a Model or Simulation hierarchy -
http://www.imcva.com/simulation/Fact%20Sheet%205%20What%20is%20a%20model%20or%20simulation%20hierarchy%20-Final.doc

Medical study on the level of fidelity used in training surgeons -
http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=1356416

Understanding Simulation Fidelity: What is it and how much do we need? Deals with process simulation - http://www.mynah.com/pdf/Understanding%20Simulation%20Fidelity.pdf

Design Brief: Create a Discreet Event Simulation (DES)

Create a Discrete Event Simulation

Context

The growth of container traffic in the shipping industry has brought a major challenge for marine and intermodal terminals: how to successfully handle the increase in demand? Current forecasts estimate worldwide container volume doubling over the next twenty years (1). One North American port forecasts a growth rate in container traffic of 249 percent (2). Terminals must find a way to manage this additional demand, or risk losing business to their competitors.

Discrete event simulation is an important system analysis technique that can assist shipping industry decision makers in predicting demands and developing solutions to problems.

A discrete event simulation (DES) manages events in time. Most computer, logic-test, and fault-tree simulations are of this type. In this type of simulation, the simulator maintains a queue of events sorted by the simulated time they should occur. The simulator reads the queue and triggers new events as each event is processed.

Challenge

Each student will demonstrate an understanding of creating a simple Discreet Event Simulation that provides summary data useful in making effective decisions. Upon completion of this Design brief, you will be able to access data produced by a simulation, understand the event relationships and to discover logic defects in the design, or the sequence of events.

Suggested problems to simulate:

- How containers are moved (percent by rail or by truck)
- Most efficient technology used for handling containers (e.g., straddle carriers vs. crane/hostler)
- Where containers are stored (on-site or remote, stacked or on chassis)
- Expansion of terminals or creation of new storage yards
- Inefficient gate operations resulting in long queues of idling trucks
- Cost of encroachment on surrounding wetlands
- Cost of Shifting tonnage from rail to truck
- The result of increasing OTR (over-the-road) traffic
- Determining unacceptable increase in harmful emissions

Objectives

Upon completion of the design brief, students will be able to do the following:

- Identify discrete event simulations.
- Use simulation as an analysis tool.
- Describe the output distribution.

- Use historical/empirical data.
- Correctly interpret summary statistics.
- Correctly interpret confidence and prediction (certainty) intervals.
- Identify sources of error in simulations.
- Describe relationships among variables.
- Describe the effect of correlation on simulation results.

Materials
- Internet and appropriate shipping industry data
- Computer with appropriate simulation software
- Pencil and paper
- ePortfolio

References

- [Military Sealift Command.(GOVERNMENT NEWS)(Brief Article)](), February 01, 2005
- [Baltimore Chapter.(conferences)(Brief Article)](), February 01, 2005
- [Arizona Frontier Chapter.(donations)(Brief Article)](), February 01, 2005
- [Gulf coast chapter.(obituary)(Brief Article)(Obituary)](), February 01, 2005
- [Sacramento chapter.(join forces with NEWS10)](), February 01, 2005
- Discrete-Event Simulation*:* Modeling, Programming, and Analysis by G. Fishman, 2001, *Discrete-Event Simulation*: A First Course - http://www.cs.wm.edu/~esmirni/Teaching/cs526/DESAFC-1.1.ppt
- Monte-Carlo *simulation*? Teach Discrete-Event simulation? *Teaching* (Monte-Carlo) Spreadsheet *Simulation* - http://meetings.informs.org/TMSWorkshop/TMS04/presentations/Grinde.ppt
- Overview of Simulation - http://www.systems-thinking.org/modsim/modsim.htm
- Application of Discrete Event Simulation to Bulk Handling Supply Chains - http://www.ausenco.com/icms_docs/88986_Discrete-Event_Simulation_in_Java_-_A_Practitioners_Experience.pdf

Evaluation

- Present simulation to the class for peer critique
- Was the simulation valid?
- Did simulation produce desired analysis?

Unit 5: Demonstrating Programming

Unit Length:

This unit will last approximately six weeks.

Goals:

    5.1. Examine computer programming factors that influence design.
    5.2. Explain object models.
    5.3. Explain agent-based simulation.
    5.4. Explore software evolution and lifecycle.
    5.5. Apply simple gaming concepts.

Rationale:

One aspect of Modeling and Simulation encountered by many professionals is the need to modify a simulation, create a visualization of a simulation model, or integrate two or more simulation models together. To achieve this task, it is critical that students have the ability to analyze and perform problem decomposition. Computer programming knowledge and concepts provide the necessary skills to perform the necessary analysis and modify a simulation to meet the desired goal.

Unit 5.1: Programming Factors in Design

Unit Length:

This unit will last approximately fifteen days but will be reinforced throughout course.

Goals: Examine computer programming factors that influence design.

Rationale:
Understanding your computer is critical to being able to design and implement programs that will ultimately become simulations. In order to prevent unforeseen mistakes and buggy software, you will need to begin to learn about computers and programming. This unit will introduce you to basic computer hardware and introduce you to programming concepts.

Objectives:

1. Understand basic computer terminology.
2. Explain how a basic computer works.
3. Decompose problems.
4. Apply problem analysis using flowcharts and the Unified Modeling Language (UML).
5. Understand basic programming constructs.
6. Examine programming styles and design.

Related Standards of Learning (SOLs)

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Define computer.
2. Explain the basic hardware of a computer to include: memory, hard drive, CPU
3. Explain how a computer works and the requirement of detailed instructions in order for a computer to operate correctly.
4. Explain the binary numbering system to students including how to perform conversions from binary to decimal and decimal to binary.
5. Explain how a computer uses the bin.
6. If time permits, gather students around a single workstation and remove the cover of a computer. Point out each of the various components and take a photo using a digital camera. Later on, part of an exam will be to identify the components of the computer.
7. Define algorithm and give examples of algorithms.
8. Allow students to provide the detailed steps for solving a problem using an every day scenario such as making a peanut butter and jelly sandwich.
9. Explain that algorithms can be viewed pictorially using flowchart modules.

10. Define the modules of flowcharting to include: start/end, input/output, process, decision, and repetition modules
11. Apply the use of flowcharting modules using a variety of day to day activities.
12. Create an algorithm for a problem and draw it using flowchart modules.
13. Define a few of the UML modules.
    a. Explain that the Unified Modeling Language is also commonly used to represent the physical flow and layout of computer programs.
    b. By looking at flowcharts and UML diagrams, students can explain the flow of data and structure of a program.
14. Define programming language terminology
15. Understand that data types are used to **define** what can be stored in a memory location.
16. Use decision programming constructs.
17. Use repetition programming constructs.
18. Understand the organization and use of functions/methods and classes in object oriented programming.
19. Differentiate between functional design, event driven design, and object oriented design.
20. Apply functional design utilizing a programming language on simple problems.
21. Apply event driven design to the development of a simple game or program.

References:

Basic How To for a variety of computer issues: http://www.ehow.com/information_1013-computer-hardware.html

Construx Software: Software Design Specification

Developer What is Software Design: http://www.developerdotstar.com/mag/articles/reeves_design.html

Directory of Online Free Computer Related Books and Tutorials: http://2020ok.com/5.htm

Introduction to Object Oriented Programming: http://en.wikipedia.org/wiki/Object-oriented_programming

IBM Introduction to UML: http://www.ibm.com/developerworks/rational/library/769.html and http://www-128.ibm.com/developerworks/rational/library/content/03July/2500/2772/2772_uml.pdf

Introduction to Computers: http://www.grassrootsdesign.com/intro/index.php

Introduction to Functional Programming: http://www.cl.cam.ac.uk/teaching/Lectures/funprog-jrh-1996/

Introduction to Programming Languages: http://burks.bton.ac.uk/burks/pcinfo/progdocs/plbook/index.htm

Introduction to Programming Using Java – free online text: http://math.hws.edu/javanotes/

Introduction to UML PowerPoint:
http://www.javapassion.com/javaprogramming/presentations/oopuml.pdf

Java Tutorials, Introduction to Objected Oriented Programming:
http://java.sun.com/docs/books/tutorial/java/concepts/

Microsoft Windows Tutorial: http://www.functionx.com/windows/Lesson01.htm

Software Design Specification Template: http://www.cmcrossroads.com/bradapp/docs/sdd.html

Unit 5.2: Object Models

Unit Length:

This unit will last approximately seven days but objectives will be reinforced throughout course.

Goals: Explain object models.

Rationale:
This unit continues to explore programming principles with the focus on object oriented programming which leads to the development of object models. While there are many approaches to programming, by far the most frequently used and accepted is that of objected oriented design. In fact, several programming languages, including C++ and Java, are designed with object oriented programming and object models in mind.

Objectives:

1. Describe objects using object oriented design (OOD).
2. Distinguish between abstract and real objects.
3. Explain why object oriented design is an effective programming paradigm.
4. Implement classes and methods.
5. Describe the benefits of object oriented concepts.
6. Use UML to describe object oriented design.

Related Standards of Learning (SOLs)

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Define an object and explain that an object has attributes and behaviors. Ask students to describe basic day-to-day objects and describe what attributes and what behaviors each object would have.
2. Describe the concept of classes as techniques used to create objects. Provide an example using an appropriate object oriented programming language such as Java or C++ so students see the actual syntax.
3. Explain that classes implement attributes and behaviors via the use of methods and variables and is used as the container or template. Explain the idea of method names, arguments, and method bodies. Explain that the idea is very similar to when they were creating functional programs.
4. Allow students to create a basic class using object oriented design. At an introductory level, it is more important to be able to design the class than follow the exact syntax of a particular language. For example, students might create a class that describes a student.

Ask students to define the attributes and behaviors of a student. Students may come up with First name, Last name, student ID etc. Implement the attributes. Explain to students that without methods to display and modify the attribute variables, it is impossible to actually set or modify the attributes. Have students come up with names and implement the methods together. Finally, show students how to instantiate the object in the chosen programming language. Make sure to write the main program and show the students how it differs from a class.

5. Explain the difference between private and public functions and explain the benefits of using encapsulation.

6. The instructor may choose to explain the concept of encapsulation by asking students to identify something that they may be able to do, while others may not. The explanation should include an explanation that as a user of that ability, you don't care how they do it, you just care that it gets completed.

7. Explain the concept of polymorphism, why it is important and how it is use.

8. Explain the *is-a* and *has-a* relationships. A simple example that one might use includes the idea of people in a school. Schools have students, teachers, and principals who have different attributes and behaviors, but have the common attributes and behaviors of people.

9. Explain the concept of overriding a method and why this is useful.

10. Using UML or some other mechanism, allow students to describe the attributes and behaviors of the person, student, principal, and teacher classes. Ensure students identify and inherit the necessary events.

11. Provide students with a skeleton for implement the various classes for people in the school and allow them to fill in the details from their UML diagram.

12. Finally, explain that most games and simulations use object oriented design. Using some appropriate software such as GameMaker or Alice, reinforce the object oriented constructs.

References:

15 Seconds, Object Models 101: http://www.15seconds.com/issue/000927.htm

Basic C++ introduction to OOD: http://gd.tuwien.ac.at/languages/c/c++oop-pmueller/

Basic How To for a variety of computer issues: http://www.ehow.com/information_1013-computer-hardware.html

Benefits of Object Oriented Design: http://www.rtis.com/nat/user/jfullerton/BENEFIT.HTM

Introduction to Object Oriented Programming: http://en.wikipedia.org/wiki/Object-oriented_programming

Document Object Model: http://www.w3.org/DOM/

Just What is Object Oriented Programming: http://www.debreuil.com/docs/ch01_Intro.htm

Keogh, Jim and Giannini, Mario. OOP DeMystefied, McGraw Hill/IOsborne, 2004.

Object Oriented Programming Terminology: http://www.startvbdotnet.com/oop/default.aspx

Pitfalls of Object Oriented Design: http://www.westga.edu/~bquest/1997/object.html

JDO Object Model:
http://www.odbms.org/download/038.02%20Jordan%20The%20JDO%20Object%20Model%20June%202001.PDF

Object Oriented Programming Tutorial: http://aonaware.com/OOP1.htm

Unit 5.3: Agent-based Simulation

Unit Length:

This unit will last approximately three days but objectives will be reinforced throughout course.

Goals: Explain agent-based simulation.

Rationale:
This unit continues to explore programming principles with the focus on agent based programming. Agent based programming is an approach to programming that is similar to object oriented programming but focuses on a distributed approach. It is this distributed approach that is used frequently in modeling and simulation.

Objectives:

1. Understand the concept of a distributed environment.
2. Explain the architecture of agent based simulation.
3. Describe the uses of agent based modeling.

Related Standards of Learning (SOLs)

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Explain that agent based simulation uses the idea of autonomous decision making entities called agents. Each agent assesses its own situation and makes decisions based upon a set of rules.
2. Students should be able to define the following terms: agent, autonomous agent, distributed agent.
3. Demonstration: Tell students that you they are going to work together to demonstrate the concept of agent based simulation. Design a similar activity to the following: Tell students that they are going to write a paragraph on a topic by each one of them writing an individual word on a paper. The rules for the sentences are that they must be grammatically correct and have meaning to the agreed upon topic. It is up to each student to decide when a sentence should be completed and another one begins. Depending upon the number of students in the class, the instructor may want to pass the paper around the room more than once so each student has an opportunity to potentially make a decision on the structure of the paragraph. Once the paragraph is complete, the instructor then reads the paragraph. Explain to students that they performed an example of an agent based simulation. The overall objective of writing a paragraph on a particular topic was

met by my each individual contributing to the activity and making decisions based upon the given rules. This is how agents work in an agent based simulation.

4. Define and introduce artificial intelligence as an area of study and give reasons for its usage.
5. Allow students to research uses of Agent based modeling and/or artificial intelligence to create a PowerPoint presentation on its particular use.
6. Discuss complex behaviors of agents and the notion that complexity often grows exponentially as the number of agents increases.

References:

Agent Based Simulation Tutorial Paper: http://www.informs-sim.org/wsc06papers/008.pdf

A Distributed Autonomous-Agent Network-Intrusion Detection and Response System: http://faculty.nps.edu/ncrowe/barruspap.html

Book Results for Agent Based Programming: http://books.google.com/books?q=Introduction+to+agent+based+programming&source=citation

IBM Agent Based Simulation Research: http://www.research.ibm.com/trl/projects/optsim/mktsim/index_e.htm

Introduction to Agent Based Simulation of Social Processes: http://www.informs-sim.org/wsc06papers/008.pdf

Is it an Agent or Just a Program?: http://www.msci.memphis.edu/~franklin/AgentProg.html

MaterialSim: An Agent-Based Simulation Toolkit for Learning Materials Science http://www.blikstein.com/paulo/documents/papers/BliksteinWilensky-MaterialSim-ICEE2004.pdf

Multi-Agent-Based Simulation VI
International Workshop, MABS 2005, Utrecht, The Netherlands, July 25, 2005, Revised and Invited Papers
Series: Lecture Notes in Computer Science , Vol. 3891
Sublibrary: Lecture Notes in Artificial Intelligence
Sichman, Jaime S.; Antunes, Luis (Eds.)
2006, X, 191 p. With online files/update., Softcover
ISBN: 978-3-540-33380-7

Unit 5.4: Software Evolution and Lifecycle

<u>Unit Length</u>:

This unit will last approximately three days but will be reinforced throughout course.

<u>Goals</u>: Explore software evolution and lifecycle.

<u>Rationale</u>:
Now that you have the background to create programs and design some basic software, it's time to examine the software development lifecycle models. Sometimes in the classroom, we fall into the habit of having each of you create your own programs, purely for the sake of grading purposes. What will be happening in this unit is that you will understand what it's like to work on a larger project and in groups. You will explore the concepts of project management while building a project.

<u>Objectives</u>:

1. Define software lifecycle
2. Identify the three primary lifecycle models.
3. Describe the steps in the lifecycle model.
4. Describe advantages and disadvantages of each type of model.
5. Understand project management principals.
6. Understand extreme programming.

<u>Learning (SOLs)</u>

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

<u>Recommended Instructional Activities</u>:

1. Introduce software lifecycle and project lifecycle concepts by reiterating that in the workplace, most software projects are performed via a large group of people, not individuals. Explain the necessity to be professional and the responsibility to meet the customer's needs on time and within the designated budget.
2. Define the primary software lifecycle models: Waterfall, Incremental, and Spiral.
3. Describe the steps of each of the lifecycle models and explain when it is appropriate to use each model. Although the Waterfall model has fallen out of common use, for historical purposes it is relevant to mention and there are still times when it is useful. Additionally, the incremental model is based upon the waterfall model.
4. Draw pictures to visually demonstrate the steps of the lifecycle model.
5. Identify the advantages and disadvantages of each type of lifecycle model.

---

6. Ask students to compare and contrast two of the models. Provide students with a sample project and ask them to write a paragraph describing what they would perform during each of the steps in the lifecycle model as well as describe **why** the model they chose fits their plan.
7. Describe the various positions within a project. Ensure students understand the concept of Project Manager, technical lead, developers, testers etc.
8. Provide students with an activity, preferably software oriented and divide them into groups. You may need to provide a skeleton program or extra classes to assist in the development. Ask students to acquire requirements, estimate a schedule, and design and implement a prototype.

References:

Barry W. Boehm, TRW Defense Systems Group, A Spiral Model of SoftwareDevelopment and Enhancement: http://www.cs.umd.edu/class/spring2003/cmsc838p/Process/spiral.pdf

Extreme Programming - http://www.extremeprogramming.org/

Freeman,Eric, Freeman, Elisabeth, Sierra, Kathy, Bates, Bert. **Head First Design Patterns,** O'Reilly, 2004. ISBN 0596007124, 9780596007126

Risk Management in a Software Development Life Cycle: http://www.brighthub.com/office/project-management/articles/72055.aspx

Software Model Lecture: http://www.ccs.neu.edu/home/matthias/670-s05/Lectures/2.html

Spiral Model - A New Approach Towards Software Development: http://www.buzzle.com/editorials/1-13-2005-64082.asp

Kary, Russel. "QuickStudy: System Development Life Cycle (SDLC)" - http://www.computerworld.com/s/article/71151/System_Development_Life_Cycle

Waterfall Software Development Project: http://www.buzzle.com/editorials/3-13-2005-67039.asp

Unit 5.5: Simple Gaming Constructs

Unit Length:

This unit will last approximately ten days but objectives will be reinforced throughout course.

Goals: Apply simple gaming constructs.

Rationale:
Now that you've done the hard part, it's time to apply the software design skills you've learned to create a few simple games.

Objectives:

1. Describe the history of gaming and evolution of video games.
2. Design games using programming techniques.
3. Implement a simple game using appropriate software.

Learning (SOLs)

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Review the history of game programming. The History channel has a few good videos on this.
2. Describe what makes a good game. Ask students to provide input to what they like in the games they play.
3. Project: Review decision statements. Students should then design a choose your own adventure story. The presentation should have at least 5 decisions with the key being that one bad decision does not lead to the player's demise. Students will then get to play **and** rate each other's games.
4. Using appropriate software, split the class into groups. Students will have to develop requirements, provide a schedule/plan, flowchart or storyboard. Students will need to update the schedule as needed. Provide salary rates for each group member based upon their role in the group and ask students to also prepare a budget. Students will then implement their project keeping a journal of their day to day activities. At the end students must "sell" their product to the class as a whole. The class will play and rate the game. The instructor may or may not choose to incorporate this as part of the grade.

References:

Careers in Game Programming:
http://www.jobmonkey.com/videogamejobs/video_game_design_compensation.html

GameMaker Website: http://www.yoyogames.com/make

GameSpot: History of Video Games:
http://www.gamespot.com/gamespot/features/video/hov/index.html
Game Programming Lesson: http://www.sloperama.com/advice/lesson15.html

Rabin, Steve: **Introduction to Game Development,** Charles Rivever Media, 2008.
ISBN: 1-58450-377-7

Habgood, Jacob and Overmars, Mark. **The Game Maker's Apprentice: Game Development for Beginners.** Apress, 2006
ISBN 1590596153, 9781590596159

Programmer's Corner, An Introduction to Game Programming: http://www.programmers-corner.com/article/32

Introduction to Game Programming Course Outline: http://itp.usc.edu/files/ITP%20380.pdf

Links to Game Related Resources: http://www.resourcium.com/

Thorn, Alan. **Introduction to Game Programming with C++.** Worldwise Publishing Inc. 2007.
ISBN: 1598220322, ISBN13: 9781598220322

Design Brief: Programming a Calculator

Programming a Calculator

Context
Programming in Modeling and Simulation is a critical tool and one that requires some experience before becoming proficient. Equally important to the final project is to be on schedule and within the provided budget. From designing the project plan, to implementing the final product, there are a variety of positions when working as a team on a project. This project encompasses many of the skills learned during the programming unit to include functional programming, loops, and decision structures. As an introductory project, students will plan, design, and implement the functions of a basic calculator.

Challenge
Students will work in groups to design and implement a program utilizing methods, variables, loops, and decision structures. Students should design and implement the functions of a basic calculator. The program should accept both integers and decimal values and users should be able to add, subtract, multiply and divide two or more values. As time permits, students may come up with an object oriented design and implement a graphical interface.

Objectives
Upon completion of the design brief, students will be able to do the following:
- Succinctly describe the goal of the program.
- Produce a project schedule.
- Update a project schedule.
- Produce an object oriented design.
- Prepare a design document for the implementation of the program
- Declare variables.
- Get user input and display output.
- Use programming decision structures.
- Use programming repetition structures.
- Implement functions.
- Document code
- Provide instructional documentation for the program.
- Use arrays as time permits.

Materials
- Computer.
- Programming language of choice.
- Spreadsheet software.
- Word processing software.
- Flowcharting software.

References

- ATM Object Oriented Design Example
  http://www.cs.gordon.edu/courses/cs211/ATMExample/
- C and C++ Programming Tutorials
  http://www.cprogramming.com/tutorial.html
- C++ Program Documentation Guidelines
  http://www.bgsu.edu/departments/compsci/docs/documentation.html
- C++ Language Tutorial
  http://www.cplusplus.com/doc/tutorial/
- C++ Programming Language Tutorials
  http://www.cs.wustl.edu/~schmidt/C++/
- Design Document Overview from Cornell Computer Science
  http://www.cs.cornell.edu/courses/cs433/2001fa/Slides/DesignDocument.pdf
- Free Downloadable Project software
  http://www.smartdraw.com/specials/project-software.htm
- Gantt Chart in Excel
  http://www.hyperthot.com/pm_excel_gantt.htm
- How to Write a Design Document
  http://blog.slickedit.com/2007/05/how-to-write-an-effective-design-document/
- In Program Documentation
  http://www.cse.ucsc.edu/~karplus/185/w99/reader/7_In_program_Documentation.html
- Java Documentation for the Core API
  http://www.apl.jhu.edu/~hall/java/Documentation.html
- Java Tutorial
  http://www.java2s.com/Tutorial/Java/CatalogJava.htm
- Java Tutorials from Java Web Site
  http://java.sun.com/docs/books/tutorial/
- Microsoft Visual Basic Tutorials
  http://www.tutorialized.com/tutorials/Visual-Basic/1
- Object Oriented Programming Techniques
  http://www.mycplus.com/tutorials/object-oriented-programming/oop-techniques/
- Principles of Object Oriented Design
  http://c2.com/cgi/wiki?PrinciplesOfObjectOrientedDesign
- Programming Tutorials
  http://www.cprogramming.com/tutorial.html
- The Project Plan
  http://www.hyperthot.com/pm_plan.htm
- Project Planning for Dummies
  http://www.dummies.com/WileyCDA/DummiesArticle/PMP-Certification-Creating-the-Project-Plan.id-1821.html
- Six Tips for Improving Your Design Documentation
  http://www.boxesandarrows.com/view/six_tips_for_improving_your_design_documentation
- Visual Basic Tutorial
  http://www.vbtutor.net/vbtutor.html

Evaluation
- Project plan was updated regularly and followed.
- Program submitted correctly and directories correctly named.
- Design document represents the implementation of the program and contains a detailed description and/or flowchart.
- Program compiles and runs.
- Program performs exactly as described in documentation.
- Comments listed in program explain the program logic.
- Code was organized according to programming standards.
- Required functionality was provided.
- Organization of code is logical.
- Documentation of program is detailed and logical. Writing is clear and not overly technical.

Unit 6: Investigating Modeling and Simulation

Unit Length:

This unit will last approximately eleven weeks.

Goals

    6.1.Explain the history of simulation.
    6.2.Define the pieces of a simulation.
    6.3.Use modeling and simulation software.
    6.4.Explain distributed simulation.
    6.5.Explain visual simulation.
    6.6.Explain human behavior models.
    6.7.Explain intelligent systems.
    6.8.Explain environmental models.
    6.9.Build a scenario for experimentation or training.

Rationale:

At this point, students should have enough review and background information to be able to navigate solutions to modeling and simulation problems. Students get a better appreciation for these types of problems by applying a hands-on methodology. This unit provides the application of modeling and simulation.

Unit 6.1: Modeling and Simulation Software

Unit Length:

This unit will last approximately two weeks.

Goals: Use Modeling and Simulation software.

Rationale:
This unit serves as an introduction to modeling and simulation. Up to this point, you've been learning a lot of modeling and simulation skills although they were not specified during every unit. The approach now is to get you to start using more terminology and software as it directly applies to the M & S area of study.

Objectives:

1. Explain the history of simulation.
2. Explain uses of M & S.
3. Perform a hand simulation for a defined problem.
4. Identify the various components of a simulation.
5. Apply the use of discrete event simulation.
6. Describe categories of M & S.
7. Use Monte Carlo simulation.
8. Explain verification and validation.

Related Standards of Learning (SOLs):

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Ask students if they think they've ever used simulation in their lives. Explain that we've been doing this for many years, but with the advent of the computer system, we are able to run more complex simulations faster and with a higher degree of accuracy.
2. Define *simulation, modeling, system,* and *computer simulation.*
3. Describe why people use modeling and simulation (i.e. when it's too costly, too dangerous, or physically impossible to do something in the real world.)
4. Distinguish between physical models and logical/mathematical models.
5. Create a hand simulation around a topic of your choice. For example include: the spread of the Black Plague, our political system, simulate how the internet works. The idea is for students to understand that one does not **necessarily** need a computer to run a simulation. Additionally, students should understand that although there is an element of randomness in many simulations (i.e. rolling a die), simulation are inherently algorithmic.

6. Explain the use of the terms *entity, behavior, interaction, attributes, resources, queues, events,* and *simulation clock* as they relate to simulations.
7. Introduce Monte Carlo simulations as a mechanism for solving problems using random numbers and probability. Provide students with the properties and steps in a Monte Carlo method.
8. Provide students with a simple example using an Excel spreadsheet and the random functions in the software.
9. Explain *discrete event simulations* and how they are useful in optimizing manufacturing, food industry, and other industries.
10. Provide a tutorial on the chosen software for discrete event simulation. (Some software choices include Arena by Rockwell software at the site http://www.arenasimulation.com
11. Assign students to observe either the high school cafeteria line or fast food chain line. Students should observe the various stations that customers pass through in order to order, purchase, obtain, their food. Some software has an data input analyzer that will fit the data to the best distribution, however students may wish to actually simulate the real line, having customers arrive at the times noted during their observations. After the simulation is run, students should analyze the output to determine when or if there was a bottleneck in the simulation, determine what corrective action might be taken and run the simulation with their changes. Finally, students may submit a report with their data, analysis, and conclusions.
12. Explain the types of simulations that are currently most commonly used, live, virtual, and constructive. Plan a field to trip to a local company or invite a speaker into the classroom who will be able to demonstrate some the differences as well as discuss how the various types of simulations can work together.
13. Explain the terms verification and validation and emphasize the difference between the terms. Students should provide evidence of verification and validation of their models and simulation in the exercise created in #11 above.

References:

The Basics of Monte Carlo Simulation
http://www.chem.unl.edu/zeng/joy/mclab/mcintro.html

A Brief History of Flight Simulation
http://homepage.ntlworld.com/bleep/SimHist1.html

Estimation of Pi Simulation (Applet)
http://www.mste.uiuc.edu/activity/estpi/

The Future of Simulation
http://www.dtic.mil/cgi-bin/GetTRDoc?AD=ADA473368&Location=U2&doc=GetTRDoc.pdf

An Introduction to Simulation in Statistics
http://home.ubalt.edu/ntsbarsh/simulation/sim.htm#rrprobstat

Kelton W. David, Sadowski, Randall P., Sturrock , David T. **Simulation With Arena,** McGraw-Hill Professional, 2007
ISBN 0072919817, 9780072919813

Live Virtual and Constructive Simulation
http://www.peostri.army.mil/PRODUCTS/LVCIA/

Military Simulation and History (videos)
http://www.zencast.com/channels/showchannel.asp?mc=3&cid=4552

Modeling and Simulation Body of Knowledge
http://www.site.uottawa.ca/~oren/MSBOK/MSBOK-index.htm

Model Verification and Validation PowerPoint
http://jtac.uchicago.edu/conferences/05/resources/V&V_macal_pres.pdf

Reese's Pieces Simulation (Applet)
http://statweb.calpoly.edu/chance/applets/Reeses/ReesesPieces.html

Simulation in Anesthesiology
http://www.springerlink.com/content/604v67q76036227k/fulltext.pdf

Simulation, History and Computer Games
http://www.knaw.nl/smartsite.dws?id=25792&lang=ENG

Simulink Verification and Validation
http://www.mathworks.com/products/simverification/

Verification and Validation Concepts and Definitions
http://satc.gsfc.nasa.gov/assure/agbsec5.txt

Verification, Validation and Certification
http://www.ece.cmu.edu/~koopman/des_s99/verification/

Unit 6.2: Distributed Simulation

Unit Length:

This unit will last approximately three weeks.

Goals: Explain distributed simulation.

Rationale:
Distributed simulation is one of the most important aspects of modeling and simulation in terms of economic development. Due to increased costs of transporting people to a specific location for training, distributed training and, in turn, distributed simulations are becoming ever more critical. Distributed simulation implies that one or more simulations are communicating via a network connection in real time or pseudo real time. Currently, distributed simulations are a primary training tool for the military, but as other industries such as education and medical training adopt the technologies, the need for experts in this field will increase.

Objectives:

1. Explain networking concepts.
2. Explain distributed simulation protocols.
3. Apply programming skills to create a networked simulation or game.

Related Standards of Learning (SOLs):

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Review the components necessary for networking systems to include: *protocols, network cards, Ethernet cables, Internet Protocol Addresses, Subnet masks ,operating system, ping command,* and *ipconfig, TCP/IP and UDP.*
2. Explain the use of packets in computer communication and that the Internet uses the TCP/IP protocol. Give examples of other protocols such as HTTP, SMTP, etc.
3. Acquire a switch or hub for a classroom demonstration for setting up a network. To accomplish this, Administrator privileges may be required. By the end of the demonstration, students should be able to completely set up a small network and ensure that the computers are communicating.
4. Explain that simulations have a number of communication protocols built on top of TCP/IP including the High Level Architecture (HLA), Distributed Interactive Simulation (DIS), Test and training Enabled Architecture (TENA). Students should understand that these are the currently accepted protocols, but that it isn't necessary to use them.

5. Allow students to work in groups and develop their own protocol. Remind students that they will need to agree upon how the data will be transmitted and in what format. When the students have completed the assignment, at least one group will probably try and pass a large quantity of data in a single interaction or object. Discuss the idea of network bandwidth and the need for fast communications, especially in the use of real time simulation.

6. Explain that the most frequently used communication protocol is currently HLA. Provide a brief introduction to HLA by identifying the following terms about HLA: *objects, interactions, federation, federation object model, simulation object model, Runtime Infrastructure (RTI).*

7. Provide students with a simple distributed game. For example, create a simple application that allows a distributed hello. For a more complex example, Java easily allows the implementation of simple graphics so one might create a game where students move over a grid. Initially students will not be able to destroy each other, but via the implementation of interactions and objects, weapons will be able to be fired and collisions will take place. An RTI software package will be required for this exercise.

8. Invite a speaker into class to discuss the applications of distributed simulation in his or her field.

References:

Delta3D.org – Open Source Gaming Engine that can be used in distributed simulation
http://www.delta3d.org/

Department of Defense High Level Architecture
http://www.informs-sim.org/wsc97papers/0142.PDF

A Distributed Interactive Simulation using Java
http://web.nps.navy.mil/~brutzman/vrtp/dis-java-vrml/download.html

Distributed Interactive Simulation for an Australian Simulator
http://oai.dtic.mil/oai/oai?&verb=getRecord&metadataPrefix=html&identifier=ADA426113

Distributed Simulation and Industry: Potentials and Pitfalls
http://www.informs-sim.org/wsc02papers/088.pdf

A GIS-enabled Distributed Simulation Framework for Natural Resource Management
http://www.tiem.utk.edu/gem/paper2/GIS.pdf

Hamilton, John A, Nash, David A., Hamilton, Pooch, Udo W., **Distributed Simulation**, CRC Press, 1997
ISBN 0849325900, 9780849325908

Introduction to internet networking: **Internet Networking**

Introduction to TCP/IP
http://www.yale.edu/pclt/COMM/TCPIP.HTM

Magnatar Games RTI – freely downloadable IEEE 1516 RTI
http://www.magnetargames.com/Products/Chronos/

Modeling, Simulation and Synthetic Environments: **Modeling and Synthetic Environments**

Networking Basics – Key Concepts in Computer Networking.

Networking Concepts – University of Waterloo
http://ist.uwaterloo.ca/cs/sew/courses/literacy/netconcepts.pdf

Open DIS – Open Source of Distributed Interactive Simulation Protocol
http://open-dis.sourceforge.net/

SISO Product Support Groups
http://www.sisostds.org/StandardsActivities/SupportGroups.aspx

Public Domain Scalable Simulation Framework
http://www.ssfnet.org/homePage.html

Raytheon – educational version of RTI-NG available
http://www.virtc.com/rtingpro-full.jsp

Test and Training Enabled Architecture Software Development Site
https://www.tena-sda.org/display/intro/Home

TCP/IP Tutorial
http://www.w3schools.com/tcpip/default.asp

TCP vs. UDP
http://delphi.about.com/od/adptips2005/qt/udpvstcp.htm

Transportation Model Using the High Level Architecture
http://txspace.tamu.edu/handle/1969.1/440

UDP Concepts
http://www.networksorcery.com/enp/protocol/udp.htm

Understanding the UDP Protocol
http://www.windowsnetworking.com/articles_tutorials/Understanding-UDP-Protocol.html

Unit 6.3: Visual Simulation

<u>Unit Length</u>:

This unit will last approximately two weeks.

<u>Goals</u>: Explain visual simulation.

<u>Rationale</u>:
The use of two dimensional and three dimensional visualizations are a growing piece of the simulation community. The ability to view the data transition visually, allows for a better understanding of the overall simulation being observed. In addition, models of specific tools such as those used in welding, shipbuilding, and space travel are becoming increasingly important in the overall design of the product. Very often, a visualization of the data being translated in a distributed simulation will be integrated into the overall simulation. This visualization becomes critical to get a better understanding of the training or educational activity being simulated. Finally, visualization is a critical aspect of the gaming industry and in great need.

<u>Objectives</u>:
1. Define visual simulation.
2. Explain uses of visual simulation.
3. Understand the use of visual simulation in distributed simulation.

<u>Related Standards of Learning (SOLs)</u>:

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

<u>Recommended Instructional Activities</u>:

1. Define visual simulation.
2. Explain the uses of visualization simulations to include applications in the health industry, defense, sciences etc. It is critical to understand that a visual simulation is only as good as the data feeding it. If a visualization does not represent what should be happening as if it was running in reality, it will not be at all beneficial, no matter how great the graphics may be.
3. Provide students with a series of websites that use visual representations to assist in the understanding of a concept. Medical visual simulations are relatively abundant on the Internet.
4. Refer students to visual simulation packages on the web such as OpenSceneGraph http://www.openscenegraph.org/projects/osg), an open source gaming and visualization engine.

---

5. Reinforce the concept of distributed simulation by reusing the distributed aspect of the hello world program, only this time, with the instructor's assistance, the students will be able to create a visual representation of the data they sent rather than simply text. Depending upon the fidelity of the visual program being used or created, students may be able to send hello's to other students in various colors and font sizes.

6. Provide some information about 3D graphic formats; the fact that such formats are in reality tree-structured databases that help with real-time rendering; a good example is OpenFlight or OpenInventor. In particular, OpenInventor can be an ASCII format that allows students to build 3D scenes by specifying shapes/objects in a text file. If time allows, Presages (from the developers of Vega Prime) provides a free API that allows reading/writing open flight databases.

7. Many companies use 3-D visual simulations in training their employees to perform a particular task (i.e. Northrop Grumman Shipbuilding). Find a local company and see if a visualization demonstration can be arranged. Many organizations will now use virtual reality.

References:

Delta3D Organization
http://delta3d.org

FlightGear – a freely downloadable flight simulator
http://www.flightgear.org/

Google SketchUp
http://sketchup.google.com/

An Integrated Global GIS and Visualization System -- Paper
http://smartech.gatech.edu/bitstream/1853/3527/1/97-07.pdf

ISS Foresight Free Visualization Tool
http://3d-visual-simulation.qarchive.org/

Open Flight - http://www.multigen.com/products/standards/openflight/index.shtml

Open Inventor - http://oss.sgi.com/projects/inventor/

OpenSceneGraph - http://www.openscenegraph.org/projects/osg

Second Life 3-D virtual world
http://secondlife.com/

Visual Simulation of Ice Crystal Growth
http://www.cs.unc.edu/~geom/ICE/

Visual Simulation of Smoke
http://physbam.stanford.edu/~fedkiw/papers/stanford2001-01.pdf

Visual Simulation of Shockwaves
http://gamma.cs.unc.edu/SHOCK/

Vega Prime Commercial Visualization Tool by Presagis
http://www.presagis.com/products/visualization/details/vegaprime/options/vega_prime_distributed_rendering/

Unit 6.4: Human Behavior Models

Unit Length:

This unit will last approximately one week.

Goals: Explain human behavior models.

Rationale:
Integrating human behavior into models and simulations increases the reality of the simulation. By decreasing the required number of humans in the loop, the cost of running training exercises in various environments is decreased. The human model allows us to create both simulations and games that lead us closer to the reality of artificial intelligence.

Objectives:
1. Define human behavior models.
2. Explain importance of human behavior models
3. Summarize the use of current research in human behavioral models.

Related Standards of Learning (SOLs):

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Define human behavioral models as it relates to psychology, emphasizing the need of interdisciplinary communication.
2. Provide students with a few research papers on integrating human behavior into non human characters in games and simulation. Students will read the paper, summarize and present the material to the class. Students that do not present will need to submit discussion questions prior to the presentation.
3. Perform the Black Plague hands-on simulation which shows how this disease would have spread throughout Europe and Asia. Human behavior was key in the spread of the plague http://www.bayarearenaissancefest.com/images/the_black_plague_classroom_simulation.pdf
4. Explore a few of the ethical questions regarding the use of human behavioral models in simulations. For example, explore the use of stereotypes when trying to simulate the activities of a particular group. Should we train with human representations of a particular group? What impact does the military have on these questions? What risks do we take when training medical professionals with "human" respondent simulators?
5. Explore the financial impacts of trying to simulate human behavior when purchasing stocks or other financial assets.

References:

Computational Models of Human Behavior
http://www.isle.org/~langley/psych.html

Crowd Simulation on Playstation 3
http://www.research.scea.com/research/pdfs/GDC2006ReynoldsTemp.pdf

Game Worlds Show Their Human Behavior
http://news.bbc.co.uk/2/hi/technology/6917924.stm

Human Behavioral Models for Agents in Simulators and Games
www.seas.upenn.edu/~barryg/PRESENCEpt2.doc

Human Behavior Models for Game-Theoretic Agents: Case of Crowd Tipping
http://works.bepress.com/barry_silverman/14/

Human behavior models for game-theoretic agents
http://citeseerx.ist.psu.edu/viewdoc/summary?doi=10.1.1.25.3621

Interoperable Human Behavior Models for Simulations
http://www.lsi.upc.edu/~npelechano/2006_BRIMS_paper.pdf

Leveraging Human Behavior Modeling Technologies to Strengthen Simulation-Based C2
System Acquisition
http://www.mitre.org/work/tech_papers/tech_papers_02/flournoy_leveraging/flournoy_leveraging.pdf

Positive Effects of VR Technology on Human Behavior
http://www.idemployee.id.tue.nl/g.w.m.rauterberg/publications/ICAT2004paper.pdf

Thalmann, Daniel, **Musse**, Soraia Raupp, Crowd Simulation, 2007, ISBN: 978-1-84628-824-1
http://www.springer.com/computer/computer+imaging/book/978-1-84628-824-1

University of Wisconsin Crowd Simulation
http://www.cs.wisc.edu/graphics/Gallery/Crowds/

Unit 6.5: Intelligent Systems

Unit Length:

This unit will last approximately one week.

Goals: Explain intelligent systems.

Rationale:
Although scientists have not yet built a truly artificially intelligent being as shown in television programs and movies, the progress continues. Due to the ever increasing ability for processors to interpret instructions, the creation of an artificially intelligent system is getting closer. This is not to say that we do not use artificially intelligent systems in our day to day lives for uses such as scheduling, diagnostic behaviors, and data mining. An ever growing aspect of artificially intelligent systems is the use of agents, which are small components that use instructions to make decisions. When agents combine their individual data together, the system can be considered "intelligent." This concept is comparable to the cells in our body all working together thus making us one organism.

Objectives:

1. Define intelligent system.
2. Perform first order logic/predicate logic.
3. Explain the use of intelligent systems.
4. Examine program using the elements of an intelligent system.

Related Standards of Learning (SOLs):

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Explain that intelligent systems are generally a specific area of study in the broader research area of artificial intelligence.
2. Explain concepts of predicate logic to include: *definition of first order logic, quantifiers (for every), symbols of first order logic, terms and formulas, inferences, provable identities.* Other concepts may be added as time permits to include automation and formation and natural languages, but these are generally presented at a higher level.
3. Review the concept of artificial intelligence and ensure students understand that no computer is truly intelligent at this point in time.
4. Have students perform research on the chess champion "Deep Blue" and write a summary including the computer's specifications as well as why this was an important computer in history.

---

5. Explain the concept of search trees and have students create a binary search tree. Explain the use of search trees in projects like data mining for web sites.
6. Ask students to perform some research on the web and list sites that may have some artificial intelligent games. After the instructor approves the sites, students will go back and try and determine what makes the games "intelligent."

References:

Artificial Intelligence in Games
http://www.cs.rochester.edu/~brown/242/assts/termprojs/games.pdf

Artificial Intelligence in Game Design
http://ai-depot.com/GameAI/Design.html

Artificially Intelligent Games
http://www.dmoz.org/Computers/Artificial_Intelligence/Games/

Binary Search Trees
http://www.cs.nyu.edu/algvis/java/bst.html

Britannica Online – Deep Blue
http://www.britannica.com/EBchecked/topic/155485/Deep-Blue#tab=active~checked%2Citems~checked&title=Deep%20Blue%20--%20Britannica%20Online%20Encyclopedia

First Order Logic
http://pages.cs.wisc.edu/~dyer/cs540/notes/fopc.html

First Order Logic Tutorial
http://www.cs.ucsd.edu/groups/tatami/handdemos/doc/folidx.htm

IBM Deep Blue
http://www.thocp.net/hardware/deep_blue.htm

Journal of Field Robotics - http://journalfieldrobotics.org/Home.html

Kasparov vs. Deep Blue
http://www.cs.drexel.edu/~jpopyack/Kasparov.html

Intelligent Systems at NASA Ames Research
http://ti.arc.nasa.gov/

Intelligent Systems Group
http://www.uu.nl/faculty/science/EN/organisation/depts/ics/research/is/Pages/default.aspx

Planet Math – Logic
http://planetmath.org/encyclopedia/FirstOrderLogic.html

Search Trees
http://www.brpreiss.com/books/opus5/html/page298.html

Simple Binary Search Tree Applet
http://www.ibr.cs.tu-bs.de/courses/ss98/audii/applets/BST/BST-Example.html

Translating English to First Order Logic
http://www.earlham.edu/~peters/courses/log/transtip.htm

Unit 6.6: Environmental Models

Unit Length:

This unit will last approximately one week.

Goals: Explain environmental models.

Rationale:
In initial experiments with simulations, weather factors were not integrated into the systems. As time progressed, it became apparent that weather, smoke, and other environmental factors are an important improvement needed in simulations in order to get closer to the real environment. It is important to understand the integration of environmental effects into a simulation and ensure that simulations you build can be affected appropriately. Consider the simulation of an aircraft; pilots must be trained to respond when encountering bad weather, wind, ice and snow. As modeling and simulation specialists, it is important to integrate both the creation of these effects as well as a simulation's response to the effects.

Objectives:

1. Explain the use of environmental modeling.
2. Discuss how to model environmental effects.
3. Discuss the effects of environmental simulations on related simulations.
4. Examine some environmental models on the web.

Related Standards of Learning (SOLs):

Computer/Technology:C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Explain that there are really two aspects to environmental modeling: (1) The ability to incorporate wind, temperature, time of day etc. and have other models within the simulation be affected by these factors, and (2) The ability to study and model phenomenon of nature that will assist in the understanding of the phenomena or assist in the understanding of the mathematical principles of the phenomena.
2. Explain the impact of environmental effects on visualizations. For example, if a building is perhaps set on fire, how does the creation of smoke affect the overall simulation? Ask students to give other examples of environmental models in visualization.
3. Explain the impact of environmental effect on sensors. For example, if you are participating in a game that is being played in the ocean but waves are not factored in, then the simulation is not accurate.

4. Explain the connection between Geographic Information Science and (GIS) and environmental models.
5. Explore how to design and implement something as simple as fog in a simulation. One might think it's as easy as adding a layer on top of single picture, but ensure students consider that there are more factors than just the fog. How does the fog move? Why would we need to come up with a mathematical equation for the movement of fog? Ask students to explain some of the factors that would influence the movement of smoke. Allow students to explore the use of products and websites such as http://io9.com/380777/light+in+fog-computer-simulation-is-ultra-realistic-and-cheap. Emphasize to student that this is an actual company making money on the algorithms developed to represent, of all things, fog!
6. Using appropriate software or a game that was created in a previous unit, attempt to change some environmental issues. Because this is a game and not a simulation, one might consider changing the laws of gravity, for example. Make changes to the game as permitted by the software being used and allow other students to play both versions of the game. Write a paragraph that discusses the differences in the game keeping in mind that environmental factors should influence the game, not radically change the skill level necessary to play the game.

References:

3D Weather Data Visualization in Second Life
http://www.secondlifeinsider.com/2006/10/28/3d-weather-data-visualization-in-second-life/

Berkeley Environmental Simulation Laboratory
http://www-laep.ced.berkeley.edu/research/simlab/

Dynamic and Interactive Visualization of Weather Data with SVG
http://www.svgopen.org/2005/papers/DynamicInteractiveWeatherData/index.html

Environmental Curriculum Site
http://www.shodor.org/master/environmental/

Environmental Simulation Center
http://www.simcenter.org/

Georgia Tech 3D Weather Visualizations
http://gtresearchnews.gatech.edu/reshor/rh-f01/weather.html

GoldSim: Engineering and Environmental Simulation Software for the Mining Industry
http://www.goldsim.com/Downloads/WhitePapers/MineEvaluation.pdf

Integrated Land Use, Transportation, and Environmental Simulation: UrbanSim Program
http://dgrc.org/dgo2004/disc/posters/tuesposters/ph_borning.pdf

A NextGen Target Generation Facility (TGF) Viewpoint of National Airspace System (NAS)

Weather Processing
http://www.faa.gov/about/office_org/headquarters_offices/ato/tc/about/campus/faa_host/labs/tgf/media/Weather3.pdf

Simulating Ocean Weather -- Video
http://www.csiro.au/multimedia/pfid.html

Shambles.net – variety of Simulations and games that include environmental effects
http://www.shambles.net/pages/students/simulation/

Weather Channel Golf Game – simulates weather effects on a game of golf
http://www.weather.com/activities/recreation/golf/golfgame/golf_game_nolocalwx.html

US Environmental Protection Agency
http://www.epa.gov/epahome/models.htm

Unit 6.7: Build a Scenario

Unit Length:

This unit will last approximately two weeks.

Goals: Build a scenario for experimentation or training.

Rationale:
Whenever a few objectives are defined for a simulation training exercise, it is necessary to build a scenario to meet those objectives. Very often more than one scenario can generate the same outcome, but each should be carefully examined. Subject Matter Experts (SMEs) generally perform this activity, but as a modeling and simulation developer, it is important to know the process used in order to make the simulation meet the objectives. Additionally, the skills learned in this section of the M & S unit serve as a core for the development of today's video games.

Objectives:

1. Explain the importance of scenario building in simulations.
2. Examine building blocks of scenarios.
3. Design a storyboard for a game.
4. Build a game around the designed scenario.

Related Standards of Learning (SOLs):

Computer/Technology: C/T 9-12.1 - C/T 9-12.6, C/T 9-12.8 and C/T 9-12.9; Math: G1, G2, AII/T.1 - AII/T.19, COM.1 - COM.20, DM.5, DM.10, DM.12, PS.1, PS.2, PS.3, PS.8; Science: PH.1, PH.2, and PH.3.

Recommended Instructional Activities:

1. Explain the benefits of scenario building as it relates to simulations such as terrorist preparation, defense, medical training etc.
2. Explain the five major steps to develop scenarios. Steps from (http://life.eun.org/ww/en/pub/insight/school_innovation/leadership_and_change/scenario_building.htm). Although this reference is to educational scenarios, the steps are generic enough to apply to any scenario situation.
   Step 0: Deciding the key-question for the scenarios
   Step 1: Identifying the fields of change
   Step 2: Selecting the most important fields of change
   Step 3: Identifying the scenarios to be developed
   Step 4: Describing the scenarios and bringing them to life
3. Find videos of products on the internet that show scenario preparation. Most likely candidates include terrorist preparation and medical training.

---

4. Review storyboards and flowcharts. Ask students to provide you with an every day activity. Identify the goal, background, and create a storyboard for the activity.
5. Using the skills you have learned with programming, flowcharting etc. you are going to use the appropriate software to build a game of your choice. The first step is to come up with a basic concept. Answer the question: what type of game are you looking to create. Next, you will need to clearly and succinctly define the goal of the game. Next provide the background story for the game. Create a detailed storyboard or flowchart for the game. List all of the attributes, behaviors and interactions in the game. Design and build the game using the provided software. Provide students with the rubric that will be used to grade their game.

References:

Advice for Game Design
http://www.sloperama.com/advice.html

The Anatomy of the Design Document
http://gamasutra.com/features/19991019/ryan_01.htm

The Art of Computer Game Design – Web Book
http://www.vancouver.wsu.edu/fac/peabody/game-book/Coverpage.html

Building Scenario Tutorial
http://ag.arizona.edu/futures/tou/tut2-buildscenarios.html

A Game Design Career Guide
http://www.gamecareerguide.com/features/260/game_design_career_preparation.php

Game Design Document PowerPoint
http:// www.seat.utulsa.edu/cs4513/GameDesignDocs.ppt

Game Discovery – site of Downloadable 3D game tools
http://www.gamediscovery.com/game-design/game-design-software.asp

Game Maker Development Site – freely downloadable software to create 2D games
http://www.yoyogames.com/make

An Introduction to Scenario Planning
http://www.slideshare.net/mkconway/introduction-to-scenario-planning/

Sample Outline For a Game Design
http://www.sloperama.com/advice/specs.html

Scenario Building to Plan an E-Learning Program
http://tojde.anadolu.edu.tr/tojde6/articles/lisa.htm

Serious Games Initiative
http://www.seriousgames.org/index2.html

Serious Games Source
http://www.seriousgamessource.com/

Storyboarding: Just the Basics
http://www.dcmp.org/guides/9428.pdf

Storyboarding Information
http://www.usabilitynet.org/tools/storyboarding.htm

Design Brief: Performing a Simulation Study

Creating a Discrete Event Simulation

Context

While there are many career opportunities to falling within the field of modeling and simulation, it is important to understand that ultimately there is probably going to be some form of study being performed. It is important that regardless of a person's position in a project it is good to have a basic understanding of the work being performed. In this exercise, students will work in groups to perform a simulation study that can be translated into a discrete event simulation. Discrete event simulations are used in a variety of business areas including economics, manufacturing, shipping, and transportation.
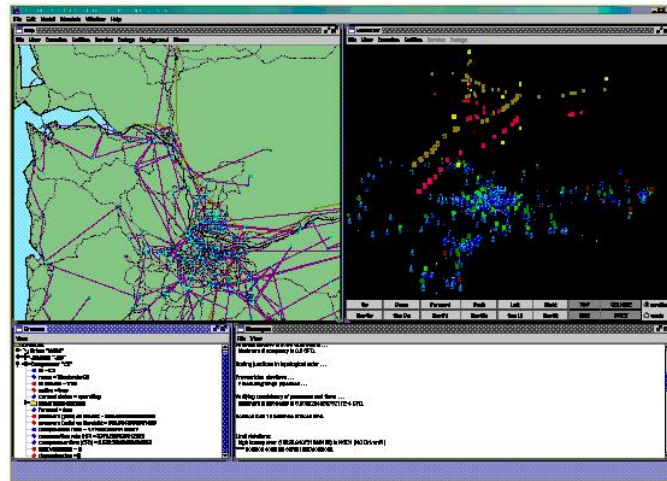
Challenge

Students will work in groups to perform a simulation study. Students will observe a situation that could be easily represented as a discrete event simulation. One might recommend that students observe a fast food restaurant, pharmacy, cafeteria line, or a traffic pattern for a specified period time over several days. Using the fast food example, students could time how long it takes for each step in the process of serving the public, determine if bottleneck exits, and recommend changes to the system.

Objectives
Upon completion of the design brief, students will be able to do the following:
- Succinctly describe the goal of the simulation study.
- Produce a project schedule.
- Update a project schedule.
- Collect data using a scientific method.
- Examine data for irregularities and outliers.
- List any possible biases in the study.
- Design a simulation of the collected data.
- Flowchart the design of the simulation.
- Determine any bottlenecks for the collected data.
- Provide recommendations to reduce the bottlenecks.
- Test bottleneck recommendations.
- Perform analysis on the updated simulation.

- Write a report specifying the procedures for collecting and analyzing data.
- Summarize the conclusions derived from the use of the simulation.
- Present finding to the class in the form of a brief.

Materials

- Computer.
- Discrete event simulation software.
- Word processing software.
- Presentation software
- Flowcharting software

References

- Bottleneck Definition
  http://searchnetworking.techtarget.com/sDefinition/0,,sid7_gci540507,00.html
- Design Document Overview from Cornell Computer Science
  http://www.cs.cornell.edu/courses/cs433/2001fa/Slides/DesignDocument.pdf
- Dependent and Independent Variables
  http://www.cool-science-projects.com/independent-and-dependent-variables.html
- A Discrete-Event Simulation Approach To Modeling Disease Progression And The Cost-Effectiveness Of Health Care Programmes In HIV-Infected Patients
  http://gateway.nlm.nih.gov/MeetingAbstracts/ma?f=102252200.html
- Discrete Event Simulation: A First Course
  www.cs.wm.edu/~esmirni/Teaching/cs526/DESAFC-1.1.ppt
- How to Conduct a Simulation Study: **Successful Study of Simulation**
- How to perform a Simulation Study
  http://organizacija.fov.uni-mb.si/index.php/organizacija-si/article/viewFile/271/253
- How to Write a Design Document
  http://www.ehow.com/how_6734245_write-software-design-document.html
- Inside Discrete-Event Simulation Software: How It Works And Why It Matters
  http://ieeexplore.ieee.org/stamp/stamp.jsp?tp=&arnumber=4117597
- Logic of Hypothesis Testing
  http://davidmlane.com/hyperstat/logic_hypothesis.html
- Methods for Summarizing Data
  http://www.uic.edu/sph/dataskills/publications/wrkbkpdfs/chap4.pdf
- Modeling and Simulation Resources
  http://home.ubalt.edu/ntsbarsh/Business-stat/RefSim.htm
- Observational Studies
  http://www.stat.wmich.edu/s160/book/node69.html
- Preparing a Simulation Study
  http://www.neirtec.org/evaluation/PDFs/PreparingtoCollect1.pdf
- Six Tips for Improving Your Design Documentation
  http://www.boxesandarrows.com/view/six_tips_for_improving_your_design_documentation

- Steps of the Scientific Method
  http://www.sciencebuddies.org/mentoring/project_scientific_method.shtml
- Summarizing Data Example
- http://www.mvps.org/dmcritchie/excel/sumdata.htm
- Writing Hypotheses
  http://www.accessexcellence.org/LC/TL/filson/writhypo.php
- An Urban Simulation Team
  http://www.ust.ucla.edu/ustweb/about_us.html

Evaluation

- All simulation assumptions are clearly identified.
- Project plan was updated regularly and followed.
- Data tables are clearly labeled and in column form. Column headings are accompanied by units.
- Data is logical with inconsistent data (resulting from inaccurate measurement techniques) identified and removed.
- The project and tested variables are elaborately summarized .
- Discovered relationships are clearly identified, follow logically from gathered data,
- Applied model of the world to explain findings.
- Design document represents the implementation of the simulation and contains a detailed description and/or flowchart.
- Simulation has no obvious errors.
- Focused on the answer to the main question(s) identified in the project's purpose and are connected to the larger context of their topic of study.
- Areas of bias are clearly identified.
- Required functionality was provided.
- Organization of simulation is logical.
- Simulation has associated animation (if software permits).
- Documentation of simulation is detailed and logical. Writing is clear and not overly technical.

Case Study: Airport Operations

Introduction

Air traffic is a critical component of the national transportation infrastructure. Virtually all passengers and cargo must utilize an airport as the place to board and deplane. On a daily basis, in excess of 100,000 air-traffic operations take place within the nation's airports. These include air-carrier, air-taxi, general aviation and military operations. Worldwide air traffic is expected to double over the next 10 to 15 years. At the same time, building new airports is extremely expensive, both in land and equipment cost but also because of environmental restrictions. Because of this, the capacity of existing airports is a significant bottleneck that ultimately limits national and world-wide air traffic expansion.

Increasing airport capacity will depend on technological measures that can address operational efficiency while maintaining current safety standards. In the short term, fielding new equipment and implementing new procedures is the only viable approach to ensuring airport capacity keeps up with demand. Due to the complexity of airport operations, modeling & simulation is critical to identifying potential benefits of new technology and procedures, and testing such procedures with little, if any safety issues.

Airport Operations Overview

Due to the stringent requirements for safety, various regulations and standard operating procedures dictate how air traffic can operate within the national and international air space. Virtually all passenger carrying aircraft are required to be in constant contact with air traffic control while enroute. Air traffic control consists of specially trained individuals whose task is to manage air traffic flow by providing clearances to aircraft as such aircraft travel through the airspace. An air traffic controller can only handle a relatively small number of aircraft at any given time, so a given region may be serviced by numerous controllers, each focusing on a subset of the region. As aircraft travel between these regions, they are handed off from one controller to the other.
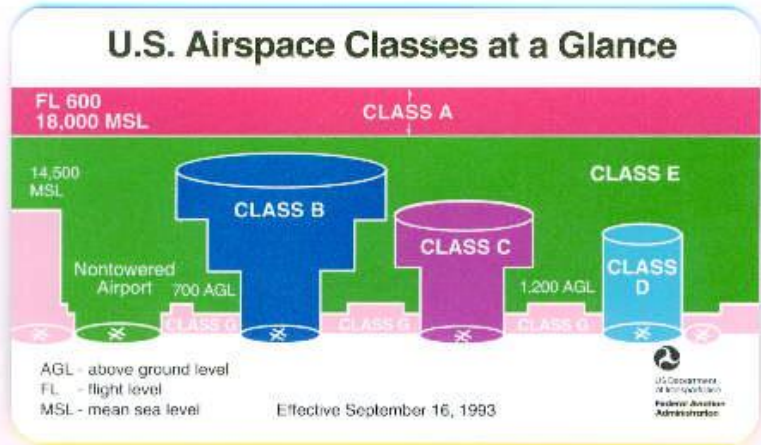

Figure 1 – Airspace Classification (Federal Aviation Administration).

Air traffic controllers manage traffic according to an extensive set of procedures and regulations. These procedures can be loosely separated according to the portion of the airspace they control. Airport operations focus on class-B airspace, a portion of the airspace that surrounds the busiest airports in the nation, and extends from the ground to approximately 10000 feet of altitude. Figure 1 illustrates the various airspace classifications.

Airport operations are responsible for guiding aircraft while on the ground and while within the class B airspace.

Aircraft inbound to the airport are typically under the guidance of en-route controllers. When near the outer boundary of the class B airspace, control the aircraft is transferred to the approach controller. The approach controller receives incoming aircraft and routes them towards the desired landing runway. When near the runway, control is transferred to the tower controller. The tower controller is responsible for sequencing aircraft as they approach the runway for landing. Once an aircraft has touched down, they are then passed to ground control. The ground controller guides the aircraft through the taxiways to the desired gate.

An outbound flight begins way before the departure time. In busy airports, departure time slots are a precious commodity that is assigned several days in advance. Provided that departure slots are available, outbound aircraft begin their journey by requesting a clearance. In seeking a clearance, the aircraft provides a desired departure time, a destination and a desired route. A clearance, once issued, may not necessarily match the request. During busy times, it is not uncommon for an aircraft to be delayed from their desired departure time. It is also common to be issued a clearance with a route that is different than what was requested. Once a clearance is issued, the aircraft begins by pushing back from the gate, at which point they are under the control of the ground controller. The ground controller guides the aircraft to the assigned runway and hands off the aircraft to the tower. The tower controller gives the takeoff clearance and hands off the aircraft to the departure controller. The departure controller guides, or "vectors" the aircraft while within the class B airspace, and once near the boundary hands off the aircraft to the en-route controllers.

Problem Statements

There are numerous factors that affect airport capacity. One of the simpler ones to understand is spacing. Regulations dictate the minimum distance between aircraft while flying and landing. Safety is the primary concern when establishing minimum spacing requirements. At the same time, spacing is directly related to the capacity of an airport, because the closer aircraft can be to each other, the faster they can take off and land.

Other factors that affect capacity include the availability and coupling of runways. Airports with multiple runways that can operate independently can drastically increase capacity. Also, the topology of the area surrounding an airport can have an impact on capacity. Airports near cities or major obstructions, such a monuments, towers, or uneven terrain have limited corridors within which to manage aircraft movement. In such cases, technological improvements that improve space awareness can have a drastic effect on capacity.

Airport topology is important in facilitating traffic flow. The availability and layout of taxiways is another critical issue that effects airport operations. Once an aircraft has exited a runway, it must travel on taxiways to get to the gate. While on a taxiway, aircraft must contend with other aircraft that are taxing to and from their gates, as well as other ground vehicles such as utility vehicles, luggage transport carts etc. In some airports, taxing aircraft must cross active runways in which case they will have to wait for a gap in arriving or departing traffic before they can cross the runway.

The ability to time aircraft arrivals is critical in maintaining maximum aircraft flow through an airport. Aircraft arriving at the designated boundaries of the class B airspace must be routed to the runway by the approach controller. When aircraft arrive in regular intervals that match the required spacing, the controller's job is easier and efficiency is maximized. Uneven arrival intervals create problems because spacing requirements force aircraft behind a slower one to slow down, creating a ripple effect that can travel across the whole airspace. At the same time, predicting the time that an aircraft will arrive at the class B boundary depends heavily on accurate estimation of travel time, which in turn depends on the weather as well as en-route traffic.

Analysis Questions

- Describe the sequence of steps that an aircraft must go through while approaching its destination airport.
- Identify airport layout factors that can affect airport capacity.
- Develop a list of performance measures that can be used to assess the effect of a proposed improvement to arrival procedures.
- Identify technology improvements that if installed on-board all aircraft could improve airport capacity.

Serious Gaming Relevance

- What elements of airport operations are best fitted for role-playing, adventure, or simulation games? How will these elements change if the game is a single-player vs. a multiplayer game?
- Describe how you would manage an airport simulation with various players in a massively multiplayer online game (MMO), i.e., aircraft call sign, location and destination airport.
- What design elements will you program to ensure competition, challenge, fantasy, safety, and entertainment?
- How does your design incorporate player goals, rules, players, equipment, constraints, penalties, and choices? How would these elements change if the game is a single-player vs. a multiplayer game?
- What is are the interface and scenarios for your game? How much realism will you include in the accuracy of the underlying model? How much fidelity will you require in the visualization?

Modeling & Simulation Relevance

- When considering continuous-time versus discrete-event simulation, which approach would be best suited for simulating airport operations, and why?
- Describe how linking an airport simulation with real-time traffic data, i.e., aircraft call sign, location and destination airport, can be used to assess the simulation fidelity.
- Describe how best to incorporate human errors (both pilots and controllers) in an airport simulation.

Unit 7: Demonstrating Visualization

<u>Unit Length</u>:

This unit will last approximately eight weeks.

<u>Goals</u>:

>   7.1. Build a visual model.
>   7.2. Render basic 3-D models.

<u>Rationale</u>:

Formerly, the output data from a computer simulation was sometimes presented in a table, or a matrix, showing how data was affected by changes in the simulation parameters. The use of simulation models were simply 'black boxes' - data going in and results coming out; however, psychologists noted that humans could quickly perceive trends by looking at graphs or even moving-images generated from the data, as displayed by computer-generated-imagery (CGI) animation. Using on-screen animations in a simulation model enables the status of the model to be viewed as it progresses. For example, a machine that breaks down may change its color to red. This enables visual cues to be passed back to the operator of the simulation model, so action could be taken.

Additionally, visualization is useful in convincing decision makers of the model's credibility. For example, in manufacturing if the directors can see a visualization of the production line with widgets traveling down a conveyor belt, it would do more to sell the concept of the model than a 'black box', churning out data.

Today visual simulation models are used in many disciplines. In geographical information systems (GIS) and meteorology, weather forecasting models balance the view of moving rain/snow clouds against maps that use numeric coordinates and timing of events. Similarly, computer simulations of CAT scans can simulate how a tumor might change, during an extended period of medical treatment, presenting the passage of time as a spinning view of the visible human head, as the tumor changes. Other applications of CGI computer simulations are being developed to graphically display large amounts of data, in motion, as changes occur during a simulation run.

Unit 7.1: Build a Visual Model

Unit Length:

This unit will last approximately six weeks.

Goals:

Build a visual model.

Rationale:

This unit will provide students with grounding in using computers and 3D modeling software to develop geometrical models and to later add realism to these models with rendering and animation. There are many applications for 3D models and animation. From special effects in movies to client presentations in the business world, the importance of motion in 3D models is very far reaching. 3D modeling skills developed in this unit are sought after throughout the world of work.

Objectives:

1. Utilize 3d modeling and other visualization tools.
2. Create a basic 3D model.
3. Apply several 3D viewing options.
4. View and control a model interactively in 3D space.
5. Generate a plan view of a 3D model.
6. Control the appearance of surface meshes.
7. Change the type and appearance of a surface mesh.
8. Place predefined 3D surface primitives in a scene.
9. Edit the placement and orientation of 3D surface primitives.
10. Create regions using Boolean operations.
11. Extrude a solid region to form a 3D model.
12. Create solid primitives, including a cylinder, torus, cone, wedge, box, and sphere.
13. Extrude a closed spline to produce a solid model.
14. Check for interference between adjacent objects in 3D space.
15. Set up a modeling session.
16. Explain different ways to select objects.
17. Define transforms and modifiers.
18. Apply modifiers.
19. Explain sub-object mode.
20. Hide and display objects.

Related Standards of Learning (SOLs):

Art: AI.4, AI.5, AII.4, AII.9, Math: G1, G2, G10, G12, Computer/Technology: C/T 9-12.1 - C/T 9-12.6

<u>Recommended Instructional Activities</u>:

1. Review <u>standard primitives</u> and write definition for each
2. Read an article on parametric modeling. Select and define five parametric modeling terms. Share the terms and their meaning with classmates.
3. Speed Quiz (Modeling professionally requires **speed** - build your speed) - Model an object of simple scene in your school.
4. Create a Second Life Avatar and enter a community.
5. Design and model a flat bed trunk with a hydraulic lift.
6. Design and model a deep draft Container Ship.
7. Model a shipping warehouse with conveyor belts.
8. Sketch and model a physical system, such as joints and muscles, a virtual operating room, virtual reality for rehabilitation, port shipping facilities, network railroad operations, or an airport baggage handling system etc.

<u>Workplace Readiness Skills</u>: 1, 2, 3, 5, 6, 8, 10, 11, and 13

<u>References:</u>

3dk.org – Excellent source of 3d model tutorials - http://www.3dk.org/tutorials/date/15/1.html

<u>3ds max and its Applications</u> by Eric K. Augspurger, Goodheart Wilcox Co, Inc., Tinley Park, Illinois

Autodesk games tools - http://usa.autodesk.com/adsk/servlet/index?id=10225745&siteID=123112

Doron trucking simulators - http://www.doronprecision.com/450truck.html

Florida University High School's Global Technologies Magnet Program - https://www.ocps.net/lc/east/hun/academics/programs/gt/Pages/default.aspx

Full Sail University - http://www.fullsail.edu/index.cfm?fa=landing.CA_1a&mnc=210&kw=3d%20graphic&utm_source=yahoo&utm_medium=cpc&utm_term=3d%20graphic&utm_content=CA_1a&utm_campaign=CA

Great 3d website source: By Google

Google SketchUp is software that you can use to create, modify and share 3D models - http://sketchup.google.com/

Ignition Game Design Academy Curriculum: - http://www.applied-ideas.com/products/ignition

ProModel is a of simulation-based, decision making tool - http://www.promodel.com/

Second Life is a 3-D virtual world created by its residents- http://secondlife.com/

SEDRIS - Environmental Data Representation & Interchange - http://www.sedris.org/

STELLA tutorials and demos -
http://www.iseesystems.com/community/downloads/tutorials/stella.aspx#

Visualizations with the TU Dresden 3d traffic simulator - http://www.vwi.tu-dresden.de/~treiber/movie3d/index.html

Using 3d Models for Visualizing 'The City as It Might Be' -
http://www.isprs.org/proceedings/XXXVI/part2/pdf/cartwright.pdf

Unit 7.2: Basic 3-D Models

Unit Length:

This unit will last approximately two weeks.

Goals:

Render basic 3-D models.

Rationale:
Rendering is applying color and shading to a model or scene giving it a more realistic look. Once the model has materials applied to them, the computer with powerful graphics software performs the rendering process.
During rendering, the computer "draws" the 3D objects to the screen and/or to a file, usually a bitmap. Real-time rendering occurs when viewing objects interactively in 3D view ports, or in a game or simulation application. Production level rendering draws a much higher quality image, at the expense of speed. A production render may take anywhere from a few seconds per frame to an indefinite period of time… sometimes hours or even days for a single frame.

Objectives:

1. Define rendering.
2. Get a material from a library.
3. Apply materials and maps to an object and scene.
4. Apply lighting and shading to an object and scene.
5. Apply an environment to a scene.
6. Apply rendering effects.
7. Create a rendering.
8. Animate a model.
9. Save a rendering to an output file.

Related Standards of Learning (SOLs):

Art: AI.4, AI.5, AII.4, AII.9, Math: G1, G2, G10, G12, Computer/Technology: C/T 9-12.1 - C/T 9-12.6

Recommended Instructional Activities:

1. Render the same scene at 3 different resolution sizes. Determine which level provides the most effective and efficient output.
2. Render and animate a flat bed trunk with a hydraulic lift.
3. Render and animate a deep draft Container Ship.
4. Render and animate a shipping warehouse with conveyor belts.

---

5. Complete the Modeling of a planet. Setting up the scene and light - http://www.3dm3.com/tutorials/planet/index.php

Workplace Readiness Skills: 1, 2, 5, 6, 8, 10, and 11, 13

References:
3dk.org – Excellent source of 3d model tutorials - http://www.3dk.org/tutorials/date/15/1.html

3ds max and its Applications by Eric K. Augspurger, Goodheart Wilcox Co, Inc., Tinley Park, Illinois

Autodesk games tools - http://usa.autodesk.com/adsk/servlet/index?id=10225745&siteID=123112

Great 3d website source: By Google

Google SketchUp is software that you can use to create, modify and share 3D models - http://sketchup.google.com/

Ignition Game Design Academy Curriculum - http://www.applied-ideas.com/products/ignition

ProModel is a of simulation-based, decision making tool - http://www.promodel.com/

Second Life is a 3-D virtual world created by its residents- http://secondlife.com/

SEDRIS - Environmental Data Representation & Interchange - http://www.sedris.org/

STELLA tutorials and demos - http://www.iseesystems.com/community/downloads/tutorials/stella.aspx#

Visualizations with the TU Dresden 3d traffic simulator - http://www.vwi.tu-dresden.de/~treiber/movie3d/index.html

Design Brief: Create a Model a Transportation Asset

Model a Transportation Asset

Context

Transportation planning simulations evaluate the impacts of regional urban development patterns on the performance of the transportation infrastructure. As input, these models generally accept census data on population, employment, and land use. On output, they estimate demand for travel (by origin and destination), the impact of that travel on the surface transportation infrastructure, and subsequent impacts of that travel on air quality. Early plans were not truly "simulations" (in that they did not incorporate some sense of time, or explicit interactions between model components.) These models were based on a sequential four-stage process including trip generation, trip distribution, mode split, and route assignment.

Challenge

Each student will demonstrate an understanding of creating a 3D model of a transportation asset such as a ship, truck, train, or forklift etc.

Objectives

Upon completion of the design brief, students will be able to do the following:

- Utilize 3D modeling and other visualization tools.
- Create a basic 3D model.
- Apply several 3D viewing options.
- View and control a model interactively in 3D space.
- Generate a plan view of a 3D model.
- Control the appearance of surface meshes.
- Change the type and appearance of a surface mesh.
- Place predefined 3D surface primitives in a scene.
- Edit the placement and orientation of 3D surface primitives.
- Create regions using Boolean operations.
- Extrude a solid region to form a 3D model.
- Create solid primitives, including a cylinder, torus, cone, wedge, box, and sphere.
- Extrude a closed spline to produce a solid model.
- Check for interference between adjacent objects in 3D space.
- Set up a modeling session.
- Explain different ways to select objects.
- Define transforms and modifiers.
- Apply modifiers.
- Explain sub-object mode.
- Hide and display objects.

Materials
- Computer with appropriate graphical software
- Pencil and paper

References
- Institute of Transportation Studies: California Partners for Advanced Transit and Highways (PATH) (University of California, Berkeley) - http://repositories.cdlib.org/cgi/viewcontent.cgi?article=1096&context=its/path
- Simulation-Based Operations Planning For Regional Transportation Systems - http://dgrc.org/dgo2004/disc/presentations/transportation/fitzgibbons.pdf
- Universal Transportation Model Simulation Center - http://www.utmsc.org/
- An Overview of Simulation Models in Transportation – **Overview of Transportation Models in Simulation**
- Vehicle Dynamic Simulation Laboratory - http://www.vss.psu.edu/VSRC/vsrc_simulation_lab.htm
- Great 3d website source: By Google
- ProModel is a of simulation-based, decision making tool - http://www.promodel.com/
- Visualizations with the TU Dresden 3d traffic simulator - http://www.vwi.tu-dresden.de/~treiber/movie3d/index.html
- 3ds max and its Applications by Eric K. Augspurger, Goodheart Wilcox Co, Inc., Tinley Park, Illinois

Evaluation

- Discuss the level of fidelity in the model.
- Determine in the polygon count is within predetermined allowance.

Case Study: Seaport Container Terminal

Introduction

Containers have quickly become the universal means by which goods are transported in international and national trade. Containers are boxes with uniform width and height that can vary in length, from 20 to 53 feet. Containers remain sealed during their transfer from a point of origin to their destination. Cargo capacity is measured in Twenty-foot Equivalent Units (TEUs), the capacity of a 20 ft x 8 ft container. The size uniformity allows the development of standardized loading and unloading processes that can be customized for truck, rail, and sea transport. Today, the majority of cargo is transported in containers, and most new ship designs are optimized for container transport. Ships designed in the early 70's could carry approximately 1700 TEUs, but the latest generation "Super Post-Paramax" ship designs can carry in excess of 8600 TEUs. Figure 1 shows loaded container ships en route.

Figure 1. Loaded container ships en route.[1]

A seaport container terminal is the place where container ships dock to unload and load containers, so they can be delivered to the next mode of transportation. The seaport terminal is an extremely complex system that consists of a number of interrelated operations. Containers are first unloaded from the ship and transported to a buffer area. From the buffer area, containers are then transported to an inter-modal transfer center. Finally, containers are loaded from the inter-modal transfer area to rails and or trucks, at which point they leave the terminal area. Figure 2 shows a diagram of this process.

---

[1] National Oceanic and Atmospheric Administration/Department of Commerce. (2009). NOAA Photo Library. Retrieved June 10, 2009, from America's Coastlines Collection: West Coast Web site: http://www.photolib.noaa.gov/htmls/line0534.htm. [Public domain and cannot be copyrighted.]
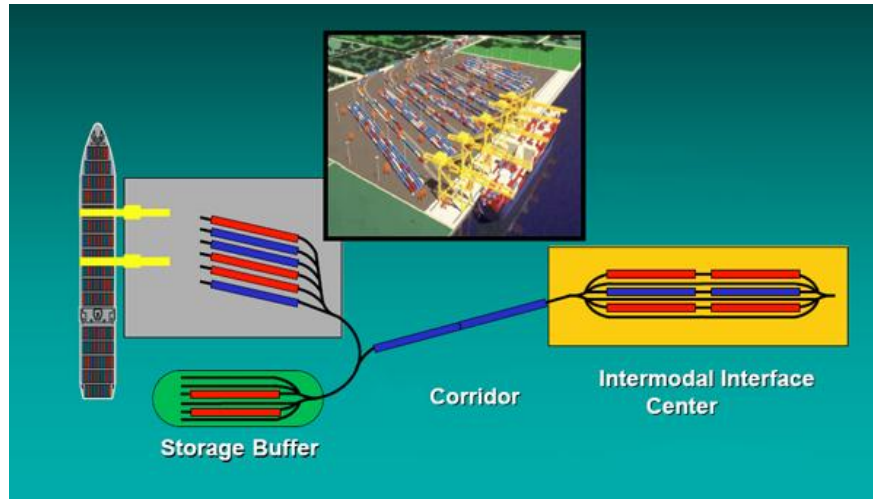

Figure 2. Container ship loading and unloading process.[2]

Typically, a container ship enters the port and docks on a specially constructed wharf. Specially designed cranes will transfer the containers from the ship onto land, from where they can be delivered to the buffer area in the terminal. These cranes, called gantry cranes are manually operated. The left side of Figure 3 is a photograph of a ship docked at the wharf while a gantry crane loading and unloading containers. Note that trucks can drive under the crane in order to receive containers for delivery to the buffer area. The right side of Figure 3 shows multiple gantry cranes that can deliver containers to the buffer area.

The transfer from the gantry cranes to the buffer, or yard, takes place through use of special mobile vehicles that are operated by humans or in some cases operate autonomously. Some terminals perform this transfer by using large overhead crane installations. Once in the yard buffer, containers are stacked in groups. To facilitate identification of their location, the yard is organized in blocks, bays, rows, and tiers. The mobile vehicle and land cranes are designed to access containers by using such an address scheme. Figure 4 shows a diagram of the yard storage organization and the crane/vehicle operation.

---

[2] Note: From http://www.transystems.com. Copyright 2003 by TranSystems. Reprinted with permission.

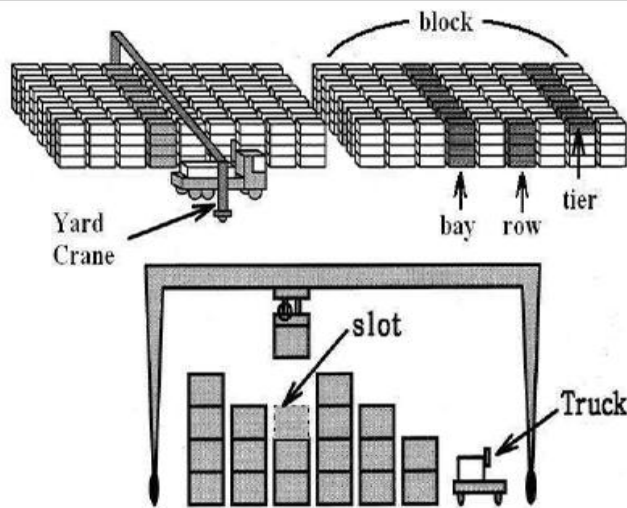Figure 3. Multiple Gantry cranes loading a ship.[3]

Figure 4. Terminal yard crane, vehicle, and storage operation.[4]

Once in the storage area within the terminal, containers await delivery to their next transportation medium. Separate areas in the terminal provide access to trucks and/or rail cars. When a truck arrives in the terminal, it gets assigned a pick-up point. The mobile vehicle or overhead crane

---

[3] Note: From Minderhoud, M. (n.d.). In *Wikipedia, the free encyclopedia.* Retrieved June 10, 2009, from http://en.wikipedia.org/wiki/File:Portainer_(gantry_crane).jpg. GNU Free Document.
[4] Note: From Vacca, I, Bierlaire, M., & Salani, M. (2007). Optimization of Container Terminal Operations [PowerPoint slides]. Retrieved from Ecole Polytechnique Federale de Lausanne web site: http://transp-or2.epfl.ch/talks/CT_IBM_07.pdf .

installation must then find the container in the buffer area and deliver it to the truck. The truck can then drive away. A similar process ensues for rail cars.

Outgoing containers are treated in a similar manner. Upon arrival, the container is delivered to the buffer area where it waits for the ship to dock. At that point, the container must be transported from the yard buffer to the gantry crane which will then load it on the ship. Once the ship is fully loaded, it departs the wharf and the next ship can dock.

The container movements to and from the wharf are collectively referred to as a waterside transshipment process (WTP). The movement of containers arriving by road or rail is collectively referred to as the landside transshipment process (LTP). Finally, the movement of containers within the terminal is collectively called the hinterland transportation process (HTP).

Problem Statements

The goal of the terminal is to minimize the time it takes for a container to transfer from the incoming to the outgoing vessel. The amount of time a container spends in the terminal is called the dwell time, and can be from several hours to 6 to 8 days. Clearly, the best case scenario is for dwell time to be 0, as this would maximize terminal throughput. However, there are numerous factors that make the logistics of seaport container terminals intractable. Each of the three processes, WTP, LTP and HTP, has numerous variables that can affect overall operation. For example, the arrival of delivery and pickup vessels is subject to unpredictable delays that make precise planning impossible. Scheduling the transport of containers from the gantry crane to the yard buffer is also an intractable problem, as is the best way to store the containers in the yard to minimize unnecessary shuffling when trying to access a specific container.

Modern terminal designs attempt to improve throughput and minimize dwell time. Examples of such improvements include mobile trucks that can carry more than one container, gantry cranes can be scheduled to load and unload a ship at the same time (see Figure 5), thus minimizing turning time. Special queuing algorithms can be used to re-order how trucks arrive to minimize internal transport time. Containers can be stacked in ways that make loading rail cars easier.
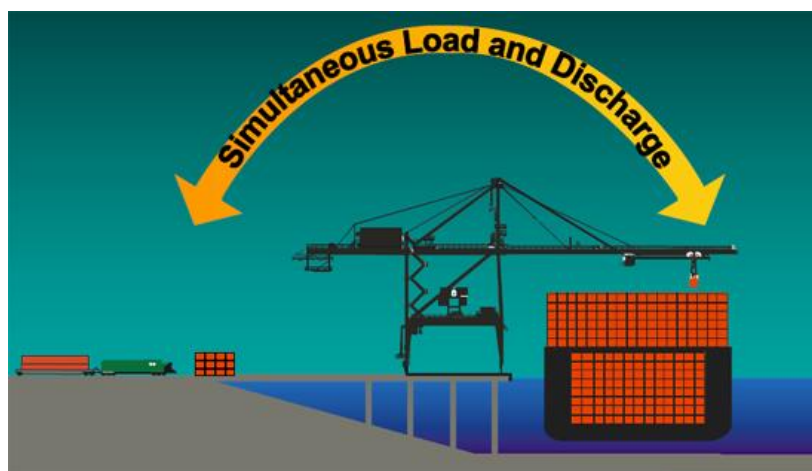

Figure 5. Modern terminal design.[5]

---

[5] Note: From http://www.transystems.com. Copyright 2003 by TranSystems. Reprinted with permission.

There is a tremendous amount of research in algorithms technology that aims to improve the logistics of a seaport terminal; however, local optimizations do not necessarily lead to improvements if the remaining processes cannot take advantage of such improvements. Modeling and simulation is a unique, and often singular way to identify the effects of different policies and algorithms on dwell time and overall terminal efficiency. Numerous case studies can be constructed to demonstrate concepts, and if desirable, open-source simulation packages could be used to construct simulations of subsets of existing seaport terminals as a way to investigate their operation, as well as the effects of different operational policies.

Analysis Questions

- Explain how the user of standardized containers has facilitated cargo shipping using ships, rails and trucks.
- Describe the sequence of steps that a container arriving in a ship will go through during its transfer from the ship to a rail car.
- Identify three factors that can affect the efficiency of the waterside transshipment process.
- Develop a list of pros and cons for the use of autonomous mobile vehicles in a terminal yard when compared to manually operated vehicles or cranes.
- Develop a list of performance measures beyond dwell time that can be used to assess the efficiency of a seaport terminal.

Modeling & Simulation Relevance

- When considering continuous-time versus discrete-event simulation, which approach would be best suited for simulating a seaport terminal, and why?
- Consider a high quality visualization component as an add-on to a seaport simulation. Assess the importance of this component with respect to the usefulness of the simulation for purposes of 1) dwell time, and 2) mobile vehicle travel time.
- Identify a list of model inputs and outputs that would be needed in order to use a seaport simulation for testing and evaluation of alternative gantry crane operation schemes.

Unit 8: Exhibit Workplace Readiness Skills (WRS)

The 21 Virginia Workplace Readiness Skills are incorporated throughout the preceding seven units. Follow the links below to find resources related to the particular standards of Virginia's Workplace Readiness Skills.

8.1. Demonstrating workplace readiness skills: Personal qualities and people skills.
- Demonstrate positive work ethic.
- Demonstrate integrity.
- Demonstrate teamwork skills.
- Demonstrate self-representation skills.
- Demonstrate diversity awareness.
- Demonstrate conflict-resolution skills.
- Demonstrate creativity and resourcefulness.

8.2. Demonstrating workplace readiness skills: Professional knowledge and skills.
- Demonstrate effective speaking and listening skills.
- Demonstrate effective reading and writing skills.
- Demonstrate critical-thinking and problem-solving skills.
- Demonstrate healthy behaviors and safety skills.
- Demonstrate an understanding of workplace organizations, systems, and climates.
- Demonstrate lifelong-learning skills.
- Demonstrate job acquisition and advancement skills.
- Demonstrate time-, task-, and resource-management skills.
- Demonstrate job-specific mathematics skills.
- Demonstrate customer-service skills.

8.3. Demonstrating workplace readiness skills: Technology knowledge and skills.

- Demonstrate proficiency with technologies common to a specific occupation.
- Demonstrate information technology skills.
- Demonstrate an understanding of internet use and security issues.
- Demonstrate telecommunications skills.

Appendix A: Related Virginia Standards of Learning (SOLs)

The Virginia Standards of Learning alpha-numeric codes have been listed for each instructional unit. The following list contains the complete listing of those standards. For updates of the SOLs, visit the Department of Education Website:
http://www.doe.virginia.gov/testing/sol/standards_docs/index.shtml
The following SOLs have been correlated within this document:

Art I: Art Foundations

The Art I standards emphasize the development of abilities to recognize visual arts content, concepts, and skills to create, discuss, and understand original works of art. The standards represent a thematic approach to visual communication and production, cultural context and art history, judgment and criticism, and aesthetics through which students will develop understanding and appreciation for the visual arts. Students will maintain a portfolio documenting their accomplishments. Students will select representative work to take to the next level of study. By the time students complete Art IV, the culminating portfolio will demonstrate quality, breadth of experience, technical skill, concentration, and growth over time.

Visual Communication and Production

AI.1   The student will maintain a sketchbook/journal of ideas and writings to use as a resource and planning tool.

AI.2   The student will select representative works of art for a portfolio.

AI.3   The student will produce works of art that demonstrate the experimental application of the elements of art and the principles of design.

AI.4   The student will recognize and identify technological developments in the visual arts.

AI.5   The student will demonstrate the use of technology and electronic media as artistic tools.

AI.6   The student will produce works of art that demonstrate an understanding of two-dimensional and three-dimensional art media, with emphases on drawing, painting, and sculpture.

AI.7   The student will use a variety of subject matter and symbols to express ideas in works of art.

AI.8   The student will create works of art that represent originality, personal expression, and craftsmanship.

AI.9   The student will define and practice ethical procedures when producing works of art.

AI.10   The student will demonstrate skill in preparing and displaying works of art.

Cultural Context and Art History

AI.11   The student will describe and discuss various art-related careers (e.g., art historian, art critic, museum educator, curator, art educator).

AI.12   The student will describe connections among media, elements of art, principles of design, themes, and concepts found in historical and contemporary art.

AI.13   The student will describe works of art, using appropriate art vocabulary.

AI.14   The student will identify major art movements and influential artists according to locations, cultures, and historical periods.

AI.15   The student will identify features of a work of art, including media, subject matter, and formal choices, that influence meaning.

AI.16   The student will describe the role of mass media in influencing preference, perception, and communication.

AI.17   The student will describe and analyze the function, purpose, and perceived meanings of specific works of art studied.

AI.18   The student will identify and examine symbols in works of art and discuss possible reasons for their use.

Judgment and Criticism

AI.19   The student will employ critical evaluation skills and use appropriate art vocabulary when evaluating and interpreting works of art.

AI.20   The student will critique works of art with reference to the elements of art and the principles of design.

AI.21   The student will analyze an original work of art by describing, responding, analyzing, interpreting, and judging or evaluating.

AI.22   The student will differentiate between personal preference and informed judgment when discussing works of art.

AI.23   The student will use established criteria to participate in critiques.

AI.24   The student will describe criteria affecting quality in a work of art, including concept, composition, technical skills, realization of perceived intentions, and the work of art as a whole.

AI.25   The student will classify works of art as representational, abstract, nonobjective, and/or conceptual.

Aesthetics

AI.26   The student will discuss how aesthetics are reflected in everyday life.

AI.27   The student will discuss ways that aesthetic responses to works of art differ from judgments.

AI.28   The student will demonstrate in writing the ability to support personal criteria for making visual aesthetic judgments.

AI.29   The student will discuss current problems and issues of the art world.

AI.30   The student will study and describe the aesthetic properties found in works of art.

AI.31   The student will speculate on the intentions and choices of those who created a work of art.

AI.32   The student will discuss art from a variety of aesthetic stances, including formalism, expressionism, contextualism, and imitationalism.

AI.33   The student will formulate a definition for the word *art* and defend that definition in relation to objects in the world.

Art II: Intermediate

The Art II standards are designed to help students extend and refine abilities to investigate and respond to the visual arts. The standards emphasize the importance of content, concepts, and skills involved in the creation of original works of art. The standards introduce a chronological approach to visual communication and production, cultural context and art history, judgment and criticism, and aesthetics that enhance student understanding of the ways in which art functions within a multicultural society. Students will continue to maintain a portfolio and select representative work to take to the next level of study.

Visual Communication and Production

AII.1   The student will expand the use of a sketchbook/journal by adding preliminary sketches, finished drawings, critical writings, and class notes.

AII.2   The student will demonstrate the ability to evaluate and select works of art for an expanded portfolio.

AII.3   The student will demonstrate effective use of the elements of art and the principles of design in a variety of art media.

AII.4   The student will use technology to create and manipulate images.

AII.5   The student will demonstrate proficiency and craftsmanship in the use of an expanded range of art media.

AII.6   The student will use historical subject matter and symbols as inspiration to produce works of art.

AII.7   The student will employ the visual problem-solving process in the production of original works of art.

AII.8   The student will adhere to ethical procedures when producing works of art.

AII.9   The student will select and prepare two-dimensional and three-dimensional works of art for display.

AII.10   The student will identify characteristics of works of art that are presented as a series or sequence.

Cultural Context and Art History

AII.11   The student will identify artists and visual arts resources within the community.

AII.12   The student will demonstrate an understanding of an art career, using oral or written communication.

AII.13   The student will identify works of art and artistic developments that relate to historical time periods and locations.

AII.14   The student will discuss or write about art history, using an expanded art vocabulary.

AII.15   The student will identify and examine works of art in their historical context and relate them to historical events.

AII.16   The student will describe distinguishing features in works of art that may be used to differentiate among a variety of historical periods and cultural contexts.

AII.17   The student will examine and discuss societal conditions that influence works of art.

AII.18   The student will identify the function and interpret the meaning of a work of art or an artifact in its original context.

AII.19   The student will describe symbols present in works of art in relation to historical meaning.

Judgment and Criticism

AII.20   The student will describe, analyze, interpret, and judge works of art, using an expanded art vocabulary.

AII.21   The student will use an expanded art vocabulary to assess the effectiveness of the communication of ideas in personal works of art.

AII.22   The student will demonstrate orally and in writing, the ability to interpret and compare historical references found in original works of art.

AII.23   The student will identify and analyze characteristics of works of art that represent a variety of styles.

AII.24   The student will participate in class critiques and criticisms based on one or more established models (e.g., Feldman, Broudy, Barrett).

AII.25   The student will describe how the perception of quality in works of art has changed over time.

Aesthetics

AII.26   The student will examine, compare, and contrast aesthetic ideals throughout history.

AII.27   The student will discuss how responses to the natural environment differ from responses to a man-made or a constructed environment.

AII.28   The student will demonstrate the ability to reflect on and analyze personal responses to works of art and artifacts.

AII.29   The student will support opinions by reasoned processes, using an expanded art vocabulary.

AII.30   The student will describe, refine, and organize personal ideas about the aesthetic qualities of a work of art.

AII.31   The student will research and investigate the intentions of those who created specific works of art.

AII.32   The student will investigate and demonstrate the fact that art can be viewed from a variety of aesthetic stances.

Computer/Technology Standards of Learning

Grades 9-12

Basic Operations and Concepts

C/T 9-12.1   The student will demonstrate knowledge of the nature and operation of technology systems.
- Discuss the inherent advantages and limitations of technology.
- Define the relationship between infrastructure, electronic resources, and connectivity.
- Identify and describe the impact of new and emerging technologies and their applications.

C/T 9-12.2   The student will demonstrate proficiency in the use of technology.
- Identify and resolve hardware and software compatibility issues.
- Develop and communicate strategies for solving routine hardware and software problems.

Social and Ethical Issues

C/T 9-12.3   The student will demonstrate knowledge of ethical, cultural, and societal issues related to technology.
- Assess the potential of information and technology to address personal and workplace needs.
- Demonstrate knowledge of electronic crimes such as viruses, pirating, and computer hacking.
- Explore and participate in online communities, and online learning opportunities.
- Identify the role that technology will play in future career opportunities.

C/T 9-12.4 The student will practice responsible use of technology systems, information, and

software.

- Adhere to fair use and copyright guidelines.
- Adhere to the school division's Acceptable Use Policy as well as other state and federal laws.
- Model respect for intellectual property.

C/T 9-12.5   The student will demonstrate knowledge of technologies that support collaboration, personal pursuits, and productivity.

- Respectfully collaborate with peers, experts, and others to contribute to an electronic community of learning.
- Model responsible use and respect for equipment, resources, and facilities.

Technology Research Tools

C/T 9-12.6   The student will use technology to locate, evaluate, and collect information from a variety of sources.

- Integrate databases, spreadsheets, charts, and tables to create reports.
- Use available technological tools to expand and enhance understanding of ideas and concepts.

C/T 9-12.7 The student will evaluate and select new information resources and technological

innovations based on the appropriateness for specific tasks.

- Analyze and draw conclusions about the comprehensiveness and bias of electronic information sources.
- Design and implement a variety of search strategies to retrieve electronic information.

Problem-solving and Decision-making Tools

C/T 9-12.8   *The student will use technology resources for solving problems and making informed decisions.*

- Investigate and apply expert systems, intelligent agents, and simulations in real-world situations.
- Select and apply technology tools for information analysis, problem-solving, and decision-making.
- Use technology resources such as educational software, simulations, and models for problem-solving, and independent learning.
- Produce and disseminate information through collaborative problem-solving activities.

Technology Communication Tools

C/T 9-12.9   *The student will use a variety of media and formats to communicate information and ideas effectively to multiple audiences.*

- *Determine the most effective tool, format, and style to communicate to specific audiences.*
- *Use technology-based options, including distance and distributed education, to collaborate, research, publish, and communicate.*
- *Practice self-directed use of advanced technology tools for communicating with specific audiences.*

Mathematics

Algebra I

The standards below outline the content for a one-year course in Algebra I. All students are expected to achieve the Algebra I standards. When planning for instruction, consideration will be given to the sequential development of concepts and skills by using concrete materials to assist students in making the transition from the arithmetic to the symbolic. Students should be helped to make connections and build relationships between algebra and arithmetic, geometry, and probability and statistics. Connections also should be made to other subject areas through practical applications. This approach to teaching algebra should help students attach meaning to the abstract concepts of algebra.

These standards require students to use algebra as a tool for representing and solving a variety of practical problems. Tables and graphs will be used to interpret algebraic expressions, equations, and inequalities and to analyze functions. Matrices will be used to organize and manipulate data.

Graphing calculators, computers, and other appropriate technology tools will be used to assist in teaching and learning. Graphing utilities enhance the understanding of functions; they provide a powerful tool for solving and verifying solutions to equations and inequalities.

Throughout the course, students should be encouraged to talk about mathematics, use the language and symbols of mathematics in representations and communication, discuss problems and problem solving, and develop their confidence in mathematics.

A.1   The student will solve multistep linear equations and inequalities in one variable, solve literal equations (formulas) for a given variable, and apply these skills to solve practical problems. Graphing calculators will be used to confirm algebraic solutions.

A.2   The student will represent verbal quantitative situations algebraically and evaluate these expressions for given replacement values of the variables. Students will choose an appropriate computational technique, such as mental mathematics, calculator, or paper and pencil.

A.3   The student will justify steps used in simplifying expressions and solving equations and inequalities. Justifications will include the use of concrete objects; pictorial representations; and the properties of real numbers, equality, and inequality.

A.4   The student will use matrices to organize and manipulate data, including matrix addition, subtraction, and scalar multiplication. Data will arise from business, industrial, and consumer situations.

A.5   The student will create and use tabular, symbolic, graphical, verbal, and physical representations to analyze a given set of data for the existence of a pattern, determine the domain and range of relations, and identify the relations that are functions.

A.6   The student will select, justify, and apply an appropriate technique to graph linear functions and linear inequalities in two variables. Techniques will include slope-intercept, *x*- and *y*-intercepts, graphing by transformation, and the use of the graphing calculator.

A.7   The student will determine the slope of a line when given an equation of the line, the graph of the line, or two points on the line. Slope will be described as rate of change and will be positive, negative, zero, or undefined. The graphing calculator will be used to investigate the effect of changes in the slope on the graph of the line.

A.8   The student will write an equation of a line when given the graph of the line, two points on the line, or the slope and a point on the line.

A.9   The student will solve systems of two linear equations in two variables both algebraically and graphically and apply these techniques to solve practical problems. Graphing calculators will be used both as a primary tool for solution and to confirm an algebraic solution.

A.10   The student will apply the laws of exponents to perform operations on expressions with integral exponents, using scientific notation when appropriate.

A.11   The student will add, subtract, and multiply polynomials and divide polynomials with monomial divisors, using concrete objects, pictorial and area representations, and algebraic manipulations.

A.12   The student will factor completely first- and second-degree binomials and trinomials in one or two variables. The graphing calculator will be used as a tool for factoring and for confirming algebraic factorizations.

A.13   The student will express the square root of a whole number in simplest radical form and approximate square roots to the nearest tenth.

A.14   The student will solve quadratic equations in one variable both algebraically and graphically. Graphing calculators will be used both as a primary tool in solving problems and to verify algebraic solutions.

A.15   The student will, given a rule, find the values of a function for elements in its domain and locate the zeros of the function both algebraically and with a graphing calculator. The value of *f(x)* will be related to the ordinate on the graph.

A.16   The student will, given a set of data points, write an equation for a line of best fit and use the equation to make predictions.

A.17   The student will compare and contrast multiple one-variable data sets, using statistical techniques that include measures of central tendency, range, and box-and-whisker graphs.

A.18   The student will analyze a relation to determine whether a direct variation exists and represent it algebraically and graphically, if possible.

Geometry

This course is designed for students who have successfully completed the standards for Algebra I. The course includes, among other things, properties of geometric figures, trigonometric relationships, and reasoning to justify conclusions. Methods of justification will include paragraph proofs, two-column proofs, indirect proofs, coordinate proofs, and verbal arguments. A gradual development of formal proof is encouraged. Inductive and intuitive approaches to proof as well as deductive axiomatic methods should be used.

This set of standards includes emphasis on two- and three-dimensional reasoning skills, coordinate and transformational geometry, and the use of geometric models to solve problems. A variety of applications and some general problem-solving techniques including algebraic skills, should be used to implement these standards. Calculators, computers, graphing utilities (graphing calculators or computer graphing simulators), dynamic geometry software, and other appropriate technology tools will be used to assist in teaching and learning. Any technology that will enhance student learning should be used.

G.1   The student will construct and judge the validity of a logical argument consisting of a set of premises and a conclusion. This will include
    a) identifying the converse, inverse, and contrapositive of a conditional statement;
    b) translating a short verbal argument into symbolic form;
    c) using Venn diagrams to represent set relationships; and
    d) using deductive reasoning, including the law of syllogism.

G.2   The student will use pictorial representations, including computer software, constructions, and coordinate methods, to solve problems involving symmetry and transformation. This will include
    a) investigating and using formulas for finding distance, midpoint, and slope;
    b) investigating symmetry and determining whether a figure is symmetric with respect to a line or a point; and
    c) determining whether a figure has been translated, reflected, or rotated.

G.3   The student will solve practical problems involving complementary, supplementary, and congruent angles that include vertical angles, angles formed when parallel lines are cut by a transversal, and angles in polygons.

G.4   The student will use the relationships between angles formed by two lines cut by a transversal to determine if two lines are parallel and verify, using algebraic and coordinate methods as well as deductive proofs.

G.5   The student will
    a) investigate and identify congruence and similarity relationships between triangles; and
    b) prove two triangles are congruent or similar, given information in the form of a figure or statement, using algebraic and coordinate as well as deductive proofs.

G.6   The student, given information concerning the lengths of sides and/or measures of angles, will apply the triangle inequality properties to determine whether a triangle exists and to order sides and angles. These concepts will be considered in the context of practical situations.

G.7   The student will solve practical problems involving right triangles by using the Pythagorean Theorem, properties of special right triangles, and right triangle trigonometry. Solutions will be expressed in radical form or as decimal approximations.

G.8   The student will
       a) investigate and identify properties of quadrilaterals involving opposite sides and angles, consecutive sides and angles, and diagonals;
       b) prove these properties of quadrilaterals, using algebraic and coordinate methods as well as deductive reasoning; and
       c) use properties of quadrilaterals to solve practical problems.

G.9   The student will use measures of interior and exterior angles of polygons to solve problems. Tessellations and tiling problems will be used to make connections to art, construction, and nature.

G.10   The student will investigate and solve practical problems involving circles, using properties of angles, arcs, chords, tangents, and secants. Problems will include finding arc length and the area of a sector, and may be drawn from applications of architecture, art, and construction.

G.11   The student will construct a line segment congruent to a given line segment, the bisector of a line segment, a perpendicular to a given line from a point not on the line, a perpendicular to a given line at a point on the line, the bisector of a given angle, and an angle congruent to a given angle.

G.12   The student will make a model of a three-dimensional figure from a two-dimensional drawing and make a two-dimensional representation of a three-dimensional object. Models and representations will include scale drawings, perspective drawings, blueprints, or computer simulations.

G.13   The student will use formulas for surface area and volume of three-dimensional objects to solve practical problems. Calculators will be used to find decimal approximations for results.

G.14   The student will
       a) use proportional reasoning to solve practical problems, given similar geometric objects; and
       b) determine how changes in one dimension of an object affect area and/or volume of the object.

Algebra II

The standards below outline the content for a one-year course in Algebra II. Students enrolled in Algebra II are assumed to have mastered those concepts outlined in the Algebra I standards. A thorough treatment of advanced algebraic concepts is provided through the study of functions, "families of functions," equations, inequalities, systems of equations and inequalities, polynomials, rational expressions, complex numbers, matrices, and sequences and series. Emphasis will be placed on practical applications and modeling throughout the course of study. Oral and written communication concerning the language of algebra, logic of procedures, and interpretation of results also should permeate the course.

These standards include a transformational approach to graphing functions. Transformational graphing uses translation, reflection, dilation, and rotation to generate a "family of graphs" from a given graph and builds a strong connection between algebraic and graphic representations of functions. Students will vary the coefficients and constants of an equation, observe the changes in the graph of the equation, and make generalizations that can be applied to many graphs.

Graphing utilities (graphing calculators or computer graphing simulators), computers, spreadsheets, and other appropriate technology tools will be used to assist in teaching and learning. Graphing utilities enhance the understanding of realistic applications through mathematical modeling and aid in the investigation and study of functions. They also provide an effective tool for solving/verifying equations and inequalities. Any other available technology that will enhance student learning should be used.

AII.1   The student will identify field properties, axioms of equality and inequality, and properties of order that are valid for the set of real numbers and its subsets, complex numbers, and matrices.

AII.2   The student will add, subtract, multiply, divide, and simplify rational expressions, including complex fractions.

AII.3   The student will
a) add, subtract, multiply, divide, and simplify radical expressions containing positive rational numbers and variables and expressions containing rational exponents; and
b) write radical expressions as expressions containing rational exponents and vice versa.

AII.4   The student will solve absolute value equations and inequalities graphically and algebraically. Graphing calculators will be used as a primary method of solution and to verify algebraic solutions.

AII.5   The student will identify and factor completely polynomials representing the difference of squares, perfect square trinomials, the sum and difference of cubes, and general trinomials.

AII.6   The student will select, justify, and apply a technique to solve a quadratic equation over the set of complex numbers. Graphing calculators will be used for solving and for confirming the algebraic solutions.

AII.7   The student will solve equations containing rational expressions and equations containing radical expressions algebraically and graphically. Graphing calculators will be used for solving and for confirming the algebraic solutions.

AII.8   The student will recognize multiple representations of functions (linear, quadratic, absolute value, step, and exponential functions) and convert between a graph, a table, and symbolic form. A transformational approach to graphing will be employed through the use of graphing calculators.

AII.9   The student will find the domain, range, zeros, and inverse of a function; the value of a function for a given element in its domain; and the composition of multiple functions. Functions will include exponential, logarithmic, and those that have domains and ranges that are limited and/or discontinuous. The graphing calculator will be used as a tool to assist in investigation of functions.

AII.10   The student will investigate and describe through the use of graphs the relationships between the solution of an equation, zero of a function, *x*-intercept of a graph, and factors of a polynomial expression.

AII.11   The student will use matrix multiplication to solve practical problems. Graphing calculators or computer programs with matrix capabilities will be used to find the product.

AII.12   The student will represent problem situations with a system of linear equations and solve the system, using the inverse matrix method. Graphing calculators or computer programs with matrix capability will be used to perform computations.

AII.13   The student will solve practical problems, using systems of linear inequalities and linear programming, and describe the results both orally and in writing. A graphing calculator will be used to facilitate solutions to linear programming problems.

AII.14   The student will solve nonlinear systems of equations, including linear-quadratic and quadratic-quadratic, algebraically and graphically. The graphing calculator will be used as a tool to visualize graphs and predict the number of solutions.

AII.15   The student will recognize the general shape of polynomial, exponential, and logarithmic functions. The graphing calculator will be used as a tool to investigate the shape and behavior of these functions.

AII.16   The student will investigate and apply the properties of arithmetic and geometric sequences and series to solve practical problems, including writing the first *n* terms,

finding the nth term, and evaluating summation formulas. Notation will include Σ and a_n.

AII.17   The student will perform operations on complex numbers and express the results in simplest form. Simplifying results will involve using patterns of the powers of i.

AII.18   The student will identify conic sections (circle, ellipse, parabola, and hyperbola) from his/her equations. Given the equations in *(h, k)* form, the student will sketch graphs of conic sections, using transformations.

AII.19   The student will collect and analyze data to make predictions and solve practical problems. Graphing calculators will be used to investigate scatterplots and to determine the equation for a curve of best fit. Models will include linear, quadratic, exponential, and logarithmic functions.

AII.20   The student will identify, create, and solve practical problems involving inverse variation and a combination of direct and inverse variations.

Computer Mathematics

This course is intended to provide students with experiences in using computer programming techniques and skills to solve problems that can be set up as mathematical models. Students enrolled in Computer Mathematics are assumed to have studied the concepts and skills in Algebra I and beginning geometry. Students who successfully complete the standards for this course may earn credit toward meeting the mathematics graduation requirement. It is recognized that many students will gain computer skills in other mathematics courses or in a separate curriculum outside of mathematics and prior to high school. In such cases, the standards indicated by an asterisk (*) should be included in the student's course of study and treated as a review.

Even though computer ideas should be introduced in the context of mathematical concepts, problem solving per se should be developed in the most general sense, making the techniques applicable by students in many other environments. Strategies include defining the problem; developing, refining, and implementing a plan; and testing and revising the solution. Programming, ranging from simple programs involving only a few lines to complex programs involving subprograms, should permeate the entire course and may include programming a graphing calculator or scripting a problem solution in a database or spreadsheet. Programming concepts, problem-solving strategies, and mathematical applications should be integrated throughout the course.

These standards identify fundamental principles and concepts in the field of computer science that will be used within the context of mathematical problem solving in a variety of applications. As students develop and refine skills in logic, organization, and precise expression, they will apply those skills to enhance learning in all disciplines.

COM.1   The student will apply programming techniques and skills to solve practical problems in mathematics arising from consumer, business, other applications in mathematics. Problems will include opportunities for students to analyze data in charts, graphs, and tables and to use their knowledge of equations, formulas, and functions to solve these problems.

*COM.2   The student will design, write, test, debug, and document a program. Programming documentation will include pre-conditions and post-conditions of program segments, input/output specifications, the step-by-step plan, the test data, a sample run, and the program listing with appropriately placed comments.

*COM.3   The student will write program specifications that define the constraints of a given problem. These specifications will include descriptions of pre-conditions, post-conditions, the desired output, analysis of the available input, and an indication as to whether or not the problem is solvable under the given conditions.

*COM.4   The student will design a step-by-step plan (algorithm) to solve a given problem. The plan will be in the form of a program flowchart, pseudo code, hierarchy chart, and/or data-flow diagram.

*COM.5   The student will divide a given problem into manageable sections (modules) by task and implement the solution. The modules will include an appropriate user-defined function, subroutines, and procedures. Enrichment topics might include user-defined libraries (units) and object-oriented programming.

*COM.6   The student will design and implement the input phase of a program, which will include designing screen layout and getting information into the program by way of user interaction, data statements, and/or file input. The input phase also will include methods of filtering out invalid data (error trapping).

*COM.7   The student will design and implement the output phase of a computer program, which will include designing output layout, accessing a variety of output devices, using output statements, and labeling results.

COM.8   The student will design and implement computer graphics, which will include topics appropriate for the available programming environment as well as student background. Students will use graphics as an end in itself, as an enhancement to other output, and as a vehicle for reinforcing programming techniques.

COM.9   The student will define simple variable data types that include integer, real (fixed and scientific notation), character, string, and Boolean.

COM.10   The student will use appropriate variable data types, including integer, real (fixed and scientific notation), character, string, and Boolean. This will also include variables representing structured data types.

---

*COM.11 The student will describe the way the computer stores, accesses, and processes variables, including the following topics: the use of variables versus constants, variables addresses, pointers, parameter passing, scope of variables, and local versus global variables.

COM.12 The student will translate a mathematical expression into a computer statement, which involves writing assignment statements and using the order of operations.

COM.13 The student will select and implement built-in (library) functions in processing data.

COM.14 The student will implement conditional statements that include "if/then" statements, "if/then/else" statements, case statements, and Boolean logic.

COM.15 The student will implement loops, including iterative loops. Other topics will include single entry point, single exit point, pre-conditions, and post-conditions.

*COM.16 The student will select and implement appropriate data structures, including arrays (one-dimensional and/or multidimensional), files, and records. Implementation will include creating the data structure, putting information into the structure, and retrieving information from the structure.

*COM.17 The student will implement pre-existing algorithms, including sort routines, search routines, and simple animation routines.

COM.18 The student will test a program, using an appropriate set of data. The set of test data should be appropriate and complete for the type of program being tested.

COM.19 The student will debug a program, using appropriate techniques (e.g., appropriately placed controlled breaks, the printing of intermediate results, and other debugging tools available in the programming environment), and identify the difference between syntax errors and logic errors.

COM.20 The student will design, write, test, debug, and document a complete structured program that requires the synthesis of many of the concepts contained in previous standards.

Discrete Mathematics

The following standards outline the content of a one-year course in Discrete Mathematics. If a one-semester course is desired, the standards with an asterisk (*) would apply. Students enrolled in Discrete Mathematics are assumed to have mastered the concepts outlined in the Standards of Learning for Algebra II.

Discrete mathematics may be described as the study of mathematical properties of sets and systems that have a countable (discrete) number of elements. With the advent of modern technology, discrete (discontinuous) models have become as important as continuous models. In

this course, the main focus is problem solving in a discrete setting. Techniques that are not considered in the current traditional courses of algebra, geometry, and calculus will be utilized. As students solve problems, they will analyze and determine whether or not a solution exists (existence problems), investigate how many solutions exist (counting problems), and focus on finding the best solution (optimization problems). Connections will be made to other disciplines. The importance of discrete mathematics has been influenced by computers. Modern technology (graphing calculators and/or computers) will be an integral component of this course.

*DM.1 The student will model problems, using vertex-edge graphs. The concepts of valence, connectedness, paths, planarity, and directed graphs will be investigated. Adjacency matrices and matrix operations will be used to solve problems (e.g., food chains, number of paths).

*DM.2 The student will solve problems through investigation and application of circuits, cycles, Euler Paths, Euler Circuits, Hamilton Paths, and Hamilton Circuits. Optimal solutions will be sought using existing algorithms and student-created algorithms.

*DM.3 The student will apply graphs to conflict-resolution problems, such as map coloring, scheduling, matching, and optimization. Graph coloring and chromatic number will be used.

*DM.4 The student will apply algorithms, such as Kruskal's, Prim's, or Dijkstra's, relating to trees, networks, and paths. Appropriate technology will be used to determine the number of possible solutions and generate solutions when a feasible number exists.

*DM.5 The student will use algorithms to schedule tasks in order to determine a minimum project time. The algorithms will include critical path analysis, the list-processing algorithm, and student-created algorithms.

*DM.6 The student will solve linear programming problems. Appropriate technology will be used to facilitate the use of matrices, graphing techniques, and the Simplex method of determining solutions.

*DM.7 The student will analyze and describe the issue of fair division (e.g., cake cutting, estate division). Algorithms for continuous and discrete cases will be applied.

DM.8 The student will investigate and describe weighted voting and the results of various election methods. These may include approval and preference voting as well as plurality, majority, run-off, sequential run-off, Borda count, and Condorcet winners.

DM.9 The student will identify apportionment inconsistencies that apply to issues such as salary caps in sports and allocation of representatives to Congress. Historical and current methods will be compared.

DM.10 The student will use the recursive process and difference equations with the aid of appropriate technology to generate

---

a) compound interest;
b) sequences and series;
c) fractals;
d) population growth models; and
e) the Fibonacci sequence.

DM.11   The student will describe and apply sorting algorithms and coding algorithms used in storing, processing, and communicating information. These will include
a) bubble sort, merge sort, and network sort; and
b) ISBN, UPC, Zip, and banking codes.

DM.12   The student will select, justify, and apply an appropriate technique to solve a logic problem. Techniques will include Venn diagrams, truth tables, and matrices.

DM.13   The student will apply the formulas of combinatorics in the areas of
a) the Fundamental (Basic) Counting Principle;
b) knapsack and bin-packing problems;
c) permutations and combinations; and
d) the pigeonhole principle.

Mathematical Analysis

The standards below outline the content for a one-year course in Mathematical Analysis. Students enrolled in Mathematical Analysis are assumed to have mastered Algebra II concepts and have some exposure to trigonometry. Mathematical Analysis develops students' understanding of algebraic and transcendental functions, parametric and polar equations, sequences and series, and vectors. The content of this course serves as appropriate preparation for a calculus course.

Graphing calculators, computers, and other appropriate technology tools will be used to assist in teaching and learning. Graphing utilities enhance the understanding of realistic applications through modeling and aid in the investigation of functions and their inverses. They also provide a powerful tool for solving and verifying equations and inequalities.

MA.1   The student will investigate and identify the characteristics of polynomial and rational functions and use these to sketch the graphs of the functions. This will include determining zeros, upper and lower bounds, y-intercepts, symmetry, asymptotes, intervals for which the function is increasing or decreasing, and maximum or minimum points. Graphing utilities will be used to investigate and verify these characteristics.

MA.2   The student will find compositions of functions and inverses of functions. Analytical methods and graphing utilities will be used to investigate and verify the domain and range of resulting functions.

MA.3   The student will investigate and describe the continuity of functions, using graphs. The functions will include absolute value, piecewise, and step functions.

MA.4   The student will expand binomials having positive integral exponents through the use of the Binomial Theorem, the formula for combinations, and Pascal's Triangle.

MA.5   The student will solve practical problems involving arithmetic and geometric sequences and series. This will include finding the sum (sigma notation included) of finite and infinite convergent series that will lead to an intuitive approach to a limit.

MA.6   The student will use mathematical induction to prove formulas/statements.

MA.7   The student will find the limit of an algebraic function, if it exists, as the variable approaches either a finite number or infinity. A graphing utility will be used to verify intuitive reasoning, algebraic methods, and numerical substitution.

MA.8   The student will investigate and identify the characteristics of conic section equations in *(h, k)* and standard forms. The techniques of translation and rotation of axes in the coordinate plane will be used to graph conic sections.

MA.9   The student will investigate and identify the characteristics of exponential and logarithmic functions in order to graph these functions and solve equations and practical problems. This will include the role of e, natural and common logarithms, laws of exponents and logarithms, and the solution of logarithmic and exponential equations. Graphing utilities will be used to investigate and verify the graphs and solutions.

MA.10   The student will investigate and identify the characteristics of the graphs of polar equations, using graphing utilities. This will include classification of polar equations, the effects of changes in the parameters in polar equations, conversion of complex numbers from rectangular form to polar form and vice versa, and the intersection of the graphs of polar equations.

MA.11   The student will perform operations with vectors in the coordinate plane and solve practical problems using vectors. This will include the following topics: operations of addition, subtraction, scalar multiplication, and inner (dot) product; norm of a vector; unit vector; graphing; properties; simple proofs; complex numbers (as vectors); and perpendicular components.

MA.12   The student will use parametric equations to model and solve application problems. Graphing utilities will be used to develop an understanding of the graph of parametric equations.

MA.13   The student will identify, create, and solve practical problems involving triangles. Techniques will include using the trigonometric functions, the Pythagorean Theorem, the Law of Sines, and the Law of Cosines.

Probability and Statistics

The following standards outline the content of a one-year course in Probability and Statistics. If a one-semester course is desired, the standards with an asterisk (*) would apply. Students enrolled in this course are assumed to have mastered the concepts identified in the Standards of Learning for Algebra II. The purpose of the course is to present basic concepts and techniques for collecting and analyzing data, drawing conclusions, and making predictions.

A graphing calculator is essential for every student taking the Probability and Statistics course and is required for the Advanced Placement Statistics Examination. The calculator may not fully substitute for a computer, however. In the absence of a computer for student use, teachers may provide students with examples of computer output generated by a statistical software package.

*PS.1   The student will analyze graphical displays of data, including dotplots, stemplots, and histograms, to identify and describe patterns and departures from patterns, using central tendency, spread, clusters, gaps, and outliers. Appropriate technology will be used to create graphical displays.

*PS.2   The student will analyze numerical characteristics of univariate data sets to describe patterns and departure from patterns, using mean, median, mode, variance, standard deviation, interquartile range, range, and outliers. Appropriate technology will be used to calculate statistics.

*PS.3   The student will compare distributions of two or more univariate data sets, analyzing center and spread (within group and between group variations), clusters and gaps, shapes, outliers, or other unusual features. Appropriate technology will be used to generate graphical displays.

*PS.4   The student will analyze scatterplots to identify and describe the relationship between two variables, using shape; strength of relationship; clusters; positive, negative, or no association; outliers; and influential points. Appropriate technology will be used to generate scatterplots and identify outliers and influential points.

PS.5   The student will find and interpret linear correlation, use the method of least squares regression to model the linear relationship between two variables, and use the residual plots to assess linearity. Appropriate technology will be used to compute correlation coefficients and residual plots.

PS.6   The student will make logarithmic and power transformations to achieve linearity. Appropriate technology will be used.

PS.7   The student, using two-way tables, will analyze categorical data to describe patterns and departure from patterns and to find marginal frequency and relative frequencies, including conditional frequencies.

*PS.8   The student will describe the methods of data collection in a census, sample survey, experiment, and observational study and identify an appropriate method of solution for a given problem setting.

*PS.9   The student will plan and conduct a survey. The plan will address sampling techniques (e.g., simple random and stratified) and methods to reduce bias.

PS.10   The student will plan and conduct an experiment. The plan will address control, randomization, and measurement of experimental error.

*PS.11   The student will compute and distinguish between permutations and combinations and use technology for applications.

*PS.12   The student will identify and describe two or more events as complementary, dependent, independent, and/or mutually exclusive.

*PS.13   The student will find probabilities (relative frequency and theoretical), including conditional probabilities for events that are either dependent or independent, by applying the "law of large numbers" concept, the addition rule, and the multiplication rule.

*PS.14   The student will develop, interpret, and apply the binomial probability distribution for discrete random variables, including computing the mean and standard deviation for the binomial variable.

PS.15   The student will simulate probability distributions, including binomial and geometric.

PS.16   The student will identify random variables as independent or dependent and find the mean and standard deviations for sums and differences of independent random variables.

*PS.17   The student will identify properties of a normal distribution and apply the normal distribution to determine probabilities, using a table or graphing calculator.

*PS.18   The student, given data from a large sample, will find and interpret point estimates and confidence intervals for parameters. The parameters will include proportion and mean, difference between two proportions, and difference between two means (independent and paired).

PS.19   The student will apply and interpret the logic of a hypothesis-testing procedure. Tests will include large sample test for proportion, mean, difference between two proportions, and difference between two means (independent and paired) and Chi-squared test for goodness of fit, homogeneity of proportions, and independence.

PS.20   The student will identify the meaning of sampling distribution with reference to random variable, sampling statistic, and parameter and explain the Central Limit Theorem. This will include sampling distribution of a sample proportion, a sample mean, a difference between two sample proportions, and a difference between two sample means.

PS.21   The student will identify properties of a t-distribution and apply t-distributions to single-sample and two-sample (independent and matched pairs) t-procedures, using tables or graphing calculators.

Physics

The Physics standards emphasize a more complex understanding of experimentation, the analysis of data, and the use of reasoning and logic to evaluate evidence. The use of mathematics, including algebra and trigonometry, is important, but conceptual understanding of physical systems remains a primary concern. Students build on basic physical science principles by exploring in depth the nature and characteristics of energy and its dynamic interaction with matter. Key areas covered by the standards include force and motion, energy transformations, wave phenomena and the electromagnetic spectrum, light, electricity, fields, and non-Newtonian physics. The standards stress the practical application of physics in other areas of science and technology and how physics affects our world.

The Physics standards continue to focus on student growth in understanding the nature of science. This scientific view defines the idea that explanations of nature are developed and tested using observation, experimentation, models, evidence, and systematic processes. The nature of science includes the concepts that scientific explanations are based on logical thinking; are subject to rules of evidence; are consistent with observational, inferential, and experimental evidence; are open to rational critique; and are subject to refinement and change with the addition of new scientific evidence. The nature of science includes the concept that science can provide explanations about nature, can predict potential consequences of actions, but cannot be used to answer all questions.

PH.1   The student will plan and conduct investigations in which
   a)   the components of a system are defined;
   b)   instruments are selected and used to extend observations and measurements of mass, volume, temperature, heat exchange, energy transformations, motion, fields, and electric charge;
   c)   information is recorded and presented in an organized format;
   d)   metric units are used in all measurements and calculations;
   e)   the limitations of the experimental apparatus and design are recognized;
   f)   the limitations of measured quantities are recognized through the appropriate use of significant figures or error ranges;
   g)   data gathered from non-SI instruments are incorporated through appropriate conversions; and
   h)   appropriate technology including computers, graphing calculators, and probeware, is used for gathering and analyzing data and communicating results.

PH.2   The student will investigate and understand how to analyze and interpret data. Key concepts include
   a)   a description of a physical problem is translated into a mathematical statement in order to find a solution;
   b)   relationships between physical quantities are determined using the shape of a curve passing through experimentally obtained data;

c) the slope of a linear relationship is calculated and includes appropriate units;
d) interpolated, extrapolated, and analyzed trends are used to make predictions; and
e) analysis of systems employs vector quantities utilizing trigonometric and graphical methods.

PH.3   The student will investigate and understand how to demonstrate scientific reasoning and logic. Key concepts include
a) analysis of scientific sources to develop and refine research hypotheses;
b) analysis of how science explains and predicts relationships;
c) evaluation of evidence for scientific theories;
d) examination of how new discoveries result in modification of existing theories or establishment of new paradigms; and
e) construction and defense of a scientific viewpoint (the nature of science).

PH.4   The student will investigate and understand how applications of physics affect the world. Key concepts include
a) examples from the real world; and
b) exploration of the roles and contributions of science and technology.

PH.5   The student will investigate and understand the interrelationships among mass, distance, force, and time through mathematical and experimental processes. Key concepts include
a) linear motion;
b) uniform circular motion;
c) projectile motion;
d) Newton's laws of motion;
e) gravitation;
f) planetary motion; and
g) work, power, and energy.

PH.6   The student will investigate and understand that quantities including mass, energy, momentum, and charge are conserved. Key concepts include
a) kinetic and potential energy;
b) elastic and inelastic collisions; and
c) electric power.

PH.7   The student will investigate and understand properties of fluids. Key concepts include
a) density and pressure;
b) variation of pressure with depth;
c) Archimedes' principle of buoyancy;
d) Pascal's principle;
e) fluids in motion; and
f) Bernoulli's principle.

PH.8   The student will investigate and understand that energy can be transferred and transformed to provide usable work. Key concepts include
a) transformation of energy among forms including mechanical, thermal, electrical, gravitational, chemical, and nuclear; and
b) efficiency of systems.

PH.9   The student will investigate and understand how to use models of transverse and longitudinal waves to interpret wave phenomena. Key concepts include
a) wave characteristics (period, wavelength, frequency, amplitude, and phase);

b) fundamental wave processes (reflection, refraction, diffraction, interference, polarization, Doppler effect); and

c) light and sound in terms of wave models.

PH.10 The student will investigate and understand that different frequencies and wavelengths in the electromagnetic spectrum are phenomena ranging from radio waves through visible light to gamma radiation. Key concepts include

a) the properties and behaviors of radio waves, microwaves, infrared, visible light, ultraviolet, X-rays, and gamma rays; and

b) current applications based on the wave properties of each band.

PH.11 The student will investigate and understand, in describing optical systems, how light behaves in the fundamental processes of reflection, refraction, and image formation. Key concepts include

a) application of the laws of reflection and refraction;

b) construction and interpretation of ray diagrams;

c) development and use of mirror and lens equations; and

d) predictions of type, size, and position of real and virtual images.

PH.12 The student will investigate and understand how to use the field concept to describe the effects of gravitational, electric, and magnetic forces. Key concepts include

a) inverse square laws (Newton's law of universal gravitation and Coulomb's law); and

b) operating principles of motors, generators, transformers, and cathode ray tubes.

PH.13 The student will investigate and understand how to diagram and construct basic electrical circuits and explain the function of various circuit components. Key concepts include

a) Ohm's law;

b) series, parallel, and combined circuits; and

c) circuit components including resistors, batteries, generators, fuses, switches, and capacitors.

PH.14 The student will investigate and understand that extremely large and extremely small quantities are not necessarily described by the same laws as those studied in Newtonian physics. Key concepts include

a) wave/particle duality;

b) wave properties of matter;

c) matter/energy equivalence;

d) quantum mechanics and uncertainty;

e) relativity;

f) nuclear physics;

g) solid state physics;

h) superconductivity; and

i) radioactivity.