CORE CURRICULUM COMPONENT APPLICATION
Sam Houston State University

PART I – Course Information

Course Type
☒ Existing/Restructured
☐ New Course Proposed Fall 2013
If new, have you submitted a Form B to the SHSU Curriculum Committee? ☐ Yes ☐ No

Course Prefix & Number: GEOG 1436

Course Title: Foundations of Science

Course Catalog Description (Copy and paste from online catalog for existing courses):
The course focuses on the nature of science as a reliable method of acquiring knowledge about the natural world. Students will learn how to apply key scientific facts, concepts, laws and theories to distinguish science from non-science, bad science, and psedudoscience by analyzing a variety of claims and case studies. By employing an innovative, interdisciplinary approach to science education, this course is designed to increase science literacy and critical thinking skills for introductory-level students. This course is designed for non-science majors to help them meet their General Education science requirement. Students must enroll concurrently in the corresponding lab for this course. Credit: 4

Course Prerequisites: None

Available Online? ☐ Yes ☒ No ☒ Anticipated (Semester: F 2013)

Number of Sections to be Offered per Year: 10-12

Estimated Enrollment per Section: 55

Course Level (freshman, sophomore): freshman

Requestor Full Name (designated department rep – contact person): Dr. Marcus Gillespie

E-Mail Address: marcusg@shsu.edu

Approvals

Department Chair: _____ Signature _____ Date

Academic Dean: _____ Signature _____ Date

Submit completed, signed form to Core Curriculum Committee - Box 2478 or Fax 4-1271

PART II – THECB Foundational Component Areas

See Appendix for full description of each component area.

Select Component Area: III. Life and Physical Sciences

How Component Area Addressed:

PART III – Course Objectives

Insert the appropriate course objectives stated in student learning outcomes (e.g., Students completing the course will be able to…)

Objective 1: Understand and apply scientific terminology pertaining to the nature and conduct of science, such as hypothesis, law, theory, control group, placebo group, confirmation bias, and double-blind study

How will requirement be addressed (including strategies and techniques)?
This material is covered explicitly and in depth in both the lecture and lab components of the course. The concepts of scientific laws, theories, and hypotheses form the framework for much of the course and are referenced continuously in the context of lecture discussion and activities designed to help students understand key scientific laws (gravity, thermodynamics, Kepler's Laws of Planetary motion, Newton's laws, etc), as well as scientific theories (Big Bang, Plate Tectonics, Evolution). The criteria for scientific theories are emphasized and are used to evaluate both scientific and non-scientific (pseudoscientific) theories and claims. Students use these concepts to evaluate a variety of claims to determine if the claims meet the criteria for a scientific claim. Control groups, placebo groups, and double blind studies are discussed in depth as a means of helping students understand why they are necessary to help eliminate errors regarding claims, especially those pertaining to the allleged efficacy of a variety of health products. This discussion occurs in the context of a discussion of the FDA approval process and alternative medicines (which are typically not tested using these experimental procedures). The concept of potential bias (in many of its forms) occurs throughout the course and is intended to help students understand why the scientific method is necessary to eliminate bias and errors. Students use all of these concepts in case studies in both lecture and lab activities.

Describe how requirement will be assessed: This is assessed using a variety of methods in the course, the most important of which is the the Critical Thinking Assessment Test (CAT) which was developed by six universities, primarily Tennessee Tech University (TTU), and was supported by the National Science Foundation. The test is used by more than 120 universities and schools in the U.S. The test is scored by a team of faculty members at SHSU and the results are then sent to TTU for analysis. TTU then prepares an institutional report which compares our results with other universities which use the exam. The exam measures a variety of things which map onto the objectives of this course. This is why it is used as the primary assessment instrument for many of our obejctives. We also use a locally-developed instrument called the Foundations of Science Exam (FSE). This exam, which was Beta-tested by the

Office of Institutional Research, consists of several parts which measure knowledge of basic scientifc facts, knowledge of scientific terminology, and critical thinking. In addition, we use the Measure of the Acceptance of the Theory of Evolution (MATE) survey which, by measuring students' attitues toward evolution - one of the most important theories in science - correlates with students' understanding of science as a reliable way of knowing, and their understanding of what a scientific theory actually is. In addition, the course uses case studies in lecture and lab, homework assignments consisting of a total of more than 600 questions, and group assignments to assess their understanding of this objective. Finally, 3 major exams are given in lecture, pre-lab and post-lab tests are given in lab, and a midterm is also given in lab.

Objective 2: Apply methods of reasoning used by scientists: i.e., the scientific method based on the requirements of falsifiability/testability, logical consistency, comprehensiveness of evidence, intellectual honesty (objectivity), replication of results, and sufficiency of evidence.

How will requirement be addressed (including strategies and techniques)?
These methods of reasoning, which we group together under the acronym FiLCHeRS, form the backbone of the course. These criteria are introduced early in the course and every topic/claim covered in the course is evaluated using these criteria in order to help students improve their critical thinking skills and to help them understand both how scientists think (; i.e., how science is done) and why science is a reliable way of knowing.

Describe how requirement will be assessed: The CAT exam specifically requires students to consider how a claim might be tested, whether the evidence provided is sufficient to warrant a stated conclusion, and what conclusions can be logically drawn given the information provided. It also requires students to propose aleternative hypotheses and describe how they would test them. The FSE exam, the homework assignments, group assignments, and case studies and labs (which are based on case studies and group activities) specifically require students to use these criteria.

Objective 3: Analyze and evaluate common logical fallacies and perceptual biases that interfere with the ability to draw reasonable and/or correct conclusions, as well as the difference between facts, informed opinions, and uninformed opinions

How will requirement be addressed (including strategies and techniques)?
The use of the FiLCHeRS rules throughout the course, which are based on critical thinking, address this. Just as importantly, the students use two textbooks, one of which is titled, "How to Think about Weird Things", and was written by two philospophers who specialize in logic. The entire text is devoted specifically to using critical thinking skills, coupled with relevant scientific information, to evaluate both scientific and pseudoscientific claims. It teaches students common logical fallacies and sources of bias, and it repeatedly stresses, as does the lecture material, the need to think critically in order to make better decisions. Hypotheses and theories are specifically contrasted with opinions as, for example, when discussing the Big Bang theory and the Theory of Evolution - theories which many students commonly think of as mere 'opinions' - not as scientific theories founded on empirical evidence, the laws of nature, and logic. Objective information is contrasted with subjective experience and both are discussed in terms of their reliability as a means of gaining knowledge about the world.

Describe how requirement will be assessed: The CAT and locally-developed FSE exam both test students' tendency to avoid (or not) common logical fallacies and biases that might interfere with the drawing of a correct inference. The homework assignments have questions that

directly address these ideas, as do the case studies. Logical fallacies and biases are referenced repeatedly and continuously throughout the course.

Objective 4: Learn key concepts and theories from a variety of scientific disciplines, especially physics, biology, and geology

How will requirement be addressed (including strategies and techniques)?
The lecture material focuses directly on this as does one of the texts used, which is an integrated science textbook. Specifically, students are taught, among many topics, the evidence for the geocentric and heliocentric model of the solar system, the nature of stars and galaxies, the quivalence of matter and energy, the evidence for the Big Bang, basic concepts regarding Relativity Theory, the nature of matter, the four fundamental forces of nature, geologic topics dealing with rocks and minerals, sedimetary environments, relative and absolute dating, uniformitarianism, plate tectonics, and, in biology, principles of ecology, genetics, thermodynamics, and evolution. Students are required to use these concepts to evaluate claims. For example, students evaluate paranormal claims based on their understanding of the forces of nature and, in so doing, come to realize that these claims contradict our understanding of the way in which the universe works. They evaluate the claim regarding the Loch Ness monster by using principles of ecology and thermodynamics, primary productivity and food chains, minimum population breeding size required to maintain a population, the geographic distribution of ectotherms, and certain geologic concepts related to isostatic adjustment and continental glaciation. They evaluate UFO claims using information about stellar distances (the size of the galaxy), planetary evolution, the Theory of Relativity, energy requirements for space travel, biological and psychological considerations associated with prolonged isolation, and Newtons laws pertaining to acceleration/g-forces.

Describe how requirement will be assessed: This topic is assessed with the FSE exam, homework assignments, a group assignment, and lab activities. We also use an instrument called the MATE [Measure of the Acceptance of the Theory of Evolution] as an indicator of student's understanding and acceptance of evolution - and, by inference, of the reliability of science as a way of knowing. * Using a pre-and post analysis, our results show a highly statistically significant increase in the acceptance of evolution. The results of comparisons with other science courses, including Environmental Science, showed no change in the test results.)

Objective 5: Demonstrate how to distinguish science from pseudoscience by scientifically evaluating a wide variety of extraordinary claims that are common in our culture today.

How will requirement be addressed (including strategies and techniques)?
This is addressed throughout the course, as many of the course activities require students to apply scientific information to an analysis of extraordinary claims, many of which are pseudoscientific in nature and can be regularly seen on TV, in the movies, and in advertisements. For example, one of the lab case studies concerns astrology, a long-standing pseudoscience. Students use their knowledge of astronomy and physics to evaluate the claims of this pseudoscience and, in so doing, apply their knowledge and critical thinking skills to evaluate a claim with which virtually all students are familiar.

Describe how requirement will be assessed: This is assessed using the FSE exam, the homework assignnments, the group activities, case studies (such as the ones dealing with Xango juice, and another delaing with the alleged connection between the MMR vaccine and autism). In one of the labs, students choose a health product (non-FDA approved) and evaluate it using FiLCHeRS, critical thinking skills, and the knowledge they have gained in lecture regarding the experimental method.

PART IV – THECB Skill Objectives

Address each of the required THECB skill objectives that the course addresses and explain how the requirement is addressed, specific strategies to address the objective(s), and how each objective will be assessed. ***Address ALL skill objectives associated with the selected Component Area. (See Appendix)***

1. Critical Thinking Skills: to include creative thinking, innovation, inquiry, and analysis, evaluation and synthesis of information

How will requirement be addressed (including strategies and techniques)?
As discussed above, the improvement of critical thinking is one of the primary goals of this course. (The other is the enhancement of scientific literacy.) Objectives 1,2, 3, and 5 above specifically address the improvement of critical thinking and, as discussed above, this is done using a combination of case studies in lecture and in lab, through specific questions in homework assignments, and in the two group activities which specifically require students to use critical thinking skills.

Describe how requirement will be assessed: This skill is assessed using the CAT and FSE exams, as well as the case study grades in lecture, home work assignments, and lab activities (which are based on case studies). * I would like to note that we have now used the CAT exam for 3 years in the Foundations of Science course (in a pre-test/post-test format) and our results are the best obtained by any of the 120+ universities using this exam. Our students show more improvement in critical thinking after this one course than most students do after 3-4 years of their college education. In short, our approach to teaching critical thinking has been rigorously assessed using an NSF-supported instrument specifically designed to assess the sort of critical thinking used by scientists and has been shown to be highly effective.

2. Communication Skills: to include effective development, interpretation and expression of ideas through written, oral and visual communication

How will requirement be addressed (including strategies and techniques)?
Students in the Foundations of Science class, in both lecture and lab, are placed into groups and are required to work together on case studies in lecture and on the two group homework assignments. In lab, students work together on all lab activities - including the group quizzes given in each lab. Some of these group quizzes require a written response, as do some of the individual lab quizzes. (Each lab entails both an individual, pre-lab quiz and a group, post-lab quiz.) All of the group activities require the students to orally communicate with the other members of the group, and to the class as a whole during discussions. One of the labs specifically requires the students to give a group presentation, using Power Point, at the end of the lab and it is this report that is evaluated by the instructor and the other students in the lab. So, these activities require oral and visual communication and necessarily require the interpretation of ideas. Two of the lecture group assignments are written. Students are required to contribute to the group's paper for the first assignment. For the second group assignment, each student must submit his or her own version of the assignment (though only one from the group is selected for grading under the premise that they worked together as a team to develop their responses).

Describe how requirement will be assessed: This is assessed based on the scores students earn on the specific assignments referenced above. It is indirectly assessed on the CAT exam, which requires short answer responses on several of the questions.

3. Empirical and Quantitative Skills: to include the manipulation and analysis of numerical data or observable facts resulting in informed conclusions

How will requirement be addressed (including strategies and techniques)?
Th entire course requires that students use empirically-derived information to evaluate both scientific and pseudoscientific claims. (The concept of emiricism, as one of the 'foundations of science' is specifically discussed early in the course and used throughout the course.) In the case studies used in lecture and lab, students are given data and asked to interpret it. For example, in the lab dealing with perceptual biases, students are given data regarding the alleged link between cell phone use and brain cancer and asked to interpret the correlation based on sample size and the scatter in the data points. In the lecture case study concerning the alleged association between the MMR vaccine and autism, students are given the actual data set obtained by the investigator that first suggested a possible link between the two. They are also presented with subsequent experimental results and asked to draw conclusions based on the information available. Several of the homework questions provide data and then ask students to intepret it. As regards quantitative data, students are asked to do such things as calculate the age of rocks based on radiometric dating information, calculate the buoyancy of continental crust vs. oceanic crust based on data obtained in lab experiments, calculate the distances to the stars, and calculate the force exerted by a star on a person. In one of the physics-related homework assignments, students calculate such things as kinetic energy, work, and free fall time.

Describe how requirement will be assessed: As just described, these are assed based on the grades received on the individual assignments. In addition, the CAT test has a question requiring a calculation and the results can be compared to those of other universities.

4. Teamwork: to include the ability to consider different points of view and to work effectively with others to support a shared purpose or goal

How will requirement be addressed (including strategies and techniques)?
As discussed above, all students in the Foundations of science class, in both lecture and lab, are placed into groups and are required to work together on case studies in lecture and on the two group homework assignments. This necessarily requires the students to work as members of a team and to develop their ability to work effectively with one another. In lecture, guidelines are presented to help students understand the importance of respect when expressing ideas. They are also informed about some of the common things that can adversely affect a group's ability to work together, such as failure to allow everyone to express their opinion or assuming that the person who most strongly expresses an opinion is necessarily correct. (This, too, relates to a common bias.)

Describe how requirement will be assessed: The ability to work together as a member of a team is directly assessed using a peer evaluation system in which group members evaluate one another using a set of guidelines/rules that are provided at the beginning of the semester. Based on this approach (which was developed by experts in team-based learning at SUNY), each student in a group assigns a score to every other member of the group on each group assignment (which includes all labs). These scores are then used to determine the overall score received by each student for their participation and contributions to the team on group assignments. If a student receives an average of 10, he or she receives 100% of the points earned by the group. If he or she receives, for example, an 8.5, the student receives 85% of the points earned by the group. If a student receives less than 7, he or she loses all group points, which (if this were to occur for both the lecture and lab group work), would constitute about 20% of the course grade. (Lecture and lab have never been separate courses in the FoS class, they have always been considered a single course in which the lab component constitutes about 25% of the total course grade.) The grades earned on group assignments are also indicative of the performance of the group on group activities.

5. Personal Responsibility: to include the ability to connect choices, actions and consequences to ethical decision-making

How will requirement be addressed (including strategies and techniques)?
NA for science classes

Describe how requirement will be assessed:

6. Social Responsibility: to include intercultural competence, knowledge of civic responsibility, and the ability to engage effectively in regional, national, and global communities

How will requirement be addressed (including strategies and techniques)?
NA for science classes

Describe how requirement will be assessed:

PART V – SHSU Core Curriculum Committee Requirements

1. Using a 15-week class schedule, identify the topics to be covered during each week of the semester. Provide sufficient detail to allow readers to understand the scope and sequence of topics covered.

Week 1	"Weird Things People Believe and Witch Trials of the Past and Present: Why Evidence and Reason Matter" (This section attempts to show students that it does matter whether people understand how the world works and whether or not they think critically. This is empahsized by reviewing what happened to people who were erroneously accused of being witches because of a lack of understanding of the world and of the relevance of evidence. Students also do a lab concerning the Salem Witch hysteria and examine alternative natural explanations as to what might have happened.)
Week 2	"The Nature of Science - What's the difference between scientific and non-scientific 'ways of knowing'?" (TheFiLCHeRS rules are introduced, as are the the concepts of empiricism, skepticism, and critical thinking as three of the foundations of science.)
Week 3	Continuation of the Nature of Science discussion
Week 4	"Why Things Aren't Always What They Seem to Be". (This section concerns the limits to perception and memory; i.e., the ease with which we can make mistakes based on the misinterpretaion of information and bad memory. Occam's Razor is also introduced as another "foundation of science'.)
Week 5	Continuation of the Limits to Perception and Memory lectures including actual instances in which people made mistakes with tragic consequences. This discussion reinforces the need for the scientific method as a means of helping to reduce the possibility of making mistakes by trying to account for errors in both reasoning and perception. It shows why science works; i.e., why it's reliable.
Week 6	Begin Astronomy section: "What are those Lights in the Sky? Stars, Planets, Galaxies and the Size of the Universe"
Week 7	Conitnue astronomy with focus on the evidence for the geocentric and helioentric models of the solar system. (This section focuses on the importance of empiricism and highlights how humankind

	had been misled by their senses when developing the earlier geocentric model of the solar system. It also introduces a discussion of scientific laws in the context of Kepler's Laws of Planetary motion. Students begin learning the difference between a hypothesis, law, and theory.)
Week 8	"The Big Bang and the Nature of the Universe – or is it a Multiverse?" (This discussion emphasizes the nature of a scientific theory and the importance of observable evidence when developing a scientific theory. The expansion of the universe (Hubble's constant), the cosmic microwave background radiation, and nucleosynthesis are discussed.)
Week 9	"Paranormal phenonmena" (This section requires students to critically evaluate claims regarding paranormal phenomena using their understanding of physics and the nature of forces and matter covered in the previous section. Scientific tests of paranormal phenomena, such as ESP, are also discussed with an emphasis on the problem of experimenter bias and flawed studies.)
Week 10	"Complimentary and Alternative Medicines" (This section of the course deals with the experimental method as applied to this topic; e.g., independent and dependent variables, control groups, placebo effects, and double-blind studies - again with an emphasis on the need for these to reduce sources of error in our interpretation of results and experiences. It also discusses the FDA approval process and many factors that can cause us to incorrectly conclude that a 'treatment' has worked. Specific pseudoscientific and/or unfounded claims are evaluated, such as homeopathy, therapeutic touch, acupuncture, and the alleged benefits of megadoses of vitamins.)
Week 11	Continuation of CAM lecture material
Week 12	"Atlantis and Geology" (This section covers geologic information pertaining to rocks and minerals, plate tectonics, dating techniques, and uniformitarianism. The goal is to show that knowledge of geology (and by implication, science in general) can be used to evaluate an extraordinary claim while at the same time providing students with another example of a scientific theory and how the information upon which it is based was obtained. It also relates to the age of the earth as determined by science. This ties to the information regarding the age of the universe and will relate to evoution - which requires an immense amount of time to occur.
Week 13	"The Loch Ness Monster" and "Genetics" (The section on Loch Ness requires students to apply concepts from ecology, biology, physics and the psychology of perception to evaluate this claim. The section on genetics lays the basis for the discussion of evolution in terms of understanding what DNA is, how it is copied, and how changes in the genetic code occur.)
Week 14	Complete genetics and begin "Evolution" (The section on evolution contrasts the Theories of Evolution and Intelligent Design using the FiLCHeRS criteria and the Criteria for Adequacy discussed in the course. In this section, the evidence of evolution is discussed (e.g., vestigial structures, comaprative embryology, the fossil record) and it also explains the process of evolution via natural selection acting on genetic change.)
Week 15	Complete Evolution with an emphasis on the fact that strong theories in science are based on empricial data and critical thinking. It also stresses the significance of the consistency of information, from multiple branches of science, in the development and evaluation of scientific theories.

2. Attach course syllabus

Syllabus Attached? ☒ Yes ☐ No

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Appendix: THECB Component Area Descriptions and Skill Requirements

I. Communication (Courses in this category focus on developing ideas and expressing them clearly, considering the effect of the message, fostering understanding, and building the skills needed to communicate persuasively. Courses involve the command of oral, aural, written, and visual literacy skills that enable people to exchange messages appropriate to the subject, occasion, and audience.)

II. Mathematics (Courses in this category focus on quantitative literacy in logic, patterns, and relationships. Courses involve the understanding of key mathematical concepts and the application of appropriate quantitative tools to everyday experience.)

III. Life and Physical Sciences (Courses in this category focus on describing, explaining, and predicting natural phenomena using the scientific method. Courses involve the understanding of interactions among natural phenomena and the implications of scientific principles on the physical world and on human experiences.)

IV. Language, Philosophy, and Culture (Courses in this category focus on how ideas, values, beliefs, and other aspects of culture express and affect human experience. Courses involve the exploration of ideas that foster aesthetic and intellectual creation in order to understand the human condition across cultures.)

V. Creative Arts (Courses in this category focus on the appreciation and analysis of creative artifacts and works of the human imagination. Courses involve the synthesis and interpretation of artistic expression and enable critical, creative, and innovative communication about works of art.)

VI. American History (Courses in this category focus on the consideration of past events and ideas relative to the United States, with the option of including Texas History for a portion of this component area. Courses involve the interaction among individuals, communities, states, the nation, and the world, considering how these interactions have contributed to the development of the United States and its global role.)

VII. Government/ Political Science (Courses in this category focus on consideration of the Constitution of the United States and the constitutions of the states, with special emphasis on that of Texas. Courses involve the analysis of governmental institutions, political behavior, civic engagement, and their political and philosophical foundations.)

VIII. Social and Behavioral Sciences (Courses in this category focus on the application of empirical and scientific methods that contribute to the understanding of what makes us human.
Courses involve the exploration of behavior and interactions among individuals, groups, institutions, and events, examining their impact on the individual, society, and culture.)

Required Skill Objectives

Foundational Component Areas	CT	COM	EQS	TW	SR	PR
Communication	✓	✓		✓		✓
Mathematics	✓	✓	✓			
Life and Physical Sciences	✓	✓	✓	✓		
Language, Philosophy & Culture	✓	✓			✓	✓
Creative Arts	✓	✓		✓	✓	
American History	✓	✓			✓	✓
Government/Political Science	✓	✓			✓	✓
Social and Behavioral Sciences	✓	✓	✓		✓	