B.Ed.Hons. 2.5 Secondary

Teaching of Science (Pedagogy)
(Semester 5)

No. of weeks
16

Credit value
3 credits

Prerequisites
Science I (*Semester 2*), Science II (*Semester 3*) and Science III (*Semester 4*)

Course description
Science education needs reform in the philosophical, instructional, and pedagogical dimensions of current practice. Particularly, instructional settings and strategies used by teachers can create an environment that fosters a constructive and active view of the learning process. Learning does not occur by passive absorption of scientific facts; rather, it involves learners in constructing their own meaning and assimilating new information to develop new understandings. In Science III, the overall thrust of the course is on the development of scientific knowledge, skills, and attitudes in Student Teachers in the areas of life science, physical science, and Earth and space science. Therefore, this course emphasizes developing inquiry, problem-solving, and decision-making abilities in Student Teachers so they may maintain a sense of wonder and curiosity about the world around them.

We believe that to make learners scientifically literate citizens requires diverse learning experiences that provide opportunities to explore, analyses, evaluate, synthesize, appreciate, and understand the interrelationships among science, technology, society, and the environment. This experiential learning will affect learners' personal lives, careers, and their roles as global citizens. Hence, the aim of developing this course is to address all of these facets of curriculum and instruction.

Course outcomes
Knowledge
By the completion of the course, Student Teachers will be able to:
- discuss the concepts related to life science, physical science, and Earth and space science;
- apply these understandings to interpret, integrate, and extend their knowledge; and,
- discuss important features differentiating the traditional science classroom and the interactive science classroom.

Science, technology, society, and education (STSE)
By the completion of the course, Student Teachers will be able to:
- describe and discuss the nature of science and technology;
- explain the relationships between science and technology and between the social and environmental contexts of science and technology;

- develop and use the related skills and conceptual knowledge necessary for making connections between scientific, technological, social, and environmental issues; and,
- apply the aspects of environmental education in their personal and social lives.

Skills

By the completion of the course, Student Teachers will be able to:

- exhibit the skills required for scientific and technological inquiry;
- use these skills for solving problems as well as communicating scientific ideas and results;
- work collaboratively;
- make informed decisions in their personal and social lives; and,
- use a variety of teaching skills while planning and conducting science lessons.

Attitudes

By the completion of the course, Student Teachers will be able to:

- use their understanding to support the responsible acquisition and application of scientific and technological knowledge to the mutual benefit of self, society, and the environment; and,
- develop an interest in and motivation toward science education and related careers.

Teaching and learning approaches

Student Teachers would be introduced to science concepts through the inquiry approach, constructivism, and learning by doing. They would be encouraged to engage in independent learning, group projects, assignments, and presentations guided by the instructor. Literature suggests that students learn more through experience, which makes learning more interactive and interesting. Therefore, the Instructor's role would be that of a facilitator who will bridge theoretical concepts with daily life experiences. This will provide Student Teachers an opportunity to learn science through the application approach.

Overview of the course

UNIT 1	**Overview of Science IV: Creating linkages**
Learning outcomes	It is expected that Student Teachers will: • describe the course outline, pedagogy, and assessment criteria; • build connections between their learning in different science courses; and, • explain the role of science in daily life.
Week	**Topics**
1	• Introduction to course project/s, intended topics to be covered, and assessment criteria • Connections of Science IV with earlier courses • Science in daily life

Theme 1: Life Science

UNIT 2	The constructivist approach to teaching the concept of heredity
Learning outcomes	It is expected that Student Teachers will: • experience the concept of heredity through the constructivist approach to teaching science; • explain different cell components through analogies; • discuss the implication of a constructivist approach for learning science in the classroom; • explain that cell components play an important role in heredity; • explain the structure of chromosomes with reference to their function; • elaborate the importance of DNA in terms of its function and importance for life; and, • differentiate between acquired and inherited traits.
Week	**Topics**
2	• Social constructivism and its implication for teaching science • Cell components and cell division • Basis of heredity (chromosomes, DNA, and genes in plant and animal cells) • Human traits (acquired and inherited)

UNIT 3	Teaching biotechnology through daily life applications
Learning outcomes	It is expected that Student Teachers will: • discuss the role of genes in determining characteristics and traits; • recognize the potential role (both positive and negative) of genetic engineering; • describe the common application of biotechnology in various fields; and, • discuss the ethical implication of biotechnology.
Week	**Topics**
3	• Introduction to biotechnology • General applications of biotechnology (agriculture, environment, health, food production and preservation) • Ethical issues involved in biotechnology

Theme 2: Physical Science

UNIT 4	Laboratory work in the science classroom
Learning outcomes	It is expected that Student Teachers will: • use different laboratory instruments to measure physical quantities; • discuss safety and planning considerations for laboratory work in science teaching; • explain the need for units when considering physical quantities; • explain derived quantities and obtain their units in terms of base units; • discuss the meaning and significance of accuracy and precision in science; • identify the nature and properties of elements; • discuss the arrangements of elements in the periodic table; • perform laboratory work to investigate chemical reactions in different compounds; • differentiate different groups of elements based on their chemical and physical properties; • investigate properties and uses of acid, alkalis, and salts; and, • prepare and use natural indicators to determine pH of different solutions.
Week	**Topics**
4	• Physical quantities (length, volume, mass, time) • Système Internationale (SI) units (metre, litre, kilogram, second) • Instruments for measurement (metre rule, measuring cylinder, flasks, pipettes) • Accuracy and precision in measurements • Laboratory work: Planning, precautions, and safety measures
5	• Different types of elements in the periodic table • Distribution of electrons: Valence shell configuration • Arrangements of elements in the periodic table
6	• Physical properties of different elements in the periodic table • Chemical properties and the reactivity of elements in the periodic table
7	• Properties and uses of acids, alkalis, and salts • pH and its range (1–14) in aqueous medium • Natural indicators (from fruits and vegetables) • Significance of laboratory work in science teaching

UNIT 5	Low-cost, high-thought materials when teaching force and pressure
Learning outcomes	It is expected that Student Teachers will: • investigate the relation between pressure, force, and area by using low-cost, high-thought resources; • discuss the hydraulic system; • explore water pressure and its application; • discuss the significance and implications of low-cost materials; and, • prepare low-cost, high-thought resources for their own teaching practice.
Week	**Topics**
8	• Use of low-cost, high-thought resources in the science classroom • Relation between pressure, force, and area • Hydraulics and hydraulic systems • Water pressure

UNIT 6	Teaching heat and light through the inquiry approach
Learning outcomes	It is expected that Student Teachers will: • discuss the inquiry approach of teaching science and its implications for science teachers; • observe the effects of heat (thermal expansion and contraction) in different states of matter; • discuss the phenomena of thermal expansion and contraction at the molecular level; • discuss the application of thermal contraction and expansion in daily life; • explore the nature of light (phenomena such as transmission, absorption, and reflection); • differentiate between reflection and reflection phenomena (process, effect, and causes); • differentiate between different types of lenses; and, • compare the working of the human eye with a camera lens.
Week	**Topics**
9	• Activity-mania vs. inquiry • Thermal expansion and contraction (solids, liquids, and gases) • Effects of heat (explanation at macro and micro levels)

10	• Factors affecting the contraction and expansion process • Application of expansion and contraction of solids in everyday life (concrete road surfaces, railway tracks, bridges, overhead power lines, telephone lines, pipelines)
11	• Nature of light • Reflection and refraction • Types and uses of lenses • Image formation in a simple camera and the human eye

UNIT 7	**Common misconceptions about electricity**
Learning outcomes	It is expected that Student Teachers will: • identify students' misconceptions about electricity; • design activities to teach the concept(s) based on students' misconceptions; • define *current*; • investigate different types of circuits; • explain the process and factors of generating electricity; and, • design an experiment to generate electricity.
Week	**Topics**

12	• Common misconceptions about electricity and its implications in the science classroom
	• Static vs. moving charges: The concept of electric current
	• Production of electricity
	  o Circuits
	  o Conductor
	  o Power source
	• Explanation at the molecular level

Theme 3: Earth and Space Sciences

UNIT 8	**Space exploration through ICT integration**
Learning outcomes	It is expected that Student Teachers will: • compare the physical characteristics of different environments (planets and space) with that of Earth; • explore the force of gravity and its implications in space; • investigate how aircraft, satellites, and spaceships have improved our knowledge about space and how they are used for space research; and, • discuss the importance and levels of ICT integration in the science classroom.

Week	Topics
13	• Levels and pros and cons of ICT integration • Comparison of different environments (space, Earth) • Force of gravity and factors responsible for it • Aircraft, satellites, and spaceships

UNIT 9	Science, Technology, Society, and Environment (STSE): A new approach to teaching science
Learning outcomes	It is expected that Student Teachers will: • reflect on teaching strategies to make learners aware of STSE issues, how to investigate, and how to make intelligent decisions; • describe the effects of human activity on the environment; • participate in environmental safety through social action; • understand the process of human growth and development; • discuss factors that affect the development process; and, • develop awareness about health care and its importance in daily life.
Week	**Topics**
14	• Science, Technology, Society, and Environment (STSE) • Benefits and challenges related to teaching science through STSE

UNIT 10	Traditional and alternative assessment methods
Week	**Topics**
15	**Topic 1:** Traditional vs. alternative assessment methods **Topic 2:** Developing multiple choice questions (MCQs **Topic 3:** Developing constructed response questions (CRQs
16	**Topic 1:** Developing peer-assessment and self-assessment tasks and tools **Topic 2:** Portfolio assessment

Reference

National Curriculum for General Science Grades IV–VIII (2006). Government of Pakistan, Ministry of Education, Islamabad.

Additional Resources

Chiappetta, E. L., & Koballa, T. R. (2010). *Science instruction in the middle and secondary schools: Developing fundamental knowledge and skills* (7th ed.) Boston: Allyn & Bacon.

Driver, R., Rushworth, P., Squires, A., & Wood-Robinson, V. (1994). *Making sense of secondary science: Research into children's ideas*. London: Routledge.

Fensham, P. J., Gunstone, R. F., & White, R. T. (1994). *The content of science: A constructivist approach to its teaching and learning*. Bristol, PA: Falmer Press.

Suggested articles for reading

Gupta. A. (2013). *Learning science through activities and toys*. (Also many relevant materials). Retrieved from http://arvindguptatoys.com

Halai, N. (2010). Teaching teachers and students about the nature of science. *Journal of Educational Research, 13*(1), 171–179.

Moscovici, H., & Nelson, T. H. (1998). Shifting from activitymania to inquiry. *Science & Children*, 14–18. Retrieved from http://thecenter.spps.org/uploads/shifting_from_activitymania.pdf

Steinert, Y., & Snell, L. S. (1999). Interactive lecturing: Strategies for increasing participation in large group presentations. *Medical Teacher, 21*(1), 37–42.

Course Assignments

Suggested assignments are included in the unit guides of the course. Some are short-term assignments and others take several weeks to complete. Individual and group assignments are also provided.

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

Examples of assignments include:

- Academic paper to elaborate, 'Nature of science'
- Analyse science textbooks to identify misconceptions if mentioned in the book and suggest correct information
- Conduct an investigation on a science topic and present your findings and conclusions.

Grading Policy

The university and its affiliated colleges will determine the course grading policy. The policy should be shared with Student Teachers at the beginning of the course. It is recommended that at least 50 per cent of the final grade be determined by coursework completed by Student Teachers. Coursework may include work assignments completed in or outside the classroom, or assignments completed while practice teaching at school.