Modeling and Simulation Technology

8460 36 weeks

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Course Description

Suggested Grade Level: 10 or 11 or 12

Students will explore the use of modeling, simulation, and game-development concepts and software to solve real-world problems in multiple domain areas. Activities will include developing, evaluating and testing engineering designs, employing geospatial data, observing and analyzing physics simulations, programming games for educational purposes, creating visualization systems with 3-D models, animating 3-D models and characters, and incorporating original models into games. Students will develop an understanding of the concepts, systems, processes, tools, and implications of the field of modeling, simulation, and visualization technology.

Task Essentials Table

- Tasks/competencies designated by plus icons (⊕) in the left-hand column(s) are essential
- Tasks/competencies designated by empty-circle icons (○) are optional
- Tasks/competencies designated by minus icons (⊖) are omitted

- Tasks marked with an asterisk (*) are sensitive.

Task Number	8460	Tasks/Competencies
Exploring Modeling and Simulation		
39	⊕	Describe models and simulations and the relationship between the two.
40	⊕	Identify types of modeling and modeling tools.
41	⊕	Identify modeling methods.
42	⊕	Identify types of simulation and simulation tools.
43	⊕	Explain the history of modeling and simulation.
44	⊕	Explain the modeling and simulation lifecycle.
45	⊕	Explain the application of modeling and simulation in specific domains.
46	⊕	Examine ethical and legal issues in modeling and simulation.
47	⊕	Examine career opportunities in modeling and simulation.
Learning Programming Skills for Modeling and Simulation		
48	⊕	Describe computer programming tools that can be used to develop models and simulations.
49	⊕	Describe the principles of object-oriented programming.
50	⊕	Describe the architecture of an existing simulation game.
51	⊕	Design a program, using an algorithm, pseudocode, a flowchart, and/or a decision table.
52	⊕	Program an electronic simulation game for educational purposes.
53	⊕	Debug an electronic game program, using troubleshooting techniques.
Designing and Creating Physical Models		
54	⊕	Explain the modeling and simulation process.

55	⊕	Design a 3-dimensional object, using 3-D software.	
56	⊕	Analyze the 3-D model, using simulation software.	
57	⊕	Optimize the design.	
58	⊕	Verify the object's performance within a simulated environment or system.	
59	⊕	Build a physical model of the design.	
Visualizing Data			
60	⊕	Explain the nature and purposes of data visualization.	
61	⊕	Explain techniques for presenting data in a visual format.	
62	⊕	Create a visual representation of data using student-collected data or a simulation model.	
63	⊕	Animate a simulated behavior of a model.	
Evaluating Complex Systems			
64	⊕	Explain the nature of a complex vs. complicated systems.	
65	⊕	Explain data variables that would be necessary to effectively model a complex system.	
66	⊕	Develop models of complex systems.	
67	⊕	Conduct experiments using developed simulation models.	

Legend: ⊕Essential ○Non-essential ⊖Omitted

Curriculum Framework

Exploring Modeling and Simulation

Task Number 39

Describe models and simulations and the relationship between the two.

Definition

Description should include the definition of *model* and *simulation* with examples of each, the process of modeling and simulating, as well as the concept that models are used as the basis for simulation.

Process/Skill Questions

- What are the similarities and differences between models and simulations?
- How are models and simulations related?
- How do modeling and simulation apply to everyday life?

Task Number 40

Identify types of modeling and modeling tools.

Definition

Identification should include

- types of modeling (e.g., physical, virtual, mathematical, process, conceptual)
- modeling tools, including engineering sketches and drawings, specialized modeling hardware and software (e.g., Maya, Stingray, 3-D Studio Max, Blender, Inventor, Flow Design, Google SketchUP), spreadsheets, and flow charts.

Process/Skill Questions

- Why are models used?
- How accurate do models need to be? What happens if models are incomplete or inaccurate?
- How is it possible to determine the best modeling tool for a given problem?
- Why is interpreting engineering sketches and drawings critical during the design phase of a project?

ITEEA National Standards

Relationships Among Technologies and the Connections Between Technology and Other Fields

The Characteristics and Scope of Technology

TSA Competitive Events

Animatronics

Architectural Renovation

Manufacturing Prototype

Scientific and Technical Visualization (SciVis)

Structural Engineering

Video Game Design

Task Number 41

Identify modeling methods.

Definition

Identification should include

- stochastic modeling
- physics-based modeling
- structural modeling
- finite element modeling and computational fluid dynamics
- Monte Carlo simulation
- discrete event simulation (DES)
- human behavior modeling
- multiresolution modeling
- continuous simulation
- agent-based modeling (ABM)
- other modeling methods.

Process/Skill Questions

- Why is it important to identify the modeling method before starting the design?
- How are the different modeling methods applied?
- What can be modeled with each method?
- How do you determine the best modeling method for a given problem (e.g., strengths, limitations)?
- What types of problems are addressed by different modeling methods?

Task Number 42

Identify types of simulation and simulation tools.

Definition

Identification should include

- types of simulation (e.g., live, virtual, constructive, discrete, continuous)
- simulation tools (e.g., storyboarding, calculators)
- appropriate software and hardware for simulation (e.g., Arena Anylogic, Vensim, Unity, NetLogo, Stella, Unreal Development Kit [UDK], Microsoft Visual Studio).

Process/Skill Questions

- What role do simulations play?
- When are live simulations appropriate?
- What are the benefits and challenges of applying simulations?
- How is it possible to determine the best simulation tool for a given problem?
- When is it appropriate to use real time vs. virtual time?
- How are simulations and electronic games related?

ITEEA National Standards

The Cultural, Social, Economic, and Political Effects of Technology

The Effects of Technology on the Environment

The Role of Society in the Development and Use of Technology

TSA Competitive Events

Digital Video Production

Geospatial Technology (Virginia only)

Scientific and Technical Visualization (SciVis)

System Control Technology

Video Game Design

Task Number 43

Explain the history of modeling and simulation.

Definition

Explanation should focus on how and why modeling and simulation have evolved, tracing modeling and simulation history from ancient times through the present to include successes and failures.

Process/Skill Questions

- How have modeling and simulation developed? What factors have driven this development?
- How has technology influenced the development of modeling and simulation over time?
- How have modeling and simulation influenced modern society?

ITEEA National Standards

The Influence of Technology on History

TSA Competitive Events

Geospatial Technology (Virginia only)

Scientific and Technical Visualization (SciVis)

Video Game Design

Task Number 44

Explain the modeling and simulation lifecycle.

Definition

Explanation should include conceptual modeling, development, verification and validation, and implementation.

Process/Skill Questions

- Why is it important to implement conceptual modeling before starting the development process?
- What is the difference between verification and validation?
- How can the information gathered be used in development?

Task Number 45

Explain the application of modeling and simulation in specific domains.

Definition

Explanation should include student hands-on experience with the application of simulation models in various domains (e.g., academic, business, social science, manufacturing, military, logistics, transportation, energy, environment and ecology, medicine).

Process/Skill Questions

- How are modeling and simulation applicable to research in the social sciences? In music? In sports? In academics?
- What makes a simulation effective? Are all simulations equally effective? Why, or why not?
- What are the applications of modeling and simulation?

ITEEA National Standards

Relationships Among Technologies and the Connections Between Technology and Other Fields

The Role of Society in the Development and Use of Technology

TSA Competitive Events

Animatronics

Architectural Renovation

Manufacturing Prototype

Scientific and Technical Visualization (SciVis)

Structural Engineering

Video Game Design

Task Number 46

Examine ethical and legal issues in modeling and simulation.

Definition

Examination should include an analysis of ethical concerns (e.g., conflict of interest, misrepresentation of data) and legal issues (e.g., intellectual property, incorporating copyrights, patents, trademarks, trade secrets) related to modeling and simulation.

Process/Skill Questions

- How do intellectual property laws apply to modeling and simulation? What are some current examples?
- Is it ethical to simulate a successful bank robbery? A successful terrorist act? Why, or why not?
- Why are ethical issues important in modeling and simulation? What are some current examples?

ITEEA National Standards

The Cultural, Social, Economic, and Political Effects of Technology

TSA Competitive Events

Digital Video Production

Geospatial Technology (Virginia only)

Scientific and Technical Visualization (SciVis)

Video Game Design

Task Number 47

Examine career opportunities in modeling and simulation.

Definition

Examination should include researching and evaluating current employment opportunities related to modeling and simulation in a wide range of fields (e.g., combat and military, aerospace, medicine and healthcare, manufacturing and material handling, logistics and supply chain, transportation, computer and communications systems, environment and ecology, business, social science).

Many websites offer career exploration resources, including the Virginia Department of Education's Career Planning Guide.

Process/Skill Questions

- Where can a student locate resources for modeling and simulation careers? For modeling and simulation job openings in a given geographical area?
- What are the educational requirements for various occupations in modeling and simulation?
- What are the salary ranges for employees in modeling and simulation occupations?

ITEEA National Standards

Agricultural and Related Biotechnologies

Construction Technologies

Energy and Power Technologies

Information and Communication Technologies

Manufacturing Technologies

Medical Technologies

Transportation Technologies

TSA Competitive Events

Career Preparation

Digital Video Production

Geospatial Technology (Virginia only)

Scientific and Technical Visualization (SciVis)

Video Game Design

Learning Programming Skills for Modeling and Simulation

Task Number 48

Describe computer programming tools that can be used to develop models and simulations.

Definition

Description should include major programming languages (e.g., C++, C#, Java, R), major simulation software packages (e.g., Arena, Any Logic, Cloudes), typical electronic game and visualization software (e.g., Unity, Stingray, UDK, GameMaker, Simio, SimuLink), and similar software development tools.

Process/Skill Questions

- How does one determine the best software tool for a particular project?
- What are the benefits and limitations of each software product for a particular project?
- What programming skills are required for each software product?
- What are the advantages of program libraries?

ITEEA National Standards

Information and Communication Technologies

TSA Competitive Events

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Geospatial Technology (Virginia only)

Scientific and Technical Visualization (SciVis)

Video Game Design

Task Number 49

Describe the principles of object-oriented programming.

Definition

Description should include the following principles:

- Inheritance
- Polymorphism
- Encapsulation
- Abstraction.

Process/Skill Questions

- What are the benefits of inheritance?
- What are the benefits of polymorphism?
- What are the advantages of encapsulation?
- What are the advantages of abstraction?

ITEEA National Standards

Information and Communication Technologies

TSA Competitive Events

System Control Technology

Video Game Design

Task Number 50

Describe the architecture of an existing simulation game.

Definition

Description should include objects, events, actions, a data exchange (e.g., basis of data exchange with databases, text files, csv files, MS excel files) and environment and the role of each in simulation game architecture.

Process/Skill Questions

- What is the difference between an event and an action in game architecture?
- How are objects, events, and actions related in game architecture?
- How can it be useful to analyze the architecture of an existing game?

ITEEA National Standards

Information and Communication Technologies

Use and Maintain Technological Products and Systems

TSA Competitive Events

System Control Technology

Video Game Design

Task Number 51

Design a program, using an algorithm, pseudocode, a flowchart, and/or a decision table.

Definition

Design should include

- diagrams (e.g., flowcharts, storyboards, other Unified Modeling Language [UML] diagrams)
- descriptive narrative describing the program, its purpose, and how it works

- examples of how abstraction is being used in the program.

Process/Skill Questions

- How are abstractions used in modeling and simulation?
- How are different types of data, physical phenomena (e.g., gravity, force, collision), and mathematical concepts represented on a computer?
- Why is it important to understand Boolean expressions?
- Why is documenting important during the design phase of a project?

Task Number 52

Program an electronic simulation game for educational purposes.

Definition

Programmed game should

- be created using a 2-D, 3-D, or console programming tool
- be engaging
- be aesthetically pleasing
- meet an educational goal (e.g., a STEM concept).

Process/Skill Questions

- How can games lead to enhanced learning?
- What makes one game better than another?
- How can a game be used to simulate real-life behavior?
- What features might make a game more engaging?
- Why should you consider the audience before designing a game?

ITEEA National Standards

Information and Communication Technologies

The Attributes of Design

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

TSA Competitive Events

Task Number 53

Debug an electronic game program, using troubleshooting techniques.

Definition

Debugging should consist of following a procedural process to locate and resolve problems.

Process/Skill Questions

- What tools are available for troubleshooting a game program?
- What role does testing play in troubleshooting?
- What are common programming mistakes?

ITEEA National Standards

Apply Design Processes

Information and Communication Technologies

TSA Competitive Events

System Control Technology

Video Game Design

Designing and Creating Physical Models

Task Number 54

Explain the modeling and simulation process.

Definition

Explanation should include the following steps of the M&S design process:

- Initial analysis
    - Identify the need or opportunity for a simulation model
    - Define a problem
    - Identify requirements and constraints
- Conceptual modeling
    - Research potential solutions for a design problem
    - Generate multiple solutions (brainstorming) for a design problem
    - Sketch solutions for a design problem
    - Evaluate potential solutions to a design problem
    - Choose the optimal solution to a design problem
- Model development
    - Implement the solution to the design problem
- Verification and validation
    - Verify correctness of the implementation (i.e., Did we build it correctly?)
    - Validate the solution against requirements first and then communicate the solution to stakeholders to make sure they agree that the simulation model does what it supposed to do (i.e., Did we build the right thing?)
- Plan and execute experiments or training
    - Plan activity: experiments (design of experiment) or training
    - Conduct experiments or training
    - Evaluate results
    - Improve the solution

Process/Skill Questions

- What is the most crucial step in the engineering modeling and simulation design process? Why?
- Do the modeling and simulation engineering design steps need to be completed in order? Why, or why not?
- What can happen if the modeling and simulation engineering design process is not used when solving a problem?
- What is the result when changes occur in the requirements and scope of the design?
- What is the relationship between time, cost, and quality in the modeling and simulation engineering design process?
- What steps require reevaluation of the initial design request? Why?

ITEEA National Standards

Engineering Design

TSA Competitive Events

Animatronics

Architectural Renovation

Engineering Design

Manufacturing Prototype

Scientific and Technical Visualization (SciVis)

Structural Engineering

Video Game Design

Task Number 55

Design a 3-dimensional object, using 3-D software.

Definition

The working model should accurately reflect the 3-D design, and the design process should include

- a multiview and/or pictorial view
- dimensions of the object
- lighting effect of the object
- materials
- scenes
- rendering of an animation
- notes
- specifications
- a bill of materials.

Process/Skill Questions

- What are the advantages of using 3D software over 2D hand drawings?
- What are the benefits of geometric dimensioning and tolerancing (GD&T)?
- How are specifications established?
- What are the different methods of rendering?

ITEEA National Standards

Apply Design Processes

Engineering Design

The Attributes of Design

TSA Competitive Events

Architectural Renovation

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Dragster Design

Manufacturing Prototype

Structural Engineering

Technical Sketching and Application

Task Number 56

Analyze the 3-D model, using simulation software.

Definition

Analysis should include

- explaining the role of simulation as an analysis tool
- defining the analysis problem
- identifying sources of error in the simulation
- describing relationships among variables
- describing the effect of correlation on simulation results
- identifying use case for historical/empirical data
- describing the output distribution
- interpreting summary statistics
- interpreting confidence and prediction (certainty) intervals.

Process/Skill Questions

- What types of analyses can be conducted on the model (e.g., flow, structural, stress)?
- What is the difference between destructive and nondestructive testing?
- Why is it important to know the design life cycle?
- Can an analysis using simulation software ensure the effectiveness of a design? Why, or why not?

ITEEA National Standards

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

Use and Maintain Technological Products and Systems

TSA Competitive Events

Dragster Design

Structural Engineering

Transportation Modeling

Task Number 57

Optimize the design.

Definition

Optimization should remedy deficiencies uncovered during the analysis and should include any necessary tradeoffs.

Process/Skill Questions

- Why are tradeoffs necessary when optimizing a design?
- Is it possible to optimize all aspects of a design? Why, or why not?
- Which phase(s) of the design process could optimization affect? What effects might result?

ITEEA National Standards

Apply Design Processes

Engineering Design

The Attributes of Design

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

TSA Competitive Events

Architectural Renovation

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Dragster Design

Manufacturing Prototype

Structural Engineering

Transportation Modeling

Task Number 58

Verify the object's performance within a simulated environment or system.

Definition

Verification should validate that the object was implemented correctly and works as required within the context of its purpose.

Process/Skill Questions

- How is verification and validation accomplished?
- Why is it essential to verify and validate an object's performance?
- What types of software could be useful for verification?

ITEEA National Standards

Apply Design Processes

Engineering Design

The Role of Troubleshooting, Research and Development, Invention and Innovation, and Experimentation in Problem Solving

TSA Competitive Events

Dragster Design

Structural Engineering

Transportation Modeling

Task Number 59

Build a physical model of the design.

Definition

Build of the physical model should accurately reflect the 3-D design.

Process/Skill Questions

- What is a scale model?
- What is the purpose of scale models? Prototypes?
- What are the benefits of using a physical model?
- What further steps are needed to finalize a physical model?

ITEEA National Standards

Apply Design Processes

Engineering Design

TSA Competitive Events

Animatronics

Engineering Design

Flight Endurance

Manufacturing Prototype

Structural Engineering

Visualizing Data

Task Number 60

Explain the nature and purposes of data visualization.

Definition

Explanation should include the concept of data visualization and purposes in a variety of fields (e.g., geospatial technologies, physics environments, visualizing satellite data, MRI, telemetry, thermal imaging, remote sensing).

Process/Skill Questions

- In what ways can numeric data be presented?
- Why is it important to present data visually?
- What effects has data visualization had on society?
- How does data visualization affect your life?

ITEEA National Standards

Assess the Impact of Products and Systems

Relationships Among Technologies and the Connections Between Technology and Other Fields

The Cultural, Social, Economic, and Political Effects of Technology

The Effects of Technology on the Environment

The Role of Society in the Development and Use of Technology

TSA Competitive Events

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Digital Video Production

Geospatial Technology (Virginia only)

Photographic Technology

Scientific and Technical Visualization (SciVis)

Technical Sketching and Application

Video Game Design

Task Number 61

Explain techniques for presenting data in a visual format.

Definition

Explanation should include the process by which data are converted to visual representations (e.g., graphs, 3-D models, charts, maps, vectors, rasters, coordinates) in a variety of fields (e.g., medicine, meteorology, topography).

Process/Skill Questions

- What is the difference between vectors and rasters?
- How is this difference important in data visualization?
- What are the relative strengths of the different visualization tools?
- How can you determine the best way to present numeric data?
- How can data be misrepresented?

ITEEA National Standards

Use and Maintain Technological Products and Systems

TSA Competitive Events

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Digital Video Production

Geospatial Technology (Virginia only)

Photographic Technology

Scientific and Technical Visualization (SciVis)

Technical Sketching and Application

Video Game Design

Task Number 62

Create a visual representation of data using student-collected data or a simulation model.

Definition

Creation should use the visualization process, which includes

- determining the data to be collected
- gathering the data (e.g., using GPS, using simulation results, surveying, identifying credible sources)
- interpreting the data
- creating a model to display the data, considering the purpose and audience
- describing the results represented by the model.

Process/Skill Questions

- What data are important to capture for a given representation?
- How much data are needed for an effective representation?
- What is the purpose of interpreting the data? Why is data interpretation critical?
- Who uses data to make decisions?
- What is the importance of an audience in building a model?

ITEEA National Standards

Assess the Impact of Products and Systems

Use and Maintain Technological Products and Systems

TSA Competitive Events

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Digital Video Production

Geospatial Technology (Virginia only)

Photographic Technology

Scientific and Technical Visualization (SciVis)

Video Game Design

Task Number 63

Animate a simulated behavior of a model.

Definition

Animation should serve a purpose of M&S activity and incorporate sequenced data that represent the state of a system over a given period.

Process/Skill Questions

- How can animation help visualize data?
- How do animations enhance human understanding beyond static models?
- How can the sequence of data affect the animation?

ITEEA National Standards

Assess the Impact of Products and Systems

Use and Maintain Technological Products and Systems

TSA Competitive Events

Computer-Aided Design (CAD)-Architecture 2D

Computer-Aided Design (CAD)-Engineering 3D

Digital Video Production

Geospatial Technology (Virginia only)

Photographic Technology

Scientific and Technical Visualization (SciVis)

Video Game Design

Evaluating Complex Systems

Task Number 64

Explain the nature of a complex vs. complicated systems.

Definition

Explanation should include the concepts that

- a complicated system contains multiple subsystems, each of which performs a specific function
- a complex system cannot be divided into its subsystems and still function; it often produces adaptive behavior
- the complex system exhibits complex behavior as a result of the interconnectivity of its subsystems (e.g., queuing, biological, computer integrated manufacturing, transportation systems).

Process/Skill Questions

- What are the differences between complex and complicated systems?
- Why are different models needed for different systems?
- What is the purpose of feedback within a complex system?
- Can simple models accurately describe complex systems? Why, or why not, using examples?

ITEEA National Standards

The Core Concepts of Technology

TSA Competitive Events

Animatronics

Engineering Design

System Control Technology

Video Game Design

Task Number 65

Explain data variables that would be necessary to effectively model a complex system.

Definition

Explanation should include data variables such as

- input variables (e.g., arrival time, volumes)
- process variables (e.g., customer service time, production time, transit time, inventory levels, error rate)
- output variables (e.g., profit, loss, total time in system, average time in queue, parts manufactured)
- simulation execution performance variables (e.g., events per second, frames per second, time scale, cost, weight).

Process/Skill Questions

- How does one decide which data to collect for modeling a complex system?
- What statistical tools can help ensure that data are valid?

- How confident can one be in the validity of a model?
- What is the importance of time studies?

ITEEA National Standards

Assess the Impact of Products and Systems

The Core Concepts of Technology

Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

System Control Technology

Video Game Design

Task Number 66

Develop models of complex systems.

Definition

Development should

- include accurate reflection and description of a real or conceptual system (e.g., a predator-prey relationship using difference equations; a discrete event simulation for customer service in a salon; the operation of traffic lights using finite state machines; the biological response of an ecosystem to a new species of fish using systems dynamics)
- be based on specifications, including
    - concept, input, and process variables
    - modeling and simulation methods (e.g., systems dynamics, discrete event simulation, agent-based modeling, multimethod)
    - modeling and simulation software.

Process/Skill Questions

- What role(s) do complex systems play in improving society?
- How do models help humans make predictions?
- How can models help humans make responsible decisions?

ITEEA National Standards

Apply Design Processes

The Core Concepts of Technology

Use and Maintain Technological Products and Systems

TSA Competitive Events

Animatronics

Architectural Renovation

Engineering Design

Geospatial Technology (Virginia only)

Principles of Technology (Virginia only)

System Control Technology

Video Game Design

Task Number 67

Conduct experiments using developed simulation models.

Definition

Conducting should include

- multiple executions
- controlled-variable modifications
- calibration
- optimization
- sensitivity analysis
- design of experiment (e.g., what-if scenarios).

Process/Skill Questions

- Why is input data typically random?

- What is meant by relevant output data?
- How do you decide the best measures of a system's performance?
- Why would you run an experiment multiple times?
- How can an experiment be refined?

ITEEA National Standards

Apply Design Processes

Assess the Impact of Products and Systems

The Core Concepts of Technology

Use and Maintain Technological Products and Systems

TSA Competitive Events

Geospatial Technology (Virginia only)

Video Game Design

SOL Correlation by Task

39	Describe models and simulations and the relationship between the two.	English: 10.5, 11.5, 12.5
40	Identify types of modeling and modeling tools.	English: 10.5, 11.5, 12.5 Science: PH.1, PH.2
41	Identify modeling methods.	
42	Identify types of simulation and simulation tools.	English: 10.2, 10.5, 11.2, 11.5, 12.2, 12.5 Science: PH.1
43	Explain the history of modeling and simulation.	English: 10.5, 11.5, 12.5 History and Social Science: WHII.2
44	Explain the modeling and simulation lifecycle.	English: 10.5, 11.5, 12.5
45	Explain the application of modeling and simulation in specific domains.	English: 10.5, 11.5, 12.5

46	Examine ethical and legal issues in modeling and simulation.	English: 10.5, 11.5, 12.5
47	Examine career opportunities in modeling and simulation.	English: 10.5, 10.8, 11.5, 11.8, 12.5, 12.8
48	Describe computer programming tools that can be used to develop models and simulations.	English: 10.5, 11.5, 12.5 Mathematics: COM.1, COM.2
49	Describe the principles of object-oriented programming.	English: 10.5, 11.5, 12.5 Mathematics: COM.1, COM.2
50	Describe the architecture of an existing simulation game.	English: 10.5, 11.5, 12.5 Mathematics: COM.1, COM.2
51	Design a program, using an algorithm, pseudocode, a flowchart, and/or a decision table.	Mathematics: COM.4, COM.9
52	Program an electronic simulation game for educational purposes.	Mathematics: COM.1, COM.2, COM.3, COM.4, COM.5, COM.10
53	Debug an electronic game program, using troubleshooting techniques.	Mathematics: COM.1, COM.2, COM.3, COM.4, COM.5, COM.17, COM.18
54	Explain the modeling and simulation process.	English: 10.3, 10.5, 10.8, 11.3, 11.5, 11.8, 12.3, 12.5, 12.8 Mathematics: G.3, G.14, COM.1, COM.2, COM.3, COM.17, COM.18, PS.10* Science: PH.4
55	Design a 3-dimensional object, using 3-D software.	Mathematics: G.14, COM.1
56	Analyze the 3-D model, using simulation software.	
57	Optimize the design.	
58	Verify the object's performance within a simulated environment or system.	Mathematics: COM.1
59	Build a physical model of the design.	Science: BIO.1, BIO.2, CH.1, ES.1, ES.2, PH.3
60	Explain the nature and purposes of data visualization.	English: 10.5, 11.5, 12.5 History and Social Science: GOVT.12 Science: ES.1, ES.8
61	Explain techniques for presenting data in a visual format.	English: 10.5, 11.5, 12.5

		History and Social Science: WG.1 Science: ES.1, PH.4, PH.6
62	Create a visual representation of data using student-collected data or a simulation model.	English: 10.5, 11.5, 12.5 Mathematics: A.9, AFDA.3, AII.9, COM.1, COM.2, PS.1*, PS.14, PS.15, PS.17, PS.2*, PS.3*, PS.4*, PS.7*, PS.8*, PS.10*, PS.16* Science: BIO.8, ES.1, PH.2, PH.4
63	Animate a simulated behavior of a model.	
64	Explain the nature of a complex vs. complicated systems.	English: 10.5, 11.5, 12.5
65	Explain data variables that would be necessary to effectively model a complex system.	English: 10.5, 11.5, 12.5
66	Develop models of complex systems.	History and Social Science: GOVT.1 Mathematics: A.4, A.9, AFDA.3, AFDA.4, AII.7, COM.1, COM.2, COM.6, COM.7, COM.8, COM.9, COM.10, COM.13, COM.14, COM.15, COM.16, COM.17, COM.18 Science: BIO.4
67	Conduct experiments using developed simulation models.	Mathematics: AFDA.3, AFDA.8, AII.9, PS.2*, PS.3*, PS.4*, PS.10*

Teaching Resources

Books

- 3*DS Max and Its Applications*. Eric K. Augspurger and Blake J. Fisher. Tinley Park, IL: Autodesk Goodheart-Willcox, 2004.
- *The Game Maker's Apprentice: Game Development for Beginners*. Jacob Habgood and Mark Overmars. Berkeley, CA: Apress, 2006.
- *GIS Fundamentals: A First Text on Geographic Information System*s. Paul Bolstad. White Bear Lake, MN: Eider Press, 2008.
- *Modeling & Simulation: A Model Curriculum for High Schools.* Norfolk, VA: Opportunity Inc. of Hampton Roads, 2008.
- *Simulation Model Design and Execution: Building Digital Worlds*. Paul Fishwick. Upper Saddle River, NJ: Prentice Hall, 1995.
- *Simulation with Arena*. W. David Kelton, et al. 4th ed. Columbus, OH: McGraw-Hill, 2007.

Websites

- Autodesk Education Community. http://students.autodesk.com. Provides free three-year licenses of Autodesk software.
- CGTrader. http://www.cgtrader.com. A 3-D model marketplace for computer graphics and 3-D printing.
- Cloudes. http://test.cloudes.me/. Web access to discrete event simulations.
- George Mason University College of Science. "Dynamic Modeling and Simulation." http://cos.gmu.edu/research/computing/modeling. Describes the university's modeling and simulation efforts and provides images of their work in areas such as biology, physics, astrophysics, Earth sciences, social sciences, and applied science.
- Logic Gate Simulator. http://www.kolls.net/gatesim. An open-source tool for experimenting with and learning about logic gates.
- The MMS Big Data Book Teacher Supplement Guide. https://sites.google.com/site/nasabigdata/. A supplement guide for teachers regarding data visualization and geographic information systems.
- Microsoft Virtual Academy. "Creative Coding through Games and Apps." https://mva.microsoft.com/en-US/training-courses/creative-coding-through-games-and-apps-12533?l=H9LnvClPB_4904668934. Offers online and in-class resources for teaching programming and gaming competencies.
- Microsoft Virtual Academy. "Game Production Basics." https://mva.microsoft.com/en-US/training-courses/game-production-basics-8395?l=sIZcTCJz_2104984382. Offers resources for teaching the basic elements of games, game assets, and how to make money in the gaming industry.
- NetLogo. http://ccl.northwestern.edu/netlogo/. A multi-agent programmable modeling environment.
- PhET Interactive Simulations. http://phet.colorado.edu/en/simulations/category/new. Website with educational simulation games.
- RevitCity. http://www.revitcity.com. A comprehensive resource for Revit content and one of the most active Revit communities.
- Simulation and Gaming Software Development Tools and Languages. http://eurosis.org/cms/?q=node/61. Website providing a curated list of free/open source software simulation and gaming development packages, along with others that are reasonably priced.
- TurboSquid. http://www.turbosquid.com. A digital media company that sells stock 3-D models used in 3-D graphics.
- Unity. https://unity3d.com. A development platform for creating multiplatform 3-D and 2-D games and electronic simulations.
- University of Southern California Institute for Creative Technologies. http://ict.usc.edu. Describes the Institute's development of interactive digital media to develop computer training simulations and other tools used for decision making, cultural awareness, leadership, and health.
- Unreal Engine 4. http://www.unrealengine.com. Source with free game development tools made by game developers.

- Virginia Modeling, Analysis and Simulation Center (VMASC). http://www.vmasc.odu.edu.

Software

The following list includes samples of some of the software commonly used in modeling and simulation; it is not intended as a list of recommendations.

- Adobe PhotoShop. http://www.adobe.com/products/photoshop/family.
- Adobe Premiere. http://www.adobe.com/products/premiere.
- Alice. Carnegie Mellon University download. http://www.alice.org.
- Arena. Rockwell Automation. http://www.arenasimulation.com.
- Blender. http://www.blender.org.
- GameMaker. For Apple Macintosh Computers. http://www.yoyogames.com/make.
- Google SketchUp. http://sketchup.google.com.
- Greenfoot. http://www.greenfoot.org.
- Multisim. National Instruments (NI) Multisim Student Edition. http://www.ni.com/academic/multisimse.htm.
- ProEngineer. http://www.ptc.com/products/proengineer.
- SolidWorks. http://www.solidworks.com.
- WestPoint BridgeBuilder. https://bridgecontest.org/resources/download/.

Design Briefs

Creating an ePortfolio

Suggested Learning Application

Task 11: Explain the application of modeling and simulation software to the study of a variety of academic topics.

Context

The ePortfolio is a learner-centered collection designed to empower students to acquire the 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 students have gained both in and out of school with peers, teachers, and prospective employers, as well as a way to encourage students to be proud of their achievements. In short, the ePortfolio provides a forum for developing personal competencies (e.g., 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 for creating an electronic portfolio, such as FrontPage, Dreamweaver, Word, or PowerPoint. To begin, the student should create a list of the attributes/skills/competencies that he/she and the teacher want to highlight. The student will then identify supporting artifacts that demonstrate those competencies. Artifacts can include Word documents, Excel files, assignments, research papers, digital images, audio files, scanned letters of recognition, and other formats. The student should use these artifacts to create an ePortfolio that will do the following:

- Show participation in activities.
- Demonstrate internship/work experiences.
- Announce professional memberships.
- Explain contributions to community, including community service projects.
- Create a plan of study.
- Maintain a dynamic résumé of relevant experiences in life, work, study, and at play.
- Store examples of professional achievements (e.g., documents, photos, graphics, spreadsheets, web pages).
- Create media-rich information to share with family, friends, employers, faculty, and others.
- Showcase 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 search and evaluation strategies while using electronic resources.
- Use technology tools to collaborate and publish their work.
- Develop a digital presentation.
- Develop an electronic portfolio (ePortfolio).
- Demonstrate appropriate use of an online library catalog.
- Present a multimedia presentation, including text, audio, and images, based on content from class work.

Materials

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

References

- Electronicportfolios.org, by Dr. Helen Barrett. http://electronicportfolios.org.
- ePortfolio. LaGuardia Community College. http://www.eportfolio.lagcc.cuny.edu.

Evaluation

Have students write a response to the questions, "What is an ePortfolio?" and "How does my ePortfolio meet these criteria?" Their response should include the following tasks:

- List information that could be placed in an ePortfolio.
- Explain the benefits of having an ePortfolio.
- Explain their reasons for selecting specific entries for their ePortfolio and for opting not to select others.

Dealing with Ethical Issues

Suggested Learning Application

Task #12: Examine ethical and legal issues in modeling and simulation.

Context

Ethical standards are the basis for being a good person and are the social rules that govern our behavior. Ethics in business is essentially the study of what constitutes 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 is a group of people who work together to achieve a common purpose. The moral challenges that these men and women face each day, while dealing with a whole range of problems, are the reason that 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 must follow. In summary, a good modeling and simulation 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. Students should read and answer the following questions as individuals, then in a team setting. Last, each team should come to a consensus and present its answers to the class.

Workplace Integrity Situations

The student should read the following situations carefully and give answers and explanations as directed by the teacher. The student should be prepared to discuss his/her explanation.

1. Your boss is working up a bank deposit. He/she drops a $20 bill on the floor, then 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/she hasn't noticed it yet. Do you pay the employee the money?

3. Your company is giving an aptitude test for its employees who 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 the boss that an employee fired last week was the one who made the mistake?
5. One night in an informal conversation, a colleague at your company shares with you an idea he/she has for improving a simulation developed by your department. Several weeks later, you have the opportunity to suggest this improvement in a private meeting with your supervisor. Do you present the improvement as your own idea and probably receive a monetary bonus?
6. 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?
7. You catch a shoplifter with $10 of merchandise. The shoplifter offers you $20 to ignore it. Do you take the money?
8. 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? After another year, the owner offers to make you a partner in the company. Now, do you fire your friend?
9. Your boss is considering someone in your department for a promotion. You know he/she is well qualified, but you dislike him/her strongly. Do you lie to your boss and say the person won't do a good job?
10. Your company desperately needs a loan. If you fill out the loan application honestly, you won't get the loan. Do you lie on the form?
11. Your boss asks you for a date. You don't like him/her, but he/she hints that it could help your career. Do you go?
12. 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?
13. You've been buying paper from the same excellent salesperson for the past 10 years. A competitor offers you a 20 percent price break. Do you switch suppliers?
14. Other businesses are boycotting a supplier because the company refuses to give up its racist hiring policies. The supplier offers you a substantial discount. Do you join the boycott?
15. (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?
16. A friend helped get you a job at a stereo store. After three months, you find out that your friend has been stealing from the cash drawer. Do you report your friend?
17. You're a plumber. You guarantee your work for 30 days. A client springs a leak in a pipe you fixed 31 days ago. Do you fix it for free?
18. A key employee has taken two weeks off due to the death of his/her mother. A crucial project in your department is overdue. Do you call and ask the employee to come back three days early?
19. You are a volunteer in a political campaign outside your job. Another volunteer sends you an urgent e-mail message at work and needs your immediate reply. You have left your cell phone in the car and have no alternative means to respond except your office e-mail. What should you do?

20. You have been assigned to prepare an electronic presentation for an important meeting tomorrow. After a quick web search, you find the perfect graphic to use in the presentation, but you see that it is copyrighted. What do you do?

Objectives

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

- Apply ethical and legal issues (including copyright) related to technology.
- Develop an understanding of professional and ethical responsibilities.
- Demonstrate 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. University of Ottawa, Canada. http://www.site.uottawa.ca/~oren/pubs/D81_Code.pdf.
- 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.
- 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.
- Conduct role plays on ethical dilemmas, followed by peer evaluations of students' ethical choices.
- Observe students in team interactions and assess the team dynamics.

Creating a Discrete Event Simulation (DES)

Suggested Learning Application

Task #27: Simulate a complex system.

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 20 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 at which 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 discrete 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 discover logic defects in the design or the sequence of events.

Suggested problems to simulate

- Determining how containers are currently moved (percent by rail or by truck)
- Determining the most efficient technology used for handling containers (e.g., straddle carriers vs. crane/hostler)
- Determining where containers are currently stored (on-site or remote, stacked or on chassis)
- Determining how terminals are expanded or how new storage yards are created
- Determining how inefficient gate operations can result in long queues of idling trucks
- Determining the costs of encroachment on surrounding wetlands
- Determining the costs of shifting tonnage from rail to truck
- Determining the costs 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.
- Interpret summary statistics.
- 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

Evaluation

Present simulation to the class for peer critique based on the following questions:

- Was the simulation valid?
- Did the simulation produce desired analysis?
- Was the simulation introduced and presented clearly and completely?

Entrepreneurship Infusion Units

Entrepreneurship Infusion Units may be used to help students achieve additional, focused competencies and enhance the validated tasks/competencies related to identifying and starting a new business venture. Because the unit is a complement to certain designated courses and is not mandatory, all tasks/competencies are marked “optional.”

Appendix: Credentials, Course Sequences, and Career Cluster Information

Industry Credentials: Only apply to 36-week courses

- Autodesk Certified Professional Examinations
- Autodesk Certified User Examinations
- Certified SOLIDWORKS Associate (CSWA) Examination
- College and Work Readiness Assessment (CWRA+)
- Modeling & Simulation Certification Examination
- National Career Readiness Certificate Assessment
- Workplace Readiness Skills for the Commonwealth Examination

Concentration sequences: *A combination of this course and those below, equivalent to two 36-week courses, is a concentration sequence. Students wishing to complete a specialization may take additional courses based on their career pathways. A program completer is a student who has met the requirements for a CTE concentration sequence and all other requirements for high school graduation or an approved alternative education program.*

- Digital Visualization (8459/36 weeks)
- Geospatial Technology I (8423/36 weeks)
- Graphic Communications Systems (8458/36 weeks)
- Graphic Communications Systems (8494/18 weeks)
- Programming (6640/36 weeks)
- Programming, Advanced (6641/36 weeks)

Career Cluster: Education and Training	
Pathway	**Occupations**
Teaching and Training	**Secondary School Teacher** **Training Consultant/Training Specialist**

Career Cluster: Information Technology	
Pathway	**Occupations**
Information Support and Services	**Applications Integrator** **Computer Numerical Control Programmer (CNC Programmer)** **Data Modeler** **Database Analyst** **Geographic Information Systems (GIS) Technician** **Multimedia Artist, Animator** **Systems Analyst**
Network Systems	**Computer Software Engineer**

Career Cluster: Information Technology	
Pathway	**Occupations**
	Database Analyst **Systems Analyst**
Programming and Software Development	**Computer Software Engineer** **Game Designer, Programmer** **Multimedia Artist, Animator** **Programmer**
Web and Digital Communications	**Game Designer, Programmer** **Multimedia Artist, Animator** **Systems Analyst**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
Engineering and Technology	**Aerospace Engineer** **Aerospace Engineering Technician** **Architect** **Biomedical Engineer** **Chemical Engineer** **Civil Engineer** **Civil Engineering Technician** **Commercial and Industrial Designer** **Computer Software Engineer** **Electrical Engineer** **Electrical Engineering Technician** **Electro-Mechanical Technician** **Electronics Engineering Technician** **Engineer** **Engineering Technician** **Environmental Engineer** **Industrial Engineer** **Industrial Engineering Technician** **Landscape Architect** **Manufacturing Systems Engineer** **Marine Engineer** **Materials Engineer** **Mechanical Engineer** **Mechanical Engineering Technician** **Nuclear Engineer** **Petroleum Engineer** **Power Systems Engineer** **Systems Analyst**
Science and Mathematics	**Atmospheric Scientist** **Biologist** **Chemist** **Ecologist** **Economist** **Environmental Scientist** **Geoscientist** **Hydrologist**

Career Cluster: Science, Technology, Engineering and Mathematics	
Pathway	**Occupations**
	Microbiologists **Oceanographer** **Research Chemist**