ADE/B.Ed. (Hons.) Elementary

Syllabus

Science 2

Semester 3

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Technical Support: Education Development Centre (EDC); Teachers College, Columbia University

Syllabus: Science II

SEMESTER: Year 2 / Semester 3
DURATION (Hours): 48 hours (16 weeks)
CREDIT VALUE: 03 credits
PREREQUISITES: Matriculation (with a science subject)

COURSE DESCRIPTION:

This Science II course will strengthen prospective elementary teachers' subject matter knowledge. It provides further opportunity to deepen the pedagogical science content knowledge required to effectively teach general science in elementary school. The course covers core concepts in physical science, life science, and earth science. It also covers teaching strategies and instructional approaches that best support the development of a conceptual understanding of science. In contrast to Science I, which dealt with simpler concepts, Science II establishes connections between core concepts, such as matter and energy, and entire systems, such as Earth's systems or systems within the human body.

After taking Science I and Science II, the prospective student teachers will be well prepared to implement the National Curriculum in elementary grades 1-5.

Science I and Science II integrate science content with science pedagogy and skill building. Both courses are designed to prepare prospective elementary teachers to teach inquiry science in grades 1-5. Their (pedagogical) content knowledge is chosen accordingly. It is recommended that prospective science teachers who want to teach science in higher elementary grades (6-8) deepen their science knowledge further by attending additional science classes offered in Year 3 and Year 4 of the B.Ed. (Hons) program.

COURSE OUTCOMES

After completing this course, student teachers will be able to:

1. Describe forms and interactions of energy and matter, including energy transfer and transformations, as they apply to chemical and physical processes with an emphasis on events/phenomena in everyday life.
2. Begin to see that complex interactions between the atmosphere, the hydrosphere, and the lithosphere in Earth's systems undergo constant change. Understand the theory of plate tectonics as it relates to Pakistan's mountain formations and earthquakes. Provide examples of advances in technologies that have made it possible to more accurately predict natural disasters and provide life-saving warnings (for floods, hurricanes, etc.). Explain how human activities influence air and water quality, ecosystems, and climate across the globe.
3. Begin to understand the vastness and age of the universe, and be able to discuss the characteristics and differences of objects within our Solar System.
4. Describe the flow of matter and energy in living systems, and apply it to the human body to explain, for instance, the circulatory and digestive system.
5. Be able to understand the purpose of scientific models and tools, and use them appropriately. Examples are the periodic table, classification tables, maps, and models of particle theory and the atom. In addition, be able to demonstrate and teach data collection, recording, and graphing to present conclusions of investigations.

Teaching-Learning Framework

Throughout this course, pedagogy is interwoven with the content development. Faculty will model inquiry teaching to student teachers in order for them to experience the learning and teaching of science in an inquiry way. Thoughtful discussions will follow such hands-on experiences to clarify the applied methods and expected learning. These reflections are essential because it is through these discussions that prospective teachers will gain essential transfer and pedagogical content knowledge needed for after graduation when they enter the field and teach science to elementary students. Therefore, it is critical to give prospective teachers the opportunity to reflect on what they are experiencing as learners as well as opportunities to practice their role as teachers. Teachers can thus develop meaningful activities around core concepts that will enable their students to gain deeper conceptual understanding and allow them to modify these activities to best meet the needs of their individual classrooms.

This course is also designed to help students develop science thinking and process skills in addition to content and pedagogical content knowledge.

After completing this course, student teachers will be able to:

1. Apply inquiry to the teaching of science at the elementary level.
2. Identify, adapt, and modify investigations that lead to conceptual understanding.
3. Design science investigations around core concepts.
4. Understand the need for learning progressions.
5. Recognize common misconceptions and be able to respond with appropriate remedies.
6. Use open-ended questions to assess students' conceptual understanding.
7. Provide their students with exciting science experiences that extend their natural fascination with the world and help them learn the science skills and concepts they will need in later schooling and in life.
8. Reflect on their teaching to develop a personal approach to the teaching of science.

SEMESTER II OUTLINE

Unit 1: Course Overview

Week	Topics/Themes
1	Overview of course content (science and teaching) Life of scientists and the role of science in society Nature of science and its application for teaching Introduction to independent course project, possible topics, and criteria

During this unit, prospective teachers will:

- Understand that science reflects its history and is an ongoing, changing enterprise.
- Read and reflect about the nature of science, and apply it to their own learning and teaching.
- Distinguish between observation and inference.
- Read about famous scientists and their lives, and relate their scientific quest to their own lives.
- Investigate and present a science topic of their choice, applying their science and teaching of science knowledge following specific criteria (research component, science explanations, conclusions, transfer to teaching in elementary school grades).

Unit 2: Energy Transfer, Transformations, and Conservation

Week	Topics/Themes
2	Types of energy (heat, light, sound, kinetic, potential, gravitational, etc.) Investigating light
3	Energy transfer and transformation - Concept of conduction, convection, and radiation Law of conservation of mass and energy
4	Teaching "Energy transfer, transformation, and conservation" in elementary grades

During this unit, prospective teachers will:

- Distinguish among different forms of energy (kinetic, potential) and demonstrate that energy can be transferred and transformed.
- Provide examples of kinetic energy being transformed into potential energy and vice versa.
- Recognize that heat can spread from one place to another in predictable ways.
- Provide examples of the transfer of energy from hotter to cooler objects by conduction, radiation, or convection.
- Explain that energy can be transferred (e.g., by collisions and radiation) but never destroyed (conservation of energy).
- Differentiate the states of matter based on their energy state (e.g., the structure of molecules and atoms in these different states varies from rigid in solids to independent motion in a gas).
- View thermal energy (i.e., heat) in terms of atomic and molecular motion (i.e., the higher the temperature, the greater the atomic or molecular motion).[1]
- Compare the transmission, reflection, refraction, and absorption of light using different materials.
- Listen for student misconceptions about properties and particle theory, and try to correct them.
- Identify the underlying core science concepts in this unit for elementary students
- Design age-appropriate, inquiry-based activities and identify learning outcomes.

[1] These objectives will be continued and deepened in Unit3, Energy and Matter where the focus of energy transfers will be on the microscopic level (between and within atoms)—for instance, understanding chemical reactions (exothermic and endothermic) and radioactivity.

Unit 3: Interactions of Energy and Matter

Week	Topics/Themes
5	Review of physical and chemical properties and physical change Solutions and solubility Conservation of mass in solutions
6	Introduction to chemical reactions Difference between chemical and physical reactions The role of energy in explaining bonds Applications of electrolysis
7	Teaching "Interactions of Energy and Matter" in elementary grades

During this unit, prospective teachers will:

- Differentiate between physical and chemical properties, and physical and chemical change.
- Gain an understanding that mass is conserved even when materials are dissolved.
- Investigate how some common materials interact to form new materials.
- Explain how in physical change properties of substances remain the same.
- Provide examples of how the properties of a product of a chemical change are different than the products of the reactants.
- Provide examples of the natural world in which energy is released (or needed) in chemical reactions (e.g., burning fossil fuels, photosynthesis).
- Be able to identify some of the underlying core science concepts in this unit for elementary students.
- Design age-appropriate, inquiry-based activities and identify learning outcomes.
- Be aware of misconceptions about energy and matter, and learn what to do about them.

Unit 4: Earth's Systems Undergoing Constant Change

Week	Topics/Themes
8	Water, carbon, and rock cycle Theory of plate tectonics - Living in the shadow of the big mountains
9	Climate change
10	Teaching "Earth's Systems Undergoing Constant Change" in elementary grades

During this unit, prospective teachers will:

- See the Earth as a system consisting of major interacting components that consistently undergo change. Identify physical, chemical, and biological processes act within and among them on a wide range of scales.
- Begin to see that there are complex interactions between the atmosphere, the hydrosphere, and the lithosphere.
- Apply the theory of plate tectonics to explain the formation of Pakistan's mountain ranges and the threat of earthquakes.
- Recognize how the movement of Earth's lithospheric plates causes slow changes in Earth's surface (e.g., formation of mountains and ocean basins) and rapid ones (e.g., volcanic eruptions and earthquakes).
- Give examples of advances in technology that have made it possible to more accurately predict natural disasters.
- Understand how human activities influence air and water quality, ecosystems, and climate across the globe.
- Identify the underlying core science concepts in this unit for elementary students.
- Design age-appropriate, inquiry-based activities and identify learning outcomes.

Unit 5: Solar System and the Universe

Week	Topics/Themes
11	Characteristics of our Solar System Earth and Sun compared to other objects in the sky Working with and understanding large distances
12	Origin and evolution of Earth (and the Solar System)
13	Teaching "Our Solar System and the Universe" in elementary grades

During this unit, prospective teachers will:

- Differentiate groups of objects in the Solar System—including the Sun; the planets and their moons and rings; and smaller objects, such as asteroids and comets—by their size, composition, and position in the Solar System.
- Compare and contrast the properties and characteristics of Earth with those of the other planets in our Solar System.
- Explain, based on the naked eye and telescopic observation, how objects in the Solar System change position against the background of stars.
- Begin to understand the scale of time and distance involved in deep space.
- Describe how the early Earth was very different from the planet we live on today.
- Identify the underlying core science concepts in this unit for elementary students.
- Design age-appropriate, inquiry-based activities and identify learning outcomes.

Unit 6: Human Body as a System

Week	Topics/Themes
14	Flow of matter and energy in living systems Circulatory and digestive system Structure, function, and organization of different cells
15	Cell processes Cellular respiration
16	Teaching "Human Body as a System" in elementary grades

During this unit, prospective teachers will:

- Connect an organism's need for food with cells' need for food.
- Explain how multiple body systems work together to meet cell energy needs.
- Examine and describe the flow of matter and energy in living systems.
- Demonstrate through investigations that food is a source of energy (fuel) and building materials for cells.
- Relate cellular respiration to the functions of body systems (e.g., how body systems function to provide cells with the necessary raw materials).

SUGGESTED TEXTBOOKS AND REFERENCES

There are many science books and other resources that could be useful during this course. Here is just a selection:

Target Science - Physics by Stephen Pople
Target Science - Chemistry by Michael Clugston and Rosalind Fleming
The Teaching of Science in Primary schools – Wynne Harlen
Inquiry – Thoughts, Views, and Strategies for the K-5 Classroom – National Science Foundation
Ready, Set, Science! Putting Research to Work in K-8 Science Classrooms – National Research Council
Taking Science to School: Learning and Teaching Science in Grades K-8 – National Research Council

The "History of Science" is a website that provides standards-aligned resources that make it easier to bring the history of science into a classroom. This site focuses on chemistry standards likely to be found in an introductory chemistry or physical science class.
http://cse.edc.org/products/historyscience/default.asp.

COURSE ASSIGNMENTS

Suggested assignments are included in the Unit Guides of the course. Some are short-term assignments and some take several weeks to complete. A mix of individual and group assignments is also provided.

These assignments are designed to deepen students' learning and allow them to research and apply their knowledge to topics of personal interest. All the assignments count toward the final grade.

Assignments are similar to those conducted in Science I but are more complex and self-directed:
a) Conduct an investigation on a science topic, and present your findings and conclusions.
b) Develop an investigation around a core science concept for an elementary grade.
c) Write an editorial for a local newspaper on a relevant science topic stating an opinion supported by evidence.
d) Using the inquiry approach, plan and teach a science activity in a local elementary school.

In addition, as part of Science II, prospective teachers will conduct an independent research project during the course that will mirror a real-life context and investigation.
Examples of such topics could be:

- Design a model to explain the greenhouse effect.
- Research how Pakistan generates its electricity and provide a report on how some of it could be supplemented by using renewable energy.
- Waste management and recycling
- Natural resources in Pakistan
- Natural disasters in Pakistan
- Infectious diseases

GRADING POLICY

The course grading policy should be determined by the university and its affiliated colleges. The policy should be shared with students at the beginning of the course. It is recommended that at least 50% of the final grade is determined by course work completed by prospective teachers. Course work may include work completed in assignments in or outside the classroom.