semester 7

Science - III (Teaching Science Pedagogy Option)

WINDOWS ON PRACTICE GUIDE

B.Ed. (Hons.) Elementary

2012

Higher Education Commission

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Higher Education Commission

Foreword

Teacher education in Pakistan is leaping into the future. This updated Scheme of Studies is the latest milestone in a journey that began in earnest in 2006 with the development of a National Curriculum, which was later augmented by the 2008 National Professional Standards for Teachers in Pakistan and the 2010 Curriculum of Education Scheme of Studies. With these foundations in place, the Higher Education Commission (HEC) and the USAID Teacher Education Project engaged faculty across the nation to develop detailed syllabi and course guides for the four-year B.Ed. (Hons) Elementary and the two-year Associate Degree in Education (ADE).

The syllabi and course guides have been reviewed by the National Curriculum Review Committee (NCRC) and the syllabi are approved as the updated Scheme of Studies for the ADE and B.Ed. (Hons) Elementary programmes.

As an educator, I am especially inspired by the creativity and engagement of this updated Scheme of Studies. It offers the potential for a seismic change in how we educate our teachers and ultimately our country's youngsters. Colleges and universities that use programmes like these provide their students with the universally valuable tools of critical thinking, hands-on learning, and collaborative study.

I am grateful to all who have contributed to this exciting process, in particular the faculty and staff from universities, colleges, and provincial institutions who gave freely of their time and expertise for the purpose of preparing teachers with the knowledge, skills, and dispositions required for nurturing students in elementary grades. Their contributions to improving the quality of basic education in Pakistan are incalculable. I would also like to thank the distinguished NCRC members, who helped further enrich the curricula by their recommendations. The generous support received from the United States Agency for International Development (USAID) enabled HEC to draw on technical assistance and subject matter expertise of the scholars at Education Development Center, Inc. and Teachers College, Columbia University. Together, this partnership has produced a vitally important resource for Pakistan.

PROF. DR SOHAIL NAQVI
Executive Director
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Islamabad

Introduction

As part of nationwide reforms to improve the quality of teacher education, the Higher Education Commission (HEC), with technical assistance from the USAID Teacher Education Project, engaged faculty across the nation to develop detailed syllabi for courses in the new four-year B.Ed. (Hons) Elementary programme.

The process of designing the syllabus for each course in years 3 and 4 of the programme began with curriculum design workshops. Deans and directors from universities where these courses will be taught were invited to attend the workshops. The first workshop included national and international subject matter experts who led participants in a seminar focused on a review and update of subject (content) knowledge. The remainder of this workshop was spent reviewing the HEC Scheme of Studies, organizing course content across the semester, developing detailed unit descriptions, and preparing the course syllabi. Although the course syllabi are designed primarily for Student Teachers taking the course, they are useful resources for teacher educators, also.

Following the initial workshop, faculty participants developed teaching notes that included ideas for teaching units of studies and related resources. Working individually or in groups, participants focused on their own teaching methods and strategies and how they could be useful to the course's future teachers. Subsequent workshops were held over the course of a year to give faculty sufficient time to complete their work, engage in peer review, and receive critical feedback from national and international consultants. In designing both the syllabi and the teaching notes, faculty and subject matter experts were guided by the National Professional Standards for Teachers in Pakistan (2009).

All of the syllabi developed by faculty who participated in the workshops are included in this document, along with a list of topical teaching notes. Additional references and resources appear at the end of the document. These should provide a rich resource for faculty who will teach this course in the future. Sample syllabi with accompanying teaching notes are also included to provide new Instructors with a model for developing curriculum and planning teaching. This Windows on Practice guide is not intended to provide a complete curriculum with a standard syllabus and fully developed units of study; rather, it aims to suggest ideas and resources for Instructors to use in their own planning. Hence, readers will find sample units and materials that reflect the perspective of faculty designers rather than prescriptions for practice.

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Initial drafts were reviewed by the National Curriculum Review Committee (NCRC) and suggestions were incorporated into final drafts, which were then submitted to the NCRC for approval.

Faculty involved in course design: Anjum Akhtar, Fatima Jinnah Women University, Rawalpindi; Dr Ahmad Sher Awan, IER, University of the Punjab, Lahore; Dr Muhammad Amin, University of Education, Lahore; Dr Muhammad Sarwar, University of Sargodha; Dr Saifullah, University of Gujarat; Dr Syed Munir Ahmad, IER, University of Peshawar; Sahar Yasmeen, University of Karachi; Dr Waheed Akbar, Hazara University, Mansehra; Khalid Khurshid, Bahauddin Zakariya University, Multan; Misbah Malik, University of Education, Lahore; Sadia Suleman Khan, Sardar Bahadur Khan Women University, Quetta; and Sumera Irum, Sindh University, Jamshoro.

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National subject expert leading the course design: Shairose Irfan Jessani, Science Educationalist, Aga Khan Education Service, Pakistan.

NCRC review dates: 24–25 April 2013.

NCRC reviewers: Dr Allah Noor, IER Gomal University; Dr Parveen Munshi, Sindh University; and Dr Rizwan Akram Rana, IER Punjab University.

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1

Rationale for a course on teaching science

In the Higher Education Commission 2010 document 'Curriculum of Education: B.Ed. (Hons) 4-year Degree Program (Elementary and Secondary), Associate Degree in Education, M. Ed./Ms. Education', this course was included to continue preparing prospective teachers for innovative and creative ways of teaching science. It is clearly mentioned in the course description that:

> The study of General Science in Primary and Secondary school is linked to National prosperity and economic development. The course is designed for the effective interactive ways of teaching science. The course will highlight the power of observation and inquisitiveness in general sciences studies. It will also focus on how to relate facts, concepts, and theories to every day experience.
>
> (HEC, 2010, p. 47)

In the past, teaching science was not considered an important element in the curriculum of education because mastery of science content was considered only necessary for science teachers. However, it is now realized that pedagogical knowledge and pedagogical content knowledge are key for an effective teaching-learning process. In this course, elements of effective teaching are highlighted while integrating them with the science content. This gives a rich experience for learners to see the significance and application of these elements for their future teaching practices. Further, the Science III course is an extension of Science I and II, both in terms of the depth of topics covered as well as the application of the overall ideas of Science I and II, which include the nature of science, science for all, planning, resources, teaching approaches, and assessment in the science classroom. The main focus during the development process of this course was to provide a reflective opportunity to Student Teachers to learn, unlearn, and relearn their notion of learning and perceptions about science education. For this, several activities and assessment strategies are suggested in this manual that would provide a wide array of experiential learning to prospective teachers.

2

Common misconceptions about science education

Science education in primary schools aims to prepare students to become scientifically and technologically literate so that they may make intelligent decisions in the biotechnological, electronic, and communications era. For this, science teachers need to be updated with new developments in science as well as new approaches, models, and methods of teaching science. Unfortunately, there is a wide gap between teachers' and students' preferences for science content and approaches. Along with this, teachers enter the training programme with some common misconceptions about science content and pedagogy. The course Instructor should be aware of these misconceptions and how they can surface during the training period so that Student Teachers can consciously critique their pre-existing ideas and take necessary action to assimilate and accommodate new learning with their existing knowledge. Some of the common misconceptions regarding science subject and pedagogy include the following:

- Science is a body of knowledge that is mainly based on facts. Therefore, scientific theories and laws are unchangeable and should be accepted as fact.
- Designing a science curriculum is the responsibility of experts, whereas teachers are responsible only to implement them in the classroom.
- Scientific knowledge should be transferred correctly from the teacher (the knowledge source) to students (the knowledge seekers). Hence, the best pedagogy is the lecture method.
- There are no sociocultural influences on science—scientific ideas and concepts are understood in the same way all over the world.
- Making scientific discoveries and inventions are up to scientists using sophisticated equipment.
- Science does not connect with society, art, culture, and technology. Hence, learning about science is only appropriate for those who want to make their careers in science fields. It is of no use in everyday life.
- Doing science only involves the cognitive domain. The psychomotor and affective domains are not involved.
- The resources required to do practical science work are very costly.
- Science teaching is limited to the classroom as all equipment and resources are available only within the classroom.
- Science practical work calls for the reproduction of results with the help of pre-decided sets of instructions to be followed by students.

Hence, it is important for course Instructors to design activities around these misconceptions and to ask Student Teachers to reflect on their learning from each experience and analyse it with reference to their pre-existing ideas. In this way, teachers will challenge their own perceptions and practices and will use assimilation and accommodation processes for new learning.

3

Course syllabi

In this section, you will find syllabi that have been written by faculty or groups of faculty. Using the HEC Scheme of Studies for the course, they considered the balance between the demands of the subject itself, active learning pedagogies, their students, and the particular university milieu in which they work. All three syllabi reflect the same key concepts and broad goals, but they vary in sequence and emphasis.

SYLLABUS 1

Prepared by

Dr Waheed Akbar, Dr Muhammad Amin, Anjum Akhtar, and Dr Syed Munir Ahmad

Year/Semester

Year 4/Semester 7

Number of weeks

16

Credit value

3 credits

Prerequisites

Science I (Semester 1) and Science II (Semester 3)

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, analyse, 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
- 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
- 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
- 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
- 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 III: 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 • 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 III with earlier courses Science in daily life

Theme 1: Life science

2 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 • 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)

3 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 • 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

4 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 • 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

5 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 • 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

6 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 • compare the working of the human eye with a camera lens.
Week #	Topics
9	Activitymania 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

7 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 • 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 • Circuits • Conductor • 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 • 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 • 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
15	Effects of human activity on the environment Saving the Earth project
16	Healthy life: Growth and development Factors affecting growth and development Balanced diet

References

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:

- Conduct an investigation on a science topic and present your findings and conclusions.
- Develop hands-on activities around a core science concept for an elementary grade.
- Plan and conduct a science activity with a group of children using the inquiry approach.

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.

SYLLABUS 2

Prepared by

Khalid Khurshid, Misbah Malik, Sadia Suleman Khan, Sahar Yasmeen

Year/Semester

Year 4/Semester 7

Duration and hours

48 hours (16 weeks)

Prerequisite

Science I and II

Credit value

3 credits

Course description

Science is a process rather than a product of knowledge; therefore, the testing and retesting and thus occasional discarding of theories, whether new or old, happen continuously. The Science III course is an attempt to progress from Science I and Science II, and it is also guided by the National Curriculum. It will expand the subject matter knowledge of Student Teachers in three themes of the national curriculum—life science, physical science, and Earth and space sciences—so that Student Teachers can teach effectively in the higher elementary grades (6 to 8). This course will also provide them the opportunity to enhance their understanding in the areas of content, pedagogy, and content pedagogy.

In this course, Student Teachers will learn about science, teaching, and assessing science through a variety of interactive strategies; for example, project work, group inquiry, interactive lectures, directed activities related to text (DARTs), predict, observe and explain (POE), and discrepant events. This will in turn develop curiosity, interest, and problem-solving skills among students and will result in better learning outcomes.

Course outcomes

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

- expand/maximize their subject matter knowledge
- develop knowledge and a coherent understanding of the living, physical, material, and technological components of their environment
- encourage students to develop skills for investigating the living, physical, material, and technological components of their environment in scientific ways
- provide opportunities for students to develop the attitudes on which scientific investigation depends
- promote science as an activity that is carried out by everyone in their everyday lives
- teach science effectively in higher elementary grades (6 to 8)
- make connections between events and scientific concepts
- promote conceptual understanding
- assess students' prerequisite knowledge and adapt or change their pedagogy accordingly.

Teaching and learning approaches

The constructivist view of pedagogy sees learning as a dynamic and social process in which learners actively construct meaning from their experiences in connection with their prior understandings and social setting. In this course, pedagogy will heavily rely on the constructivist approach through structured and open inquiry, demonstration, fieldwork, case studies, investigations, individual and group projects, research activity, and the use of discrepant events. (A discrepant event is something that surprises, startles, puzzles, or astonishes students as they observe the event. Often, a discrepant event is one that does not appear to follow basic 'rules of nature', and the outcome is unexpected or contrary to what they predicted.) The main goal is to develop a sense of connection in the learner between science and the real world so that they realize the application and significance of scientific concepts. This then develops learners' interest and active involvement in science education.

Semester outline

Unit 1: Preparing teachers to teach science

After completion of this unit, Student Teachers will be able to:

- identify the changing nature of science
- define vocabulary related to scientific processes and skills
- experience different interactive teaching methodologies that can be used in the science classroom
- discuss the importance of lesson planning in science classrooms
- discuss different components of a lesson plan
- develop a lesson plan related to a science concept
- discuss the importance of using low-cost, high-thought science resources
- share different assessment strategies, such as self, peer, portfolio, paper-pencil, and performance based.

UNIT 1:	**Preparing teachers to teach science**
Week #	Topics
1	**Topic 1:** The changing nature of science **Topic 2:** Vocabulary related to scientific processes **Topic 3:** Learner-focused science teaching methods
2	**Topic 1:** Planning to teach science **Topic 2:** Low-cost, high-thought science teaching resources **Topic 3:** Assessment in the science classroom

Unit 2: Connection of science to daily life

After completion of this unit, Student Teachers will be able to:

- discuss why it is important that everyone has some basic understanding of science
- discuss cell components and their roles
- explain that cell components play an important role in heredity
- discuss how dominant and recessive genes can influence different physical features
- discuss the role of genes in determining characteristics and traits
- recognize the role of genetic engineering in genetic diseases
- describe the common application of biotechnology in various fields
- discuss the ethical implication of biotechnology.

UNIT 2:	**Connection of science to daily life**
Week #	Topics
3	**Topic 1:** Science for all **Topic 2:** Creating scientific literacy
4	**Topic 1:** Cell components and cell division **Topic 2:** Basics of heredity **Topic 3:** Acquired and inherited traits in humans
5	**Topic 1:** Introduction to biotechnology **Topic 2:** General applications of biotechnology (agriculture, environment, health, food production and preservation) **Topic 3:** Ethical issues involved in biotechnology

Unit 3: Teaching global climate through the Science, Technology, Society, and Environment (STSE) approach

After completion of this unit, Student Teachers should be able to:

- discuss the salient features of the STSE approach to science education
- explain the source, properties, and harmful effects of air pollutants
- describe problems in human organ systems caused by air pollutants
- plan and conduct a campaign that can help to reduce air pollution in their local environment
- discuss the effect of pollution on the environment.

UNIT 3:	**Teaching global climate through the Science, Technology, Society, and Environment (STSE) approach**
Week #	Topics
6	**Topic 1:** STSE approach to science education **Topic 2:** Air pollutants (sulphur dioxide, carbon monoxide, oxides of nitrogen, and chlorofluorocarbons) **Topic 3:** Sources (natural and from human activities)
7	**Topic 1:** Harmful effects of pollution on human organ systems (such as lung diseases, headaches, breathing difficulties) **Topic 2:** Harmful effects of pollution on the environment (such as the greenhouse effect, global warming, ozone depletion)
8	**Topic 1:** Saving the Earth (solid waste management, recycling, environmental campaigns, green clubs)

Unit 4: Teaching measurement of physical quantities through interactive lectures

After completion of this unit, Student Teachers should be able to:

- discuss the significant features of interactive lectures
- differentiate between interactive lectures and traditional lectures
- explain quantity
- explain the need for units when handling physical quantities
- state how the base units used in this course are defined
- explain derived quantities and obtain their units in terms of base units
- discuss the International System (unit system)
- practice unit conversions
- use different instruments of measurement
- discuss the important concepts related to measurement such as precision and accuracy, and least count[1]
- discuss the application of measurement in daily life.

[1] Least count is the highest degree of accuracy of measurement that can be achieved.

4 UNIT 4:	**Teaching measurement of physical quantities through interactive lectures**
Week #	Topics
9	**Topic 1:** Physical quantities (length, volume, mass, time) **Topic 2:** Système Internationale units (metre, litre, kilogram, second)
10	**Topic 1:** Instruments for measurement (metre rule, measuring cylinder, flasks, pipettes) **Topic 2:** Measurements in daily life **Topic 3:** Traditional lectures vs interactive lectures

Unit 5: Force and pressure through low-cost, high-thought resources

After completion of this unit, Student Teachers should be able to:

- discuss the importance of low-cost, high-thought resources in science classrooms
- share examples of how these resources are made and used
- investigate the relationship between pressure, force, and area
- discuss the hydraulic system
- explore water pressure and its application
- perform activities to observe air pressure
- develop teaching resources while planning the above concepts.

5 UNIT 5:	**Force and pressure through low-cost, high-thought resources**
Week #	Topics
11	**Topic 1:** Significance of low-cost, high-thought resources **Topic 2:** The relationship among pressure, force, and area **Topic 3:** Hydraulics and hydraulic systems
12	**Topic 1:** Water pressure **Topic 2:** Air pressure **Topic 3:** Development of low-cost, high-thought resources

Unit 6: Teaching electricity through the guided-inquiry approach

After completion of this unit, Student Teachers should be able to:

- differentiate between guided and free inquiry in the science classroom
- define *current*
- investigate different types of circuits used for different purposes
- explain the process and factors of generating electricity
- design an experiment to generate electricity
- reflect on the experience of the inquiry approach
- differentiate between active learning and doing activities

UNIT 6:	**Teaching electricity through the guided-inquiry approach**
Week #	Topics
13	Charges and their interaction Electricity Simple circuits
14	Types of circuits Electrical appliances Renewable and non-renewable energy resources

Unit 7: Traditional and alternative assessment methods

After completion of this unit, Student Teachers should be able to:

- experience different types of assessment while learning the concepts of acid, base, and salts
- distinguish between traditional (paper-pencil) assessment and alternative (performance-based) assessment
- develop different assessment tools and tasks on different themes of acid, base, and salts.

UNIT 7:	**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

Suggested materials

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.

Gupta. A. (2013). *Learning science through activities and toys*. (Also many relevant materials.) Retrieved from

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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:

- Conduct an investigation on a science topic and present your findings and conclusions.
- Develop hands-on activities around a core science concept for an elementary grade.
- Plan and conduct a science activity with a group of children using the inquiry approach.

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.

SYLLABUS 3

Prepared by

Dr Ahmad Sher Awan, Sumera Irum, Dr Muhammad Sarwar, and Dr Saifullah

Year/Semester

Year 4/Semester 7

Duration and hours

48 hours (16 weeks)

Prerequisite

Science I and II

Credit value

3 credits

Course description

Science is a logical way of understanding the universe, which attempts to describe the phenomena of nature. Also, it is a body of interconnected and validated ideas about the physical, biological, psychological, and social worlds over the course of history through scientific inquiry. The means used to develop these ideas are observing, thinking, experimenting, and validating. Student Teachers will take this course after completing Science I and Science II, which included some of the basic ideas of science. The present course is a step forward toward consolidating scientific ideas and extending the content. The previous two courses may have been dominated by content, but at the outset of Science III, Student Teachers are introduced to pedagogical skills built on some larger ideas from the three science disciplines: physical science, life science, and Earth science.

The Instructor will adopt innovative teaching approaches dominated by the inquiry approach along with cooperative learning and problem-solving, which involve Student Teachers in the active learning process. In this syllabus, the use of inquiry-based pedagogy in the paradigm of the constructivist approach should help Student Teachers experience making meaning in science, and help them relate science learning with their daily experiences.

Course outcomes

After completing this course, Student Teachers will be able to:

- explain the nature of science
- develop a 'scientific attitude' in their students
- demonstrate scientific thinking in their daily and professional lives
- engage learners actively by applying the scientific inquiry approach
- plan science lessons using interactive teaching strategies
- identify and rectify the common misconceptions about major scientific ideas
- promote learners' understanding of the processes of learning, unlearning, and relearning
- incorporate assessment approaches that are aligned with science teaching and correlate with intended learning areas such as learning strands, content standards, benchmarks, and student learning outcomes
- read, record, and analyse data, and present that data in meaningful ways.

Teaching and learning approaches

This course is designed to educate Student Teachers in pedagogical skills for use in the science classroom. This course will use both the direct and indirect approaches. The direct approach will include mastery learning through interactive lectures, demonstrations, and laboratory work, whereas the indirect approach will be based on constructivist learning through inquiry, problem-solving, and cooperative learning. The teaching approaches will be supplemented with the use of appropriate technology and daily life experiences, which will make science learning more contextual, interesting, and relevant.

Unit 1: Complexities of teaching science

Student Teachers should be able to:

- discuss the complexities of science concepts
- discuss their implication for science teaching
- explore various teaching-learning approaches in science classrooms.

UNIT 1:	**Complexities of teaching science**
Week #	Topics
1	Challenges for science teachers (for example, its abstract nature and sometimes difficult vocabulary) Practical work in science classrooms Demonstration in science classrooms ICT integration in science classrooms Role play and drama in science classroom

Unit 2: Planning and teaching science lessons through the constructivist approach

Student Teachers should be able to:

- discuss photosynthesis, respiration, pollination, and reproduction through the constructivist learning approach
- distinguish between traditional and constructivist science classrooms
- discuss key components in a science lesson plan.

UNIT 2:	**Planning and teaching science lessons through the constructivist approach**
Week #	Topics
2	Photosynthesis: Its process, significance, and factors Respiration: Its process, significance, and factors Pollination and types of pollination
3	Types of reproduction Traditional vs constructivist learning activities Lesson plan and its components

Unit 3: Teaching the human organ system through ICT integration

Student Teachers should be able to:

- explain concepts such as the excretory system and heredity through ICT integration (models, presentation, etc.)
- discuss different levels of ICT integration and its implication in science teaching
- design lesson plans about the human organ system that include the use of ICTs
- conduct microteaching sessions.

UNIT 3:	Teaching the human organ system through ICT integration
Week #	Topics
4	Nervous system (central and peripheral) and the reflex action Excretory system (structure of kidney and its role in excretion)
5	ICT integration: Levels and models Developing lesson plans
6	Microteaching and team reflections

Unit 4: Understanding the periodic table through active learning

Student Teachers should be able to:

- discuss the significance and structure of the periodic table
- compare the different models of the periodic table
- describe the role of elements in the formation of compounds
- explain the importance of the configuration of an atom's electrons to understanding an element's properties
- classify the periodic table on the basis of energy levels (shells) and sub-energy levels (sub-shells)
- briefly explain the properties of s-block and p-block elements
- differentiate between active learning and activity-based learning
- discuss the formation, properties, and use of different types of compounds through laboratory exploration
- use precautionary measures while conducting laboratory work
- explain the significance of laboratory work for the science classrooms

4 UNIT 4:	**Understanding the periodic table through active learning**
Week #	Topics
7	Elements and their arrangements Historical background of the periodic table Developing the periodic table
8	Metals and their properties Non-metals and their properties Ionic and covalent compounds

Unit 5: Teaching acids, alkalis, and salts through demonstration

Student Teachers should be able to:

- discuss the formation of acids, alkalis, and salts
- differentiate the properties and uses of acids, alkalis, and salts
- explain the pH scale and its significance
- give examples of natural and artificial indicators of pH (acidity and alkalinity)
- explain concepts related to acid and base by using demonstration techniques
- experience the usefulness of demonstration as a science teaching method
- understand the factors to be considered while planning and executing effective demonstrations.

5 UNIT 5:	**Teaching acids, alkalis, and salts through demonstration**
Week #	Topics
9	Acids, alkalis, and salts • Properties • Uses • Formation
10	pH scale pH indicators (natural and artificial) Key features of effective demonstration

Unit 6: Exploring misconceptions while teaching electricity, light, and sound

Student Teachers should be able to:

- discuss the implications of students' misconceptions about science for science teachers
- explore these misconceptions while teaching the following topics
- define *current*
- investigate different types of circuits used for different purposes
- explain the process and factors of generating electricity
- investigate the nature of light (phenomena such as transmission, absorption, and reflection)
- differentiate between the reflection and refraction phenomena (process, effect, and causes)
- differentiate between different types of lenses
- compare the workings of a human eye with a camera lens
- describe the nature and characteristics of sound
- differentiate between noise and music
- explain the structure of the human ear with a diagram
- discuss the effects of noise on the human ear and health.

6 UNIT 6:	**Exploring misconceptions while teaching electricity, light, and sound**
Week #	Topics
11	Students' misconceptions about science and their implications The nature of electricity Production of electricity Electric circuits
12	The nature of light Lenses, their types and uses The camera lens and the human eye The nature of sound
13	The human ear and how it is affected by noise Steps to reduce noise in the environment Common misconceptions related to electricity, light, and sound Implications of students' misconceptions while planning science activities

Unit 7: Exploring space through interactive lectures

Student Teachers should be able to:

- discuss the salient features of interactive lectures in science classrooms
- 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 of space and are used for space research.

UNIT 7:	**Exploring space through interactive lectures**
Week #	Topics
14	Comparison of different environments (space, Earth) The force of gravity and factors responsible for it
15	Aircraft, satellites, and spaceships Satellite communications, Google Maps Interactive lectures: Their significance, features, and implications
16	Submission of assignment Test and evaluation

References

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

Additional resources

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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

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.

Grading policy

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4

Teaching notes

During the curriculum development process, faculty were encouraged to keep notes that would be useful to others who may teach specific units from the syllabus. These were submitted along with the course syllabi. Teaching notes include ways to introduce the course, ideas for teaching units and sessions, sample assessment tasks, and suggestions for reading and resource material. These have been integrated into a single section of this document to avoid repetition and to make the collection of rich and varied ideas easily accessible to others. Faculty are credited with their contribution.

SYLLABUS 3: COMPLEXITIES OF TEACHING SCIENCE

Prepared by Dr Ahmad Sher Awan, IER, University of the Punjab; and Dr Saifullah, University of Gujarat.

Overview

Over time, the goal of science education has changed as different viewpoints have come into favour. Some educators advocate knowledge attainment, whereas others are strong proponents of skill and attitude development. However, there are several complexities attached to the content and pedagogy of science. The first is the abstract nature of certain topics, which students often find irrelevant and uninteresting. For example, the concept of electron movement is very abstract for students as they neither see its practical significance nor understand the phenomenon. In some cases, with modern inventions and ICT development, these phenomena can be observed, but a challenge occurs when students need to go to the micro level (that is, the subatomic or molecular level) for its explanation and description. Such abrupt shifts between micro and macro levels create complexity for learners. Another challenge is the language of science, which sometimes is misinterpreted by students because the same vocabulary is used with different meanings in the daily life. For example, the words *pressure*, *force*, and *energy* have different connotations in daily life and in scientific contexts.

In Science I and II, Student Teachers learned about the nature of science. In this course, however, they will see the implications of what they learned in the teaching process. In this unit, Student Teachers will reflect on the complexities of science and use teaching-learning strategies that could help them overcome these challenges during the learning process.

Learning outcomes for this unit

It is expected that Student Teachers will:

- discuss the complexities of science concepts
- discuss their implication for science teaching
- explore various teaching-learning approaches in science classrooms.

Session 1: Complexities of science concepts

The Instructor will ask Student Teachers to share their experiences as science students. The Instructor may ask the following questions to generate a whole-class discussion:

- How do you feel about the subject of science?
- Which topics or concepts did you find the most challenging? Why?
- What was your role as a student in your science classroom?

After listening to Student Teachers' experiences, the Instructor will relate their feelings and experiences to the complexities of science, such as its abstract nature, the macro and micro nature of concepts in science (e.g. energy, a macro concept, and pH, a micro concept), and challenges with potentially difficult vocabulary. The Instructor will then create three groups of Student Teachers and give one of the above issues to each and ask them to discuss the following:

- What does this complexity refer to?
- How does it influence the teaching-learning process?
- What measures can a teacher take to overcome the challenge in a real classroom?

The Instructor will sum up the discussion by emphasizing different teaching-learning strategies to minimize the challenges faced while teaching these concepts.

Session 2: Role play and ICT integration in the science classroom

The Instructor will ask Student Teachers' what they know about solids, liquids, and gases. All responses will be noted in three columns on the board. The Instructor will create three groups and give each of them a Kinetic Molecular Theory (KMT) claim related to one of the three states of matter (solid, liquid, or gas).

Each group must read, discuss, and then plan role play to show the arrangement and movement of particles in each particular state. (The Instructor can help Student Teachers' to plan the role play. For example, those in the 'solid' group can act as a particle by holding their hands tightly with shoulders and legs touching with no space in between. Their movement is only to and fro and not a free motion, and if pressure is applied, one layer of the particle will slide and thus deform instead of compress.) While each group performs its role play, the Instructor will give input to strengthen the displayed concept.

After this activity, the Instructor will show the same concept through simulation. For this, the Instructor can download any simulation software available, such as:

➢ http://www.edinformatics.com/mathmol/mm_software.htm

At the end of the activity, the Instructor will ask Student Teachers to reflect on the following questions and discuss:

- the pros and cons of role play and simulation in teaching about KMT
- points to be considered while using these strategies in the classroom

The Instructor can give input during the discussion. The Instructor can use the reference material available on the following websites:

- http://serc.carleton.edu/introgeo/roleplaying/index.html
- http://www.slideshare.net/suchetanapawar/ict-integration-in-science-15202832

Session 3: Demonstration in the science classroom

The Instructor will ask Student Teachers what they understand by the term *compressibility*. Student Teachers' responses will be noted on the board. The Instructor will ask if solid, liquid, and gas were placed in a syringe, which would compress and why. Student Teachers will predict and give reasons for their answers. The Instructor will then take three syringes: one holding a wooden piece, one with water, and one with air. Press the first two syringes to remove the extra air from them. Now apply pressure on the syringes one at a time, keeping the thumb tight on the open side to have a closed system. Student Teachers will see that the contents of the third syringe will compress, whereas no obvious effect is seen on the first two syringes. The Instructor will explain the phenomena based on the intermolecular spaces in solids, liquids, and gas.

After this demonstration, the Instructor will ask Student Teachers to write their reflections about the session with the help of following questions:

- What is the significance of demonstration in the science classroom?
- How do demonstrations help overcome the challenges of science teaching?
- What are important issues to be considered while using this teaching strategy in the classroom?
- Which safety measures should be taken while handling chemicals and flame during demonstrations?

The Instructor will conclude the session by discussing these aspects of demonstrations in science classrooms.

Assignment and assessment

The Instructor will ask Student Teachers to select a topic of their choice. They will develop a lesson plan for the topic, including learning outcomes, teaching notes and steps, and resources for activities and strategies. They should select teaching strategies based on the concept(s) they are teaching.

Assessment criteria

The assignment will be assessed on the following criteria:

- Lesson plans have SMART objectives (specific, measurable, achievable, realistic, and timebound) and clear evidence of the grade level.
- Choice of teaching approaches and activities is relevant to both the learning objectives and the concept.
- Teaching resources are specific, meaningful, and based on low-cost materials.
- Assessment is relevant, interesting, and links with the objectives for the lesson.

SYLLABUS 2: PREPARING TEACHERS TO TEACH SCIENCE

Prepared by Misbah Malik, University of Education; Khalid Khurshid, Bahauddin Zakariya University; Sadia Suleman Khan, Sardar Bahadur Khan Women University, Quetta; and Saher Yasmeen, University of Karachi.

Overview

The learning philosophy for this syllabus is based on the constructivist approach to teaching and learning and the idea that learners make sense of new knowledge and experience based on their own prior knowledge and experience, and assimilate or accommodate new learning.

Therefore, this unit helps Student Teachers to learn about aspects of science teaching that foster or hinder students' learning. These include the nature of science, scientific process and vocabularies, science pedagogy, and lesson planning and assessment.

This unit is a review of Science I and Science II, in which Student Teachers also learned about teaching and learning science.

Common misconceptions

- A mastery of scientific concepts is the only requirement to become an effective science teacher. Pedagogical content knowledge is not very important when teaching science.
- The traditional teaching approach—the lecture method—is the best way to transfer knowledge from teacher to students as it avoids any misinterpretation and misunderstandings.
- Teacher training should be focused on science content, as teachers are already aware of students' perceptions, value, and misconceptions.

Learning outcomes for this unit

After completion of this unit, it is expected that Student Teachers will be able to:

- identify the changing nature of science
- define vocabulary related to scientific processes and skills
- experience different interactive teaching methodologies that can be used in the science classroom
- discuss the importance of lesson planning in the science classroom
- discuss different components of a lesson plan
- develop a lesson plan related to a science concept
- discuss the importance of using low-cost, high-thought science resources
- share different assessment strategies, such as self, peer, portfolio, paper-pencil, and performance based.

Session 1: The changing nature of science

Instructors will describe the following situation to Student Teachers in three steps and involve them in a discussion by asking questions after each step:

Smoke was coming out of a box.

- What might this indicate?
- What could have happened?
- Who or what could be responsible for this?

When we looked into the box, we found burnt ash and a cigarette.

- What might this indicate?
- What could have happened?
- Who or what could be responsible for this?

We noticed that the box was beside the outside door of an office.

- What might this indicate?
- What could have happened?
- Who or what could be responsible for this?

The Instructor will engage Student Teachers in a discussion about how they interpret information and create a picture of what happened and why it might have happened. To do this, they build on prior knowledge, look at evidence, and propose hypotheses. The Instructor will then link this to misperceptions about the nature of science and give additional examples from the history of science.

- Science is fact-based knowledge. (Instructor's note: It is a process rather than product that includes interpretation, hypothesis, conclusion, observation, and measurement.)
- Science is fixed and unchangeable. (Science is tentative; for example, it was once believed that the Sun rotates around the Earth, but the theory has changed.)
- Theory becomes law once it is proven. (A law is confirmed with experimentally verifiable conclusions, whereas theory is the current best explanation to justify a phenomenon that cannot be proved through experiment; however, both change.)
- Science is a masculine subject. (Discuss the many successful female scientists, such as Fabiola Gianotti, a physicist leading the team working on the Large Hadron Collider at CERN in Switzerland, and Rosalind Franklin, who was involved in DNA research in the 1950s.)
- Science is only for scientists. (Science is for everyone. Explain some of the applications of science in everyday life.)
- All scientific inventions started with a hypothesis and then underwent systematic experiment. (The discovery of radioactive elements was a shocking discovery and not a planned experiment.)

Instructors can ask Student Teachers to give examples and share their knowledge during discussion. At the conclusion, Instructors will ask them to define science in pairs, with reference to their understanding based on the discussion. All statements will be shared in class, and the Instructor will give input wherever necessary.

Session 2: Vocabulary related to scientific processes

The Instructor will pass a completely sealed box to groups of Student Teachers and ask them to describe what is inside of it. (The Instructor will need to prepare the sealed boxes in advance, perhaps with different objects or materials in each box.) They can explore the box as many ways as they can without opening it. Once Student Teachers have developed a hypothesis about what is in the box and explained why they think this, the Instructor will ask them to open the box and see what actually is there. The Instructor will then lead a discussion to connect the activity with discovery in science. The Instructor will note that discovery in science uses many of the same processes they used to decide what was in the box: observation, collecting data, and formulating a hypothesis.

The Instructor will distribute the worksheet 'Scientific Processes', on which scientific processes and their definitions are written in jumbled form. Student Teachers will be asked to match the items after reading in pairs. The Instructor will discuss each science process one by one and explain its importance and purpose through examples from different scientific inventions (such as the invention of the light bulb by Thomas Edison, radium by Marie Curie, the aeroplane by the Wright brothers, etc.)

Session 3: Learner-focused science teaching methods

The Instructor will ask Student Teachers about their experiences as science students. Student Teachers will share what they found interesting in science classes or not and why. The Instructor will ask them to differentiate the following aspects in traditional and interactive science classrooms:

- The role of the teacher
- The role of students
- Classroom management
- Seating arrangements
- Teaching-learning resources
- Nature of questions
- Nature of activities
- Nature of assessment

After Student Teachers' discussion in groups, the Instructor will collect their responses and discuss these aspects with respect to learner-centred teaching approaches, such as predict, observe, and explain (POE) activities; group projects; research work; and critical reading.

Session 4: Planning to teach science

The Instructor will offer this situation to the Student Teachers: 'You want to go on a picnic at the seaside. What you will do to prepare?' They will give responses such as preparing food, planning or making a list of requirements, arranging resources, and the like. The Instructor will connect the situation with different stages of teaching and highlight the importance of planning for teachers. Then the Instructor will give a lesson plan format and discuss its different components, such as the topic, learning outcomes, resources, teaching steps, and assessment, along with their importance. The Instructor can refer to the following website and adapt the suggested format:

➢ http://www2.honolulu.hawaii.edu/facdev/guidebk/teachtip/lesspln3.htm

The Instructor will divide the class into groups and give each a topic and lesson plan format and ask them to develop a lesson plan based on an interactive teaching strategy learnt during Science I and II.

> NOTE: The Instructor can collect the lesson plans, give feedback to improve them, and display to share them with other groups.

Session 5: Low-cost, high-thought science teaching resources

The Instructor will ask Student Teachers to share their knowledge about atoms. All responses will be noted on the board. The Instructor will divide the class into pairs and give them reading material related to the following models of atomic structure (relevant websites are mentioned below). Student Teachers will be asked to read the handouts, discuss them in pairs, and prepare an atomic structure model by using available materials (such as plasticine, beads, or threads).

- Dalton's atomic model:
  ➢http://antoine.frostburg.edu/chem/senese/101/atoms/dalton.shtml
- J. J. Thomson's plum pudding model:
  ➢http://www-outreach.phy.cam.ac.uk/camphy/nucleus/nucleus1_1.htm
- Bohr's atomic model:
  ➢http://atomicstructureforelectrons.webs.com/bohrsmodel.htm

After this group work, each group visits another group to listen to its explanation. At the end, the Instructor will discuss the importance of low-cost, high-thought materials in science teaching by using examples, such as the balloon and bottle model to demonstrate the human exhalation and inhalation process.

Assignment and assessment

The Instructor will ask Student Teachers to think about or search the Internet or in books about different examples of lost-cost, high-thought materials to use to teach a variety of science concepts. They will submit their ideas to the Instructor for review and then share with the whole class. (Student Teachers will then be encouraged to prepare one such resource from their list.)

Assessment criteria

- Relevance of product with the concept
- Creativity in making the product
- Durability of product
- Cost-effectiveness of final product

Session 6: Assessment in the science classroom

The Instructor will ask Student Teachers about the purpose of assessment in the science classroom. The Instructor will connect their responses with ideas about assessment for learning and assessment of learning. The Instructor will explain different assessment approaches such as paper-pencil and performance-based assessment, with different strategies such as peer assessment, self-assessment, portfolio assessment, rubrics, Multiple Choice Questions (MCQs), and Closed Response Questions (RCQs). The Instructor will give appropriate examples while explaining each. The Instructor can use material on the following website for this activity:

- http://pinterest.com/pebaldwin/assessment-of-and-for-learning/

The Instructor will provide a sample rubric to Student Teachers and will then ask them to prepare a rubric with reference to the last session's activity; that is, developing a model of atomic structure. Each group will share their rubric with other groups for feedback and comments (peer assessment). The Instructor will conclude the discussion by asking for their reflection on the pros and cons of using rubrics for assessment in science classrooms. The Instructor can use reference material available on this website:

- http://pinterest.com/pebaldwin/assessment-of-and-for-learning/

Assignment and assessment

The Instructor will ask the Student Teachers to write an academic paper (an individual task) on any of the following topics:

- Assessment in the science classroom
- Low-cost, no-cost resources in the science classroom
- The nature of science

The paper, which should have an approximate length of 800 to 1000 words, should include:

- Introduction and background of the topic
- Literature review
- Connection of the topic with teaching science and the teacher's role
- Implications
- References

Assessment criteria

- Clarity, language accuracy, and organization
- Supporting claims through critical analysis of available literature
- Making connections with prior experience and linking with new learning
- Quoting references and keeping within the word limit

SYLLABUS 1: SCIENCE, TECHNOLOGY, SOCIETY, AND ENVIRONMENT (STSE): A NEW APPROACH TO TEACHING SCIENCE

Prepared by Dr Waheed Akbar, Hazara University, and Dr Syed Munir Ahmad, IER Peshawar University.

Overview

Scientific literacy—which is the core objective of science education—cannot be achieved with traditional science teaching methods. A new approach has been introduced in science education so that each individual can integrate the notion of science, technology, society, and the environment (STSE). In this context, teacher training programmes should revise the function, content, structure, and sequence of science curricula under the new broader paradigm.

This unit in the Science III course links with the first unit of Science I and II, in which Student Teachers were introduced to the social and personal perspectives of science. They have also experienced how different science concepts connect with a changing society. Hence, this unit will give them some theoretical understanding about this new paradigm and its significance and challenge as a science teacher. Further, they will see how science content and pedagogy can be tailored for this integrated science education.

Common misconceptions

- Science is fact-based knowledge and has no link with personal or societal needs, values, and beliefs.
- Scientific knowledge is absolute and therefore cannot be changed.
- Science students should know the content as it is presented in standardized tests. The application of science content is not important to know.

Along with these misconceptions, teachers usually feel unprepared to teach topics using an integrated approach such as STSE, as they themselves have not learnt science subjects this way.

Learning outcomes for this unit

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 human development process
- develop awareness about health care and its importance in daily life.

Session 1: STSE approach to science education

The Instructor will ask Student Teachers to reflect on the following:

- What are some of the challenges in traditional science education?
- Why do students feel a lack of interest and involvement in science subjects?

While taking Student Teachers' responses, the Instructor will introduce STSE, a new approach in science education. The Instructor will then divide the class into small groups and give them the handout 'Need and Emergence of STS Approach' from the Teaching Resources section to read about the need, purpose, and significance of the STSE approach. The groups will read, discuss, and then present their understanding in any creative way; for example, through poster making, writing a poem, or skit writing. Each group will get five minutes to present their understanding of the STSE approach to science education.

Session 2: Experiencing the STSE approach

Student Teachers will be asked to share their prior knowledge about global warming. All responses will be noted on the board. The Instructor will then ask them to perform the task described in the worksheet 'Global Warming' from the Teaching Resources section in groups of three. The Instructor then will give each group's work to another group for peer assessment and feedback. However, the last question—i.e. the decision taken as the weather scientist—will be discussed and critiqued as a whole class.

Session 3: Opportunities and challenges of the STSE approach

The Instructor will divide the whole class into two groups (proponents and opponents of the STSE approach). Each group will be asked to discuss the benefits and opportunities (the proponent group) or the issues and challenges (the opponent group), keeping in mind their experience in the previous session and the reading. After discussion in groups, the Instructor will facilitate a debate between the two groups and raise critical questions whenever necessary without influencing the natural flow of debate. Each group will be asked to present their point of view with examples and evidence in 10 minutes and will reply to the critique of the other group for five minutes in the second round of discussion. The Instructor will conclude the discussion by emphasizing the key benefits and challenges of the STSE approach. The Instructor can use the handout 'Advantages and Issues of STS Science Teaching' from the Teaching Resources section.

Session 4: Environmental pollution I

Pre-session activity

The Instructor will ask Student Teachers to cut out several 5 cm by 5 cm squares of white card. They should then smear the surface of each with petroleum jelly and fix the squares to as many different areas they can think of; for example, by the bus stop, inside the classroom, under trees, by a car park, on a post by traffic lights, on the back door, and so on. They should leave them there for 24 hours. (As an alternative, they could use slightly damp cotton wool to swab different surfaces, such as road signs, leaves on trees, window panes, and so on.)

Student Teachers will bring those cards with them to the next class, labelling the locations where these were placed. The squares will now have tiny particles stuck to them, making them grey. Student Teachers will be asked to look at the particles with their eyes or under the microscope and score each card on how polluted it is on a scale of 1 to 10. They will use this data to draw a graph showing the level of air pollution in the various areas (they can use a bar graph).

In groups, they will interpret their graphs with the help of the following questions:

- What areas were least polluted?
- What areas were most polluted?
- Are there any links between the areas that are most polluted?
- What are natural and artificial sources of air pollution?

The Instructor will further ask Student Teachers to share different types of pollution (water, air, noise, land, radioactive, etc.) and how they affect health (such as skin rashes, asthma, kidney damage, liver damage, difficulty breathing, coughing, bronchitis, headaches, heart problems, dizziness, throat and eye irritation, damage to the inside of the body, childhood health problems, birth defects, and cancer).

Sessions 5 and 6: Environmental pollution II and III

The Instructor will write these four words on the board: *reduce*, *reuse*, *recycle*, and *recover*. The Instructor will explain that each of these R's is a waste management strategy that can be implemented to help reduce the amount of waste we produce or do something positive with the waste we do produce. The Instructor will then ask Student Teachers working in pairs to list their daily activities and then consider what they can do to reduce, reuse, recycle, and recover, with examples. Each pair will share their work during a whole-class discussion.

The Instructor will make group of at least five or six Student Teachers and ask them to select any focused action area for a 'Saving the Earth' project; for example, solid waste management, reducing water waste, paper waste management, and green school. They will be given the following directions:

- Search for information related to the project topic from reliable websites, books, and journals about pollutants, their sources, current statistics, and the like.
- Design a group project on 'Saving the Earth'. (They can ask the Instructor for suggestions and comments before execution.)
- Take part in a social action (such as conducting a project at school or in the community or an awareness-raising campaign, writing a newspaper article, conducting a survey, etc.).

NOTE FOR THE INSTRUCTOR: The Instructor will give basic guidelines, form groups, and discuss the topics in the first session. The next session will be used for planning and researching material. After they complete the project in their own study time, the Student Teachers will be asked to write a project report as a part of the assignment. Criteria of assessment are as follows.

- Introduction and rationale of this project
- Literature support
- Action plans and steps undertaken
- Evidences of social reform or change
- Use of resources (if any) and references

Session 7: Healthy life I

The Instructor will ask Student Teachers to define the terms *growth* and *development*. The Instructor should clarify that these indicate two different concepts related to health. Growth is the progressive increase in the size of a child or parts of a child. Development is progressive acquisition of various skills (abilities) such as head support, speaking, learning, expressing feelings, and relating with others. Growth and development go together but at different rates.

The Instructor can then give them this case study: 'Fahim was weighed on three occasions. In the first week of March 2013, he weighed 6 kilograms; in the second week of May 2013, he weighed 7.56 kilograms; and in the second week of July he weighed 8.6 kilograms. Using this information, plot Fahim's growth on a graph paper, squared paper, or an actual growth chart of a child health card. Is Fahim's growth adequate?' The Instructor will ask Student Teachers to draw and interpret the graph in pairs. The Instructor will collect the responses and will relate them to the following aspects of growth:

- Ways to measure growth (height, weight, head circumference, etc.)
- Significance of measuring growth
- Factors affecting human growth (such as environment, nutrition, and genetic factors)

The Instructor will provide a development chart (age versus motor, social, and language development) and discuss the following aspects of human development:

- Aspects of development (motor skills, language, and social development)
- Factors that promote or hinder development (nutrition; emotional support such as love, trust, and security; diseases)

A development chart is available at:
➢ http://wikieducator.org/Lesson_5:_Growth_and_Development

The Instructor and Student Teachers can share examples and stories about these aspects of growth and development.

Session 8: Healthy life II

The Instructor will provide some relevant health statistics from the following webpage:

➢ http://www.unicef.org/infobycountry/pakistan_pakistan_statistics.html

The Instructor will ask Student Teachers to discuss in pairs the following critical questions:

- Where does Pakistan rank compared to other nations in a ranking of the infant mortality rate and the death rate from curable diseases?
- Why do curable diseases continue to cause deaths?

After a discussion, the Instructor will ask Student Teachers to prepare a survey questionnaire on health awareness and conduct it with a small group of people (in a school or university, in the community, etc.). The Instructor will help Student Teachers develop questions for the survey. For example:

1) How are the following diseases transmitted?
    - Malaria
    - Typhoid
    - Hepatitis
    - Tuberculosis (TB)

2) Which of the following will help you avoid heart disease?
    - Eating plenty of meat
    - Low-calorie drinks
    - Exercise

3) What is the best way to reduce the chances of catching a cold?

Some open-ended questions can also be added.

Student Teachers will be asked to conduct surveys in groups as a home task, compile their results, and present their findings in the form of a report along with recommendations.

Session 9: Healthy life III

The Instructor will ask Student Teachers to work in pairs and list different foods they eat on a daily basis. The Instructor will then provide reading material about food components, available at:

➢ http://www.sistersrunningthekitchen.com/2011/02/components-of-a-healthy-diet/

Student Teachers will then analyse their own food intake against the advice on the website. Afterward, the Instructor will ask them to develop a balanced eating plan for a day or week by using the right balance and amount of each food component.

SYLLABUS 1: THE CONSTRUCTIVIST APPROACH TO TEACHING THE CONCEPT OF HEREDITY

Prepared by Dr Waheed Akbar, Hazara University

Overview

Heredity is an important concept in the life sciences, which heavily depends on understanding the relationship between genes, DNA, and chromosomes. It plays a vital role in life, as many traits and diseases are inherited and have great influence on the survival of living species. Therefore, how traits and diseases are transferred to offspring is an important concept for students to learn.

This unit is aligned with the National Curriculum prescribed for grades 6 to 8 and includes themes such as cell components and division; the relationship between DNA, genes, and chromosomes; and inherited traits and diseases. Thus, it is expected that Student Teachers will be able to link this scientific concept with society and technology to develop a deeper understanding in students.

The themes that revolve around the concept of heredity in Science III are linked with Science I and II in two ways. In Science II, Student Teachers reviewed the concept of diversity in response to the evolution process. They also studied the cell and its structure. Here, Student Teachers will learn about diversity in relation to gene transfer and mutation. They can also link the cell component chromosomes to heredity. Secondly, Science I also considers the nature of science, such as tentative and progressive nature, science for all, and its creative nature. Hence, constructivist pedagogies used to teach these concepts in Science III will reflect on the same nature of science so that Student Teachers can connect their learning in all three courses. The inquiry approach will be used in the teaching-learning process, in which Student Teachers discuss the concept from the macro to micro level. This means they first explore the observable traits and later connect them with concepts at the micro and sub-micro level; that is, DNA and genes.

It is important that teachers in life science classes in the elementary grades ask students to share their understanding when introducing these themes. This will allow misconceptions to surface. For example, students struggle in understanding the relationship between DNA, chromosomes, and genes. They consider genes as structures on DNA rather than segments with specific locations on a DNA molecule. It is therefore suggested to give students some hands-on, minds-on activities that they can manipulate to understand this abstract concept.

Learning outcomes for this unit

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
- differentiate between acquired and inherited traits.

Essential vocabulary

Key terms that students should know are *DNA*, *genes*, *chromosomes*, *cell division*, *traits*, *inherited traits*, and *acquired traits*.

Session 1: Acquired and inherited traits

The Instructor can start the session by asking a few questions, such as:

- In what ways are we all same?
- How different are we from each other?

The Instructor will probe Student Teachers so that they come up with examples of different physical characteristics (traits) in different people; for example, having or not having dimples. It is encouraged for Student Teachers to share their prior knowledge without judgement as to whether it is right or wrong. This will allow the Instructor to understand any misconceptions related to concept. It is very possible that Student Teachers will mix the inherited and acquired traits. The Instructor should list all traits, however; the difference between inherited and acquired will be distinguished in the later stage.

After this general discussion, the Instructor will divide the class into small groups (of five or six) and ask them to identify different inherited traits and explore them among their group members. The Instructor can provide a few examples, such as a widow's peak, or a cleft chin. Student Teachers can use the worksheet 'Exploring Inherited Traits' in the Teaching Resources section for this purpose.

The Instructor will provide necessary support and explanation to Student Teachers for the terms and traits. The Instructor can perform a Google search of the terms ‘inherited human traits’ and ‘quick reference’ to find relevant resources on the Internet. From there, the Instructor can show pictures of various traits on PowerPoint slides or the overhead projector, or by using personal examples.

At the end of group work, the Instructor will then collect each group’s response about how many in each group exhibited the various traits. Discuss the following questions with the whole class:

- What makes us different?
- Why do we mostly find similarities in siblings?

Student Teachers might have some idea that parents transfer characteristics to their children. For example, a few Student Teachers might have characteristics similar to their parents. The Instructor can further challenge Student Teachers by asking why not all children are like their parents if characteristics are simply transferred. This concept can be later linked with gene sequencing and dominant and recessive characteristics. The Instructor can ask them to differentiate types of traits from their initial list; for example, eyesight and eye colour, about which the former is acquired and the latter is inherited. The Instructor can add more examples to distinguish the two.

Session 2: The cell and its components

The Instructor will begin the session with the following questions:

- What is the basic unit responsible for everything in the human body?
- Where is this basic unit (the cell) located in our bodies?
- Are these cells alive? Give reasons.
- What functions do cells perform?

Student Teachers will use what they learned in Science I and II and list different components of a human cell. They might include other aspects, such as from plant cells. However, the Instructor will direct the discussion on cell structure and components, speaking about the cell as a system whose different parts function in coordination. Here the Instructor can show Student Teachers the interactive feature at this webpage to build interest and understanding about cell size:

➢ http://www.cellsalive.com/howbig.htm

The Instructor will then ask the Student Teachers to discuss the following in small groups (of five or six):

- What are the functions of the various cell components?
- Which component is most important? Why?
- Compare the cell with any other system (such as a school, bicycle, factory, or city) and build analogies of each component of a cell.

In this context, the Instructor can give examples by making analogies with a city; for example, Karachi. The nucleus can be compared to the Governor’s House (the controlling unit), chromosomes to policy documents (because of the commands written on them), ribosomes to a factory (the manufacturing centres), lysosomes to the Karachi Municipal Council (because of its cleaning functions), mitochondria to the Karachi Electricity Supply Company (a powerhouse of energy), the cell membrane to rangers and guards (protection), and Golgi bodies to packaging and shipping (transportation). If they struggle to remember the structure and functions of cell components, the Instructor can prepare a handout for Student Teachers to read, have them discuss it in groups, and then develop analogies for deeper understanding. The Instructor will then take their responses for each component from different groups and relate its structure and function with the analogy. The Instructor will emphasize that every structure in a cell is important just as every part of a city is important due to its specific function. Moreover, the Instructor will explain the complex nature of a cell due to its various structures and functions, and then conclude the discussion by linking chromosomes with inherited patterns that result in specific traits and other characteristics. The Instructor can end with the question, 'How many cells are in our body?' The Student Teachers can guess but should be asked why they chose that number.

Discuss their different estimates and then share a common approximation: 100 trillion!

Reference for the Instructor

See the Wikipedia for information about cell organelles at:

- http://en.wikipedia.org/wiki/Cell_(biology)

Session 3: Chromosomes, DNA, and genes

Student Teachers have already learned in Sessions 1 and 2 that the chromosome is the part of cell responsible for carrying inherited traits to the next generation. At this point, the Instructor needs to introduce the terms *DNA* and *genes*. For this, the Instructor can share the historical perspective of genetics and reference Gregor Mendel's work. This will also help to overcome the common misconception that genetics only involves humans.

The Instructor can start the session by asking the following questions to discover Student Teachers' thinking related to this misconception:

- Is the concept of heredity applicable to plants and animals?
- Why in some cases does a child have blue eyes when both parents have brown eyes?

After asking for responses as well as the reasoning behind their responses, the Instructor will explain how Mendel, while working in his garden on pea plants, observed that traits can be mixed or transferred to later generations. This can lead to a discussion of dominant and recessive traits. The Instructor can use the video from the following website for resource material:

- http://www.brainpop.com/science/cellularlifeandgenetics/heredity/

Further, to understand DNA and genes, their importance, and how they carry traits, the Instructor can initiate the discussion by defining the term DNA and explaining its structure. The Instructor can use the reference material to describe DNA structure and ask Student Teachers to think of a ladder as an analogy for DNA. Student Teachers can then be asked to draw the structure on paper while listening to the description about the structure of DNA. The Instructor can use the video on the following website to conclude the discussion:

- http://www.brainpop.com/health/geneticsgrowthanddevelopment/dna/

Further, the Instructor can use games and activities on the following website according to the lesson's need and objectives:

- http://learn.genetics.utah.edu/content/begin/traits/activities/

At the end of the session, the Instructor will ask Student Teachers to write their reflections on this unit with the help of the following guiding questions (this can be given as a homework assignment):

- After your experiences during this unit, what do you understand by the phrase 'constructivist approach of teaching science'?
- How is the constructivist approach of teaching different from the traditional approach for the transmission of knowledge?
- What are some of the strategies used during these sessions and how effective were they? Strengthen your answers with your reasons and evidence.
- What are the roles of teachers and students in the constructivist approach to learning?

Reference for the Instructor

Useful websites about DNA, chromosomes, and genes:

- http://www.bbc.co.uk/schools/gcsebitesize/science/add_aqa_pre_2011/celldivision/celldivision1.shtml
- http://www.biotopics.co.uk/genes1/genesDNAchromosomes.html
- http://www.pdesas.org/module/content/resources/16743/view.ashx

Assignment and assessment

The Instructor can give vocabulary, concepts, and key ideas from the unit as answers and challenge Student Teachers to develop as many questions as possible with those answers. For example, DNA could be on the vocabulary list, and Student Teachers can create multiple questions with the answer DNA. Framing a question is a good assessment technique as it enables students to review the concept with all possible dimensions. This can be done as a pair task, and at the end, Student Teachers can share their questions with other groups to check the validity of their questions and understanding of the concept.

SYLLABUS 1: TEACHING BIOTECHNOLOGY THROUGH DAILY LIFE APPLICATIONS

Prepared by Dr Waheed Akbar, Hazara University

Overview

Literature shows that the main difficulties in learning genetics include:

- Various technical vocabulary terms (such as *homozygous*, *heterozygous*, *homozygote*, *homologue*, and *homologous*) are often very similar and therefore difficult for students to remember and differentiate.
- Some terms related to genetics are also used in everyday language but have very different meanings in both contexts (for example, *mutation*).
- The mathematical nature of Mendelian genetics is a challenge for students as they find it difficult to relate real-life problems to the concept of probability.
- Observable characteristics in living things are the physical expression of complex interactions between sections of DNA (genes).

These factors can make genetics a complex subject for students to learn. Students prefer to learn those aspects of genetics that they can easily relate to real-life situations, particularly those that address ethical dilemmas. Hence, the emerging field of biotechnology is increasingly gaining acceptance as part of the school curriculum. On the other hand, Kidman (2009)[2] reports that teachers are hesitant to teach controversial topics of biotechnology in the classroom. Thus it is important for Student Teachers to experience learning these concepts so that they feel comfortable when teaching them.

In the previous unit, Student Teachers learned the basic concepts of heredity, and therefore it is easy for the Instructor to extend the same concepts to the level of application. The Instructor will connect the understanding of genes while explaining different genetic diseases and biotechnology. This will enable Student Teachers to discuss how biotechnology influences human life from multiple perspectives and diverse viewpoints around the world. This will also give Student Teachers a chance to connect scientific concepts with society and technology and their relevance to the life of any lay person. This ultimately provides them a basis to make intelligent and informed decisions as ethical citizens. For this, the Instructor's role is to give them a platform to discuss and share ideas rather than influence their opinions.

[2] Kidman, G. (2009). Attitude and interest towards biotechnology: The mismatch between students and teachers. *Eurasia Journal of Mathematics, Science and Technology Education,* 5(2), 135–143.

Learning outcomes for this unit

It is expected that Student Teachers will:

- discuss the role of genes and alleles 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
- discuss the ethical implication of biotechnology.

Session 1: Monster lab

Begin the session by explaining the following.

Heredity is the passing on of traits, or characteristics, from parent to offspring. The units of heredity are called *genes*. Different versions of the same gene are called *alleles*. Genes are found on the chromosomes in a cell. The combinations of genes for each trait occur by chance.

When one allele in a pair is stronger than the other allele, the trait of the weaker allele is masked, or hidden. The stronger allele is the *dominant* allele, and the allele that is masked is the *recessive* allele.

Dominant alleles are written as capital letters, and recessive alleles are written as lowercase letters. If both alleles are different, the trait is said to be *heterozygous*, or hybrid. Sometimes alleles are neither dominant nor recessive. The result of such a situation is a blending of traits.

The genetic makeup of an individual is known as their *genotype*. The observable physical characteristics of an individual that are the result of the genotype are known as the *phenotype*.

After developing a basic understanding of these concepts, the Instructor will ask Student Teachers to work in pairs to create a monster. Share the following instructions (from http://www4.bluevalleyk12.org/BVNW/jmohn/biology/assignments/monster_genetics_lab.pdf):

1) You and your partner should toss two coins at the same time.

Heads = allele 1, tails = allele 2

Example: If you flip two heads, your monster will have two copies of allele 1 for its genotype.

The two coins should be flipped only once for each trait.

2) Determine the genotype for each trait and record it in the table below.

3) Determine the phenotype resulting from the allele pair for each trait and record it in the table below.

4) Repeat steps 1 and 2 for each trait and complete the table below. An example is provided:

	Allele 1	Allele 2	Genotype	Phenotype
Eyes	Two small eyes E	One large eye e	Ee	Two eyes
Tail shape	Straight S	Curly s		
Eye colour	Blue B	Pink b		
Fur	Fur F	No Fur f		
Claws	Long C	Short c		

Discuss the question: What if we don't flip a coin and we choose alleles for the phenotype we want? What are the implications of being able to do this? Explain that this question is related to genetic engineering and the option to choose has both positive and negative implications.

There are variations on this activity at

- http://www4.bluevalleyk12.org/BVNW/jmohn/biology/assignments/monster_genetics_lab.pdf

Reference for the Instructor

Definition of basic terms:

- http://library.thinkquest.org/28751/review/heredity/2.html

Session 2: Biotechnology and ethics

At the beginning of the session, the Instructor will share the objectives of this session and divide Student Teachers in small groups (of five or six). Each group will be given a biotechnology application from one of the following (the Instructor can identify other applications having ethical dilemmas for this activity), along with the guiding questions to discuss.

Application 1

Read the article 'Zain Has a Right to Life' at http://news.bbc.co.uk/2/hi/health/2903723.stm, then discuss the following questions in your group.

- Why does Zain Hashmi need help?
- What causes thalassaemia?
- How can IVF techniques help?
- Critique this article from different perspectives (e.g. of parents, religious leaders, or health officials managing the health budget).

Application 2

Read the article 'Cloning' at http://freedownloadb.com/pdf/cloning-grace-communications-foundation-39179075.html, then discuss the following questions in your group.

- What is cloning?
- How can this technique be used for plants, animals, and humans?
- Critique this article from different perspectives (e.g. of parents without children, religious leaders, doctors, or society as a whole).

Reference for the Instructor

The Instructor can facilitate discussion by raising critical questions and arguments, but it is important not to influence Student Teachers' viewpoints. The Instructor will then invite one Student Teacher from each group to present their viewpoint to the whole class and also reply to the counter-arguments raised by the class. The Instructor will conclude the session by discussing the importance of different perspectives about the modern application of genetic engineering and ask Student Teachers to understand the necessity of openness and respect of others' opinions. They can also reflect on the importance of real-life examples in the science classroom.

Session 3: Biotechnology in various fields

The Instructor will initiate the discussion by discussing the historical background of the field of biotechnology. Biotechnology is the use of biological processes, organisms, or systems to manufacture products intended to improve the quality of human life. The earliest biotechnologists were farmers who developed improved species of plants and animals by cross-pollination or cross-breeding. In recent years, biotechnology has expanded in sophistication, scope, and applicability.

For reference, see this website:

➢ http://whatis.techtarget.com/definition/biotechnology

The Instructor can then make small groups (of five or six) and ask each group to research how biotechnology influences one of the following:

- Food industry
- Medicine and health
- Agriculture
- Environment
- Crime

The Instructor will share some material and reference websites for them to search. Student Teachers are expected to use one week to find relevant material, discuss it, and then present to the class in a 15-minute presentation that discusses the following aspects:

- The impact of biotechnology on their topic
- The pros and cons of biotechnology in relation to their topic

The Instructor can ask Student Teachers to do their research outside of classroom time and seek help whenever needed.

Reference for the Instructor

A few applications of biotechnology are mentioned for the Instructor's reference. These could be assigned to groups as research topics:

1) Genetically modified fruits: Student Teachers can compare the taste, size, colour, and shape of genetically modified and non-genetically modified fruits (one set could be tomatoes, sweetcorn, and pluots, for example).
2) Drug production: An example is artemisinin, an anti-malarial drug that can now be mass-produced in *E. coli*.
3) In biofuels, many different prokaryotes and single-celled eukaryotes (yeasts) have been engineered to produce ethanol and hydrocarbons.
4) Cloning involves asexual reproduction and results in the exact copying of the 'parent' cell (an example is Dolly the sheep).
5) Selective breeding involves sexual reproduction, and as a result, new combinations of alleles are produced and offspring may vary from their parents (an example is the development of different breeds of dog).
6) In genetic engineering, genes can be swapped across species, and new cells then contain new combinations of DNA (an example is the use of bacteria to make human insulin).

SYLLABUS 3: UNDERSTANDING THE PERIODIC TABLE THROUGH ACTIVE LEARNING

Prepared by Dr Ahmad Sher Awan, IER, University of the Punjab

Overview

Learning chemistry is far more than just memorizing facts and formulae. It is believed that as students progress, they enjoy learning about how the properties of elements and compounds affect the world we live in and the role that chemistry plays in modern society. However, the biggest challenge that students face while learning chemistry concepts is their abstract nature and macro-micro shifts in explanation. Most of the time, students find physical phenomena quite interesting; however, the very next moment they must go to the atomic and sub-atomic levels to understand a phenomenon, which is abstract and can be difficult to comprehend. Specifically, when we talk about the elements, compounds, and their properties, students cannot visualize atomic particles, orbits, energy levels, and the forces that hold two or more elements together in compounds. As a result, the abstract nature of much of chemistry learning has often led to students' lack of interest and disbelief in the relevance of chemistry concepts. It is therefore imperative to use interactive teaching approaches to make them interesting, relevant, and engaging for students.

This unit extends the previous discussions in Science I and II about physical and chemical properties of matter and states of matter, classification of matter as pure substances (into elements and compounds) and mixtures, and a very brief introduction to the periodic table. In Science III, Student Teachers use these concepts to explore the arrangement of elements in the periodic table. They will learn about the different properties of elements and how these interact to form new compounds with new properties, which is the foundation of chemistry.

Learning outcomes for this unit

Student Teachers should be able to:

- discuss the significance and structure of the periodic table
- compare the different models of the periodic table
- describe the role of elements in the formation of compounds
- explain the importance of the configuration of an atom's electrons to understanding an element's properties
- classify the periodic table on the basis of energy levels (shells) and sub-energy levels (sub-shells)
- briefly explain the properties of s-block and p-block elements
- differentiate between active learning and activity-based learning
- discuss the formation, properties, and uses of different types of compounds through laboratory exploration
- use precautionary measures while conducting laboratory work
- explain the significance of laboratory work for the science classroom.

Common misconceptions

- The periodic table in its present form is the way the elements have always been categorized.
- There is only one way to categorize the elements. Consensus was easily achieved about how to do so.
- Science and its methods provide absolute truth and are not tentative and evolving.
- All that is to be known is known regarding atoms and elements.
- Science is procedural more than creative.
- All chemical compounds are dangerous and poisonous.
- All metals are hard and difficult to break.

Session 1: Elements and their arrangements

The Instructor can start the session with either of the following activities. For both, the Instructor will divide Student Teachers into small groups (of five or six).

Activity 1

The Instructor should prepare picture puzzles: one image per group. Do this by cutting an image from a magazine into between six and eight pieces. (Stick the image on to blank paper before you cut it into pieces.) The Instructor will give the puzzle pieces from one picture to each group; however, exchange one piece with another group's. The Instructor will ask them to complete the picture puzzle.

When Student Teachers realize that the last piece doesn't match with their picture, the Instructor will ask them to discuss the following questions in their groups:

- Why do you think this piece does not belong to your picture?
- Can you guess what the missing piece looks like?
- What are some of the parameters and properties you have used to predict the missing piece? (They might say colour, shape, drawing in other pieces, etc.)

The Instructor will then ask them to go to other groups and find their missing piece based on the predicted properties and see if it completes their puzzle. At the end of this activity, the Instructor will ask the questions above of the whole class and relate that scientists went through the same process when they started to arrange elements. They found that the arrangement led to gaps in the sequencing and properties, which gave them clues that the arrangement was not correct.

Activity 2

The Instructor can provide a bag containing identical collections of small and easily obtained items. These items should be inexpensive things such as paper clips, measuring tape, pens, pencils, nails, thumbtacks, or wooden blocks. When choosing these items, do not pick a collection that will naturally fall into easy categories. Also, these items should be easy to handle and dissimilar in many ways. Along with the familiar items, include some the Student Teachers probably have not seen before.

Ask the Student Teachers to classify these items while considering each as an element. They will use various properties while classifying; for example, composition (wood, plastic, etc.), colour, or shape (round, oval, etc.). Then they will arrange the items with an increasing or decreasing trend of properties (heaviness, size, etc.). After they have completed the task, ask the following questions:

- How did you classify these items (elements)?
- Why did you select that particular property for the grouping?
- What is the trend (or property) shown in your descending or ascending arrangement?
- How are your arrangement criteria different than other groups' criteria? Which do you think are better? Why?

The Instructor will then relate the activity with the concept of the periodic table and how elements have been arranged based on their properties. After this initial activity and discussion, which emphasizes the importance of properties in the classification of the elements, the Instructor will ask about different types of properties (i.e. physical and chemical properties) of elements. Student Teachers might say colour, texture, solubility, melting or boiling points, or conductivity are the physical properties, whereas reaction with oxygen or water and whether it is acid or alkali are the chemical properties. The Instructor will conclude the session by sharing that these properties are used by scientists for the purposes of classification. The Instructor can ask Student Teachers to discuss whether physical or chemical properties should be used as criteria for classification, and why. The Instructor at this stage should lead the discussion without giving any answers. Student Teachers can be asked to explore the same question through various resources after the session.

Session 2: Historical background of the periodic table

The Instructor will provide a handout for Student Teachers with information about how scientists started to classify elements into the periodic table and how this resulted in different models, as well as how these models were different from each other, leading to the revised version.

This handout can be prepared from resources on the Internet or in books or from material in the Instructor's reference section. Student Teachers will be asked to read and discuss the information in pairs, and then compare an earlier model of the periodic table with the modern periodic table in the form of a Venn diagram. The Instructor should explain how to make and fill in the Venn diagram (the separate part of each side should include the characteristics specific to that periodic table, whereas the overlapping area should cover those points common to both).

The Instructor can share one example of each with the whole class after the reading and discussion.

After the Student Teachers have completed the task, the Instructor will lead a discussion with the whole class, emphasizing the following points:

- Science is evolving and tentative.
- Science is creative rather than procedural.
- Chemical properties depend on the number of electrons (atomic number), which lead to the arrangement of elements.

Reference for the Instructor

The following websites provide information about the history of the periodic table:

- http://www.aip.org/history/curie/periodic.htm
- http://www.rsc.org/education/teachers/resources/periodictable/

Session 3: Developing the periodic table

Student Teachers have now learned that chemical properties are the main properties that scientists use to classify elements in different groups (in the vertical columns), and that their arrangement within their own group shows the trend in physical properties (for example, variation from a solid to a gaseous state). It is now important that they learn how to use these properties creatively for designing a periodic table. For this, the Instructor needs to create some 'mystery element cards' (about 24), in which the common physical and chemical properties of the elements are mentioned without the name of element. An example is given below for elements 'A' and 'B'.

A	**B**
Black crystalline solid	Colourless gas
Melting point = 3652° C	Melting point = –233° C
Boiling point = 4200° C	Boiling point = –188° C
Ionization energy = 1088 kJ/mol	Ionization energy = 1682 kJ/mol
Hydride = AH_4	Hydride = BH
Oxide = AO_2, AO	Oxide = B_2O
Chloride = AC_{14}	Chloride = BCl

(The *ionization energy* of an atom or molecule describes the amount of energy required to remove an electron from the atom or molecule in the gaseous state.)

The Instructor will divide Student Teachers in small groups (of five to six) and give each group 24 mystery element cards along with following instructions.

- Instructions: You have been given data on 24 mystery elements. Your team's mission is to arrange these elements in a table according to their chemical and physical properties. Use the following guidelines to help you accomplish your mission: Tables typically contain vertical columns and horizontal rows. This format is recommended but not required.
- First, sort the elements into groups according to similar chemical properties (hydride, oxide, and chloride). Make each group as specific as possible. Try a few different methods and choose the one that works best.
- Within each of your groups, arrange the elements in some logical order according to at least one physical property. Try to develop a pattern that incorporates as many properties as possible. Also, try to incorporate both horizontal and vertical patterns into your layout.
- Once you have finalized the layout of your table, glue it to a piece of paper. In the space below, write a brief, but specific, description of how your table is organized.

After the task is completed, the Instructor will discuss the different periodic tables prepared by the groups, then show the basic structure of Dmitri Mendeleyev's periodic table (bring a large copy of it) to highlight different sections such as s-block, p-block, and d- and f-block elements. The Instructor will also explain that each group or block within the periodic table has elements with similar physical and chemical properties that vary regularly within the group. This is because the outermost electrons are exposed to other atoms when they react. The elements with similar properties have similar outer shell electron configurations. For example, the alkali metals with similar outermost electron configuration (only 1s electrons) clearly illustrate similarities when they react. Each of these elements (Li, Na, K, Rb, Cs) has only one outer shell electron, which is in an s sub-shell. When they react, each loses one electron to form ions with a charge of 1+. The only electrons normally important in controlling chemical properties are those in the outer shell. This outer shell is known as the *valence shell* and the electrons in this shell are called *valence electrons*.

Bonding in compounds of an element is dependent on its ionization energy, which is related to the number of electrons in the outermost shells of its atom. The elements of the periodic table can be naturally divided into four groups—s-block, p-block, d-block, and f-block elements—on the basis of their outermost electronic configuration.

For more activities, the Instructor can refer to the website at:

- http://www.nclark.net/PeriodicTable

Session 4: Metals and their properties

Student Teachers are already aware of the terms *metal* and *non-metal*; however, here they need to distinguish between different elements having metallic characteristics in the periodic table. For this, the Instructor might start the session with questions to ascertain their prior knowledge, such as the following:

- How is an iron rod different from a copper rod?
- What are the properties of metal?
- What are some chemical reactions that are common with metal?

Student Teachers might share some of their observations with respect to physical properties (such as conductivity) and chemical properties (such as rusting).

The Instructor will then provide Student Teachers with the three worksheets 'Properties of Elements' in the Teaching Resources section of this course guide. One worksheet is about element A, another about element B, and another about element C. The Instructor will ask Student Teachers to work in groups of five or six to conduct an experiment and record their observations on the worksheet.

After they complete the task, the Instructor will discuss the three different groups of metals in the periodic table, with the help of following questions:

- Which of these elements shows metallic characteristics? Please explain.
- How are elements A, B, and C different from each other?
- Which one is more reactive? Please explain.
- Do you still think they are similar?

The Instructor will then explain the three different metals—alkali metals, alkaline earth metals, and transition metals—in the periodic table, and compare their reactivity in relation to their valence shell electrons.

Session 5: Non-metals and their properties

Student Teachers have learned in previous sessions that the properties of elements are linked to their position in the periodic table. In this session they will learn about the importance of the atomic number (number of electrons) for an element's position on the periodic table and its resultant chemical properties.

The Instructor will start this session by giving some 'mystery elements' to the Student Teachers along with their atomic number (the Instructor will not disclose the names or actual symbol of these elements but will identify them with random letters).

Mystery Elements			
A (5)	B (7)	C (6)	D (18)
E (13)	F (16)	G (9)	H (10)

The Instructor will ask Student Teachers how, if they do not know the names of these elements nor their placement on the periodic table, they would identify them. The Instructor will explain that elements can be identified by their atomic number. The atomic number is equal to the number of protons in an element's atom. In an atom of neutral charge, this is the same as the total number of electrons. Because the properties of an element are mostly determined by its electron configuration, the properties of the elements likewise show recurring patterns, or periodic behaviour.

The electron configuration or organization of electrons orbiting neutral atoms shows a recurring pattern, or periodicity. The electrons occupy a series of electron shells (numbered shell 1, shell 2, and so on). Each shell consists of one or more sub-shells (named s, p, d, f, and g). As the atomic number increases, electrons progressively fill these shells and sub-shells. These shells fill up more or less according to a set of rules.

The Instructor will then give a few examples of known elements. For example:

- Neon: $1s^2\ 2s^2\ 2p^6$
- Hydrogen: $1s^1$
- Lithium: $1s^2\ 2s^1$

The Instructor will explain the example of element C with an atomic number of six. Six will show as $1s^2$, $2s^2$, $2p^2$, and 2 + 2 = 4 (s + p of second shell), which means it is in group 4 of the periodic table.

The Instructor will help Student Teachers to identify the placement of unknown elements in the periodic table by using the atomic numbers and the configuration of electrons. The Instructor will then assign one element to each group and ask them to discuss its properties, uses, and the like. For this, prepare a reference handout about the general characteristics of each group of p-block elements in the periodic table. After their discussion in small groups, the Instructor will take Student Teachers' feedback while summarizing the discussion collectively on the basis of the following questions:

- Why are these elements called p-block elements?
- What different properties did you find in different p-block elements (such as state, nature, and reactivity)?
- How are elements of the s block in the periodic table different than those in the p block?

Reference for the Instructor

General properties of elements:

➢ http://www.learner.org/interactives/periodic/index.html

Session 6: Ionic and covalent compounds

The Instructor will divide Student Teachers into small groups of five or six and give each group three beakers: one with NaCl (common salt), the second with glucose, and the third with oil. Explain that each beaker contains a compound but do not tell them what it is.

Student Teachers will be asked to find out about the following properties in all three substances. Remind them to keep a record of their findings.

- Conductivity
- State
- Solubility in water

Once they complete their investigation, ask the following questions and generate a discussion with the whole class:

- What does a conductivity test tell you? Which of these substances carry ions? What does it show about the nature of a compound?
- What does state represent about the bonding in a compound?
- Which of the compounds is soluble in water? What does this tell you about the compound?

The Instructor will take Student Teachers' feedback and explain ionic and covalent compounds and how they form, as well as the nature of bonding and how it is responsible for certain properties. The Instructor will also discuss those covalent compounds that have ionic characteristics.

Assignment and assessment

The Instructor will ask Student Teachers to write a two-page reflection on either of the following topics and support their claims with literature and examples (evidence) from their experiences.

- The significance and challenges of laboratory work in the science classroom
- Active learning versus activity-based learning

SYLLABUS 3: EXPLORING SPACE THROUGH INTERACTIVE LECTURES

Prepared by Sumera Irum, Sindh University Jamshoro

Overview

This unit builds on Unit 4 in Science I, which introduced Earth as a unique planet in the universe. In that unit, Student Teachers discussed some loose ties that Earth has with the Sun and Moon. Science II extended these concepts further and explained Earth's place in the solar system and its origin. They further explored phenomena such as day and night, the year, lunar phases, eclipses of the Sun and Moon, seasons, and tides, and investigated different planets and objects that orbit the Sun. In Science III, Student Teachers continue their investigation of space. The difference between life on Earth and space will be explored with respect to the force of gravity and the factors that affect it. They will study the importance and usefulness of satellites in our lives and the implication of space exploration in the modern world.

Common misconceptions

- There is no gravity in space.
- The Moon does not have a gravitational field.
- Heavy objects fall faster than light objects.
- All objects are weightless in space.

Instructors will adopt innovative teaching strategies dominated by the inquiry method to cover the content using the constructivist learning approach. This includes POE, discussion, demonstration, and other activities in the classroom setup.

Learning outcomes for this unit

Student Teachers should be able to:

- discuss the salient features of interactive lectures in science classrooms
- 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 of space and are used for space research.

Session 1: Space and its exploration and history

The Instructor will start the session by asking Student Teachers what the word *space* brings to mind. All ideas will be noted on the board. Some of the expected responses might be 'Moon', 'spacecraft', and 'Neil Armstrong'.

The Instructor will then divide the class into small groups (of five or six) and provide different readings about space exploration. The Instructor can use this resource on the website http://news.bbc.co.uk/onthisday/hi/themes/science_and_technology/space/default.stm, or from the links available in the lesson plan on the website http://school.discoveryeducation.com/lessonplans/programs/spacemilestones/index.html. (Readings should cover a range of time periods.)

The Instructor will ask each group to present the information they collected and important landmarks in the history of space exploration.

After the task is complete, the Instructor can ask Student Teachers to hypothesize about what next step space exploration might take in the coming years and why.

Session 2: Force of gravity

The Instructor can demonstrate the following experiment to the class and ask Student Teachers to predict what would happen before each step, to observe what happens, and to explain the event.

Experiment:

1) Place a lemon on a table and put a coin over it. See what happens. (The coin should stay on the lemon.)
2) Place the lemon in a bowl filled with water and try to place the coin on it.
3) Now try to place a scrap of paper on it.
4) Cut a small slit through the lemon skin and stick the coin in it. Put the lemon back in the bowl filled with water.

The Instructor can conclude the activity by explaining the phenomena with reference to the force of gravity. The Instructor can also use the initial part of the following video to explain concepts such as force of gravity and how it relates to the concept of mass and weight, microgravity, and the centre of gravity:

- http://education.ssc.nasa.gov/mvw_intro_video.asp

Further, the Instructor can perform various experiments and explain them with reference to the force of gravity. The Instructor can use the PDF document available at:

- http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Microgravity_in_the_Classroom.html

Reference for the Instructor

Explanation of the experiment: when the coin is placed on the lemon lying on the table, the coin will not move. However, in the water bowl, the lemon turns over to find a more stable position due to a shift in its centre of gravity. This is not in case with the scrap of paper, owing to its mass. When we stick a coin into the lemon, it turns over but does not fall down; however, if the coin is not attached to the lemon, it falls off.

Session 3: Comparison of two environments

The Instructor will start the session by posing the question: 'If you are going to space for a vacation, how will you prepare, and why?' The Instructor will collect Student Teachers' responses and ask the reasons for further elaboration. Some expected responses are they will take special oxygen masks, jackets, and the like.

The Instructor will show this video to start a discussion about the basic difference between the environments of Earth and in space in terms of force of gravity:

➢ http://education.ssc.nasa.gov/mvw_stretching_mass_video.asp

The Instructor will ask Student Teachers to recall their understanding of the force of gravity and its effect. The Instructor will ask Student Teachers to predict the following situations on Earth and in space, along with the reasons, based on force of gravity. This task can be done in pairs so that they have the chance to discuss their responses with their peers.

Situation	On Earth	In space	Why
Our weight			
Free-falling ball			
Hand wrestling			
Jumping			

After learning Student Teachers' responses along with their reasons, the Instructor will show the latter part of the following video at; it will explain the different reactions on Earth and in space:

➢ http://education.ssc.nasa.gov/mvw_intro_video.asp

Session 4: Factors affecting 'g'

The Instructor will ask Student Teachers what their weight would be on Earth, Mars, and the Moon, as gravity ('g') is different on each. For this, the Instructor can use the following website link to calculate the different weights of students:

➢ http://www.exploratorium.edu/ronh/weight/index.html

Student Teachers will see how weight varies in different environments with changing g. The Instructor will make it clear to Student Teachers that mass will remain the same (this should be re-enforcement of prior learning).

The Instructor will ask following questions:

- Why is g different on Earth and the Moon?
- What are the factors that affect the value of g?

After taking Student Teachers' responses, the Instructor will then give them the following two situations.

Situation 1: If both a 2 kg and a 20 kg mass are hung with the same type and length of spring, which one is stretched most? (The Instructor will relate it to the Earth's pull and g to describe the effect of mass on the value of g.)

Situation 2: Imagine a person here on Earth throwing a ball in the horizontal direction. What happens? Imagine throwing the ball faster. What happens? (The Instructor can explain that the ball starts to fly forward but immediately begins to drop toward the ground after leaving the person's hand. The ball is eventually pulled to the ground by gravity. When the person throws the ball faster, gravity will pull it down at a farther point. In an environment where the pull of gravity is less, the ball would travel further.)

Finally, the Instructor will discuss weight and mass in different environments (e.g. in space). For this, the Instructor can use reference material available at:

➢ http://www.exploratorium.edu/ronh/weight/index.html

Session 5: Vocabulary related to space exploration

The Instructor will ask Student Teachers what some of the inventions are that come to mind with reference to space exploration. Expected responses include the telescope, space shuttle, spacecraft, and satellites.

The Instructor will divide the class into four groups and provide material taken from the following websites to each group to discuss (one site per group). The Instructor will also provide a set of guiding questions. Each group will then present what they have learned to the whole class toward the end of the session.

- Space shuttle
  ➢ http://www.nasa.gov/audience/forstudents/k-4/stories/what-is-the-space-shuttle-k4.html
- Spacecraft
  ➢ http://en.wikipedia.org/wiki/Spacecraft

- Telescopes
  - http://www.kidsastronomy.com/telescopes.htm
- Satellites
  - http://www.cssforum.com.pk/css-compulsory-subjects/everyday-science/everyday-science-notes/63252-differentiate-between-natural-artificial-satellite.html

Alternatively, this activity could be an individual assignment for homework.

Session 6: Satellites and their uses

The Instructor will start the session by asking Student Teachers about the uses of satellites in everyday activities on Earth. Expected responses include navigation, weather forecasting, and search-and-rescue satellites. The Instructor will give some input on these uses. For reference, the Instructor can use following websites:

- General information
  - http://www.stmary.ws/highschool/physics/97/JDIORIO.HTM
- Satellite oceanography
  - http://www.marine.usf.edu/pjocean/packets/f98/f98u2le1.pdf
- Communication
  - http://www.esa.int/Our_Activities/Navigation/Communication_satellites_telling_us_where_they_are
- Telecommunications
  - http://www.esa.int/Our_Activities/Telecommunications_Integrated_Applications/Telecommunications_satellites
- Weather forecasting
  - http://www.weatherwizkids.com/weather-forecasting.htm

The Instructor will then ask Student Teachers about how satellites stay in space and do not fall to Earth. For this, the Instructor can demonstrate the following processes:

- A free-falling ball, which is pulled to Earth due to force of gravity.
- A ball attached to a rope and rotated as fast as possible by outstretched arms. This shows how when centripetal force becomes equal to centrifugal force (due to the velocity of the ball), the ball stays at a constant height and does not fall. The same is true with a satellite in orbit.

The Instructor can use following website as a reference for an explanation:

- http://transition.fcc.gov/cgb/kidszone/satellite/kidz/in_space.html

Assignment and assessment

The Instructor will ask Student Teachers to present their understanding about interactive lectures in some creative way (such as a poster, poem, or skit). Student Teachers can do this task in small groups of three to four and then share their work with other groups.

SYLLABUS 2: TEACHING ELECTRICITY THROUGH THE GUIDED-INQUIRY APPROACH

Prepared by Sahar Yasmeen, University of Karachi; Khalid Khurshid, Bahauddin Zakariya University; Misbah Malik, University of Education; and Sadia Suleman Khan, Sardar Bahadur Khan Women University

Overview

In Science I and II, Student Teachers learnt about different types of energy. They also studied how energy transfers through conduction, convection, and radiation. This will be extended in Science III through different concepts related to electricity, including static versus current electricity, how electric charges flow, scientists' work and discoveries, and electrical appliances and their use.

There are many misconceptions associated with electricity. For example, many students believe that static electricity is caused by friction. This misconception arises because the activities generally used to explain static electricity include rubbing phenomena, such as rubbing balloons on hair or rubbing a comb on cloth. However, it is important to clarify that the actual cause of static electricity is touching, as this transfers charges from one surface to another and results in oppositely charged surfaces attracting each other. Another common misconception is that static and current electricity are two types of electricity, whereas they are two different ways in which electric charges can act.

Emphasis in this unit is placed on practical application of electricity in daily life by using concepts that are very suitable for elementary grades. This course also provides a basis for understanding electrical safety concepts by using the idea of a fuse. This course is intended for Student Teachers to learn about the combination of circuits and their uses in practical ways.

Learning outcomes for this unit

After completion of this unit, Student Teachers should be able to:

- differentiate between guided and free inquiry in the science classroom
- define *current*
- investigate different types of circuits used for different purposes
- explain the process and factors of generating electricity
- design an experiment to generate electricity
- reflect on the experience of the inquiry approach
- differentiate between active learning and activity-based learning.

Session 1: Charges and their interaction

Student Teachers should already have some basic ideas about energy and charges. Therefore, the Instructor will begin the session by asking the following questions:

- How does your hair feel in winter?
- Why do we sometimes feel current while touching an iron grill and the very next moment it vanishes?
- What is common to both of these examples?

Student Teachers will connect the responses to these questions with electrical charges and how these repel and attract each other.

The Instructor will then demonstrate several phenomena with a blown-up balloon (or Student Teachers can do this themselves).

- Explain that an object can have a net charge of positive or negative and it can also be neutral (with no net charge). Ask: What charge does a balloon have after it is blown up but before it has come into contact with hair?
- Rub the balloon onto someone's hair. Ask: What charge will the balloon have now? If you rub the balloon with your hair, what do you predict will happen when the balloon is moved near a few bits of paper? Repel, attract, or do nothing?
- Ask: What is your explanation for this? (What is going on with the charges on these objects?)

The Instructor will then discuss with the whole class their observations and explanation of the phenomena.

- What happened when you brought the balloons close to the paper after rubbing your hair?
- What does this indicate about the charges on the paper and balloon?

Broaden the discussion to static electricity generally and other electrostatic phenomena, such as lightning.

Extended activity

The Instructor can ask Student Teachers to repeat the same experiment by using a wooden rod, glass rod, and iron rod instead of a balloon and see of there is any difference.

Session 2: Electricity

The Instructor will start this session by asking the following question: 'Why do you think that electricity is a form of energy?' Student Teachers might talk about the effects (other forms of energy) that electricity can produce (such as light and motion, for example) or that electricity can do work and so is a form of energy.

Divide Student Teachers into pairs. Provide each pair with a torch and a set of questions. For example:

- How do you think a torch works?
- What is inside the torch?
- How does the on-off button work?
- What happens if you leave the torch on?

Use and build on Student Teachers' responses to discuss the flow of electricity in the torch from moving a switch to light emitting from the bulb.

Session 3: Simple circuits

As Student Teachers have already learned at school, electricity generation requires a source (battery), path (wire), and a light bulb. It is now time to teach them how to make a simple circuit by trial and error.

The Instructor will give the following items to each group of five or six students and ask them to make the light bulb glow:

- Light bulbs
- Batteries
- Wire
- Scissors to cut the wire
- Sticky tape
- Paper clips

Ask if there is more than one way to light the bulb using the same equipment. How many bulbs can they light? They should record each of the methods.

Review the different ways groups light their bulbs. Discuss the features of the successful and unsuccessful circuits they make.

Extended activity

The Instructor will provide a few objects (such as an eraser, metal pen, paper envelope, pencil, paper clip, chalk, coin, spoon, or nail) to each group of five or six Student Teachers and ask them to predict which are conductors and which are not. They will then connect each object through a wire in a circuit and see if a bulb lights. If the bulb lights, this indicates that the circuit is complete, as the object was a conductor and allowed charges to flow continuously.

Session 4: Types of circuits

The Instructor will provide two light bulbs and sockets with wires and batteries to each group and ask them to connect and light both bulbs in different arrangements.

The Instructor should help groups make a circuit in parallel and a circuit in series and then discuss the following questions while facilitating each group:

- Is there a difference between the light of the bulbs in the two circuits?
- What happens if one bulb is unscrewed from its socket in each circuit?

Lead a discussion about different types of circuits, their uses, and their importance.

Session 5: Electrical appliances

The Instructor will show this video:

➢ http://archive.teachfind.com/ttv/www.teachers.tv/videos/things-that-use-electricity.html

The Instructor will ask Student Teachers to watch the video and identify and make a list of all the uses of electricity in daily life. The Instructor will then ask each Student Teacher to select an electrical appliance (such as a television) and investigate:

- the history of the invention of the device
- how it works (related to electricity)
- how the device has been improved over time (and to suggest one change to improve the device, and explain why).

Student Teachers should prepare a two-page handout for children in high elementary grades based on the information they collect.

Session 6: Renewable and non-renewable energy resources

The Instructor will initiate a discussion about electricity crises in Pakistan along with their causes. The Instructor will then relate the concern with different renewable and non-renewable resources of electricity generation by asking the following questions:

- How can you distinguish between renewable and non-renewable energy resources?
- What are some examples of renewable resources?

The Instructor can give each group (of five or six Student Teachers) one renewable energy resource (such as solar, wind, water, bio-energy, geothermal, hydrogen, and fuel cells) and ask them to research through the Internet and books the following:

- How they generate electricity
- Why they are considered a renewable resource
- The advantages and disadvantages associated with using this resource

For this activity, the Instructor can suggest some websites for reference and research purposes, such as the following:

- http://www.eere.energy.gov/
- http://www.nrel.gov/rredc//

Student Teachers from each group will present their findings to the whole class either in this session or another session. They will also be asked to share their reflection on the inquiry process they experienced during this unit. The Instructor will conclude the session by giving some input on the following

- The inquiry approach: its significance and challenges
- Guided and free inquiry

Suggested reading for the Instructor

'Understanding Electricity and Circuits: What the Text Books Don't Tell You', by I. M. Sefton (the full reference is listed in 'Additional Suggested Reading').

5

Teaching resources

Selected readings that faculty will find useful in preparing sessions as well as readings for Student Teachers are found in this section. Teaching materials such as handouts or activities that require elaboration are also included. Intellectual property rights are respected throughout. All materials are either free-use or are used with permission of the author and/or publisher. In some cases, original pieces written specifically for this course are included. All readings and materials in this section are for classroom use and, unless otherwise noted, may be duplicated for distribution to Student Teachers. Those who wish to use them in their own publications will need to be mindful of intellectual property rights, securing permission for their use and including proper attribution to sources.

Shairoze Jessani prepared the topical activities. These can be used by Student Teachers while studying the topics in the science syllabi.

Student handout

Scientific processes

Instructions: The following grid gives the names of scientific processes along with their definitions in jumbled form. Match the column with appropriate definitions.

	Scientific process	Definition
01	Hypothesis	The number of steps performed to test a hypothesis.
02	Observation	Sharing your learning with the scientific community.
03	Experiment	A research question or issue; what you want to know.
04	Conclusion	An organized collection of information or clearly stated data that allow you to make a conclusion.
05	Problem	An educated guess. It must be testable.
06	Communicate results	A detailed description or statement of how the data support or do not support the hypothesis.

Student handout

Global warming

Instructions: In this activity, you will analyse and graph data on observed global temperatures and CO_2 concentrations. Further, you will interpret the graph and answer questions about this data.

Task 1

On a blank sheet of paper, graph the data given below. Label the horizontal axis 'year' and label the vertical axis 'CO_2 concentrations'.

TABLE:	**Atmospheric concentrations of CO_2 during the years 1750–1990**
Year	CO_2 concentration (parts per million: ppm)
1750	282 ppm
1800	283 ppm
1850	290 ppm
1900	297 ppm
1950	312 ppm
1980	335 ppm
1990	350 ppm

Answer the following questions

1) What pattern or trend do you notice in CO_2 concentrations?
2) During which years was the trend most pronounced?

Task 2

The table below gives actual average global temperature changes during the years 1890 to 1990, using 1890 as a base year.

Graph the data on a blank sheet of paper.

Year	Global average temperature (observed change in degrees C)
1890	0.00
1900	0.18
1910	0.20
1920	0.22
1930	0.43
1940	0.54
1950	0.48
1960	0.43
1970	0.40
1980	0.55
1990	0.56
1990	350 ppm

Answer the following questions

1) During which time period was the observed temperature increase the greatest?
2) Which time period shows the greatest increase in CO_2 concentrations?
3) Examine the data carefully. Does the data support the conclusion that increasing greenhouse emissions are responsible for the 0.5 degree Centigrade increase in observed temperature during the past 110 years? Explain your reasoning.
4) What are some other natural phenomena that could possibly explain increases in temperature?
5) Assume you were a weather scientist and were called for a meeting to testify on the global warming issue. Would you recommend public policies that would require reductions in greenhouse gas emissions? Explain your position and support it with scientific evidence.

Student handout

Exploring inherited traits

S

Instructions: Identify inherited traits and explore their expression among your group members. One example is tongue rolling.

Trait description	Check the traits that you have	Total group members who have this trait

Faculty resource

F

Properties of elements

(for 'Teaching the periodic table through active learning')

Instructions: In your group, perform the following tasks and record your observations in the space below.

Element A

NOTE: This is sodium immersed in kerosene oil; however, its name should not be disclosed to the Student Teachers. **Delete this instruction before sharing the handout.**

Instructions	Observation
Look at the appearance of the element. Note your observation but don't touch it with your finger. To note the hardness, press it with a pencil. Note the state, hardness, and other properties of the material.	
Don't take this element out of the oil. Why do you think it is kept in oil?	
Cut a small piece of this metal (with the help of a knife and forceps). Don't forget to wear goggles and hand gloves. Put only small pieces (one-half of a pea sized) into the water. (Make sure that the leftover material is returned to the container with oil. Also, all material should be reacted, and nothing should be left unseen.)	

Element B

NOTE: This is a magnesium ribbon; however, its name should not be disclosed to the Student Teachers. **Delete this before sharing the handout.**

Instructions	Observation
Rub the element with the sandpaper. Look at the appearance of the element. Note its state, hardness, and appearance. Compare it with the other elements given.	
What does the shape of it remind you of? Is this significant?	
Take off a piece of the element and burn it in the air. What does it form? Put the ash into water and check it with red and blue litmus paper. What does it indicate?	
Place a piece of the element in the bottom of a Petri dish. Put some drops of water on it. What do you observe? Remove and place it in the container given by the Instructor.	
Take off about one inch of the element. Roll it and put it in a test tube. Add about 2 ml dilute HCl to it. Gently heat the test tube. Hold a burning splinter near the mouth of the test tube. A popping sound is heard. What does it indicate?	

Element C

NOTE: This is iron wire of two to three inches; however, its name should not be disclosed to the Student Teachers. **Delete this before sharing the handout.**

Instructions	Observation
Rub the element with sandpaper. Look at the appearance, hardness, and lustre of the element. Note your observation.	
Heat the wire at one end and feel if the other end becomes hot. What does this indicate?	
The element is presented as a wire. What does this suggest?	
Take this element out of the Petri dish. Does it react with oxygen? Put it in water. What happens? Put it in dilute HCl. What happens? What does this indicate?	

Faculty resource

Reading resource I: The need and emergence of the Science Technology Society (STS) approach

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Issues of traditional science teaching raise a demand of science education reform. There is a shift needed in science education from scientist focused curriculum to learner focused by changing socially isolated content to interesting, engaging and relevant content. STS approach has potential to make science relevant and practical for students, as Aikenhead (1994b) mentions that "teaching science through Science-Technology-Society (STS), refers to teaching about natural phenomena in a manner that embeds science in the technological and social environment of the student" (p. 48). This linkage enables learners to see relation, significance and impact of science for social and technological aspects of human life. Pedretti (1996) found that this need for STS approach of science teaching was strongly felt by the teachers when they got involved in developing STS curriculum units and implementing the materials in their classrooms.

Vision of STS is rooted in the notion of developing scientific literate citizenry. It targets science education for all children and not specifically for future scientists. Rennie, Goodrum and Hackling (2001) argue that developing scientific literacy is the purpose of science education. They claim that people who are employed in science related fields make use of science in more formal ways, however, everyone has right to science education which enables them for comfortable decisions about the socio-scientific issues that impact on their lives. Shamos (1995) considers this as a futile goal which can neither be achieved nor required. He claims that in the present circumstances, the majority of the people is not motivated to question and see controversial scientific issues as outside their need and competence to judge. He also raises the issues like identity problem of STS and impossibility of translating scientific thoughts, issues and actions in common language understandable to untrained, average emotional people. On the other hand, Cross and Price (1999) consider it a danger for humankind, if the majority of the people do not begin to understand the need and gain the confidence to play their citizenship role. Hence, scientific literacy is considered as the means to improve quality of life (Zahur, Barton & Upadhyay, 2002) and to produce more knowledge (Cross & Price, 1999).

What is STS approach?

STS is learner-oriented science teaching, where students acquire knowledge on the basis of their everyday experience that helps them to relate personal understanding with socially and naturally constructed environment. While implementing STS approach, Dass (2005) realized that teaching processes in STS give students a practice for identifying social problems, collecting and analyzing data, considering alternative solutions and disseminating information or action for improvement. The same focus and processes of STS were included in this study to make science education relevant and significant for students. Also, Ziman (1994) enforces the value of STS due to its multiplicity of approaches and claim that these different approaches are complementary instead of contradictory. STS helps students in making connections across different disciplines, which leads to better understanding of science. However, Shamos (1995) points out different nature and requirement of each discipline as main issue for this interdisciplinary approach.

Pedretti and Hodson (1995) broadly categorize goals of STS approach into two areas, which are "personalization of learning and politicization of science education" (p. 465). Personalization goal of STS targets holistic development of learner instead of relying only on cognitive aspect. It emphasizes on constructive philosophy of learning which focuses on learners' own experience. This relation of school science with learners' life makes learning meaningful and easy by linking new ideas with existing concepts and by applying learning in new situation (Gabel, 1998). On the other hand, politicization aspect of STS focuses on social enterprise where students get opportunity and freedom to play their role in society. Pedretti and Hodson (1995) claim that to achieve these goals, STS has to be capable of meeting local needs within a global framework and also flexible to adapt to changing circumstance. However, Oulton, Dillan and Grace's (2004) study identified that these goals need lots of changes, not only in the form and content of curriculum but also in teachers' practice of teaching, which is not an easy task.

STS science curriculum

School science must not only prepare ground to judge one's knowledge based on memorization but also provide opportunity for learners to understand and play their active role of citizenship in society. This citizen empowerment needs a different nature of curriculum, which is best fit to STS approach due to its emphasis on social responsibility and citizen action (Solomon, 1994). My experience shows that current science curriculum is scientist oriented in nature due to its content, sequence and language used. On the other hand, Jenkins (1999) includes student-centered activities, every day language and flexible content in STS curriculum to make it relevant and understandable for their students. This dichotomy between scientists' view of science education and students' view of every day world is the major difference between traditional science and STS science curriculum (Yager, 1995b).

Lochhead and Yager (1995) identified different functions of textbooks in STS teaching than in traditional practices. They said that instead of defining what should be learned and to what depth and in what order, STS textbook leaves to students the task of evaluating how and where to search for additional data. This needs STS curriculum to be flexible and embedded in scientific and technological knowledge with society issue. However, Yager and Soong (1995) state that STS curriculum is less reflective in commonly used science textbooks as well as classroom teaching. This raises the importance of including other materials for STS teaching like Internet, newspapers along with textbooks to fill the gap of knowledge based on socio-scientific issues (Lumpe, Haney & Czerniak, 1998); however, in reality most of the teachers consider textbook as their main reference for teaching (Pedersen & Totten, 2001). My study of STS integration addresses the ways to reduce the same gap of existing textbook by using innovative STS teaching strategies in the classroom. Oulton, Dillan and Grace (2004) highlighted major constraints for curriculum and pedagogical reform in terms of stakeholders' priority, bifurcation of academic and public knowledge, fear of controversies, fragmentation of knowledge into disciplines, the pressure for content coverage, teachers' lack of knowledge and their own bias. To avoid issues of ownership and understanding for usable curriculum materials of STS, Pedretti and Hodson (1995) highlight the importance of involvement of teachers in curriculum development through action research. They found that this involvement produces "rapid changes in ideas and opinions and created the condition for the speedy production of usable curriculum materials" (p. 476). Pedretti (1996) experienced the same benefits of change in teachers' belief and practices when involved them in an STS based action research.

Aikenhead (1994c) on the other hand, advocates the idea to integrate STS topics in the existing school curriculum to gain realistic implementation instead of radical restructuring whole school curriculum. This study is also built on the same idea of STS integration based on four aspects of STS curriculum highlighted by Aikenhead (1999b) that are, function, content, structure and sequence as described below:

Function

It refers to the goals of science teaching through STS. Though the whole philosophy of STS is based on the goal to built universal scientific literacy, however, Penick and Bonnstetter (1995) highlight three main goals of STS teaching based on acquisition of knowledge, development of learning skills and development of values and ideas. Though STS curriculum varies due to different priorities of goals, major focus of STS is to address needs of two groups of learners, one future scientist and engineers and other citizen to participate actively in society (Aikenhead, 1994b).

Content

Content means what should be taught in STS curriculum. Aikenhead (1994b) explained that STS curriculum includes both science content and STS content. STS content is primarily based on students' own experience and contextual needs; however, it is not at the cost of pure science content but to fill the gap for improvement of missing aspects (Ziman, 1994). Literature emphasized on issue based approach as it provides motivation to students that is usually absent in current abstract, de-contextualized science curriculum (Oulton, Dillan & Grace, 2004). This blend of STS and science concepts in curriculum supports learners in developing understanding of the role of science, in resolving controversies.

Structure

Structure means how science and STS content could be integrated. Aikenhead (1994b) identified several categories of STS that had different proportions of focus on science and STS. These categories range from pure science to pure STS with many intermediate categories of blended science and STS content. These categories would lead to different ways in which two contents combined, different nature of students' evaluation and ultimately different nature of STS programs. However, selection of any category depends on the need and demand of context, which also dictated my selection of fourth category that is Singular discipline through STS content for this study.

Sequence

Sequence refers to design of a curriculum that is very useful for successful implementation of the program. STS cannot suggest one sequence of curriculum as it depends on different nature and goals of STS program. However, Aikenhead (1994b) suggest a model where learners start from the society problem, lead to technological knowledge and scientific concepts to understand issue and then again move to the domain of technology to revisit their understanding for ultimate aim of addressing original social issue. This sequence helps to relate social issues with studied scientific concepts and also to get an understanding about the importance and relevance of science teaching.

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Reading resource II: Advantages and issues of STS science teaching

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Advantages of STS science teaching

Many studies found that STS science teaching is very significant to improve students' knowledge, high order skills, attitude towards science process skills and ability to apply concept in new situation and creativity (Hodson, 2003; Oulton, Dillan & Grace, 2004; Siegel, 2006; Yager, 1995a; Zin, 2003). This reflects the goal of holistic development of a child rather than that of impacting mere on cognitive aspect. Literature claims that STS approach results in much conceptual learning and students' interest as compare to more traditional courses where concepts are identified directly for students to master (Bennett, Grasel, Parchmann & Waddington, 2005; Tsai, 2000). This could be because in STS teaching, students see concepts as personally useful and learn it by experiences. This ultimately enables students to retain those concepts for a longer time and relate them in a new situation. Moreover, students get opportunities and freedom to select problem and develop processes for investigation of those problems that ultimately improve their higher order skills like reasoning, analyzing and decision making. Along with these concepts and skill development, it also influenced on students' attitude towards science-related subjects and career. Liu and Yager (1995) reported that students had increased their interest for science related careers during experience of STS teaching. These benefits are due to students' involvement and action during learning process.

Issues of STS science teaching

Besides diversified learning outcomes for students, STS approach has many issues that make its implementation difficult. For example, nature of STS encourages alteration of instructions and content whenever required. One argument supports this alteration to make science more relevant and interesting, however, another argument could raise question of its importance at the cost of precious little time and opportunity needed for study of pure science concepts (Altschuld & Kumar, 2000). Also, more flexibility is needed in the STS curriculum to focus more on local issues (Hodson, 2003), which sounds a big challenge for curriculum developers to decide what to select and what to leave (Lumpe, Haney & Czerniak, 1998). Yager and Soong (1995) emphasize new goals, focus and instructional strategies as special qualities of textbook for STS implementation.

Another issue is nature of STS activities that target to balance both content knowledge and practical knowledge for students. Shamos (1995) claims that STS would lead to peripheral knowledge of science rather than basic knowledge that can be problematic with those who needs specific knowledge of one discipline of science. Ratcliffe (1999) shares the same concern that this issue-based approach is not suitable for those who want to do their specialization in science field. One reason is that students focus on their personal experience and grounded ideologies exist in society rather than scientific knowledge during STS activities (Hong & Chang, 2004). Varrella (1995) supports the claim of "less is more" (p. 105) that could lead to more opportunities and experiences requiring high order thinking and learning abilities.

Furthermore, STS needs complete involvement of students in the process of inquiry, as Bennett, Grasel, Parchmann and Waddington (2005) raise the importance of students to be well motivated and self-sufficient. However, usually in classroom, majority of the students need a lot of support and is unable to do independent work. This raises the concerns about students' ability to involve and participate in the STS action for its successful implementation. Also, teachers' role is very crucial for this application based teaching approach. Teachers need to be aware of the nature of issues and how to take it in their teaching (Oulton, Dillan & Grace, 2004), which is very demanding due to limited skill and knowledge of teachers. However, while using STS approach in teaching method course, Dass (2005) found that teachers become more comfortable as module progressed. I strongly felt the importance of teachers' role in this study and developed myself with several features of the successful STS teacher, for example, providing a stimulating and accepting environment for students and bringing students and learning beyond the classroom (Penick & Bonnstetter, 1995, p. 171). Hodson (2003) found STS to be very useful in order to involve students and teachers as active participants in curriculum developments, implementation and evaluation and give them ownership and sense of accomplishment. On the other side, studies in developing contexts highlighted several challenges of STS teaching, for example, time, resources, teachers' knowledge, nature of syllabus (Halai, 2006; Zin, 2003).

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Additional suggested reading

Teaching teachers and students about the nature of science

By Nelofer Halai, Aga Khan University, Institute for Educational Development, Karachi

Available at:

- http://ecommons.aku.edu/pakistan_ied_pdck/89

Abstract

This article advocates the teaching about the nature of science to both pupils in schools and teachers in teacher education institutions in Pakistan. Not knowing about science; teachers tend to continue to teach science as fixed knowledge and not as inquiry and this cycle continues. This cycle needs to be broken. This article first discusses the salient features about the concept of the nature of science and then illustrates these ideas with the help of a simple but a powerful activity which could be used both with teacher educators and pupils in secondary and lower secondary classrooms.

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

Learning science through activities and toys

By Arvind Gupta

Available at:

- http://www.arvindguptatoys.com/arvindgupta/khagol.pdf

In this article, the writer emphasizes the importance of hands-on experience in children's learning. He suggests some great cost-cutting 'science toys' made easily from everyday items and has enunciated their use not only as toys but as simplest scientific apparatuses. In a poor country such as India the chances of educating children is scarce, and hence the importance of these low-cost toys. Items such as the Sudarshan Chakra, a simple motor, and the notched pencil are some examples made from household items such as a torch battery, rubber band, and straws, and which illustrate sophisticated scientific phenomena in an easier way. An initiative of IUCAA's Children's Science Centre (the Inter-University Centre for Astronomy and Astrophysics), where every day 50 students learn to make action toys that whistle, jump, and hop, thus helping them observe science in their daily lives. According to the writer, the best thing about using such homemade toys is that children can easily make them and experiment with them without worrying about destroying them, encouraging creative chaos.

Interactive lecturing: Strategies for increasing participation in large group presentations

By Yvonne Steinert and Linda S. Snell

Available at:

- http://med.ubc.ca/files/2012/03/Interactive-Lecturing-Strategies.pdf

The writers have focused on the merits of the interactive lecture and the fears associated with it. Interactive lecture can vary with the audience; for some it is extensive discussion, while others consider including research studies as interactive lecture. Another aspect is the role of the teacher, which may bounce from coach to instructor or facilitator. The writers reinforce the importance of interactive lecturing as a component of effective learning of students. Interactive learning enhances the active involvement of students, their motivation, learning from feedback, and ultimately creating an enabling environment for both teachers and students. Fear such as losing authority over students and being unable to cover the course in time inhibits interactive learning. Certain techniques used in interactive lecture include brainstorming, breaking the class into groups, surveying and questioning the class, incorporating students' responses into the lecture, and using case studies, role plays, audiovisual aids, and simulation. According to the writers, the best way to start is to be prepared and have clear objectives of the session while briefing the students of their role in the interactive lecture.

Shifting from activitymania to inquiry

By Hedy Moscovici and Tamara Holmlund Nelson

Available at:

- http://thecenter.spps.org/uploads/shifting_from_activitymania.pdf

In this article, the authors begin by noting that 'often when science instruction occurs in some elementary classrooms, it is in the form of a barrage of activities', what they call 'activitymania'. The article discusses how teachers and students move from activitymania to inquiry approaches to learning science. The article includes a useful table that compares activity with inquiry.

Understanding electricity and circuits: What the text books don't tell you

By Ian Sefton

Available at:

- http://science.uniserve.edu.au/school/curric/stage6/phys/stw2002/sefton.pdf

Most of the standard physics text books that we all know and either love or hate have some serious deficiencies. My particular beef [concern] here is that, by trying to oversimplify some basic physics, those books introduce or encourage some serious misconceptions and tell stories that are hard to believe.

For this discussion I have chosen the topic of simple circuits as exemplified by a battery and a small torch globe—can we find a simpler circuit than that? I will use that example to explore some really important physics that all school-level and most junior university-level texts omit and to confront a serious misconception that can arise from studying those texts.

There are four main parts to this article. In part 1 I introduce the example and in part 2 we have a look at the misconception about energy transfer together with a quick summary of a better model. In parts 3 and 4 we will examine the basic physics in more detail and justify the alternative model by applying the principles to the example in more detail.

6

Suggested assignments and assessment criteria

Assignment 1

Develop a teaching portfolio on any science concept. Your portfolio should carry:

- Lesson plan with resources (low-cost or no-cost)
- Reflection on teaching session
- Tutor and peer feedback on the lesson

For this, you need to take the following steps:

- Select one topic from the National Curriculum for General Science Grades IV–VIII. Develop a lesson plan that includes learning outcomes, teaching notes/steps, and resources for activities and strategies (resources should be low-cost or no-cost). Share the session plan and resources with your Instructor for feedback.
- Conduct a teaching session with any elementary grade class. Ask the Cooperating Teacher and/or one of your peers to observe your session and to give written as well as verbal feedback afterward.
- Identify any critical moment during your teaching process and write a reflection of 400 to 500 words.

Assessment criteria

- Your lesson plans have SMART objectives and clear evidence of the grade level.
- Choice of teaching approaches and activities is both motivating and relevant to learning objectives.
- Teaching resources are specific, meaningful, and based on low-cost materials.
- Class teaching is both engaging and outcome oriented.
- Teacher–student interaction during the teaching session is good, as feedback indicates that it facilitated active learning.
- Reflection is evidence of critical thinking about both science content and teaching-learning pedagogy.
- Reflection is written in a structured and organized manner.

Sample rubric for classroom observation

Observee's name: ______________

	1	2	3	4	5
TIME MANAGEMENT	There is no time allocation in the plan Lesson pacing is completely inappropriate There is no monitoring of time at all Time allocation is inappropriate Teacher entrance or exit hugely varies from the timetable	Time is allocated for different stages of lesson plan but this allocation is incomplete Lesson pacing is inappropriate as reflected in slow or fast progression through the lesson There is monitoring of time as lesson flows but less rigorous Time allocation is less appropriate for different activities Teacher entrance or exit is not in accordance with the timetable but engages students for an equal amount of time as usual period	Time is allocated for different stages of lesson plan but this allocation is incomplete There is no rush to complete the lesson with appropriate pacing There is monitoring of time as lesson flows but less rigorous Time allocation is less appropriate for different activities Teacher entrance or exit is not in accordance with the timetable but engages students for an equal amount of time as usual period	Time is allocated for different stages of lesson plan as shown by utilization of all minutes available in a period There is no rush to complete the lesson with appropriate pacing There is monitoring of time as lesson flows but less rigorous Time allocation is less appropriate for different activities with some activities completed under time pressure Teacher enters and exits the class on time and according to the time table	Time is allocated for different stages of lesson plan as shown by utilization of all minutes available in a period There is no rush to complete the lesson and lesson flows in a natural manner There is a rigorous monitoring of time as lesson flows Time allocation is appropriate for different activities with no undue pressure on student to complete any activity Teacher enters and exits the class on time and according to the timetable
TEACHING ACTIVITIES	Teaching activities are not relevant to the learning objectives Some SLOs do not have related activities Instructions are not clear for students Resources were inadequately supplied There is a limited variety of activities	Teaching activities are relevant to the learning objectives Some SLOs do not have related activities Instructions are not clear for students Resources were inadequately supplied There is a limited variety of activities	Teaching activities are relevant to the learning objectives There is a teaching activity for every learning objective There are clear instructions for students to follow in each activity Resources were inadequately supplied There is a limited variety of activities	Teaching activities are relevant to the learning objectives There is a teaching activity for every learning objective There are clear instructions for students to follow in each activity Adequate resources are available for students to complete any activity There is a limited variety of activities	Teaching activities are relevant to the learning objectives There is a teaching activity for every learning objective There are clear instructions for students to follow in each activity Adequate resources are available for students to complete any activity There is variety in lesson activities

	1	2	3	4	5
SPECIFIC LEARNING OBJECTIVES	There is inadequate number of SLOs or are absent altogether SLOs are not linked to syllabus SLOs are not SMART	There is adequate number of activities (at least two to three in a lesson) The SLOs are not linked to syllabus SLOs are not SMART	There is adequate number of activities (at least two to three in a lesson) The SLOs are linked to syllabus SLOs are specific, measurable, achievable, and realistic but not time bound	There is adequate number of activities (at least two to three in a lesson) The SLOs are linked to syllabus SLOs are SMART SLOs are not shared with the students at the beginning of the lesson	There is adequate number of activities (at least two to three in a lesson) The SLOs are linked to syllabus SLOs are Specific, Measurable, Achievable, Realistic and Time Bound (SMART) SLOs are shared with the students at the beginning of the lesson
ASSESSMENT	There is not mention or use of assessment strategies at all in the lesson	There are assessment strategies in lesson plan that are linked to SLOs Assessment strategies are innovative (such as Self and Peer) and go beyond traditional practices Assessment strategies are partially successful in ascertaining the achievement of SLOs Assessment instructions are not given at all	There are assessment strategies in lesson plan that are linked to SLOs Assessment strategies are innovative (such as Self and Peer) and go beyond traditional practices Assessment strategies are partially successful in ascertaining the achievement of SLOs Assessment instructions are not clear to students	There are assessment strategies in lesson plan that are linked to SLOs Assessment strategies are innovative (such as Self and Peer) and go beyond traditional practices Assessment strategies are successful in judging the achievement of SLOs Assessment instructions are not clear to students	There are assessment strategies in lesson plan that are linked to SLOs Assessment strategies are innovative (such as Self and Peer) and go beyond traditional practices Assessment strategies are successful in judging the achievement of SLOs Clear instructions are given to students before any assessment activity is conducted

	1	2	3	4	5
CLASS MANAGEMENT AND DISCIPLINE	Class management and discipline are chaotic with no appropriate measures from teacher side	Takes measure to maintain discipline in the classroom There is little care for class indiscipline Environment is supportive for students; however, there are limited chances for students to question and think creatively Disciplinary approaches are not sensitive to student voice	Takes measure to maintain discipline in the classroom Shows firm attitude toward class discipline Environment is supportive for students; however, there are limited chances for students to question and think creatively. Disciplinary approaches are not sensitive to student voice	Takes measure to maintain discipline in the classroom Shows firm attitude toward class discipline Provides supportive climate where students are encouraged to question and think creatively Disciplinary approaches are not sensitive to student voice	Takes measure to maintain discipline in the classroom Shows firm attitude toward class discipline Provides supportive climate where students are encouraged to question and think creatively Uses student-centered disciplinary approaches wherein students' self-respect is honoured and student voice is heard

Assignment 2

Writing an academic paper (an individual task) on science in daily life.

The paper, which should have an approximate length of 800 to 1000 words, should include:

- Introduction and the background of topic
- Literature review
- Connection of the topic with teaching science and the teacher's role
- Implications
- References

Assessment criteria

- Clarity, language accuracy, and organization
- Supporting claims through critical analysis of available literature
- Making connections with prior experience and linking with new learning
- Quoting references and keeping within the word limit

Assignment 3

Writing a reflective paper on common misconceptions about any science concept (an individual assignment).

- Select any science concept from the National Curriculum for General Science Grades VI–VIII; e.g. electrical current.
- Review the literature for common misconceptions children carry about the concept.
- Plan activities and questions for a group of students. Develop resources.
- Carry out activities among a small group of students. Involve them in a discussion to find out common misconceptions and ways to overcome them.
- Write a reflective paper that contains:
    - background about teaching the selected science concept (involve literature and your personal experience)
    - process and activities for the elicitation process.

Elicitation of misconceptions (sample rubric)

Group _____

Instructions: Check the requirements of your overall product and performance according to these criteria. Assess your project with your peer groups.

	Excellent 4 points	Good job 3 points	Competent 2 points	Needs work 1 point	Teacher's score
QUALITY OF INFORMATION/ ARGUMENTS	Gathers the most significant information from an extensive variety of literature sources Effectively connects complex information from various sources Uses own knowledge and experiences in the subject matter	Chooses relevant information from a variety of literature sources Effectively connects information from various sources Can generate several ideas	Chooses general information from a variety of literature sources Partially connects the information from sources Can use few ideas based on the knowledge and experience	Chooses insufficient information from a few sources Neglects to connect information from various sources Has a very hard time thinking of ideas	
QUALITY OF ACTIVITIES	Uses own knowledge of the subject and the opinions of experts and personal experience to prepare relevant activities	Gives few strong connections between the activities and the knowledge of subject matter	Very few activities planned are connected with the subject knowledge shared by experts and own experiences	No relevance between the activities and the ideas of subject knowledge	
STUDENTS' PARTICIPATION	Students participate fully and are always on task during discussion and activities carried out by prospective teachers	Students participate most of the time and are on task most of the time	Students participate but waste time regularly and/or are rarely on task	Students do not participate; waste time; or work on unrelated material	

	Excellent 4 points	Good job 3 points	Competent 2 points	Needs work 1 point	Teacher's score
QUALITY OF REFLECTIVE PAPER	Presents breadth and depth of relevant, accurate information and concepts Provides a conclusion with clear, convincing reasoning and evidence to support it Writes a paper properly without language error and with the given word count	Presents relevant and accurate information and concepts Provides a conclusion with sufficient evidence to support it Some language errors but word count is carefully considered	Presents some information relevant to the concept Provides a conclusion with some evidence to support it Language is acceptable but word limit is not considered	Presents limited, simplistic information Conclusion is muddled and with no support Does not consider appropriateness of language and word limit	
GROUP DYNAMICS	Prospective teachers in a group work well together and share the workload equally	Prospective teachers work mostly together and share the workload some of the time	Prospective teachers work together some of the time	Prospective teachers do not work well together	
TIME MANAGEMENT	All parts of the assignment are completed and turned in on time	Most of the parts of the assignment are completed and turned in on time	Some of the parts of the assignment are completed and turned in on time	None of the parts of the assignment are completed on time	

Overall score: _________

Comments:

Reviewed and checked by: ________________________

Higher Education Commission