the Virtual Solar System Project at UGA

Team Astro

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OVERVIEW

The Virtual Solar System (VSS) project's goal is to develop deep understanding of planetary light and motion. This is a teacher professional development program to support teachers in taking advantage of the new possibilities of modeling enriched modeling-based inquiry learning environments. The project, both at the undergraduate and middle school levels, employs a pedagogical model we have developed called Modeling-based Inquiry. The model is based in constructionist and inquiry based models; however, its primary focus is on learners' construction of computational models to help them answer fundamental questions about planetary light and motion. The following is an outline of the major activities in Modeling-based Inquiry:

1. Begin with an inquiry question.
2. Plan the model & collect data.
3. Create a model of the phenomenon
4. Validate the model and revise if necessary.
5. Addressing the Question
6. Presenting the Results

From VSS Website: http://lpsl.coe.uga.edu/LIVE/VSS

MOTIVATION

The primary driving force of the VSS project is to integrate this software as a learning tool in K-12 classrooms. To achieve this goal, the principal investigator's must follow Everett Rogers' Diffusion of Innovations theory (Rogers, 1962), which is highly influential theory among instructional technologists. Thus, to achieve the final Diffusion of Innovations' goal of product adoption, the VSS Project team must train teachers how to use this software as an effective learning innovation in the classroom. This project also strives to fulfill many of the state and national standards (QCCs) so that teachers can blend this technology into their classroom and successfully meet curriculum goals. The QCCs can be found in *Appendix A*.

References

Rogers, Everett M. (1962). *Diffusion of Innovations*. New York: The Free Press.

CLIENTS

The clients for this instructional design program are the four primary investigators of this project. They are

·Dr. Kenneth Hay	*Department of Instructional Technology,Learning and Performance Support Laboratory*
·Dr. Lynn Bryan	*Department of Science Education*
·Dr. Norman Thomson	*Department of Science Education*
·Dr. Scott Shaw	*Department of Physics and Astronomy*

This project also influences the Learning and Performance Support Laboratory (LPSL) at the University of Georgia (UGA), and the National Science Foundation (NSF), which provides project funding.

PRIMARY STAKEHOLDERS

The primary stakeholders of this project are the four principal investigators and the LPSL. Additionally, the NSF is considered a stakeholder because of the direct funding they have provided in support of this project. The teachers who will be taught to use the VSS software in the classroom and the students who will use the software during their classroom instruction are also stakeholders in this process. Figure 1 shows the interconnected relationships among the stakeholders.

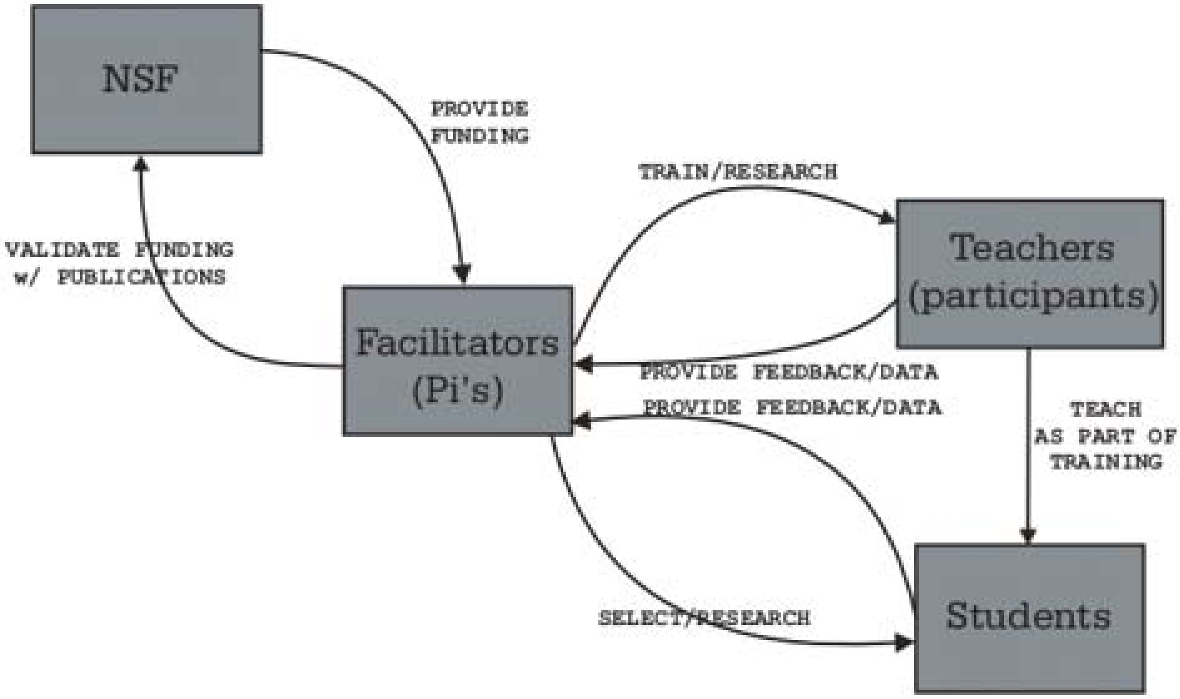

Figure 1 *The relationships among the stakeholders.*

TEAM ASTRO PROFILE

Tel Amiel	Current Position Education Experience Job Title Expertise Hometown	UGA-LPSL PhD Student - Instructional Technology BA - Communications, Virginia Tech MA - Communications & Human Computer Interaction, Virginia Tech Astronomicon Tech Support Web designer, Computer Lab Admin Interface Design, Design of Self Instruction Sao Paulo, Brazil
Ben Deaton	Current Position Education Experience Job Title Expertise Hometown	UGA - LPSL PhD Student - Instructional Technology Computer Science & Mathematics, BS, Carson-Newman College Computer Science, MS, Clemson University Computer programming, Web design Research assistant, web designer Programming, graphic design Jefferson City, TN
Sarah Grabowski	Current Position Education Experience Job Title Expertise Hometown	UGA - Graduate Student Master's Student - Instructional Technology BSED, Secondary Mathematics Education, UGA Student Teaching Bus Driver Fresh view of world Buffalo, NY
Jing Lin	Current Position Education Experience Job Title Expertise Hometown	UGA - LPSL PhD Student - Instructional Technology MS - Computerized Accounting Associate - Business Administration Network and Database Administrator Research Assistant Database Management, Astronomicon Beijing, China
Drew Polly	Current Position Education Experience Job Title Expertise Hometown	UGA - LPSL PhD Student - Instructional Technology MS - Curriculum and Instruction Old Dominion University BS - Exercise Science & Elem. Education 4 years teaching GA-InterMath Classroom Instruction Fairfax, Virginia

ANALYSIS

PURPOSE STATEMENT

The purpose of this training is to provide teachers with effective teaching strategies for using modeling-based inquiry with Astronomicon in their K-12 classrooms.

NEED FOR INSTRUCTION

The purpose of Instructional Design is to limit the performance gap exhibited by the learner. Instructional Design, however, can only address performance gaps that are based on a lack of knowledge and skills. For this project, some performance discrepancies will not be remedied with instructional design.

The lack of resources needed to design and implement modeling-based inquiry activities that integrate technology must be fixed. It is recommended that the client invests in hardware and software resources. Computers that are purchased must have the capacity to operate a high speed and have the hard drive space to store inquiry-based models that are created on a computer. In terms of software, programs that are used to design and develop inquiry-based models are recommended.

The learners also demonstrate a lack of motivation when it comes to integrating modeling-based inquiry into their lessons. Learners have become so accustomed to using alternative resources, such as textbooks, worksheets and videos, that they find modeling-based inquiry a hassle. More exposure to the benefits modeling-based inquiry, including the direct observation of a modeling-based inquiry lesson may improve the learner's lack of motivation.

PERFORMANCE ANALYSIS

Actual Performance	Desired Performance	Primary Cause	% of Total Discrepancy
80% were unable to describe models using basic and complex astronomical concespts.	Describe models using basic and complex astronomical concepts.	- Unaware of the components in the solar system (K+S) - Lack of information concerning key concepts in astronomy (K+S) - Learners have not had the need to learn basic and complex concepts in astronomy. (M)	30%

Performance Analysis cont.

100% were unable to explain the function and meaning of each menu item of the Astronomicon software.	Interpret the function and meaning of each menu item of the Astronomicon software	- Lack of knowledge associated with the Astronomicon software. (K+S) - Learners do not understand the benefits and applications of computer-based solar system models. (K+S) - Learners prefer not to use computer-based solar system models. (M) - Lack of access to computer software needed to design the model. (R)	14%
100% were not able to prepare a lesson plan for modeling-based inquiry activities using the Astronimicon software.	Prepare a lesson plan for modeling-based inquiry activities using the Astronimicon software.	- Lack of knowledge about how to prepare a modeling-based inquiry lesson (K+S) - Lack of knowledge about how to prepare lesson plans that integrate technology. (K+S) - Learners do not understand the benefit of modeling-based inquiry lessons in classroom instruction. (M) - Learners do not understand the benefit of technology integration into the classroom. (M) - Learners have not had the materials needed for modeling-based inquiry activities that integrate technology. (R)	14%

Performance Analysis cont.

100% were unable to teach complex astronomy concepts using Astronomicon models.	Teach complex astronomy concepts using Astronomicon models.	- Teachers are not familiar with the needed skills for using Astronomicon in accordance to complex astronomy concepts. (K+S) - Teachers do not know how to integrate modeling-based inquiry into their classroom (K+S) - Teachers dislike the the process of integrating technology in the classroom (M+R)	14%
100% were not able to assess the quality of peer and facilitator lesson plans using Astronomicon.	Assess the quality of peer and facilitator lesson plans using Astronomicon.	- Lack of knowledge about how to assess a modeling-based inquiry lesson (K+S) - Learners have not had to assess lessons based on modeling-based inquiry practices. (K+S) - Learners do not understand the benefit of modeling-based inquiry lessons in classroom instruction. (M)	14%

DISCREPANCY

Actual Performance

Teachers report having less than average skills when asked about their performance in basic astronomy, inquiry-based learning, modeling-based learning and knowledge of the State of Georgia's QCCs for astronomy (see Appendix B). These are some of the pillars of knowledge necessary to incorporate modeling-based inquiry astronomy into a middle or high-school curriculum.

Desired Performance

Teachers are expected to report having higher than average skills (seven points or higher, on a ten-point Likert scale) when asked about their performance in basic astronomy, inquiry-based learning, modeling-based learning and knowledge of the State of Georgia's QCCs for astronomy (see Appendix B).

Causes for Performance Gap

Teachers have no previous experience with a modeling-based astronomy software, which establishes a large performance gap (Knowledge and Skill). Moreover, teachers are reluctant to incorporate new technologies unless they conform to the State of Georgia's QCCs (Motivation). This training program will be able to target their knowledge and skill needs as related to basic astronomy concepts, inquiry and modeling based learning, and how they can be applied to the State of Georgia's QCCs. Motivation will not be addressed *directly* by instruction, but by demonstrating that the software can be incorporate to current curricula, teachers should be more willing to make us of it.

CONCLUSIONS

Training is needed in the delivery of this instructional process because of the performance gaps that exist in the teachers' needs. By providing training, the facilitators will be able to clearly define their goals and present a couse of action that will lead to successful technology integration in K-12 classrooms.

INSTRUCTIONAL GOALS

Upon completion of this training program, teachers who participate in the Virtual Solar System Project will be able to:

1. Describe models using basic and complex astronomical concepts.
2. Explain the function and meaning of each menu item of the Astronomicon software.
3. Prepare a lesson plan for modeling-based inquiry activities using the Astronomicon software.
4. Teach complex astronomy concepts using Astronomicon models.
5. Assess the quality of peer and facilitator lesson plans using Astronomicon software.

LEARNER ANALYSIS

The information presented here is derived from observations and a questionnaire (Appendix B) given to a group of students currently attending this class (Fall 2002).

Learner Group:

Ten students enrolled in class.

Characteristics:

The course is targeted at middle and high school teachers in the state of Georgia who wish to enhance their understanding of inquiry based learning through computer modeling tools. Average age is thirty-five. The course is expected to have a higher number of males then females (approximately two males for every three females).

Location:

The training will take place in Aderhold Hall (Room 618) at the University of Georgia during the teachers regular class time for ESCI 6130.

Experience:

General teaching experience is approximately ten years. Upon entering the course teachers report lower than average (less than five points on a one to ten point Likert scale) knowledge of basic concepts in astronomy (4.125), the State of Georgia's QCCs on astronomy (2.375), and on inquiry (4.25) and modeling (3.25) based learning, all of which are within the scope of the course. Teachers also perceive themselves as having less than average proficiency as astronomy teachers (3.25).

Attitude:

Teachers are open to the possibility of using practical modeling software in their classroom. Nevertheless, teachers face the pressures of meeting state QCCs, school demands, and time limitations, so a bit of apprehension regarding new technologies is common. If the activities in the software cannot be made to meet state QCCs. teachers are unlikely to incorporate it in their classroom. Still, teachers are excited about the prospect of using cutting-edge technology, and have a positive attitude towards inquiry-based learning.

Skills Related to Delivery Method

The Astronomicon software will run on any Windows-based machine. Teachers have demonstrated average-high ability to navigate through the Windows operating system, which should facilitate the use of the software. No training in this domain is expected.

RESOURCE ANALYSIS

Content Resources:

1. Online VSS manual.

Technology Resources:

1. Twenty Dell desktop computers with 15" monitors.
2. One facilitator desktop computer with projector.
3. Astronimocon software installed on all computers.
4. Four digital camcorders for data collection.
5. One camcorder for data collection.
6. One television and VCR.

Instructional Facilities:

The computer lab in Room 618 of Aderhold Hall at the University of Georgia will serve as the primary instructional facility.

Human Resources:

1. Dr. Kenneth Hay, Primary Investigator (PI) -
   Dr. Hay will serve as facilitator and Astronimicon expert. He has been an Instructional Technology faculty member at the University of Georgia since 1999 where he serves as the director of the LIVE (Learning in/with Virtual Environments) in the Learning and Performance Support Laboratory (LPSL).
2. Dr. Lynn Bryan, PI -
   Dr. Bryan is a faculty member in the Science Education department at the University of Georgia. She will serve as one of the teacher's facilitators, primarily focusing on inquiry within the classroom.
3. Dr. Norm Thomson, PI -
   Dr. Thomson, who will also serve as a facilitator, is also a faculty member in the University of Georgia's Science Education department.
4. Dr. Scott Shaw, PI and Content Expert -
   Dr. Shaw is a professor of Astronomy at the University of Georgia. He will serve as the astronomy content expert during this training.
5. Dr. Art Recesso, Research Scientist -
   Dr. Recesso is a new faculty member in the Instructional Department at the University of Georgia. His responsibilities include the management and handling of the 3DPD projects in the LPSL and working with the teachers in the VSS instructional process.

Attitude:

The professors who take part in this project are solidly united in changing the pedagogy that dominates today's K-12 classrooms. They are determined to provide every resource and accomodate the needs of each and every teacher that takes part in this instruction.

Instructional Options

The client has two options for instruction with Astronomicon, the modeling-based inquiry software program. The cost estimates are shown in Figure 2.

Option A

Option A involves providing the learners with a copy of the software, a manual on how to use the software and providing on-line support. On-line support would feature an on-line chat room for help during normal business hours (9-5 p.m. Monday-Friday). *Appendix C* contains a more detailed cost estimate for Option A.

Option B

Option B involves guided learning of the Astronomicon software. Learners would be instructed in a location feasible for them and undergo workshops that would present theories of modeling-based inquiry and the principles of both modeling-based inquiry and technology integration. The workshops would walk learners through the use of Astronomicon and the process of developing lessons that utilize the software. Option B also includes a direct observation approach, where we will bring in a group of high school students and demonstrate to the learner the implementation of Astronomicon. In addition, learners will have the opportunity during that session to also demonstrate their proficiency of Astronomicon and practice applying it in a simulated classroom environment. *Appendix D* contains a more detailed cost estimate for Option B.

	Option A	**Option B**
Analysis Phase	$4,400	$4,400
Design Phase Manual Classroom Training	 $6,000 	 $6,000 $1,800
Developmental Phase	$9,000	$21,600
Implementation Phase	$6,400	$1,975
Evaluation Phase	$4,400	$4,400
Total	$30,200	$40,175
Estimate Costs	**$24,160 - $36,240**	**$32,140 - $48,210**

Figure 2. *Cost-estimate table for Options A and B.*

PROBABLE DELIVERY SYSTEM

This section outlines the recommended course of training, which divides the training program is divided into four phases. The phases are described below.

1) *One week self-instruction:* The teachers will receive the software and its manual to take part in a one week self-instruction phase. During this phase, the teachers will familiarize themselves with the software and prepare a catalog of questions that might arise during the self-instruction process.
2) *Classroom Instruction*: After the teachers have become acquainted with the software, they will be provided with four weeks of intense classroom instruction. The facilitators will provide the teachers with training from content experts in the areas of inquiry methodology, astronomy, and software training.
3) *Applied Demonstration of Learning*: During the third phase of the training, the teachers will receive real-world experience using both the VSS software as a classroom tool and the Modeling-based Inquiry methodology. This experience will place the teachers in a classroom with approximately twenty middle school students for three 3-hour sessions. They, in turn, will be required to teach the students how to use the astronomy software based upon the training they received in the second phase of training.
4) *Instructor Feedback*: After the teachers have completed the third training phase, the training facilitators will evaluate their performance and provide feedback. This feedback will offer strategies for enriching their teaching methods with the astronomy software, and provide suggestions for instructional reform.

OPTION SIGN-OFF

___ Option A
___ Option B

Kenneth Hay
Project PI

____
Signature Date

Lynn Bryan
Co-PI

____
Signature Date

Norm Thomson
Co-PI

____
Signature Date

Art Recesso
Co-PI

____
Signature Date

Ben Deaton
Design Team

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Signature Date

DESIGN

PURPOSE STATEMENT

The purpose of this training is to provide teachers with effective teaching strategies for using modeling-based inquiry with Astronomicon in their K-12 classrooms.

PERFORMANCE GOALS

1. Describe models using basic and complex astronomical concepts.

2. Explain the function and meaning of each menu item of the Astronomicon software.

3. Prepare a lesson plan for modeling-based inquiry activities using the Astronomicon software.

4. Teach complex astronomy concepts using Astronomicon models.

5. Assess the quality of peer and facilitator lesson plans using Astronomicon software.

Testing Strategies

Goal 1: Describe models using basic and complex astronomical concepts.

Task	Objective	Test Item
Summarize Georgia's QCC requirements for astronomy.	In groups, summarize six of Georgia's QCC for astronomy.	Given a piece of paper, write down 6 of the 12 Georgia QCC's for astronomy in a group of three or four students.
Summarize basic astronomy concepts.	In groups, summarize the basic astronomy concepts with 90% accuracy.	Using an e-document, type all of the basic astronomy concepts in a group of three or four students.
Summarize complex astronomy concepts.	In groups, summarize complex astronomy concepts with 85% accuracy.	Using an e-document, type all of the complex astronomy concepts in a group of three or four students.
Describe models using basic and complex astronomical concepts.	When given a model, describe the model using basic and complex astronomy concepts with 95% accuracy.	Given a model, describe the model using basic and complex astronomy concepts in an e-document.

Goal 2: Explain the function and meaning of each menu item of the Astronomicon software.

Task	Objective	Test Item
Install the Astronomicon software.	Install the Astronomicon software to your personal computer according to installation directions.	Open the Astronomicon program on your personal computer.
Show use of basic computer skills (i.e., using the keyboard, mouse, and opening a file).	Show use of basic computer skills in a simulated environment with 95% accuracy.	In a computer room, open a word-processing file by using the mouse and type your name in the first line.
Describe the function of each menu category in Astronomicon.	When the menu categories in Astronomicon are given orally, describe their functions with 85% accuracy.	Given 10 menu categories from Astronomicon orally, describe their functions in an e-document.
Identify all of the keyboard commands associated with Astronomicon.	In a simulated environment, identify all of the keyboard commands of Astronomicon with 90% accuracy.	Given a photocopy of a keyboard, identify all of the keyboard commands from Astronomicon by written response on the keyboard.
Identify menu under which specific functions are listed in Astronomicon.	When the functions in Astronomicon are given orally, identify their menu with 85% accuracy.	Using the Astronomicon software, click on the menu item that contains the function given orally.
Summarize the effects of keyboard commands on visual perspective in Astronomicon.	When the keyboard commands on visual perspective from Astronomicon are given on the screen, summarize their effects with 90% accuracy.	Given all keyboard commands on visual perspective from Astronomicon visually, summarize their effects in an e-document.
Explain the function and meaning of each menu item in Astronomicon.	When the menu items in Astronomicon are given orally, explain their function and meaning with 90% accuracy.	Given 10 menu items from Astronomicon orally, explain their function and meaning in an e-document.

Goal 3: Prepare a lesson plan for modeling-based inquiry activities using the Astronomicon software.

Task	Objective	Test Item
Generate a lesson plan in teaching activities.	In a word processor, create a lesson plan for a lesson that does not utilize modeling-based inquiry with 90% accuracy.	In a word processor, construct a lesson plan that incorporates the necessary components of a lesson, but does not employ modeling-based inquiry.
Summarize the concepts and principles of modeling-based inquiry.	On paper, identify and explain key concepts of modeling-based inquiry with 100% accuracy.	On a piece of paper, write three sentences for four of the key concepts of modeling-based inquiry.
Review examples of lesson plans that are effective in teaching modeling-based inquiry.	In a stack of 10 lesson plans that are effective in teaching modeling-based inquiry, evaluate the criteria of a modeling-based inquiry lesson with 100% accuracy.	Given ten lesson plans that are effective in teaching modeling-based inquiry, create a diagram about items for each lesson. The diagram will include the concepts of modeling-based inquiry that are present and the details concerning what makes this lesson effective.
Integrate a previously designed modeling-based inquiry lesson using the Astronomicon software into a classroom activity.	In a classroom of middle school students, teach a previously designed modeling-based inquiry lesson using the Astronomicon software with 85% effectiveness.	Given a classroom of students, teach a previously designed modeling-based inquiry lesson using the Astronomicon software that will be evaluated by a facilitator using the evaluation rubric.
Identify the performance objectives for the lesson.	Write four performance objectives for a lesson that teaches modeling-based inquiry using the Astronomicon software with 85% accuracy.	Given behavior goals, write four performance objectives on paper that contains the necessary components for correctly written performance objectives.
Select teaching strategies.	Select teaching strategies and the medias that will be used in a lesson that teaches modeling-based inquiry using the Astronomicon software with 85% accuracy.	On a piece of paper, write four teaching strategies and two medias that will be used for a lesson plan that teaches modeling-based inquiry using the Astronomicon software.

Goal 3 continued

Task	Objective	Test Item
Select learner assessment measures.	Select the measure and method of assessment for a lesson that teaches modeling-based inquiry using the Astronomicon software with 85% accuracy.	In a word processor, construct two measures and methods of assessment for a lesson plan that teaches modeling-based inquiry using the Astronomicon software.
Prepare a lesson plan for modeling-based inquiry activities using the Astronomicon software.	Construct a lesson plan for a modeling-based inquiry activity using the Astronomicon software with 90% accuracy.	In a word processor, construct a lesson plan for a modeling-based inquiry activity using the Astronomicon software.

Goal 4: Teach complex astronomy concepts using Astronomicon models.

Task	Objective	Test Item
Model a Sun-Earth-Moon system using physical objects (i.e., softballs).	In a simulated environment, model a Sun-Earth-Moon system using physical objects with 100% accuracy.	Given a baseball, softball and golf ball, model a Sun-Earth-Moon system.
Identify the components of developed solar system model in Astronomicon.	Correctly identify 90% of the components of a developed solar system model according to the NASA website.	Using an e-document, type all of the components of a developed solar system model.
Apply keyboard and menu skills to maneuver through a developed solar system using Astronomicon.	In a simulated environment in Astronomicon, apply keyboard and menu skills to maneuver through a developed solar system with 100% accuracy.	Given a solar system in Astronomicon, maneuver through it using keyboard and menu skills according to the teacher's oral directions.
Create a star in Astronomicon.	Using the Astronomicon software, create a star with 100% accuracy.	Given a new file in Astronomicon, create a star.
Create a planet in Astronomicon.	Using the Astronomicon software, create a planet with 100% accuracy.	Given a new file in Astronomicon, create a planet.
Create a parent-child relationship between planets/stars in Astronomicon.	Using the Astronomicon software, create a parent-child relationship between planets/stars with 100% accuracy.	Given a file with a star and a planet, force the planet to revolve around the star.
Generate a solar system model using Astronomicon.	Using the Astronomicon software, generate a solar system model with 100% accuracy.	Given a new file in Astronomicon, generate a working solar system model.
Design an instructional unit using Astronomicon to illustrate complex astronomical concepts (i.e., seasons, phases).	Using the Astronomicon software, design an instructional unit to illustrate complex astronomical concepts with 90% accuracy.	Given a new file in Astronomicon, design all of the 4 given complex astronomy concepts.
Teach complex astronomy concepts using Astronomicon models.	Given models created in Astronomicon, teach complex concepts using the models to astronomy students with 90% accuracy.	Given a model in Astronomicon, create a lesson to teach classmates about the concept(s) associated with that model.

Goal 5: Assess the quality of peer and facilitator lesson plans using Astronomicon software.

Task	Objective	Test Item
Generate an evaluation rubric for a lesson plan that does not involve modeling-based inquiry.	Create a rubric with at least six areas of evaluation and three levels of performance to effectively assess a lesson plan that does not incorporate modeling-based inquiry with 90% accuracy.	In a word processor, create a rubric with at least six areas of evaluation and three levels of performance to effectively assess a lesson plan that does not incorporate modeling-based inquiry.
List components of an effective evaluation rubric for a modeling-based inquiry lesson plan.	Create a list that lists and describes components of an effective evaluation rubric for evaluating a modeling-based inquiry lesson using the Astronomicon software with 100% accuracy.	On a piece of paper list and describe five components of an effective evaluation rubric for evaluating a modeling-based inquiry lesson using the Astronomicon software.
Generate an evaluation rubric for peer and facilitator plans teaching modeling-based inquiry using Astronomicon.	Create a rubric for peer and facilitator lesson plans that contains three levels of performance and a well-defined description for each level of performance with 100% accuracy.	Using desktop publishing software, create a rubric for peer and facilitator lesson plans that incorporate at least six areas of evaluation and three levels of performance.
Assess the quality of peer and facilitator lesson plans using Astronomicon software.	Using the rubric that was created, evaluate three peer lesson plans and one facilitator lesson plan that employ modeling-based inquiry using the Astronomicon software with 90% accuracy.	Using the rubric that was created, evaluate three peer lesson plans and one facilitator lesson plan that employ modeling-based inquiry using the Astronomicon software.

DEvelopment

Lesson Plans

LESSON 1: Generate solar system model using Astronomicon

Event	Instructional Strategy	Teacher/Student	Media
Gain attention	Ask a volunteer to show an accurate solar system model using a baseball, softball and a flashlight	Teacher: request volunteer or select a student if no volunteersStudent: one student must volunteer	Baseball, softball, and working flashlight
Objective	Using the Astronomicon software, generate a solar system model with 100% accuracy		
Prerequisite	Model a Sun-Earth-Moon system using physical objects (i.e. softballs) Identify components of developed solar system model on Astronomicon Apply keyboard and menu skills to maneuver through a developed solar system in Astronomicon Demonstrate ability to create a parent-child relationship between planets/stars in Astronomicon Demonstrate ability to create a planet in Astronomicon Demonstrate ability to create a star in Astronomicon		
Content	Demonstrate how to create asolar system model using Astronomicon containing a planet, a satellite and a star	Teacher: Present information through a computer projector	Computer with Astronomicon connected to a LCD projector
Guided Practice	Students will create a solar system model using Astronomicon, following the guidance of the teacher	Teacher: Present information through a computer projector Student: While teacher demonstrates use Astronomicon to create solar system model	Computer with Astronomicon for the teacher and each student Teacher computer connected to a LCD projector

LESSON 1 continued

Event	Instructional Strategy	Teacher/Student	Media
Independent Practice	Using the previously created solar system model created in Astronomicon, modify it to contain real data for the Sun-Earth-Moon system	Student: create model using Astronomicon	Computer with Astronomicon for each student Handout containing astronomical parameters related to the Sun-Earth-Moon system for each student
Feedback	Three randomly selected students will demonstrate their solar system to the class using the computer with LCD projector	Teacher: select three students Students: demonstrate created solar system	Computer with Astronomicon for the teacher and each student
Assessment	Student/peers will provide verbal feedback on each other's models, created in Astronomicon (5 minutes).	Teacher: observe discussionsStudents: Pair up and discuss the Astronomicon model	
Closure	Teacher will guide a 10-minute discussion on the merits of observing a solar system in Astronomicon versus the baseball-softball-flashlight model	Teacher: Guide discussion	

LESSON 2: Summarize the concepts and principles of modeling-based inquiry.

Event	Instructional Strategy	Teacher/Student	Media
Gain attention	Ask students to memorize facts and parameters related to astronomy, mimicking an insipid class on astronomy Question students on these facts and parameters	Teacher: deliver small lecture; cue students on facts and parameters Students: Answer questions	
Objective	On paper identify and explain key concepts of modeling-based inquiry with 100% accuracy		
Prerequisite	Generate a lesson plan in teaching activities that does not involve modeling-based inquiry		
Content	Lecture on inquiry based learningExplain the how modeling aids the process of inquiryExplain how Astronomicon can be used in the process of modeling based inquiry	Teacher: Deliver lecture	Transparency projector
Guided Practice	Working in groups of three or four students, given a lesson plan, identify which elements emphasize inquiry-based learning Modify elements that do not so that they emphasize inquiry-based learning,	Teacher: Handout lesson plan Students: Get into groups of three or four	Lesson plan printed on paper
Independent Practice	Students will reflect on their group experience and write a short paragraph discussing their perceptions of inquiry-based learning	Student: Write reflections Teacher: Observe, answer any questions	
Feedback	Student groups will lead a short discussion on what they identify as an important element of modeling-based inquiry		

LESSON 2 continued

Event	Instructional Strategy	Teacher/Student	Media
Assessment	On a piece of paper, write three sentences each for four of the key concepts of modeling-based inquiry	Teacher: Handout paper Students: Complete quiz	A quiz for each student, on paper
Closure	Summarize the key differences between traditional and modeling-based inquiry based approaches to learning	Teacher: Deliver lecture	

LESSON 3: Summarize the effects of keyboard commands on visual perspectives (self-instruction through online manual).

Event	Instructional Strategy	Teacher/Student	Media
Gain attention	Student will play web-based video demonstrating the use of Astronomicon software to navigate through a Star-Planet system	Student: Play video	Computer with Astronomicon and Internet connection
Objective	When the keyboard commands on visual perspective from Astronomicon are given on the screen, summarize their effects with 90% accuracy		
Prerequisite	Identify all of the keyboard commands associated with Astronomicon		
Content	Student will use Internet-based tutorial demonstrating the visualization features of Astronomicon (yaw, pitch, roll, etc)	Student: Navigate through the tutorial	Computer with Astronomicon and Internet connection
Guided Practice	Internet-based tutorial will ask students to open a previously designed Star-Planet system in Astronomicon Students will attempt to recreate a perspective using the Astronomicon software (i.e. view system from above) After each attempt the student should move to the next section of the tutorial which will debrief the student on how the perspective could be accomplish using Astronomicon	Student:Download the previously designed system by clicking on a web link Open system in Astronomicon Navigate through the tutorial Attempt each visualization using Astronomicon	Computer with Astronomicon and Internet connection

LESSON 3 continued

Event	Instructional Strategy	Teacher/Student	Media
Independent Practice	Given a Star-Planet-Satellite system, use the learned visualization tools to navigate through the system		Computer with Astronomicon and Internet connection
Feedback	Students will compete a short web-based survey providing feedback on the completed module	Student:Complete feedback form	Computer with Internet connection
Assessment	Given an open ended web-based questionnaire delineating a sequence of keyboard commands, identify the resulting change in perspective from a list of Astronomicon screen captures and summarize the reason for your selection	Student: Complete web based quiz	Computer with Internet connection
Closure	Tutorial will present a summary of the keyboard commands that have an effect on perspective and visualization		Computer with Internet connection

LESSON 4: Generate an evaluation rubric for lesson plans teaching modeling-based inquiry using Astronomicon.

Event	Instructional Strategy	Teacher/Student	Media
Gain attention	Discuss the problems with an activity where students can get full points or no points (zero or one-hundred) and the need for a rubric	Teacher: Facilitate discussion	
Objective	Create a rubric for peer and facilitator lesson plans that contains three levels of performance and a well-defined description for each level of performance with 90% accuracy		
Prerequisite	List components of an effective evaluation rubric for a modeling-based inquiry lesson plan Generate an evaluation rubric for a lesson plan that does not involve modeling-based inquiry		
Content	Summarize the differences between a rubric for lesson plans not involving modeling-based inquiry and those that do Verbally emphasize the components of a rubric for a lesson plan using modeling-based inquiry giving examples	Teacher: Present information	Computer with slideshow software (i.e., PowerPoint)
Guided Practice	Students will be given a previously designed rubric. The instructor will discuss each section of the rubric and if it is suited to modeling-based inquiry	Teacher: Facilitate discussion Students: Participate in discussion	Paper copies of previously designed rubric for each student
Independent Practice	Students will be given a previously designed lesson plan for Astronomicon. Each student should, independently, create a rubric for the given lesson plan (rough draft)	Teacher: Answer questions Student: Design rubric (written)	Piece of black paper for each student to write on

LESSON 4 continued

Event	Instructional Strategy	Teacher/Student	Media
Feedback	Instructor and students will engage in discussion about issues/concerns/problems related to generating a rubric for a lesson plan involving modeling-based inquiry	Teacher: Facilitate discussion	
Assessment	Students will return to the rubric rough draft and make changes based on the class discussion	Teacher: Collect modified rough draft Student: Turn in modified rough draft to teacher for assessment	
Closure	Summarize the elements of a well-designed rubric for a lesson plan including modeling-based inquiry Handout a previously designed rubric that is judged to be of good quality (serves as a reference and summarizes presented concepts)	Teacher: Handout rubric	Media: Handout (paper copies)

LEARNER GUIDE - TABLE OF CONTENTS

FACILITATOR GUIDE - TABLE OF CONTENTS

PILOT TEST PLAN

Participants	Four teachers with no previous exposure to the Astronomicon software will participate in the pilot test. This number is based on the average number of students that will participate in a regular classroom setting.
Prerequisites	The participants are expected to have knowledge of both basic computer skills and astronomy concepts. Critical thinking skills are also required for the participants to be able to successfully engage in incorporating modeling-based inquiry methods into their lessons.
Location, Date, Time	The pilot test will be conducted in the LPSL conference room, located on the sixth floor of Aderhold Hall at the University of Georgia in Athens, Georgia. The initial training will take place on January 17, 2003 and January 24, 2003 from 10:00 A.M. to 2:30 P.M. A review session will take place on February 7, 2003 at 2:00 P.M.
Instructional Environment	The LPSL conference room contains a projection unit with a Dell Pentium machine. Additionally, laptops with the Astronomicon software will be provide for each participant. This facility provides ample room for training to take place. The offices of the LPSL are open from 9:00 A.M - 4:30 P.M. If the participants wish to work with the software at this time, the graduate assistants working on the project will be available to help those participating in the Pilot Study.
Facilitator Qualifications	The facilitator is required to have the following qualifications: ▫ Experience with the Astronomicon software (at least 6 months, or equivalent training). ▫ Experience working with the modeling-based inquiry pedagogy. ▫ Experience working with teachers.

PILOT TEST PLAN continued

Evaluation Plan	The participants' progress will be measured at the completion of each training session. They will be asked to demonstrate the following procedures, as observed and evaluated by the facilitator: 1. Participants will be required to demonstrate each of the lessons that are demonstrated to them. They will be given documentation and support as needed. 2. Participants will discuss and demonstrate cognition of the astronomy concepts that are discussed in each training session. 3. Participants will write summaries on how to incorporate modeling-based inquiry into their own classrooms. This process will be undertaken after each training session. After the second session is completed, the lead facilitator and the Instructional Design team will evaluate the quality of the sessions. They will then formulate a course of action in designing instruction needed for the review session to address areas of inadequacy in regards to the Astronomicon software.
Pilot Team Description	The evaluation team will be comprised of: ▫ The facilitator, who will lead the Pilot Test ▫ Three members of the Instructional Design Team ▫ Two subject matter experts (one for astronomy and another for inquiry-based learning)

Implementation

LEARNER PLAN

Participants	Participants for the "Learning to Use Astronomicon" will be K12 teachers with no experience using the Astronomicon software.
Schedule	*Logistics* ▫ The class will be held in the Fall 2003 on Thursday nights. ▫ The class will meet in Room 618 of Aderhold Hall at the University of Georgia in Athens, Ga. *Registration* Participants must be a registered graduate student at the University of Georgia. *Registration* DeadlineRegistration must be completed by August 15, 2003. *Resources Needed* ▫ Television and VCR ▫ 15 PCs ▫ Astronomicon software ▫ Computer projector
Notifications and Communications	Each participant will receive (see attachment).
Tracking	Tracking of participants involvement in the ESCI 6130 is an important task. Information that should be considered to include in this tracking system includes: participation records from their teaching experience. Records should be maintained for a time of no less than 4 years. Participants will be tracked by name and instructor evaluation, which is to be completed throughout the duration of the course. The participant survey evaluation of the ESCI 6130 class will be completed immediately following the final class meeting. Completed evaluations are to be submitted immediately following the course's conclusion.

Example Invitation Letter

Dear Mr. Doe,

Your registration for ESCI 6130 has been received. We are excited that you have chosen to participate in this course and we look forward to helping you further develop your classroom technology integration skills!

When: Aug. 21 – Dec. 12 5:00 P.M. – 7:45 P.M.
Where: University of Georgia
Aderhold Hall
Room 618
Athens, GA

We have assembled a highly qualified and enthusiastic group of professors and graduate students to facilitate the course this year. We are fully confident that you will take a lot away from this experience and that you will enjoy your time here developing your classroom skills. You will find the program guide and objective outlines enclosed. Please make an effort to review them before your visit with us.

Be sure to bring an open mind and a positive attitude!

Sincerely,

Kenneth E. Hay
LPSL - UGA

FACILITATOR PLAN

Facilitators	1 Lead Facilitator ▫ 3 years experience with Astronomicon 5 Assistant Facilitators -Minimum 2 years experience with Astronomicon ▫ Worked under the direction of the lead facilitator *Additional facilitators may be guest speakers*.
Schedule	Astronomicon: Facilitator Workshop When: May 12, 2003, 9:00 AM - 3:00 PM Where: Aderhold Hall, LPSL Conference Room ESCI 6130 When: Aug. 21 - Dec. 12 2003 Time: 5:00 PM - 7:45 PM, Fall 2003
Notification	The assistant facilitators will be notified of the date and time of the workshop by the lead facilitator.
Preparation	Each person selected as facilitator should: ▫ Read the facilitators and participants guide, learner profile, and analysis summary ▫ Contact the ISD coordinator if any questions/concerns arise ▫ Attend the Train the Trainer Workshop

ESCI 6130: FACILITATOR WORKSHOP
Date: May 12, 2003, 9:00 AM - 3:00 PM

9:00 AM - 9:30 AM	Introductions and Objectives
9:30 AM - 10:00 AM	Overview of lead facilitator's research goals
10:00 AM - 11:00 AM	Course Overview ▫ Review ▫ Learner Profile ▫ Purpose ▫ Objectives
11:00 AM-11:30 AM	Review the facilitator guide
11:30 AM-12:30 PM	Lunch provided by Golden Dragon
12:30 PM - 12:50 PM	Present training event agenda
12:50 PM - 2:50 PM	Train-the-trainer lessons (see next page)
2:50 PM - 3:00 PM	Final Questions/Closing

Train-the-Trainer Exercises

Note: Each team of facilitators will consist of 2 assistant facilitators. Each team will be assigned one module and will then present to the group.

Exercise 1:	Assign module 1 (Astronomy Concepts) to a team of facilitators. They will: ▫ Summarize the main points in the module ▫ Describe the goals and learner outcomes ▫ Describe a minimum of one training inadequacy ▫ Give a recommendation for the handling of potential problems they see arising during the training
Exercise 2:	Assign module 2 (Modeling-based Inquiry) to a team of facilitators. They will: ▫ Summarize the main points in the module ▫ Describe the goals and learner outcomes ▫ Describe a minimum of one training inadequacy ▫ Give a recommendation for the handling of potential problems they see arising during the training
Exercise 3:	Assign module 3 (Learning to Use Astronomicon) to a team of facilitators. They will: ▫ Summarize the main points in the module ▫ Describe the goals and learner outcomes ▫ Describe a minimum of one training inadequacy ▫ Give a recommendation for the handling of potential problems they see arising during the training
Exercise 4:	Assign module 4 (Designing a Lesson in Modeling-based Inquiry with Astronomicon) to a team of facilitator. They will: ▫ Summarize the main points in the module ▫ Describe the goals and learner outcomes ▫ Describe a minimum of one training inadequacy ▫ Give a recommendation for the handling of potential problems they see arising during the training
Exercise 5:	Facilitator team will evaluate the effectiveness of Exercises 1 - 4. Give recommendations for Teams 1 - 4 lesson oversights. This will serve as practice for the future critiquing and evaluating of participants.

IMPLEMENTATION PLAN ENDORSEMENT

Kenneth Hay
Project PI

Signature Date

Lynn Bryan
Co-PI

Signature Date

Norm Thomson
Co-PI

Signature Date

Art Recesso
Co-PI

Signature Date

Ben Deaton
Design Team

Signature Date

EVALUATIOn

PHILLIPS' LEVELS OF EVALUATION

Level	Objectives	Task	Data Collection Methods and Measurement Tools	Timing	Responsibility
1	Reaction and Satisfaction	Determine learners' perception to training and facilitator	Written questionnaire using a Likert scale of 5 units of measurements on the last day of training	End of Training	Each learner will answer anonymously and is responsible to turn in the evaluation information.
2	Learning	Demonstrate the knowledge and skills in a performance-based environment	Subjective test on the knowledge of Astronomy and Astronomicon software	End of Session	Learners will take the exam organized by the and Facilitators
3	Application	Demonstrate the knowledge and skill needed to prepare lesson plans for modeling-based inquiry activities using Astronomicon	Written documentation of the observation checklists for the teaching activities Interviews with supervisors and students Self-evalution form of performance comparison	Every other week after the training	Supervisors will responsible to make field note observations and interview students. The documents will be returned to the training manager. Learners will return the evaluation forms.
4	Business Impact	80% of teachers will make use of modeling-based inquiry practices using Astronomicon in their Astronomy courses	Survey will be mailed to school principles once every 6 months for 3 years.	Every other month after the training	Supervisors will mail the survey to school principles who will return the survey within two weeks.
5	ROI	Achieve 140% ROI in the semester following the training program	Compare the students' knowledge of Astronomy with whose who learned in traditional way by gathering average student scores on Astronomy final exam.	Every 6 months after the training for three years	Supervisor will direct the data collection and data analysis processes. Learners will report the student scores to the supervisor.

Evaluation Forms

The following pages represent:

Level 1 Evaluation
Level 2 Evaluation
Level 3 Evaluation

COURSE EVALUATION

Directions for completing evaluation:
Use blue/black ink or #2 pencil
Fill in circle completely
Use white out to erase mistakes

Course Content

1. Course Objectives, as stated, were met

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

2. Course content was relevant to your needs

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

3. Couse objectives were appropriate

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

4. Sufficient instructions were given to allow me to apply learned skills on my job

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

5. Online manual supported my learning.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

6. The class activities added value to my learning.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

7. Couse activities enhanced my understanding of the skills

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

8. The delivery method was appropriate.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

9. The evaluation methods enhanced my under-anding of the skills covered in the class.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

10. The class schedule was appropriate..

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

11. The course met your learning needs.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

Facilitators

1. Knowledge of the material.

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

2. Presentation Style

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

3. Ability to communicate clearly

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

4. Feedback and direction during instruction

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

5. Efectively organized the class.

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

6. Had the needed skills to prepare me for use the computer technologies.

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

Learners'

12. Participation during instructional process.

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

13. Contribution to overall learning environment

Poor ◯ Fair ◯ Average ◯ Above Average ◯ Excellent ◯

Comments (please take time to add ideas for instructional improvement in the content, delivery, and participation).

Resources

1. The learner guide was helpful.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

15. The software did what I expected.

Strongly Disagree ◯ Disagree ◯ Not Sure ◯ Agree ◯ Strongly Agree ◯

Overall

16. What lesson(s) helped you better understand modeling-based inquiry?

17. What lesson(s) did not help you better understand modeling-based inquiry?

18. What one thing would make the courrse more effective?

19. What one thing would you not change about the course?

Thank you for your participation!

1. What causes the seasons ?

2. What is the relationships between the length of day and the season of the year?

3. List two means of measuring distance in space?

4. What are the methods by which early humans subdivided the solar day?

5. What is the difference between lunar and solar eclipses?

6. What is the effect of the moon on earth tides?

7. Distinguish orbital characteristics of meteors, asteroids and comets.

8. What are the standard criteria to classify stars ?

9. What are the physical differences between the sun and the earth?

10. State the characteristics of the Milky Way Galaxy

11. What is the function of these keyboard command : PgUp, + ,A, Z, F ?

12. Describe the functions of the following menu categories: File/New Solar System, Edit/New Star, Waypoints/ Add waypoint, Waypoints/view objects from front .

13. What are the components of a developed solar system model?

14. In Astronomicon, create a parent-son Star-planet System.

15 According to the oral direction, use the keyboard and menu commands to maneuver a given solar system (on computer)

16 In Astronomicon, create a star, a planet, and a working solar system according to oral direction.

17. Identify four key concepts of modeling-based inquiry

18. List three criteria of making an effective lesson plan?

19 Identify a teaching strategy to teach modeling-based inquiry using the Astronomicon software?

20 State your measure selection for a lesson that teaches modeling-based inquiry using the Astronomicon software?

21 List and describe five components of an effective evaluation rubric for evaluating a modeling-based inquiry using Astronomicon software.

22. Create a rubric to evaluate peer and facilitator lessons.

This level measures the use of new skills on-the-job. It determines how much the participants actually use the skills taught in the training program and provides feedback on the ability of the learners to transfer what they learned to the job itself.

Performance Comparison

Direction: this form is to evaluate how much you actually use the skills taught in the training and provides feedback on the ability of the learners to transfer what they learned to the job itself. Please fill out the form.

Name ______________________________

*Department*__________________________

*Course*_____________________________

*Semester*____________________________

	Before the Training	After the Training
How did you teach astronomy in your class?		
How did you organize your teaching activities?		
How did you evaluate the learning results?		
What aspects of the class plan have changed?	Not applicable	

On-the-job Performance Objectives

1. Able to use Astronomicon in teaching activities
2. Able to use modeling-based inquiry teaching method
3. 70% of astronomy classes are taught using modeling-based inquiry on Astronomicon
4. Teachers are using Astronimicon to aid in the instructional process.
5. The evaluation procedure includes a new rubric for modeling-based inquiry.

Level 3 Evaluation continued

Supervisor Rating Sheet

Name ______________________________ *Department*___________________________ *Course*_______________________________ *Semester*_____________________________	
The ability to use Astronomicon in teaching activities	Poor ○ Fair ○ Average ○ Good ○ Excellent ○
The ability to use modeling-based inquiry method	Poor ○ Fair ○ Average ○ good ○ excellent ○
Percentage of participants using modeling-based inquiry with Astronomicon in their coursework	0-20 ○ 20-40 ○ 40-60 ○ 60-80 ○ 80-100 ○
Are teachers using Astronomicon in their classes?	Yes ○ No ○
Are the evaluation procedures an effective rubric for cauterizing the effectiveness of modeling-based inquiry?	Yes ○ No ○
Comment:	

Supervisor ______________________________

*Date*____________________________

APPENDICES

APPENDIX A - STANDARDS

NATIONAL STANDARDS

Earth and Space Science

Content Standard D
As a result of their activities in grades 9-12, all students should develop an understanding of

- Energy in the earth system
- Geochemical cycles
- Origin and evolution of the earth system
- Origin and evolution of the universe

Content Standard D
As a result of their activities in grades 5-8, all students should develop an understanding of

- Structure of the earth system
- Earth's history
- Earth in the solar system

Reference

National Science Education Standards [Online]: http://books.nap.edu/html/nses/html/

Georgia Standards

Georgia - Grade 9-12 Science Astronomy	
1 - Core Skill	**Topic**: Inquiry, Process and Problem Solving **Standard**: Uses science process skills in laboratory or field investigations, including observation, classification, communication, metric measurement, prediction, inference, collecting and analyzing data. **1.1** Designs and conducts a scientific experiment that identifies the problem, distinguishes manipulated, responding and controlled variables, collects, analyzes and communicates data, and makes valid inferences and conclusions. **1.2** Evaluates procedures, data and conclusions to determine the scientific validity of research.
2 - Core Skill	**Topic**: Inquiry, Process and Problem Solving **Standard**: Uses traditional reference materials to explore background and historical information regarding a scientific concept. **2.1** Uses current technologies such as CD-ROM, Internet and on-line data search to explore current research related to a science concept.
3	**Topic**: Laboratory Safety **Standard**: Learns and uses on a regular basis standard safety practices for laboratory or field investigations. **3.1** Learns and uses safety procedures specific to an investigation or research activity.
4	**Topic**: The science of astronomy **Standard**: Recognizes astronomy as a quantitative science devoid of superstition. **4.1** Identifies astronomy as a study of physical objects in space. **4.2** Recognizes that the study of the cycles in space may have made astronomy the most ancient of sciences. **4.3** Investigates the beginnings of astronomy as a science. **4.4** Identifies the economic, political, and societal importance of astronomy.
5	**Topic**: Measurement and motion **Standard**: Observes, investigates, and models the motions of the earth, moon, sun, planets and stars. **5.1** Demonstrates the relationship among the various means of measuring distances in space. **5.2** Distinguishes physical effects on earth that are the result of celestial motions, e.g., the seasons. **5.3** Measures altitude and azimuth. **5.4** Observes the motion of stars located close to the celestial equator. **5.5** Analyzes how ideas of celestial motion evolved over the ages. **5.6** Compares the methods used by ancient astronomers to measure the distances between and the sizes of the sun, moon, and earth. **5.7** Explains how a knowledge of celestial motions and mechanics enabled humans to leave the planet earth. **5.8** Applies knowledge of measurements and motions to practical terrestrial navigation.

Georgia - Grade 9-12 Science Astronomy (cont.)	
6	**Topic**: Celestial clocks **Standard**: Recognizes the significance of the relative motions of the sun, moon, and earth. **6.1** Discovers the relationships between the length of day and the season of the year. **6.2** Distinguishes the difference between a solar day and a sidereal day. **6.3** Identifies methods by which early humans subdivided the solar day. **6.4** Recognizes that time is arbitrary. **6.5** Defines the concept and purpose of daylight savings time. **6.6** Theorizes the impact that a changed rotation of the earth might have on humanity.
7	**Topic**: The moon **Standard**: Determines the orbital and physical characteristics of the moon. **7.1** Distinguishes between lunar and solar eclipses. **7.2** Describes physical characteristics of the moon. **7.3** Quantitatively calculates a surface feature of the moon as observed from the earth. **7.4** Analyzes the motions of the moon. **7.5** Postulates possible origins of the moon. **7.6** Relates the effect of the moon on earth tides. **7.7** Recognizes the various factors involved in sending humans to the moon.
8	**Topic**: The Solar system **Standard**: Describes the major characteristics of the planets. **8.1** Identifies non-planetary objects. **8.2** Determines the distances between and the sizes of the planets. **8.3** Recognizes the observable motions of the planets. **8.4** Distinguishes orbital characteristics of meteors, asteroids and comets. **8.5** Researches the discoveries of the outer planets. **8.6** Analyzes possible origins of solar systems. **8.7** Relates the significance of our space program and the potential for beneficial discoveries.
9	**Topic**: Stars **Standard**: Explains the life cycle of a star. **9.1** Examines the interior structure of stars and how energy is transformed. **9.2** Classifies stars according to standard criteria. **9.3** Identifies early theories concerning stars. **9.4** Traces the historic progress in measuring stellar distances. **9.5** Analyzes the impact of fusion reactions. **9.6** Develops the concept of supernova.
10	**Topic**: The sun **Standard**: Contrasts our sun with other stars. **10.1** Determines the physical differences between the sun and the earth. **10.2** Identifies three apparent motions of the sun as observed from the earth. **10.3** Recognizes the historical significance of our sun. **10.4** Evaluates the significance of solar energy for human beings.

Georgia - Grade 9-12 Science Astronomy (cont.)	
11	**Topic**: The Milky Way and other galaxies **Standard**: Describes the evolution of a galaxy. **11.1** Distinguishes characteristics of the Milky Way Galaxy. **11.2** Locates the sun's position in our galaxy. **11.3** Recognizes the existence of other galaxies in the universe. **11.4** Examines early beliefs about the Milky Way galaxy. **11.5** Investigates the promise of future energy production from studies of galaxies and quasars.
12	**Topic**: Cosmology **Standard**: Investigates possible beginnings of the known universe. **12.1** Develops ideas concerning origins of the universe. **12.2** Investigates beliefs concerning the universe from ancient to modern times.

Reference

[Online] www.glc.k12.ga.us

APPENDIX B - QUESTIONNAIRE

PRE-TRAINING QUESTIONS

1. How would you rate your knowledge of Georgia's QCCs for astronomy?

2. How would you rate your proficiency as an astronomy teacher?

3. Before attending this class, how would you rate your knowledge of basic concepts in astronomy (i.e. solar systems, planetary motion, phases, eclipses, seasons)?

4. Before attending this class, how would you rate your knowledge of modeling based learning?

5. Before attending this class how would you rate your knowledge of inquiry based learning?

RESULTS

Question	1	2	3	4	5
Mean	2.375	3.25	4.125	3.25	4.25

APPENDIX C - OPTION A COST ANALYSIS

OPTION A
2 graduate students for software support
1 PI (faculty)
Program span: 2 months

1	PI	**$4400**	**Analysis**
55	$/hour PI		
80	hours		

20	$/hour grad	**$1600**	Grad Design - Manual
1	grad	**$4400**	PI Design - Manual
55	$/hour PI	**$6000**	**Total**
1	PI		
80	hours/design		

20	$/hour grad	**$2400**	Grad Design
1	grad	**$6600**	PI Design
55	$/hour PI	**$9000**	**Total**
1	PI		
120	hours/design		

20	$/hour	**$6400**	Grad Support
2	grads		
40	hours/week		
4	months		

1	PI	**$4400**	**Evaluation**
55	$/hour PI		
80	hours		

$21400	**Total Option A**

APPENDIX D - OPTION B CoST ANALYSIS

OPTION B
1 graduate student
1 PI (faculty)
Program span: 2 months

1	PI	**$4400**	**Analysis**
55	$/hour PI		
80	hours		

20	$/hour grad	**$1600**	Design - Manual
1	grad	**$4400**	
55	$/hour PI	**$6000**	**Total**
1	PI		
80	hours/design		

20	$/hour grad	**$480**	Grad Design
1	grad	**$1320**	PI Design
55	$/hour PI	**$1800**	**Total**
1	PI		
12	hours in class		
24	hours development		

20	$/hour grad	**$5760**	Grad Development
1	grad	**$15840**	PI Development
55	$/hour PI	**$21600**	**Total**
1	PI		
12	hours in class		
24	days		
288	hours development		

20	$/hour grad	**$420**	Grad Implementation
1	grad	**$1155**	PI Implementation
55	$/hour PI	**$1575**	**Total**
1	PI		
12	hours in class teaching		
9	hours in class supervising teachers		
21	hours total		

20	$/hour	**$400**	Implementation - Support
1	grads		
20	hours/week		
1	month	**$1975**	**Total Implementation**

1	PI	**$4400**	**Evaluation**
55	$/hour PI		
80	hours		

$31375	**Total - Option B**