JUNE 22, 2026

1.5 B.Ed. Specialization Courses Curriculum

SUBJECTS: CHEMISTRY, PHYSICS, BIOLOGY, MATHEMATICS, ENGLISH, SINDHI, URDU, AND SOCIAL SCIENCE

SINDH TEACHER EDUCATION DEVELOPMENT AUTHORITY
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Contents

Foreword

The Sindh Teacher Education Development Authority (STEDA), established under the STEDA Act, 2012, is mandated to regulate, standardize, and strengthen teacher education across the province. In fulfilling this mandate, STEDA has undertaken a significant initiative to standardize the Bachelor of Education (B.Ed.) 1.5-Year Secondary Program, to ensure consistency, quality, and alignment of teacher preparation programs offered by universities in Sindh.

The B.Ed. 1.5-Year Secondary Program is designed to prepare subject-specialist teachers for secondary schools in disciplines such as Mathematics, Physics, Chemistry, Biology, English, Urdu, Pakistan Studies, Commerce, and other secondary-level subjects.

In 2024, STEDA reviewed B.Ed. programs offered by major universities across Sindh and found significant variation in the implementation of the B.Ed. 1.5-Year Secondary Program. While some institutions offered subject-specific teaching specializations, others had introduced broader or non-teaching tracks, resulting in inconsistencies in curriculum design and graduate competencies.

These variations raised concerns about the preparedness of future secondary teachers, particularly regarding subject-specific Pedagogical Content Knowledge (PCK). They posed challenges to maintaining common professional standards and implementing a standardized teacher licensing framework across the province.

The need for curriculum standardization became even more critical following the Government of Sindh's launch of the Teacher Licensing initiative through STEDA in 2024. While the initial licensing cycle focused on elementary teachers, future phases were envisioned to include secondary subject teachers; however, the absence of a standardized curriculum framework for the B.Ed. The 1.5-Year Secondary Program made it difficult to define common competencies and content expectations for a Secondary Teacher License.

To address these challenges, STEDA initiated a collaborative curriculum development exercise in 2025, engaging universities, teacher educators, subject specialists, and other stakeholders from across Sindh. Through a series of consultations, technical workshops, reviews, and expert deliberations conducted between October 2025 and June 2026, standardized (PCK) Specialization Courses were developed for key secondary school subject areas.

The initiative also builds upon earlier national reforms in teacher education, including curriculum development efforts undertaken through the Pre-Service Teacher Education Program (Pre-STEP). While those reforms provided an important foundation for teacher education in Pakistan, the present exercise responds specifically to the evolving needs of Sindh's teacher education system. It reflects STEDA's commitment to ensuring that future secondary teachers are equipped with the specialized pedagogical competencies required for effective classroom practice.

I am grateful to colleagues at IBA Sukkur University, Ziauddin University, Institute of Business Management, Aga Khan University Institute for Educational Development, Government Elementary College of Education, Hussainabad (operated by Durbeen), and Benazir Bhutto Shaheed University for volunteering their valuable time and expertise for this curriculum development exercise.

We are hopeful that this document will be used by practicing teachers to prepare for the upcoming Secondary License test, as well as by universities to strengthen their offerings of the B.Ed. 1.5-year program in the future.

Regards,

Sayed Rasool Bux Shah
Executive Director, STEDA

Course Outline

Course: Physics Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh Physics Curriculum IX–XII (DCAR, 2024)
Developed by:	Unaeza Alvi, IBA Sukkur University

Course Description

The Physics Course aims to develop student teachers' knowledge and skills in effective pedagogical practices required for teaching at the secondary level. The course focuses on building strong Pedagogical Content Knowledge (PCK), enabling student teachers to transform subject matter into meaningful learning experiences for diverse learners. The conceptual foundation of this course draws on established research on PCK first articulated by (Shulman, 1987), Magnusson et al.,(1999) and Loughran et al., (2004,2006) which emphasizes the integration of content, pedagogy, and knowledge of learners as essential components of effective teaching to its Refined Consensus Model in Science Education that explicates the multiple and complex layers of knowledge that shapes practice (Carlson & Daehler, 2019). Furthermore, the course aims to develop a deeper understanding of the goals and purposes of teaching and learning physics by grounding it in the Nature of Science in general and the history, philosophy, the nature of physics, the key principles and conceptual linkages between core branches of Physis, interrelationship between physical phenomenon and nature, mathematical modelling of physical systems cutting-edge technological applications of modern physics. Building on what physics is, how physic knowledge is constructed, organized, interlinked and applied the student teachers will delve into the Grade 9-12 Physics Curriculum 2024 to undertake curriculum mapping and textbook analysis for informed curriculum implementation. Physics Education Research (PER) highlights that traditional numerical problem-solving alone are insufficient for developing deep conceptual understanding, and that learners often retain fragmented knowledge structures without meaningful connections. Therefore, the course places special emphasis on developing student teachers' understanding of student thinking and pedagogical approaches for addressing students' alternative conceptions and misconceptions, which are widely documented in physics education literature as persistent and deeply rooted in everyday experiences. Student Teachers (STs) will also apply formative and summative assessment strategies to assess students' conceptual understanding and experimental skills rather than algorithmic problem solving and rote memorization. Considering, the context and evidence from physics education research approaches such as conceptual change teaching, inquiry based, problem-based, simulations, virtual labs, interactive engagement, active learning, use of low cost no cost materials vs traditional lecture- based methods are applied to develop deep understanding of fundamental physics concepts, including motion, forces, energy, waves, electricity and magnetism, and elements of modern physics. However, these topics are only suggestive, and teacher-educators may use any other topics from the Physics IX-XII curriculum, that integrate well with a given pedagogy.

Course Outcomes:

1. Examine and broaden own conceptions of goals, purposes, fundamental physics principles, conceptual linkages between different concepts, interrelationship between physical phenomena and nature, mathematical modelling of physical systems and understanding of contemporary and cutting-edge technological applications and modern physics concepts;
2. Analyze the Grade IX-XII Physics Curriculum and identify the domains, standards, benchmarks, students learning outcomes, cross-cutting themes for each topic/sub-topics and develop a vertical progression map portraying its scope, sequence and conceptual linkages.
3. Explore and identify common student misconceptions, fragmented knowledge, algorithmic knowledge and learning difficulties regarding physics concepts;

4. Enhance/enrich pedagogical content knowledge and practical scientific investigation skills in selected physics concepts from Classes IX-XII;
5. Demonstrate PCK informed, pedagogical reasoning by evaluating and selecting innovative contextually relevant instructional approaches for teaching physics concepts;
6. Practice teaching Physics in grades 9-12.

Learning and Teaching Approaches:

The course is founded on the belief that transforming practices necessitate experiential learning, ongoing reflection, and the theoretical analysis of practice.

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, loud thinking, structured debriefs, and reflective dialogue. Teacher- educators will model a range of pedagogical strategies commonly used in middle and high school science classrooms—such as teaching and learning for conceptual change, teaching and learning of disciplinary literacy in physics, teaching using technology integration for visualization and teaching physics through open and guided inquiry, through simulations, physical and virtual lab work, teaching for standards-based curriculum planning and enactment, teaching grounded in understanding of nature of science and the nature of physics— allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester Outline

Week	**Session Title and Brief Description** [Pedagogy and suggested content/ concepts]	**Suggested Readings and Relevant Resources**
1	Introduction to Physis and the Nature of Science This session introduces student- teachers' to physics as a coherent, evolving body of knowledge and as a human endeavor embedded within the nature of science (NOS). Physics is presented not simply as a collection of formulas and laws, but as a discipline grounded in inquiry, experimentation, modeling, and evidence-based reasoning. NOS will be explicitly integrated with physics concepts and modelled to deepen both conceptual understanding and epistemological awareness. This Nature of Science is experienced and discussed through hands-on activities "black box", active reading and role of the history of atomic theory, comparing theories and laws. In addition, the interrelationship between physical phenomena and nature will be explored through hands-on activities,	• McComas, W. F. (2020). Principal elements of nature of science: Informing science teaching while dispelling the myths. In Nature of science in science instruction (pp. 35-65). Springer, Cham • Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of Nature of Science Questionnaire: Toward Valid and Meaningful Assessment of Learners' Conceptions of Nature of Science. Journal of Research in Science Teaching, 39(6), 497-521. • Jiménez-Valverde, G., & Marchán-Carvajal, I. (2026). Baseline views of preservice physics teachers on inquiry-based approaches and their connection with nature of science conceptions. *Education Sciences, 16*(2), 292. J

		https://doi.org/10.3390/educsci16020292 • Kara, S., & Aslan, O. (2026). Innovative evaluation of pre-service science teachers' nature of science-based activity practices and their integration with science subjects. *Science & Education, 35*(1), 83–126. • https://doi.org/10.1007/s11191-025-00665-w • Sonza, S. & Elia, M. (2013). Physics Teachers Attitudes: How Do Theory Affect the Reality of Classroom and Models for Change. Brazil: Federal University of Rio de Janeiro. • Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Physics for Sindh: Grades IX–XII.
2-3	**Curriculum Mapping and Textbook Analysis.** This session engages STs in critically examining the intended and enacted physics curriculum for Grades 9–12 through curriculum mapping and textbook analysis using a review tool/rubric developed from reading and analyzing case studies of teachers. Drawing on the recent national and provincial curriculum documents and research on physics curriculum design, student teachers will explore how physics knowledge, skills, and the Nature of Science are prioritized and sequenced. Using scholarly frameworks for textbook analysis, they will interrogate how textbooks interpret curriculum goals, represent physics concepts, and position learners and teachers. Using concept mapping, the teachers will explore intradisciplinary connections and interlinkages between concepts. The session positions teachers as curriculum designers foregrounding professional judgment in aligning curriculum intentions, textbook representations, and pedagogical decisions central to developing strong PCK in physics.	• Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Physics for Sindh: Grades IX–XII. • Alvi, U at al., (2008). Curriculum, Manual for teachers, teacher educators and textbook writers. Ministry of Education. Government of Pakistan. (Funded by UNESCO). • Grayson, D. J. (2006). Rethinking the content of physics courses. Physics Today, 59(2), 31–36. https://doi.org/10.1063/1.2186279 • Žák, V., & Kolář, P. (2023). Physics curriculum in upper secondary schools: What leading physicists want. Science Education, 107, 677–712. https://doi.org/10.1002/sce.21785

		• Mor, B.,(2025). Reimagining Physics Education for the 21st Century: A Socio-Technical Perspective on Curriculum Reform and Industrial Relevance. Schrödinger Journal of Physics Education 6(3):152-160 DOI:10.37251/sjpe.v6i3.2013 • Said, Z., Mansour, N., Abu-Tineh, A., Cevik, M., & Al-Naimi, I. (2024). Mapping of K–12 science and mathematics curriculum against sustainable development goals and addressing sustainability gap. Cogent Education, 11(1), • Roberts, D. A., & Östman, L. (Eds.). (1998). Problems of meaning in science curriculum. Teachers College Press. • Millar, V., Park, W., & Dillon, J. (Eds.). (2025). The science curriculum: Issues, tensions and future prospects [Special issue]. International Journal of Science Education, 47(15–16)
4	**Effective Physics Teaching and the Role of PCK and TPACK** This session focuses on effective physics teaching through the lenses of Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK). Student teachers examine the historical development of the main models of PCK from Shulman (1987) to the Refined Consensus Model (Carlson & Daehler, 2019).This session also provides an overview of general pedagogical and formative assessment approaches commonly used in teaching physics across Grades 9-12. Student teachers explore a range of instructional strategies grouped under the core pedagogical aims: Teaching for conceptual change; Enhancing Physics Language & Literacy; Teaching using technology; Teaching Physics through inquiry, investigation, simulation lab work, to foster active participation, reduce misconceptions, and enhance pedagogical content knowledge PCK). Student- teachers examine how different formative assessment approaches can support student learning and understanding. The session emphasizes the purposes and limitations of various pedagogies and assessment strategies, encouraging STs to consider how these	• Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1–23. • Hume, A., Cooper, R., & Borowski, A. (Eds.). (2019). Repositioning pedagogical content knowledge in teachers' knowledge for teaching science. Singapore: Springer Singapore. • Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teachers' knowledge. Teachers College Record, 108 (6), 1017–1054. • Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. Australasian Journal of

	approaches influence engagement, conceptual understanding, and evidence of learning in physics classrooms. This overview prepares STs to later examine how pedagogical and assessment choices must be adapted and refined through topic-specific PCK. Through discussion and guided analysis, the session highlights how teachers select representations, and choose instructional and technological tools appropriate to physics topics. Emphasis is placed on using PCK and TPACK as analytic frameworks to support purposeful, context-sensitive physics instruction across Grades 9–12.	Educational Technology, 33(3), 15. • Mukekhe, S. M., Indoshi, F. C., & Rabari, J. A. (2018). Methods to be emphasized in physics teacher education for acquisition of pedagogic skills needed for inclusive instruction. *International Journal of Research and Innovation in Social Science, 2*(9), 9–14 Nagl, M. G., Obadović, D. Ž., & Segedinac, M. (2012). Effective teaching of physics and scientific method. *TEM Journal, 1*(2), 85–89. https://doi.org/10.18421/TEM12-04 . Obadovic • Anderson, L. W., & Krathwohl, D. R. (2001). A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Longman. • Treagust, D. F., & Tsui, C.-Y. (2014). General instructional methods and strategies. In N. G. Lederman & S. K. Abell (Eds.), Handbook of research on science education (Vol. 2, pp. 303–320). Routledge.
5-6	**Learning Approaches and Alternative Framework:** These sessions examine how children learn physics and the alternative frameworks and misconceptions they commonly bring to the classroom. Student teachers analyze a video recording or a reading to identify students' alternative frameworks of any physic topic/subtopics, sources of alternative frameworks and nature of alternative frameworks. Student teachers then develop an interview tool, test and activities to elicit students' ideas/ alternative framework in physics and use these to elicit students' ideas in a real context. The session highlights the implications of misconceptions for instructional design, assessment, and the development of PCK in physics teaching. **Suggested Content Integration from Grades 9-12:** Scalar and Vector Quantities, Dimension, Kinetic Energy, Potential Energy, Law of Conservation of	• Resbiantoro, G., Setiani, R., & Dwikoranto. (2022). A review of misconception in physics: The diagnosis, causes, and remediation. Journal of Turkish Science Education, 19(2), 403–427. https://doi.org/10.36681/tused.2022.128 • Listianingrum, S. A., Kuswanto, H., Mundilarto, M., & Dwandaru, W. S. B. (2024). A review of various misconceptions in physics learning. AIP Conference Proceedings, 2622, 020028. https://doi.org/10.1063/5.0133832 • Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (2014). Making sense of secondary science:

	Energy, Force, Mechanics, Simple Harmonic Motion, Simple Pendulum, Momentum, Law of Conservation of Linear Momentum, Magnetism, Electric field and Potential, Current, Resistance, Ohm's Law, Optics, Spherical Mirrors, Mirror Equation, Lenses, Image formation in lenses, Defects of Eye, Digital Electronic, Earth and Space Science	Research into children's ideas (2nd ed.). Routledge. • White, R., & Gunstone, R. (2014). Probing understanding. Routledge. (Original work published 1992). • Appova, A., & Berezovski, T. (2013). Commonly identified students' misconceptions about vectors and vector operations. In *Proceedings of the 16th Annual Conference on Research in Undergraduate Mathematics Education (RUME XVI)* (pp. 8–17). Research in Undergraduate Mathematics Education Special Interest Group of the Mathematical Association of America • Maulidina, W. N., Samsudin, A., & Kaniawati, I. (2019). Overcoming students' misconceptions about simple harmonic oscillation through interactive conceptual instruction (ICI) with computer simulation. *Journal of Physics: Conference Series, 1280*(5), Article 052007. https://doi.org/10.1088/1742-6596/1280/5/052007
7,8-9	**Teaching for Understanding and Conceptual Change:** This session focuses on teaching for understanding and conceptual change in physics through research-informed instructional strategies. Student teachers study Conceptual Change Model (Posner 1982) by experiencing dissonance through Cognitive Conflict Strategies such as Discrepant Events and Predict-Observe-Explain (POE). Student-teachers also experience hands-on-minds-on activities, metacognitive scaffolding, structured probing, video analysis, inquiry, investigation, analogies to deepen and challenge students existing ideas and support deeper conceptual understanding. **Suggested Content Integration from Grades 9-12 for:** • **Hands-on-Minds-on activities** for concepts like friction (Grade IX)- sliding objects on various surfaces to measure and compare the force of limiting friction	• Krajcik, J., & Shin, N. (2023). Student conceptions, conceptual change, and learning progressions. In G. L. Norman,L.Z.Dana, &S.L.Judith (Eds.), Handbook of research on science education (1 ed.). Routledge. • Seimears, C. M., Graves, E., Schroyer, M. G., & Staver, J. R. (2012). How constructivist-based teaching influences students' learning science. The Educational Forum, 76(2), 265–271 • Anggoro, S., Widodo, A., Suhandi, A., & Treagust, D. F. (2019). Using a discrepant event to facilitate preservice elementary teachers' conceptual change about force and motion. Eurasia journal of mathematics,

	• **Video Analysis** of motion videos to identify types of motion and calculations of speed, displacement, distance, (Grade IX), from the data draw and analyze motion graphs and derive equation of motion (Grade XI) • **POE (predict, observe, explain)** for concepts like thermal expansion of liquid (Grade X)- observing inflation and deflation of a balloon tied to a bottle placed in hot and cold water • **Investigations** for concepts like the thermal conductivity of different materials (Grade X-Transfer of Heat)- why does metal feel colder at room temperature, as compared to plastic or wood? • **Analogies** like tug-of-war rope game to explain the different types of forces on objects, such as Friction, Tension, Weight/ balanced-unbalanced forces (Grade X)	science and technology education, 15(8). • Toksoy, S. E., & Bulut, E. (2024). Effect of simulation-supported prediction–observation–explanation activities on students' conception of learning physics related to solid and liquid pressure. *Science Education International*. Advance online publication. • W N Maulidina et al (2019) Overcoming students' misconceptions about simple harmonic oscillation through interactive conceptual instruction (ICI) with computer simulation.J. Phys.: Conf. Ser. 1280 052007, • Anggoro, S., Widodo, A., Suhandi, A., & Treagust, D. F. (2019). Using a discrepant event to facilitate preservice elementary teachers' conceptual change about force and motion. Eurasia journal of mathematics, science and technology education, 15(8). • Pacaci, C., Ustun, U., & Ozdemir, O. F. (2024). Effectiveness of conceptual change strategies in science education: A meta-analysis. Journal of Research in Science Teaching, 61(6), 1263–1325. https://doi.org/10.1002/tea.2188 • Østergaard, L. D. (2016). Inquiry-based learning approach in physical education: Stimulating and engaging students in physical and cognitive learning. *Journal of Physical Education, Recreation & Dance, 87*(2), 7–14. https://doi.org/10.1080/07303084.2015.1119076 • Tacla, R., & Ofrin, D. D. (2023). Inquiry-based learning strategy as correlates of independent learning skills and performance in physical education. *Industry and Academic Research Review,*

		4(1), 316–325. https://doi.org/10.53378/iarr.353629
10	**Enhancing Physics Language and Literary** This session explores disciplinary literacy in physics, emphasizing physics as a discipline with its own language, textual structures, and ways of constructing and justifying knowledge. Student teachers examine why students often struggle to read and write physics texts and learn strategies to support comprehension by foregrounding how physicists use language, representations, and evidence to explain the matter and support scientific claims. Teacher Educators first help student teachers experience Directed Activities Related to Text (DARTS) (both Reconstruction DARTS & Analysis DARTS) and Writing Frames and then develop the same for given SLOs from the Physics curriculum. **Suggested Content Integration from Grades 9-12:** Waves and Properties of Waves, Magnetism, Electric field and potential, Digital Electronic, Earth and Space Science, Medical and Modern Physics	• Uyanık, S., Yıldız, K., & Benzer, E. (2026). Investigation of pre-service science teachers' scientific text activities as a way of reading comprehension in science education. International Journal of Science Education, 48(6), 864–888. https://doi.org/10.1080/09500693.2025.2550036 • Wellington, J., & Osborne, J. (2001). Language and literacy in science education. McGraw-Hill Education • Rachmawati, D., Amirrachan, A. R., & Rachmawati, D. (2020). The use of small group discussion with directed activities related to texts (DARTs) technique in reading comprehension. Annual International Seminar on English Language Teaching, 16, 35–50.
11-12	**Practical Lab I** This session focuses on the role of laboratory work in physics teaching as a site for inquiry, evidence generation, and conceptual understanding. Student teachers examine different types of physics labs (from confirmation inquiry to open inquiry), Identification of Physics Apparatus, consider issues of lab safety, equipment safety and resource management, and analyze how practical work can be designed to support learning goals/experimental skills rather than procedural completion. Emphasis is placed on aligning laboratory activities with content, pedagogy, and assessment and teacher's practical work pedagogical content knowledge. **Suggested Content Integration from Grades 9-10:** • To measure the area of cross section of a solid cylinder by measuring its diameter with vernier calliper. • To measure the thickness of a metal strip or a wire using micro meter screw gauge. • to verify the principle of moments using a meter rod balanced on a wedge. • Refraction through glass slab.(to verify snell's law)	• New Jersey (n.d), Introductory physics Laboratory: Free Online Resources. https://research.njit.edu/introphysics/physics-laboratory-safety • Center for Experimental Physics Education LUMS. (n.d), Physic Lab Safety Handout: Free Online Resources. https://physlab.org/wp-content/uploads/2016/03/Safetyhandout.pdf • Roslan, A. N., et al. (2023). *Challenges in implementing inquiry-based learning in physics classroom*. AIP Conference Proceedings. • Rizki, I. A., et al. (2023). *Effect of physics inquiry learning with low-cost experiment tools*. Physics Education Research Journal. • Testa, I., Michelini, M., & Esposito, S. (Eds.). (2025). *Connecting Physics Education Research and Practice*.

	• To trace the path of a ray of light through glass prism and measure the angle of deviation. • Find the focal length of a convex lens by parallax method.	Springer (Challenges in Physics Education Series). • Verawati, N. N. S. P., & Nisrina, N. (2025). Enhancing scientific creativity of prospective physics teachers through guided inquiry-based electricity and magnetism materials with blended learning. *Frontiers in Education*. Advance online publication. https://doi.org/10.3389/feduc.2026.1761262
13	**Lesson Planning for Physics Teaching** This session focuses on lesson planning for effective physics teaching in school contexts. Student-teachers plan lessons using different Lesson Templates. Such as 4A Lesson Plan for Constructivist Teaching, Inquiry Based Teaching Template, Conceptual Change Based Teaching Template for POE, Guided and Open Inquiry, while integrating various pedagogies introduced in this course. Student teachers examine case studies of a planned and un-planned teacher through the lens of three questions when planning for teaching, namely: (i) what is it that you want to teach your students? (ii) how do you intend to teach/facilitate learning that you wish, desire or have decided to teach? (iii) how will the learning that has taken place be measured or how do you plan to establish the attainment of the intended learning? Student teachers examine the purposes and structure of lesson planning and explore both inductive (e.g., 5E) and deductive lesson planning frameworks. Emphasis is placed on PCK as the guiding framework while aligning learning outcome, instructional strategies, resources, and assessment with students' needs and content demands to support coherent, purposeful physics lessons.	• Alvi, U. et al., (2008). Curriculum, Manual for teachers, teacher educators and textbook writers. Ministry of Education. Government of Pakistan. (Funded by UNESCO). • Alvi, U. (2026). The Toolkit of Lesson Plans for Teaching of General Science Grade IV-VIII and Specialized Sciences from Grades IX-XII. (59) https://independent.academia.edu/AlviUnaeza
14	**ICT Integration/ Techno- Pedagogies** This session examines digital pedagogies that support Education 5.0, human centric and meaningful learning in physics. Student teachers explore how technology can enable specific physics teaching approaches, such as simulation, virtual labs, data analysis, and visualization, that are difficult to achieve through traditional methods alone. The session emphasizes	• Jiang, L., Sun, Y., Zhang, X., Liu, F., Zhuang, W., Yang, Y., & Song, J. (2025). How is the impact of ICT-assisted experiments on students physics learning: A meta-analysis of K-12 research. Journal of Science Education and Technology.

	pedagogical purpose over tools, highlighting how digital resources can be strategically integrated to enhance conceptual understanding, metacognition, creativity, inquiry, sustainability, scientific reasoning and emotional intelligence. **Suggested Content Integration from Grades 9-12:** • Quizlet for Vocabulary Introduction and Development-Earth and Space Science, Modern Physics. Thermodynamics. • Digital Games for learning difficult Physics topics/concepts. • Simulation for Physics Phenomenon (such as electric fields, magnetism, wave motion, atomic structure, particle movement in liquids and solids on cooling and heating, light and radiation) and Solar System, Quantum Physics, Modern Physics that cannot be easily observed in a traditional class room. • Virtual practical labs for Physical Processes/Phenomenon, thermodynamics, Waves, Motion, Resonance, Electromagnetism, Dilation, Refraction, Elasticity, Electronics, Quantum/nuclear physics. • Software for Electric Circuits and their connections. • Digital games for concepts like Newton's laws of motion/ Inertia (Grade IX)- Forces in Action - Motion & Resistance - Science Games & Activities for Kids	• Dayo ,N., Alvi U., & Mujtaba, M(2020) IEEE, Mechanics of Digital Mathematics Games for Learning of Problem-Solving: An Extensive Literature Review Mechanics. • Cavadas, B., & Aboim, S. (2020). Using PhET-interactive simulation plate tectonics on initial teacher education. Geoscience Communication Discussions, 2020, 1-20. • Banda, H. J., & Nzabahimana, J. (2023). The impact of physics education technology (PhET) interactive simulation-based learning on motivation and academic achievement among Malawian physics students. Journal of Science Education and Technology, 32(1), 127-141. • Abdullah, S., & Shariff, A. (2008). The effects of inquiry-based computer simulation with cooperative learning on scientific thinking and conceptual understanding of gas laws. Eurasia Journal of Mathematics, Science and Technology Education, 4(4), 387-398. • Su, C.-Y. (2026). Integrating metacognitive scaffolding into a physics simulation for elementary school students' conceptual understanding of force and motion. *Journal of Science Education and Technology*. Advance online publication. https://doi.org/10.1007/s10956-025-10288-z • Odden, T. O. B., Marin, A., & Caballero, M. D. (2020). *Thematic analysis of computational modeling in physics education*. Physical Review Physics Education Research. • Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012). *The learning effects of computer simulations in science*

		education. Computers & Education, 58(1), 136–153. • Docktor, J. L., & Mestre, J. P. (2014). *Synthesis of discipline-based education research in physics*. Physical Review Special Topics – Physics Education Research, 10(2).
15	**Microteaching, Feedback and Debriefing** This session engages student teachers in microteaching as a structured opportunity to enact PCK through physics lessons and reflect on practice. Student teachers teach short segments, receive focused peer and course facilitator feedback, and engage in guided debriefing. The session emphasizes reflective analysis of pedagogical decisions, use of representations, and responsiveness to learners as key components of developing PCK.	Albrechtsen, T.R.S., Kiær, K. (2025). A Pedagogy of Enactment: Creative Rehearsals and Feedback Literacy in Science Teacher Education. In: Svabo, C., Shanks, M., Zhou, C., Carleton, T. (eds) Creative Pragmatics for Active Learning in STEM Education. Contributions from Science Education Research, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-78720-1_11
16	**Reflecting, Reviewing, Synthesizing, Connecting and Creating** Reflection on week 1-15 and key takeaways for teaching Physics.	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination (90 minutes) presenting student-teachers with subject-specific scenarios requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exploring Student Conceptions — Elicitation, Analysis, and Remediation (30%)

Student-teachers design a theory-informed alternative framework/ misconceptions elicitation tool for a selected Grades 9–12 curriculum topic, then conduct interviews with 4–6 students to surface their existing conceptions. They analyse the data to identify patterns in student thinking and present findings and remediation strategies, supported by relevant literature, in the form of an oral presentation or a written report.

Course Outline

Course: Physics Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh Physics Curriculum IX–XII (DCAR, 2024)
Developed by:	Unaeza Alvi, IBA Sukkur University

Course Description

This course aims to strengthen student -teachers' Pedagogical Content Knowledge (PCK), by examining how physics content and pedagogical practices interact within secondary Physics classrooms in Sindh, Pakistan. The course begins by revisiting the purposes and goals of teaching Physics, anchored in nature of science (NOS) in Physics (history, philosophy, the interconnections, mathematical modelling and the applications of all domains of physics in technological advancements). This foundational orientation frames how physics knowledge evolves, is constructed, and validated by the physics community of practice, and its applications in technology and societal developments. Building on this, the course engages student teachers (STs) in a deep exploration of Cross Cutting Concepts (CCCs) and Science, Engineering Practices (SEPS). The purpose of the CCCs is to unify the domains of science in terms of thinking tools that are transferable across them. The (SEPs) aim to break away from a rigid and prescriptive "scientific method" and reflect a more authentic way of doing science which involves different combinations of practices which tend to be iterative as opposed to linear. The SEPs are further enhanced by applying science, mathematics and technology tools, to solve complex problems through the design thinking approach of engineering, explored through aesthetic experience and expressed through artistic creation (STEAM- Design Thinking). The success of including the CCCs and SEPs in the curriculum rests on their integration across all disciplinary content throughout the Sindh Curriculum and in achieving the overarching interdisciplinary STEAM. Each session of the course models and analyses a range of pedagogies for teaching, building on pedagogies introduced in Physics 1. These pedagogies are modelled through selected examples across a range of content areas of physics that align with the pedagogy and demonstrate the integration of a variety of CCCs and SEPs. Content areas that have been included are: Mechanics, Optics, Modern Physics, Relativity, Quantum Physics, Thermodynamics, Energy, Electrostatic, Electricity, Magnetism, Waves. However, these topics are suggestive, and teacher educators may use other topics from the Physics 9-12 curriculum that integrate well with a given pedagogy. Finally, student teachers (STs) will also explore the purpose and multiple forms of summative assessment strategies to evaluate students' conceptual understanding, procedural knowledge and thinking skills with attention to when and how specific assessment strategies may be used effectively.

Course Outcomes

1. Examine the purpose, goals and nature of science (history, philosophy, the applications of all domains of physics in technology) in Physics and demonstrate how these foundations inform the teaching of Grades 9-12 physics concepts.
2. Integrate Crosscutting Concepts (CCCs) across physics pedagogical planning and teaching to help learners develop a coherent and scientifically based view of the world.
3. Integrate the Science and Engineering Practices (SEPs) across disciplinary content areas to help learners investigate physics phenomena and design problems' solutions in authentic ways that reflect how scientists and engineers' work
4. Design valid and reliable summative assessments tests and alternative assessments to assess students' conceptual, procedural knowledge and thinking skills of core Physics Concepts.
5. Demonstrate PCK-informed pedagogical reasoning by selecting evidence-based and innovative pedagogies, for planning and teaching complex Physics concepts.
6. Practice theory-informed teaching of Physics in grades 9-12, and reflect on their practice.

Learning and Teaching Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, loud thinking, guided practice, structured debriefs, and metacognitive reflective dialogue. Teacher educators will model a range of pedagogies that enhance learning in middle and high school science classrooms—such as project-based learning, problem-based learning, design thinking, phenomena-based learning, integration of socio-scientific issues in learning science, STEM/ STEAM, integration with technology, Teaching Physics through lab work and out-of-school science contexts — allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's pedagogical decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester Outline

Week	Session Title and Brief Description [Pedagogy and suggested content/concepts]	Suggested Readings and Relevant Resources
1	**Nature of Physics: a tentative, evolving, evidence based-human endeavor** Through activities based on selected readings, student- teachers discuss the essentials of science that should be taught in the physics classroom. They revisit key ideas related to the nature of science and scientific literacy by exploring the development of scientific knowledge through the lens of history. In doing so, they place science in context, making connections within and between physics, other disciplines and within broader societal contexts, its application in everyday life, application of modern physics in technological advancements, medical technology and the role of values and ethics. In exploring how scientific knowledge evolves, student-teachers appreciate the development, uses and limitations of models in science, and appreciate that models are the products of intellectual processes that need to be acquired and appreciated, rather than just tools for teaching and learning. Furthermore, student teachers will explore misconceptions about what is meant by “theory” and “law” in science and explain that scientific paradigm as a theoretical model. **Suggested Content Integration from Grades 9-12:** • Introduction to Physics, Classical, Modern physics and its technological applications. • Interdisciplinary field of Physics • Mathematical Modelling of Physics-with reference to Electricity, Laws of Motion.	• S. Cuthbert & A. Standish (Eds.), What Should Schools Teach?: Disciplines, subjects and the pursuit of truth (2nd ed.). UCL Press. https://doi.org/10.2307/j.ctv14t475s.18 • Teixeira, Elder & Greca, Ileana & Junior, Olival. (2012). The History and Philosophy of Science in Physics Teaching: A Research Synthesis of Didactic Interventions. Science & Education - SCI EDUCATION. 21. 1-26. 10.1007/s11191-009-9217-3. • Seroglou, F., Koumaras, P. (2001). The Contribution of the History of Physics in Physics Education: A Review. In: Bevilacqua, F., Giannetto, E., Matthews, M.R. (eds) Science Education and Culture. Springer, Dordrecht. https://doi.org/10.1007/978-94-010-0730-6_21 • Corrigan, D., Buntting, C., Fitzgerald, A., & Jones, A. (Eds.). (2020). Values in science education: The shifting sands. Springer. https://doi.org/10.1007/978-3-030-26860-3.

	• Explore the difference between Wave Theory and Laws of Reflection. • Creating Models of Atomic Structure and Everyday Phenomenon in Physics Tracking a Falling object, Throwing a Ball Upward, Hitting a ball with a Bat, Riding an Elevator, Lightening, Arora, Rainbow, The Twin Paradox, Electrical Impulse in Nerve Cell, Bird Navigation, Why is the Sky Blue, Walking and Floating on Water, Fuel Cell, Hydrogen Economy, A moving car horn, Noise, Music, Fusion Reaction in the Sun (Griffith. W.T., 2026)	• Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Physics for Sindh: Grades IX–XII. • Robertson, B. (2009). Q: How does a scientific theory become a scientific law?. Science and Children, 46(5), 5 • Sterling, D. R. (2009). From Aristotle to today: Making the history and nature of science relevant. Science Scope, 32(5), 30–35 • Griffith. W.T., (2026) 8th Edition "The Physics of Everyday Phenomenon a Conceptual Introduction to Physics" McGraw -Hill Education-New York
2	**Argumentation in Science and Enculturation**: Building on scientific literacy in Physics Course I, student- teachers are introduced to Argumentation as a critical historical component of scientific literacy, that helps students construct, justify, and critique scientific claims using evidence/data and warrant and become encultured into the practices of science. Student-teachers explore core components of scientific argumentation (claim, data, and warrant), backing and rebuttals and processes that allows students to put forward an argument, examine how these discourse practices shapes the social setting and classroom culture and leads to the development of scientific thinking, thus promoting an open scientific discourse culture and developing a scientifically literate society (Chang, A. G., & Alvi, U. (2012). The teacher-educator models classroom strategies such as structured debates, competing theory- using claim-data-warrant (CDW) frameworks, counter arguments, backing/peer critique and rebuttals (CDWBR) to support engagement and deeper understanding of how students can be enculturated in scientific thinking and discourse through argumentation. They also use argumentation to address multidisciplinary, ill defined, value laden socio-scientific issues and in making connections to philosophical complexities inherent in the nature of physics knowledge and practice, such as, *What*	• Kim. H., & Song, J. (2006). The features of peer argumentation in middle school students' scientific inquiry. Research in Science Education, 36, 211-233. • Nolan, E., & Zeidler, D. L. (2014). Cultivating critical reflection through socio-scientific perspectives. Science Education, 98(3), 422–450. https://doi.org/10.1002/sce.21104 • Namdar, B., & Karahan, E. (Eds.). (2024). Socio-scientific issues focused teacher education: Place-based practices from Türkiye. Springer. • Chang, A. G., & Alvi, U. (2012). Addressing socio-scientific issues (SSIs) through argumentation. International Journal of Health and Education, 1(2), 30–48. • Högström, P., Gericke, N., Wallin, J., & Bergman, E. (2025). Teaching

	is the nature of light- is it particle or wave? Can matter exist as wave **Suggested Content Integration from Grades 9-12:** • Radio isotopes (Grades IX-X)- Is the medical use of radioactive tracers ethically justifiable given the radiation exposure risks to patients? • Renewable and non-renewable energy sources (Grades IX-X)- Should Pakistan invest in nuclear energy to address its electricity crisis, given the environmental and safety risks? • Special Theory of Relativity (Grades XI-XII)- Should access to GPS navigation technology be a universal right, or is its privatization and military control ethically acceptable?	socioscientific issues: A systematic review. Science & Education, 34, 3079–3122. https://doi.org/10.1007/s11191-024-00542-y • Christopher, M., & Pinias, C. (2025). Exploring the balance between theory and practice of transformative science, technology, engineering, arts, and mathematics teacher education: A systematic literature review. Discover Education, 4(1), 386. https://doi.org/10.1007/s44217-025-00695-0 • Tuero-O'Donnell, J. D., Castrejón, G., & Olivo, P. G. (2026). Impact of a philosophical didactic approach on the development of critical thinking: Qualitative evidence from the teaching of quantum physics. Journal of New Approaches in Educational Research, 15, Article 10. https://doi.org/10.1007/s44322-026-00059-y • Han, Z., & Wei, B. (2025). When nature of science meets quantum physics: Insights from NOS representation in Chinese physics textbooks. *Science & Education, 34*, 3269–3289. https://doi.org/10.1007/s11191-024-00550-y
3-4	**Cross-Cutting Concepts (CCCs) and Science and Engineering Practices (SEPs):** Student-teachers explore the CCCs, including key aspects of scientific knowledge and SEPs that have been adopted into the Sindh Curriculum (2024) from the Next Generation Science Standards through active reading and discussions (Sindh Curriculum for Physics (IX-XII), 2024; National Research Council, 2013; NGSS Lead States, 2013). Student-teachers describe CCCs as seven specific aspects of scientific knowledge or "thinking tools" that are applicable across science domains and support scientific reasoning, interpretation, critical thinking and science literacy. (NGSS Lead States, 2013; Nordine & Lee, 2023; Talanquer,	• Bybee, R. W. (2011). Scientific and engineering practices in K-12 classrooms. Science Teacher, 78(9), 34-40. • Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Physics for Sindh: Grades IX–XII. • Fensham, P. J. (2022). The future curriculum for school science: What can be learnt

	2019) using domain specific examples. They recognize that the success of including CCCs in the science curriculum depends on their explicit inclusion alongside the disciplinary content. Through readings (Fensham, P. J. (2022) and hands-on activities, student-teachers describe the 8 SEPs and how they help to make "how science is done" in more authentic ways (Bybee 2011, Murphy, 2023). Working with examples of integration, student -teachers understand that the success of having SEPs in the curriculum is dependent on their explicit inclusion alongside disciplinary content. This allows student teachers to comprehend that doing physics is a process of becoming part of the community of practice. **Suggested Content Integration from Grades 9-12:** • Transfer of Heat: Application of Conduction, Convection, Radiation in Thermal Insulation (Grade IX-X)- Energy Green Homes (WebQuest, n.d.) SEPs: Asking testable questions, Developing and Using Models, Collecting data, Calculating and Analysing data (graphical), Constructing explanations, Engaging in argument from evidence CCCs – Cause and Effect. Patterns (in data), Systems and Systems Models (Global Warming, Convection Currents, Air Pressure, Temperature), Stability and Change • Climate Physics: Weather (Grade X and XII)- Weather Station (Life Physics, n.d.) SEPs: Planning and carrying out investigations, Analysing and interpreting data, Constructing explanations CCCs: Cause and Effect, Structure and Function, Models, Stability and Change	from the past? Research in Science Education, 52(Suppl 1), S81–S102. https://doi.org/10.1007/s11165-022-10090-6 • Murphy, B. (2023). Science, Science, Everywhere. Connected Science Learning, 5(2), 12318626. • National Research Council. (2013). Appendix G: Crosscutting concepts. In Next Generation Science Standards: For states, by states. The National Academies Press. https://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL.edited.pdf • NGSS Lead States. (2013). Appendix F: Science and engineering practices in the Next Generation Science Standards. Next Generation Science Standards. https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf • Nordine, J., & Lee, O. (2023). On the nature and utility of crosscutting concepts. Education Sciences, 13(7), 640. https://doi.org/10.3390/educsci13070640 • Talanquer, V. (2019). Crosscutting concepts: Productive ways of thinking in science. *The Science Teacher*, 86(6), 12–17. • Webquest (n.d) Energy and Heat Loss- Building an Energy Efficient House. Simple Weather Station https://www.createwebquest.com/webquest/energy-and-heat-loss-building-energy-efficient-house

		• Life Physics (n.d): Simple Weather Station. https://livephysics.com/labs/weather-station-lab/
5-6	**Unit Planning** In this session, student teachers explore "Understanding by Design" which is an approach to unit planning that focuses on deep understanding and meaningful, transferable learning rather than coverage of isolated content. They learn how to identify and develop "Big (or enduring) Understandings" as the long-term learning goals of a unit. Student teachers align the big understanding with a Domain/ Domains and Cross-Cutting themes, standards, benchmarks, topics, sub-topics and student learning outcomes. They also explore and craft companion "essential questions" that promote inquiry and lead to these understandings. By the end of the session, student teachers will apply these principles by then developing 8-10 lesson plans based on the pedagogies and assessments experienced in Physics Course I and II and corresponding designing their own Big Understandings and essential questions for a selected topic. **Suggested Content Integration from Grades 9-12:** • Conversion of Energy (Grades IX-X) Essential Question: If energy can never be destroyed, why do we keep running out of it?Big Understanding: Energy cannot be created or destroyed it is only transformed from one form to another — yet every transformation comes at a cost, as useful energy inevitably degrades into less usable forms, making efficiency and sustainability persistent challenges in the natural world and in human technological systems. • General Wave Properties (Grades IX-X) Essential Question: "If nothing is actually moving from place to place, how does a wave carry anything at all? What are the different ways of wave propagation and how is it related to types of waves? Big Understanding: Waves do not transport matter — they transport energy and information through disturbances in a medium or field, and it is this invisible transfer that underlies how we see, hear, communicate, and make sense of the universe around us. .	• Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Physics for Sindh: Grades IX–XII. • McTighe, J., & Wiggins, G. (2012). Understanding by design framework. Alexandria, VA: Association for Supervision and Curriculum Development. • Wiggins, G., & McTighe, J. (2011). The understanding by design guide to creating high-quality units. ASCD. • Wiggins, G., & McTighe, J. (n.d.). Essential questions: Opening doors to student understanding. Center for Learning. https://www.centerforlearning.org/wp-content/uploads/2015/04/ACD109EX.pdf

7-8	**Complex Pedagogies I: Problem Based Learning and Phenomena-Based Learning:** Student teachers read and discuss essential elements of phenomena-based learning (PhBL) and problem-based learning (PBL) and compare and contrast them with each other (Chin & Chia, 2008; Saberi and Nouri, 2024). They identify the multilayered nature of PhBL and PBL that involve extended tasks, multiple steps, and integration of concepts, skills and real-world contexts. Student-teachers explore other pedagogies that play a contributing role here such as inquiry-based learning (Anderson, R. D., 2002), investigation, argumentation etc. Through the selected readings, student-teachers explore the essentials of developing effective PBL lessons, such as creating an effective problem scenario or case study introducing the problem to students (Hasanah et al., 2023). Student teachers further define what a "phenomenon" is in science and how to formulate one that anchors effective teaching and learning in PhBL. They explore how PhBL holds the potential to engage students in learning about the natural world as scientists do, integrating all three dimensions of disciplinary content, SEPs and CCCs (Amplify Science, 2018; Saberi & Nouri, 2024). **Suggested Content Integration from Grades 9-12** (teacher educators should also integrate CCCs and SEPs within chosen content): PBL: • Acoustics (Grade XI-XII)- Solving the problem of Noise Pollution and Acoustics of an auditorium or large hall. • Capacitors (Grade XI-XII) - Problems with Electrical Instruments in which students analyse factors affecting the capacitance of parallel plate capacitors and solve the problem/fault with the charging and discharging of capacitors PhBL: • Geometrical Optics (Grades IX-X)- A swimming pool appears shallower than it actually is • Electromagnetic Spectrum (Grades IX-X)- A microwave oven heats food but not the plate. Acoustics (Grades XI-XII)- Noise-cancelling headphones eliminate background sound	• Amplify Science. (2018). What's so phenomenal about phenomena? An introduction to phenomenon-based learning. The Lawrence Hall of Science, University of California, Berkeley. • Chin, C., & Chia, L. G. (2008). Problem-based learning tools. The Science Teacher, 75(8), 44 • Hasanah, D., Prihatni, Y., Lisdayanti, L., & Purwanto, J. (2023). How did problem-based learning with the TPACK approach (PBL-TPACK) enhance physics learning outcomes? Jurnal Riset dan Kajian Pendidikan Fisika, 10(2), 36–45. https://doi.org/10.12928/jrkpf.v10i2.54 • Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. Journal of Science Teacher Education, 13(1), 1–12. https://doi.org/10.1023/A:1015174221746. • Dayo ,N., Alvi U., & Mujtaba, M (2020) IEEE, Mechanics of Digital Mathematics Games for Learning of Problem-Solving: An Extensive Literature Review Mechanics. • Saberi, M., & Nouri, N. (2024). Promoting understanding of three dimensions of science learning plus nature of science using phenomenon-based learning. *Innovations in Science Teacher Education.*
9-10	**Complex Pedagogical Planning II: Project Based Learning (PjBL) and STEAM**	• Colley, K. (2008). Project-Based Science Instruction: A

	Student teachers experience and explore STEM/ STEAM and PjBL both of which are multi-layered, based in real-world contexts. Following on from their learnings in the previous sessions, student teachers reflect on and discuss where PjBL, STEM/STEAM, PBL and PhBL overlap and how they differ. PjBL: Through readings, student teachers explore how PjBL learning in physics centers on an extended, real-world project/task to investigate and respond to a complex question, challenge, or problem that culminates in a tangible product (still/working models, research-based designs, research reports, poster presentations), that requires 'application" of learning in science (Colley, 2008). STEAM/ STEM: At the outset, student teachers connect with their own ideas about STEAM and then engage in experiencing STEAM. Through readings, discussion and working on a problem, they apply and clarify their ideas on: • What is technology? (Childers & Hite, 2022) • What is a prototype? • The role of the engineering challenge in STEM/STEAM. • The nature of engineering challenges as open-ended challenges that lead to multiple solutions. • Integration of "engineering" into physics through the Engineering Design Process (EDP). • How and where is mathematics integrated in STEAM? • How and where is art integrated in STEAM? (Bequette & Bequette, 2012) • Communication and Collaboration • Connections within science disciplinary content and with other disciplines As STEAM evolves from STEM, it involves blurring disciplinary boundaries to frame and solve problems—it involves thinking creatively and working on projects that aim at real-world inquiry integrating technology and design (Connor, Karmokar & Whittington, 2015). **Suggested Content Integration from Grades 9-12** (teacher educators should also integrate CCCs and SEPs within chosen content)**:** • Renewable and nonrenewable energy sources (Grades IX-X)- Design a Solar	PRIMER. Science Teacher, 75(8). • Bybee, R. W. (2013). The case for STEM education: Challenges and opportunities. National Science Teachers Association Press. • Honey, M., Pearson, G., & Schweingruber, H. (Eds.). (2014). STEM integration in K–12 education: Status, prospects, and an agenda for research. National Academies Press. • Moore, T. J., Stohlmann, M. S., Wang, H.-H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K–12 STEM education. In Engineering in pre-college settings: Synthesizing research, policy, and practices. Purdue University Press. • Childers, G., & Hite, R. (2022). The role of emerging technologies in science teacher preparation. In J. A. Luft & M. G. Jones (Eds.), *Handbook of research on science teacher education* (pp. 218–230). Routledge. • Ojeogwu, J., & Mumba, F. (2025). Preparing pre-service teachers in engineering design integrated science teaching: A systematic review. Journal of Science Education and Technology. https://doi.org/10.1007/s10956-025-10247-8 • Buchanan, R. (2001). Design research and the new learning. Design Issues, 17(4), 3–23. https://doi.org/10.1162/07479360152681056 • Pahl, G., & Beitz, W. (1996). *Engineering design: A systematic approach* (K. Wallace, L. Blessing, & F. Bauert, Trans. & Eds.). Springer-Verlag.

	powered /Energy Efficient and SMART house. • Oscillations (Grades XI-XII)- Designing Earthquake/ Shock Resistant Structures.	Lammi, M., & Becker, K. (2013). *Engineering design thinking and systems thinking in high school students engaging in engineering design. Journal of Technology Education, 24*(2), 55–73. • Kroes, P. (2012). *Technical artefacts: Creations of mind and matter: A philosophy of engineering design.* Springer Science+Business Media B.V. • Brown, T. (2008). Design Thinking. Harvard Business Review, 86(6), 84–92. • Pleasants, J., & Olson, J. K. (2019). What is engineering? Elaborating the nature of engineering for K–12 education. Science Education, 103(1), 145–166. • Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. Art education, 65(2), 40-47. https://doi.org/10.1080/00043125.2012.11519167 • Connor, A. M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for enhancing engineering and technology education. International Journal of Engineering Pedagogy, 5(2), 37–47.
11-12	**Assessments Approaches for Assessing Physics Learning:** Building on Formative assessment (assessment for learning) in Physics Course 1, this session specifically examines summative assessments (assessment of learning) and helps student-teachers see how they serve different but interconnected purposes. Through analysis of different summative assessment tools, techniques, methods and readings, student-teachers explore the purposes, types and limitations of assessment approaches commonly used in assessing student learning in Physics across Grades 9-12, and consider how these approaches influence conceptual understanding, scientific thinking skills, scientific literacy, SEPs, CCCS and higher order thinking in physics classrooms referring to Fensham, P. J. (2022).	• Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives. Longman. • Fives, H., & DiDonato-Barnes, N. (2013). Classroom test construction: The power of a table of specifications. Practical Assessment, Research & Evaluation, 18(3), 1–7.

	STs also explore how to assess CCCs and SEPs which are integrated with the disciplinary content. This overview prepares STs to examine how assessment choices must be adapted and refined through topic-specific PCK. The student teachers apply and design multiple forms of summative assessments for assessing student learning in the context of physics: • TOS Development and Expert Validation (Fives, H., & DiDonato-Barnes and N. (2013); Han, C., & Xiang, J. (2025)). • SLO Based and Blooms Cognitive Taxonomy Based SRQs and CRQs item Development, Review and Analysis • Designing of Marking Keys, rubrics, test marking, tabulation, analysis, reporting and SLO based feedback • Rubrics • Observation-assessments and tools • e-assessments and digital tools • Performance and Authentic Assessment Tasks and Tools **Suggested Content Integration from Grades 9-12:** Any topic may be chosen to develop a summative assessment	https://doi.org/10.7275/cztt-7109 • Haladyna, T. M., Downing, S. M., & Rodriguez, M. C. (2002). A review of multiple-choice item-writing guidelines for classroom assessment. Applied Measurement in Education, 15(3), 309–334. • Fensham, P. J. (2022). The future curriculum for school science: What can be learnt from the past? Research in Science Education, 52(Suppl 1), S81–S102. https://doi.org/10.1007/s11165-022-10090-6 • Tong, D., Tao, Y., Zhang, K., Dong, X., Hu, Y., Pan, S., & Liu, Q. (2024). Investigating ChatGPT-4's performance in solving physics problems and its potential implications for education. Asia Pacific Education Review, 25(5), 1379–1389. https://doi.org/10.1007/s12564-023-09913- • Nikolaos Fotou, Michael J. Reiss, & Rachael Sharpe. (2026). Assessing practical work in laboratory settings. In Laurinda Leite, Luís Dourado, Ana Sofia Afonso, & Susana Morgado (Eds.), Practical work in science education in the digital era (pp. 369–380). Springer. https://doi.org/10.1007/978-3-032-13788-3_26 • Chowdhury, F. (2018). Application of rubrics in the classroom: a vital tool for improvement in assessment,feedback and learning. International Education Studies, 12(1), 61. https:// doi. org/ 10. 5539/ ies. v12n1 p61
13	**Teaching and Learning Physics in Out-of-School Science Contexts and Informal Learning Spaces.**	• Sadler, T. D., Burgin, S., McKinney, L., & Ponjuan, L. (2010). Learning science through research

	Student teachers, through selected readings, explore how out-of-school contexts and informal learning spaces may enrich the learning by providing experiential learning in authentic and real-world contexts thus enhancing career aspirations, ideas about the nature of science (NOS), attitudes towards science, understandings of scientific content, confidence for doing science and intellectual development (Sadler, Burgin, McKinney & Ponjuan 2010). These experiences may include: • Visits to energy plants, solar systems, boiler, turbines to explore the process of energy conversion, conservation and storage; amusement parks to explore the concept of motion, laws of motion, types forces, momentum, balance, freefall, simple machines. • Visits to University Centres, Labs, Technical Vocational centres, observatory, weather station and industry to explore how science is done in modern settings and applied at large scale; • Visits to manufacturing industries and product testing; such as Automobiles, Sports etc. • Visits to Construction Sites and Buildings to study every application of heat transfer and thermal insulation. Museum and science centre programs to explore history, major developments and explore physics through interactive exhibits and interactions. • After-school STEM clubs, fairs and enrichment activities to explore the different activities, modes of communication, representations, careers and applications. Student-teachers reflect on the experience and discuss strategies to successfully implement out of school learning, and how to engage learners in SEPs and CCCs, problem-based/ hands-on inquiry, attitudes towards science, exploration of Socio-Scientific Issues to foster deeper understanding of important science concepts. Student teachers, in groups, design learning materials for a visit to any selected out-of-school science context for enriching students' authentic learning. **Suggested Content Integration from Grades 9-12** (*teacher educators should also integrate CCCs and SEPs within chosen content)*:	apprenticeships: A critical review of the literature. Journal of Research in Science Teaching, 47(3), 235–256. https://doi.org/10.1002/tea.20326 • Hazari, Z., Dou, R., Sonnert, G., & Sadler, P. M. (2022).The relationship between informal science experiences and physics identity: Unrealized possibilities. Physical Review Physics Education Research, 18(1), 010107. https://doi.org/10.1103/PhysRevPhysEducRes.18.010107 • Ertaş Kılıç, H., & Şen, A. (2014). The effect of physics education based on out-of-school learning activities and critical thinking on students' attitudes. Education and Science, 39(176), 13–30. https://doi.org/10.15390/EB.2014.3635. • Solis, D. H., Hutchinson, D., & Longnecker, N. (2021).Eaton, D. (2000). *Cognitive and affective learning in outdoor education* University of Toronto. • Gilbertson, K., Ewert, A., Siklander, P., & Bates, T. (2022). *Outdoor education: Methods and strategies*. Human Kinetics.

	• Mechanics, Laws, Forces and Momentum in Daily Life Situation (Grade IX, XI). • Fluid Statics (Grade XI) • Energy types, transfer, renewable and non-renewable sources and conservation (Grade IX) • Optics (Grade X) • Thermodynamics (Grade XI)	
14	**Practical Lab II** This session builds on Physics Lab I, in Physics Course I, where STs will review safety in the lab, process skills and examine how laboratory experiences can be structured along a continuum from guided to open inquiry-to-problem based labs with increasing student autonomy. Emphasis is placed on designing labs that require learners to apply SEPs—such as such as asking testable questions, defining design problems, developing models, planning investigations (with controls and variables), collecting, recording, analyzing, interpreting data, making calculations, identifying systematic and random errors, and engaging in argument from evidence—while making explicit connections to CCCs such as patterns, cause and effect, systems and system models, energy and matter flows/conservation, structure and function and stability and change. Student teachers also apply mathematical calculations, graphical representations, and analysis of the data obtained from experiments using multiple methods. **Suggested Content Integration from Grades 9-12** • Electronics (Grade X) r- Logic gates demonstration. • Ohm's Law (Grade IX- X)- Verify Ohm's law (using wire as conductor) and technology based labs. • Resistors (Grade IX-X)- To find the resistance of galvanometer by half deflection method. • Electromagnetism (Grade IX-X)- To trace the magnetic field due to a current carrying circular coil. • Forces and Matter –Hook's Law (Grade IX-XII)- Investigating how the extension of a loaded wire depends on the diameter of the wire. • Acoustics (Grade XI-XII)- Determine the wavelength of sound in air using stationary waves and to calculate the speed of sound using resonance tube.	• Eclat Institute (2025) Teacher Toolkit: Moderating O-Level Physics Practical Online Resources. https://eclatinstitute.sg/blog/o-level-physics-experiments/O-Level-Physics-Practical-Teacher-Moderation-Toolkit • IOP (2026) Teaching Practical Physics Online Resources. https://spark.iop.org/collections/general-guidance-teaching-practical-physics. • Benamer, A., Benouioua, D., & Bennaa, Y. (2024). Difficulties of conducting scientific experiments in physics in the middle school stage from the point of view of the physics professor. Journal for Educators, Teachers and Trainers, 15(3), 271–284. https://doi.org/10.47750/jett.2024.15.03.023 • Winter, J., & Millar, R. (2023). From broad principles to content-specific decisions: pre-service physics teachers' views on the usefulness of practical work. International Journal of Science Education, 45(13),1097-1117. https://doi.org/10.1080/09500693.2023.2187673. • Ilomuanya, M. D., Ikusika, A., & Aramide, J. O. (2024). Effect of practical teaching approach on physics students' achievement in the concept of reflection and refraction of light. International Journal of Physics and Chemistry Education, 16(1), 9–20.

	• Physical Optics (Grade XI-XII)- Determine the wavelength of light by using a diffraction grating and spectrometer.	https://doi.org/10.51724/ijpce.v16i1.297 • Singh, R., & Kumar, P. (2025). Arduino-based educational kit for teaching Ohm's law. European Journal of Physics Education, 16(3), 89–98. • Garcia, L., & Chen, X. (2026). Fostering scientific engagement through Arduino-based experiments in physics classrooms. Journal of Science Education and Technology, 35(1), 22–34.
15	**Microteaching, Feedback and Debriefing** This session engages STs in microteaching as a structured opportunity to enact PCK through physics lessons and reflect on practice. STs teach short segments from previously developed unit plans, receive focused peer and course facilitator feedback, and engage in guided debriefing. The session emphasizes reflective analysis of pedagogical decisions, and responsiveness to learners as key components of developing PCK.	• Albrechtsen, T.R.S., Kiær, K. (2025). A Pedagogy of Enactment: Creative Rehearsals and Feedback Literacy in Science Teacher Education. In: Svabo, C. Shanks, M., Zhou, C., Carleton, T. (eds) Creative Pragmatics for Active Learning in STEM Education. Contributions from Science Education Research, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-78720-1_11 • Gourlay, H. (2022). Becoming a science teacher: Is it merely a process of trial and error? *Research in Science Education, 52*(6), 1677–1698. https://doi.org/10.1007/s11165-021-10023-9 • Li, X., Li, F., Chen, X., & Wang, L. (2024). Using reflection and dialog feedback to promote the development of situated and dynamic pedagogical content knowledge. *Disciplinary and Interdisciplinary Science Education Research, 6*, 23. https://doi.org/10.1186/s43031-024-00114-8
16	**Synthesis of the course:** The student teachers will reflect on the entire experience and articulate the role and responsibilities of a 21st Century Secondary Physics Teacher. Using the following questions	• Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-

	and excerpts from the reading the student teachers will identify, discuss, present key roles. Questions: i. What are the purposes of teaching physics? What should be taught and why? ii. How should physics be taught? Why? iii. How do students learn and how does learning of physics takes place? iv. How is learning assessed? v. What are the roles of students and teachers? Why? vi. What are the supporting and hindering factors? vii. How can practical work improve pedagogical content knowledge (PCK) for physics teachers? viii. In what ways do labs, projects, and models help teachers connect physics concepts with effective teaching strategies? ix. How can modern technologies enhance physics practical work x. How would you continue to learn and share your learning?	service teachers' twenty-first century skills. Australasian Journal of Educational Technology, 33(3), 15. • Alvi, U., & Gioko, M (2010). Science Subject Leadership in the Enhancement of Information Communication Technology (ICT) Integration in Project Based Learning (PBL) in Khaki, J., &Safdar, Q. (Eds). Educational Leadership in Pakistan: Ideals and Realities. Karachi: Oxford University Press.

Assessment:

2. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination presenting student-teachers with subject-specific scenarios and requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exam Development (30%)

Student-teachers design a subject-specific summative examination intended for secondary learners, complete with a marking rubric and examiner's rationale. Each item must be accompanied by a written justification explaining the targeted learning outcome, cognitive level (using Bloom's Taxonomy), and how it assesses conceptual understanding rather than rote recall.
This demonstrates advanced PCK by requiring student-teachers to think from both the teacher's and learner's perspective simultaneously.

Course Outline

Course: Biology Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh Biology Curriculum IX–XII (DCAR, 2024)
Developed by:	Dr. Tasneem Anwar, AKU IED

Course Description

This course aims to strengthen student-teachers' Pedagogical Content Knowledge (PCK), a construct first articulated by Shulman (1987) and later refined in the Refined Consensus Model (Carlson & Daehler, 2019), by examining how biological content and pedagogical practices interact within secondary Biology classrooms. The course begins by exploring the purposes and goals of teaching Biology, anchored in science (NOS) and the history and philosophy of Biology. This foundational orientation frames how biological knowledge is constructed, justified, and taught. Building on this, the course engages student-teachers (ST) in a careful review of the Grades 9-12 Biology curriculum (2024), including the scope and sequence of key concepts and alignment with national standards. Students' thinking in Biology, including common misconceptions, learning difficulties, and learning progressions, will be examined to deepen understanding of how learners make sense of biological ideas. Student Teachers (STs) will also explore formative and summative assessment strategies to evaluate students' conceptual understanding, with attention to when and how specific assessment approaches may be used effectively. Finally, each session of the course models and analyses a range of instructional strategies for teaching through select content areas of biology, such as cell biology, heredity, and evolution. These topics are intentionally chosen because research shows they pose persistent challenges for both teachers and learners (Fuchs et al., 2021; Kumandaş et al., 2019). However, these topics are only suggestive, and teacher-educators may use any other topics from the Biology IX-XII curriculum that integrate well with a given pedagogy.

Course Outcomes

1. Examine the purposes, goals, and nature of science (NOS) in Biology education and articulate how these foundations inform the teaching of Grades 9-12 Biology concepts.
2. Analyze the Grades 9-12 Biology curriculum (scope, sequence, and standards) to identify key concepts, conceptual progressions, and alignment with instructional goals.
3. Interpret students' biological thinking by identifying common misconceptions, learning difficulties, and learning progressions, and use this understanding to plan responsive instruction.
4. Design and justify formative assessment strategies that effectively gauge students' understanding of core Biology topics and inform instructional decision-making.
5. Demonstrate PCK-informed pedagogical reasoning by evaluating and selecting evidence-based instructional approaches for teaching Biology concepts.
6. Practice teaching Biology in grades 9-12.

Learning and Teaching Approaches

The course is founded on the belief that the transformation of practices necessitates experiential learning, continuous reflection, and the theoretical analysis of practice.

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher- educators will model a range of pedagogical strategies commonly used in middle and high school science classrooms—such as teaching and learning for conceptual change, teaching and learning of disciplinary literacy in Biology, teaching using technology, and teaching Biology through lab work — allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching. Throughout the course, a constructivist philosophy guides engagement with PCK and TPACK, emphasizing active meaning-making, inquiry, and reflective practice in Biology teaching.

Semester Outline

Week	**Session Title and Brief Description** [Pedagogy and suggested content/concepts]	**Suggested Readings and Relevant Resources**
1	**An Introduction to Biology and the Nature of Science** This opening session introduces STs to Biology as a way of knowing and to the Nature of Science (NOS) as a foundation for developing Pedagogical Content Knowledge (PCK) in secondary biology (Grades 9–12). Through guided engagement with selected readings, STs examine how biological knowledge is generated, validated, and represented, and how historical, social, and epistemic factors shape scientific explanations. The session challenges common views of biology as a fixed body of facts and foregrounds science as a dynamic, evidence-based, and human enterprise by engaging STs in 'What's in the box?' inquiry. **Suggested Content Integration from Grades 9-12:** Cell biology (grade 9), Biotechnology (grade 10), Reproduction and Inheritance (grade 12)	• McComas, W. F. (2020). Principal elements of nature of science: Informing science teaching while dispelling the myths. In *Nature of science in science instruction* (pp. 35-65). Springer, Cham • Xiang, L., & Srinivasan, M. (2023). A Hands-on Activity to Understand the Nature of Science and Authentic Scientific Inquiry in Large Laboratory Courses: What's in the Box?. *Journal of College Science Teaching*, *52*(5), 51-60. • Demirdöğen, B., & Aydın-Günbatar, S. (2021). Teaching nature of science through the use of media reports on COVID-19. *Science Activities*, *58*(3), 98-115.
2	**Curriculum Mapping and Textbook Analysis** This session engages STs in critically examining the intended and enacted biology curriculum for Grades 9–12 through curriculum mapping and textbook analysis. Drawing on national and provincial curriculum documents and research on biology curriculum design, STs explore how biological knowledge, skills, and the Nature of Science are prioritized and sequenced. Using scholarly frameworks for textbook analysis, they interrogate how textbooks interpret curriculum goals, represent biological concepts, and position learners and teachers. The session positions teachers as curriculum designers foregrounding professional judgment in aligning curriculum intentions, textbook representations, and pedagogical decisions central to developing strong PCK in biology. STs may pick any content area and map its progression across grade 9-12.	• Curriculum of Biology for Sindh, 2024; • National Curriculum of Pakistan 2022-23, Biology Grades 9-12. • Mohlhenrich, E. (2021). Rethinking the High School Biology Curriculum. *The American Biology Teacher*, *83*(3), 135. https://www.jstor.org/stable/48737586
3		• Sindh Textbook Board Books – Biology 9,10, 11 and 12. • Leonard, W. H., & Penick, J. E. (1993). What's Important in Selecting a Biology Textbook? *The American Biology Teacher*, *55*(1), 14–19.

		https://doi.org/10.2307/4449572 • Shapiro, A. R. (2012). Between Training and Popularization: Regulating Science Textbooks in Secondary Education. *Isis*, *103*(1), 99–110. https://doi.org/10.1086/664981
4	**Effective Biology Teaching and the Role of PCK and TPACK** This session focuses on effective biology teaching through the lenses of Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK). STs examine the historical development of the main models of PCK from Shulman (1987) to the Refined Consensus Model (Carlson & Daehler, 2019). Using Yeh et al. (2015)'s Proficiency Levels TPACK, STs examine how biology-specific teaching decisions are shaped by the interplay of content knowledge, pedagogy, and technology. This session also provides an overview of general pedagogical and formative assessment approaches commonly used in teaching biology across Grades 9-12. STs explore a range of instructional strategies grouped under the core pedagogical aims: Teaching for conceptual change; Teaching disciplinary literacy in Biology; Teaching using technology; Teaching Biology through lab work etc. Participants examine how different formative assessment approaches can support student learning and understanding. The session emphasizes the purposes and limitations of various pedagogies and assessment strategies, encouraging STs to consider how these approaches influence engagement, conceptual understanding, and evidence of learning in biology classrooms. This overview prepares STs to later examine how pedagogical and assessment choices must be adapted and refined through topic-specific PCK. Through discussion and guided analysis, the session highlights how teachers select representations, and choose instructional and technological tools appropriate to biology topics. Emphasis is placed on using PCK and TPACK as analytic frameworks to support purposeful, context-sensitive biology instruction across Grades 9–12.	• Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1–23. • Hume, A., Cooper, R., & Borowski, A. (Eds.). (2019). *Repositioning pedagogical content knowledge in teachers' knowledge for teaching science*. Singapore: Springer Singapore. • Vergara, C., Bassaber, A., Núñez Nieto, P., Becerra, B., Hurtado, H., Santibáñez, D., & Cofré, H. (2025). A map of collective pedagogical content knowledge as a basis for studying the development of biology teachers' personal PCK of evolution. *International Journal of Science Education*, *47*(17), 2279-2301. • Yeh, Y. F., Lin, T. C., Hsu, Y. S., Wu, H. K., & Hwang, F. K. (2015). Science teachers' proficiency levels and patterns of TPACK in a practical context. *Journal of Science Education and Technology*, *24*(1), 78-90. • Tanner, K., & Allen, D. (2004). Approaches to biology teaching and learning: from assays to assessments—on collecting evidence in science teaching. *Cell Biology Education*, *3*(2), 69-74. • Couch, B. A., Brown, T. L., Schelpat, T. J., Graham, M. J., & Knight, J. K. (2015). Scientific teaching: Defining a taxonomy of observable practices. *CBE—Life Sciences Education*, *14*(1), ar9.

		• Bird, F. L. (2014). Assessment in biology: trends, problems and solutions. *International Journal of Innovation in Science and Mathematics Education*, *22*(2). • Arthurs, L. A., & Kreager, B. Z. (2017). An integrative review of in-class activities that enable active learning in college science classroom settings. *International Journal of Science Education*, *39*(15), 2073-2091. • Mintzes, J. J., Wandersee, J. H., & Novak, J. D. (2001). Assessing understanding in biology. *Journal of biological education*, *35*(3), 118-124. • National Research Council. (2001). Assessment in the classroom. In J. Coffey, P. Black, & J. M. Atkin (Eds.), Classroom assessment and the national science education standards (pp. 23–58). National Academies Press. https://doi.org/10.17226/9847 • Roberts, R., & Gott, R. (2003). Assessment of biology investigations. *Journal of Biological Education*, *37*(3), 114-121.
5. 6.	**Learning Approaches and alternate frameworks (Misconceptions) in Biology** This session examines how students learn biology and the alternative frameworks and misconceptions they commonly bring to the classroom. STs explore research on students' prior ideas in key biology concepts and consider how these ideas influence sense-making and learning. The session highlights the implications of misconceptions for instructional design, assessment, and the development of PCK in biology teaching. **Suggested Content Integration from Grades 9-12:** • Cell biology (grade 9) • Heredity (grade 10) • Forms and Functions of Plants (grade 11) • Biostatistics & Data Handling (grade 12)	• Keeley, P. (2012). Misunderstanding misconceptions. *Science Scope*, *35*(8), 12-15. • Kumandaş, B., Ateskan, A., & Lane, J. (2019). Misconceptions in biology: a meta-synthesis study of research, 2000–2014. *Journal of Biological Education*, *53*(4), 350-364. • Fuchs, T. T., Bonney, K. M., & Arsenault, M. (2021). Leveraging student misconceptions to improve teaching of biochemistry & cell biology. *The American Biology Teacher*, *83*(1), 5-11.

7, 8 & 9.	**Teaching for Understanding and Conceptual Change** This session focuses on teaching understanding and conceptual change in biology through research-informed instructional strategies. STs explore the use of discrepant events, Predict - Observe - Explain (POE), practical demonstrations, inquiry-based approaches, and models, analogies and modelling to deepen and challenge students' existing ideas and support deeper conceptual understanding. **Suggested Content Integration from Grades 9-12 for:** • **models and modelling** through concepts like cell biology (grade 9), heredity (Grade 10) • **concept mapping** through concepts like ecology (grade 9), Environmental Biology (grade 12).	• Ben Zvi Assaraf, O., Knippels, MC.P.J. (2022). Lessons Learned: Synthesizing Approaches That Foster Understanding of Complex Biological Phenomena. In: Ben Zvi Assaraf, O., Knippels, MC.P.J. (eds) Fostering Understanding of Complex Systems in Biology Education. Contributions from Biology Education Research. Springer, Cham. https://doi.org/10.1007/978-3-030-98144-0_12 • Homburger, S. A., Drits-Esser, D., Malone, M., & Stark, L. A. (2015). Microbes As Friends, Not Foes: Shifting the Focus from Pathogenesis to Symbiosis. *The American Biology Teacher*, *77*(9), 659–668. https://doi.org/10.1525/abt.2015.77.9.3 • Castro, F. M., & Duncan, R. G. (2022). Cross-sectional study of students' molecular explanations of inheritance patterns. *Science Education*, *106*(2), 412–447. https://doi.org/10.1002/sce.21692 • Torkar, G., Korfiatis, K. (2022). Pre-service Teachers' Conceptual Schemata and System Reasoning About the Carbon Cycle and Climate Change: An Exploratory Study of a Learning Framework for Understanding Complex Systems. In: Ben Zvi Assaraf, O., Knippels, MC.P.J. (eds) Fostering Understanding of Complex Systems in Biology
10.	**Teaching Disciplinary Literacy in Biology** This session explores disciplinary literacy in biology, emphasizing biology as a discipline with its own language, textual structures, and ways of constructing and justifying knowledge. STs examine why students often struggle to read and write biology texts and learn strategies to support comprehension by foregrounding how biologists use language, representations, and evidence to	• Jason Moore & Mary Schleppegrell (2020) A focus on disciplinary language: Bringing critical perspectives to reading and writing in science, Theory Into Practice, 59:1, 99-108, DOI: 10.1080/00405841.2019.1685337

	explain the natural world and support scientific claims. **Suggested Content Integration from Grades 9-12:** • Socio-Scientific Issues from Genetics (grade 10 & 12)	• Mellen, M. (2021). Idea Bank: Bringing Literacy into the Biology Classroom Using Story Progressions. *The Science Teacher*, *88*(5), 22-23. • Munir, U., & Bhutta, S. M. (2018). Efficacy of Teaching Science at Secondary Level through Socio-Scientific Issues-based Argumentation: Study from an Urban Context of Pakistan. *International*
11 & 12.	**Biology Labs** This session focuses on the role of laboratory work in biology teaching as a site for inquiry, evidence generation, and conceptual understanding. STs examine different types of biology labs (from confirmation inquiry to open inquiry), consider issues of safety and resource management, and analyze how practical work can be designed to support learning goals rather than procedural completion. Emphasis is placed on aligning laboratory activities with content, pedagogy, and assessment.	• Cornell Institute for Biology Teachers. (n.d.). *Labs & activities: High school*. Cornell University. https://blogs.cornell.edu/cibt/labs/high-school/ • Graham, C. (2024). Teaching microscopy using plants: what does a microscope show me? School Science Review, 106(392), 8–11. • Howard, D. R., & Miskowski, J. A. (2005). Using a module-based laboratory to incorporate inquiry into a large cell biology course. *Cell Biology Education*, *4*(3), 249-260.
13.	**Lesson Planning for Biology Teaching** This session focuses on lesson planning for effective biology teaching in school contexts. STs examine the purposes and structure of lesson planning and explore both inductive (e.g., 5E) and deductive lesson planning frameworks. Emphasis is placed PCK as the guiding framework while aligning learning objectives, instructional strategies, resources, and assessment with students' needs and content demands to support coherent, purposeful biology lessons.	• FU, X., & LIU, E. (2016). Using WISE Materials to Design an Inquiry-Based Curriculum with the 5E Instructional Model. *The American Biology Teacher*, *78*(3), 208–219. https://www.jstor.org/stable/26411029 • Bilica, K., & Flores, M. (2009). Inductive & Deductive SCIENCE THINKING. *Science Scope*, *32*(6), 36–41.
14.	**Technology Infused Pedagogies for Biology** This session examines digital pedagogies that support meaningful learning in biology. STs explore how technology can enable specific biology teaching approaches, such as modeling, simulation, data analysis, virtual labs and visualization, that are difficult to achieve through traditional methods alone. The session emphasizes pedagogical purpose over tools, highlighting how digital resources can be strategically integrated to enhance conceptual understanding, inquiry, and scientific reasoning.	• Howard Hughes Medical Institute. (n.d.). *BioInteractive*. https://www.biointeractive.org/ • PhET Interactive Simulations. (n.d.). *PhET simulations*. University of Colorado Boulder. https://phet.colorado.edu/ • Douglass, C., & Glover, R. (2003). Plastination: Preservation technology enhances biology teaching. *The*

	Suggested content Integration from Grades 9-12: • modelling *'Flip Classroom'* using *interactive simulations* and *online quiz* for concepts like Human Physiology (grade 11), Environmental Biology (grade 12) • Molecular Biology (DNA, enzymes: structure and function, inquiry labs) • Reproduction and Inheritance • Diseases and Immunity (simulation of spread of disease) • Environmental Biology (simulations and inquiry labs) • Climate Change (simulations and inquiry labs) • Structural Biology and Computational Biology • Biostatistics and Data Handling (developing data literacy)	*American biology teacher*, *65*(7), 503-510. • Oliveira, A., Feyzi Behnagh, R., Ni, L., Mohsinah, A. A., Burgess, K. J., & Guo, L. (2019). Emerging technologies as pedagogical tools for teaching and learning science: A literature review. *Human Behavior and Emerging Technologies*, *1*(2), 149-160. • Labster. (n.d.). *Virtual lab simulations*. https://www.labster.com/ • Concord Consortium. (n.d.). *Biology and ecology simulations*. https://learn.concord.org/ • National Oceanic and Atmospheric Administration. (n.d.). *Climate data and educational resources*. https://www.noaa.gov/ • Genetic Science Learning Center. (n.d.). *Teach.Genetics*. University of Utah. https://teach.genetics.utah.edu/
15	**Microteaching, Feedback and Debriefing** This session engages STs in microteaching as a structured opportunity to enact PCK through biology lessons and reflect on practice. STs teach short segments, receive focused peer and course facilitator feedback, and engage in guided debriefing. The session emphasizes reflective analysis of pedagogical decisions, use of representations, and responsiveness to learners as key components of developing PCK.	• Albrechtsen, T.R.S., Kiær, K. (2025). A Pedagogy of Enactment: Creative Rehearsals and Feedback Literacy in Science Teacher Education. In: Svabo, C., Shanks, M., Zhou, C., Carleton, T. (eds) Creative Pragmatics for Active Learning in STEM Education. Contributions from Science Education Research, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-78720-1_11
16	**Synthesis of the course** Reflection on week 1-15 and key takeaways for teaching Biology.	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination (90 minutes) presenting student-teachers with subject-specific scenarios requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exploring Student Conceptions — Elicitation, Analysis, and Remediation (30%)

Student-teachers design a theory-informed alternative framework/ misconceptions elicitation tool for a selected Grades 9–12 curriculum topic, then conduct interviews with 4–6 students to surface their existing conceptions. They analyse the data to identify patterns in student thinking and present findings and remediation strategies, supported by relevant literature, in the form of an oral presentation or a written report.

Course Outline

Course: Biology Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh Biology Curriculum IX–XII (DCAR, 2024)
Developed by:	Umber Siddiqi, GECE Hussainabad (operated by Durbeen)

Course Description

This course aims to strengthen student-teachers' Pedagogical Content Knowledge (PCK), by examining how biological content and pedagogical practices interact within secondary Biology classrooms. The course begins by revisiting the purposes and goals of teaching Biology, anchored in science (NOS) and the history and philosophy of Biology. This foundational orientation frames how biological knowledge evolves and is constructed, justified, and taught. Building on this, the course engages student teachers (STs) in a deep exploration of Cross-Cutting Concepts (CCCs) and Science and Engineering Practices (SEPs), which have been adopted into the Grades 9-12 Sindh Curriculum for Biology (2024) from the Next Generation Science Standards (National Research Council, 2013). The purpose of the CCCs is to unify the domains of science in terms of thinking tools that are transferable across them. The SEPs aim to break away from a rigid and prescriptive "scientific method" and reflect a more authentic way of doing science, which involves different combinations of practices that tend to be iterative as opposed to rigid and linear. The success of including the CCCs and SEPs in the curriculum rests on their integration across all disciplinary content throughout the Sindh Curriculum. Each session of the course models and analyses a range of instructional strategies for teaching, building on strategies introduced in Biology 1. These strategies are modeled through selected examples across a range of content areas of biology that align with the pedagogy and demonstrate the integration of a variety of CCCs and SEPs. Content areas that have been included are Molecular Biology, Metabolism, Reproduction and Inheritance, Diseases and Immunity, Biotechnology, Environmental Biology, Climate Change, Forms and Functions of Plants, Tissues, Organs, and Systems. However, these topics are suggestive, and teacher educators may use other topics from the Biology 9-12 curriculum that integrate well with a given pedagogy. Finally, student teachers (STs) will also explore formative and summative assessment strategies to evaluate students' conceptual understanding, with attention to when and how specific assessment approaches may be used effectively.

Course Outcomes

1. Examine the purposes, goals, and nature of science (NOS) in Biology education and articulate how these foundations inform the teaching of Grades 9-12 Biology concepts.
2. Integrate Crosscutting Concepts (CCCs) across biology instruction to help learners develop a coherent and scientifically based view of the world.
3. Integrate the Science and Engineering Practices (SEPs) across disciplinary content areas to help learners investigate biological phenomena and design solutions in authentic ways that reflect how scientists and engineers' work
4. Design summative assessments that effectively gauge students' understanding of core Biology topics
5. Demonstrate PCK-informed pedagogical reasoning by evaluating and selecting evidence-based instructional approaches for teaching complex Biology concepts
6. Practice teaching Biology in grades 9-12.

Learning and Teaching Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher educators will model a range of pedagogical strategies that enhance learning in middle and high school science classrooms—such as project-based learning, problem-based learning, integration of socio-scientific issues in learning science, STEM/ STEAM, Teaching using technology, Teaching Biology through lab work and out-of-school science contexts allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester Outline

	Session Title and Brief Description [Pedagogy and suggested content/concepts]	**Suggested Readings and Relevant Resources**
1	**The Nature of Biology: a tentative, evidence-based, and socially embedded enterprise** Through selected readings, student-teachers discuss the essentials of science that should be taught in the biology classroom and why (Burke, 2021). They revisit key ideas related to the nature of science and scientific literacy by exploring the development of scientific knowledge through the lens of history. In doing so, they place science in context, making connections between biology and other scientific domains, other disciplines, and within broader societal contexts. In exploring how scientific knowledge evolves, student-teachers appreciate the development, uses, and limitations of models in science and explore misconceptions about what is meant by "theory" in science. **Suggested Content Integration from Grades 9-12:** • Diseases and Immunity (Grade 12): *[SLO: B-12-L-36]* Narrate the experimental work of Griffith, Avery, McCarty, and MacLeod; and Hershey and Chase in establishing DNA as the hereditary material. *(see Clough & Olson, 2004; Sterling, 2009)* • Evolution, Biodiversity and Classification (Grade 12): *[SLO: B-12-E-06]* Describe the endosymbiotic theory explaining the evolution of eukaryotes from prokaryotes. *Reading/discussion and exploring what is "theory" in science (see Tiger Science Alvarado.n.d.; Robertson, 2009*).	• Burke, M. (2021, December 16). *The essential elements of a quality science education*. Royal Society of Chemistry. https://edu.rsc.org/feature/the-essential-elements-of-a-quality-science-education/4014866.article • Clough, M. P. (2011). The story behind the science: Bringing science and scientists to life in post-secondary science education. Science & Education, 20(7), 701-717. https://www.storybehindthescience.org/how-science-works-old • Clough, M. P., & Olson, J. K. (2004). The nature of science: Always part of the science story. *The Science Teacher*, *71*(9), 28 • Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). *Curriculum of biology for Sindh: Grades IX–XII.* • Kloser, M. J. (2012). A place for the nature of biology in biology education. *The Electronic Journal for Research in Science & Mathematics Education*, *16*(1).

	• Climate Change (Grade 12): *Global Warming: scientific data, its interpretation and implications for society (see "The Realization of Global Warming in Clough (2011))*	• Robertson, B. (2009). Q: How does a scientific theory become a scientific law? *Science and Children*, *46*(5), 5 • Sterling, D. R. (2009). *From Aristotle to today: Making the history and nature of science relevant*. Science Scope, 32(5), 30–35 **Online Resources:** • Tiger Science Alvarado. (n.d.). *Student activity: A theory on the origins of eukaryotic cells*. https://tigersciencealvarado.weebly.com/uploads/2/2/8/
2	**Argumentation in Science** Building on scientific literacy in Biology Course I, student- teachers are introduced to argumentation pedagogy as a critical historical component of scientific literacy, that helps students construct, justify, and critique scientific claims using evidence and reasoning. Student-teachers explore core components of scientific argumentation (claim, evidence, reasoning) and examine how these practices align with inquiry-based learning, philosophical debates within science, and socio-scientific issues, The teacher-educator models classroom strategies such as structured debates, claim-evidence-reasoning (CER) frameworks, and peer critique to support engagement and deeper understanding of how science is "done" and NOS, continuing the discussion introduced in the previous session. **Suggested Content Integration from Grades 9-12:** • **Evolution, Biodiversity and Classification (Grade 9**): *[SLO: B-09-E-13]* Examine the challenges involved in classifying viruses. (*see Genetic Science Learning Centre, n.d.;* Owens et al., 2023) *Here science intersects with philosophy. Student-teachers gain awareness that models in science develop through a negotiation of knowledge, are not facts but are subject to change. Furthermore, more than one model may exist to define concepts or processes.* • Immunity and Disease: Should the vaccine for measles (or polio) be mandatory by law for all citizens? (Owens et al., 2023) Student-teachers realise that all questions cannot be	• Genetic Science Learning Centre. (n.d.). *Is it alive? Teacher guide*. University of Utah. https://teach.genetics.utah.edu/content/cells/files/is%20it%20alive.pdf • Osborne, J. (2017). *What is argumentation and why does it matter in the teaching of science?* In *Understanding and Teaching for Argumentation* (pp. 1–10). Corwin. https://in.sagepub.com/sites/default/files/upm-assets/78737_book_item_78737.pdf • Osborne, J. (2010). *Arguing to learn in science: The role of collaborative, critical discourse.* Science, 328(5977), 463–466.Ross, D., Fisher, D., & Frey, N. (2009). The art of argumentation. *Science & Children*, *47*(3). • Owens, D. C., Sheridan, N. P., & Townley, A. L. (2023). Argumentation goes viral: Preservice teacher engagement in 5E learning about argumentation in the context of the coronavirus. *Journal of College Science Teaching*, *52*(7), 30-36. • Sadler, E. (2025, February 18). *A step-by-step guide to CER for science teachers*. Sadler Science.

	answered by science alone and examine the question though the lens of both science and ethics, bringing in interdisciplinarity	https://sadlerscience.com/cer-science/ • The Regents of the University of California. (2024). *The Argumentation Toolkit: Helping teachers understand and teach scientific argumentation*. Lawrence Hall of Science. https://argumentationtoolkit.lawrencehallofscience.org/
3-4	**Cross-Cutting Concepts (CCCs) & Science and Engineering Practices (SEPs)** Student-teachers explore the CCCs and SEPs that have been adopted into the Sindh Curriculum (2024) from the Next Generation Science Standards through readings and discussions (*Sindh Curriculum for Biology (IX-XII), 2024; National Research Council, 2013; NGSS Lead States, 2013*). Student-teachers describe CCCs as seven specific concepts or "thinking tools" that are applicable across science domains and support critical thinking and science literacy (*NGSS Lead States, 2013; Nordine & Lee, 2023; Talanquer, 2019).* They recognize that the success of including CCCs in the science curriculum depends on their explicit inclusion alongside the two other dimensions, namely the disciplinary content across the curriculum and the SEPs. Through readings, student-teachers describe the 8 SEPs and how they help to make "how science is done" more authentic (Bybee 2011, Murphy, 2023). They understand that the success of having SEPs in the curriculum is dependent on their explicit inclusion alongside disciplinary content and CCCs. SEPs are evident when students plan and conduct experiments, collect data, analyze patterns, and construct explanations during the investigation **Suggested Content Integration from Grades 9-12**: • Diseases and Immunity (for example, see on-line resource on spread of disease and control - Centers for Disease Control and Prevention [CDC], 2024) *SEPs: Asking Questions, Developing and Using Models, analyzing data (graphs of infection spread), Constructing explanations, Engaging in argument from evidence* *CCCs – Cause and Effect. Patterns (in data), Systems and Systems Models (immune system interactions), Stability and Change*	• Bybee, R. W. (2011). Scientific and engineering practices in K-12 classrooms. *Science Teacher*, *78*(9), 34-40. • Fick, S. J., Arias, A. M., & Baek, J. (2017). Unit planning using the crosscutting concepts. *Science Scope*, *40*(9), 40-45. • Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). *Curriculum of biology for Sindh: Grades IX–XII*. • Murphy, B. (2023). Science, Science, Everywhere. *Connected Science Learning*, *5*(2), 12318626. • National Research Council. (2013). *Appendix G: Crosscutting concepts*. In *Next Generation Science Standards: For states, by states*. The National Academies Press. https://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL.edited.pdf • NGSS Lead States. (2013). *Appendix F: Science and engineering practices in the Next Generation Science Standards*. Next Generation Science Standards. https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf

	• Metabolism (for example, enzyme investigations – see Basehore et al. (n.d.)) *SEPs: Planning and carrying out investigations, Analyzing and interpreting data, Constructing explanations* *CCCs: Cause and Effect, Structure and Function, Stability and Change* • Form and Functions of Plants, Cell and Its Organelles, Tissues, Organs and Systems *CCCs: Structure and Function, Systems and System Models* • Evolution, Biodiversity and Classification *CCCs – Patterns*	• Nordine, J., & Lee, O. (2023). On the nature and utility of crosscutting concepts. *Education Sciences, 13*(7), 640. https://doi.org/10.3390/educsci13070640 (harder) • STEM Teaching Tools. (2021). *STEM teaching tool #41: Prompts for integrating crosscutting concepts into assessment and instruction* (Version 2.0). https://stemteachingtools.org/assets/landscapes/STEM-Teaching-Tool-41-Cross-Cutting-Concepts-Promptsv2_2021-10-07-214154.pdf • Talanquer, V. (2019). Crosscutting concepts: Productive ways of thinking in science. *The Science Teacher*, 86(6), 12–17. **Online Resources:** • Basehore, B., Bucks, M. A., & Mummert, C. M. (n.d.). *Enzyme lab*. Biology LibreTexts. https://bio.libretexts.org/Courses/Harrisburg_Area_Community_College/BIOL_101%3A_Lab_Manual-_Version_2/04%3A_Enzyme_Lab • Centers for Disease Control and Prevention. (2024, August 22). *Module 2: How does disease spread?* CDC NERD Academy. https://www.cdc.gov/nerd-academy/disease-spread/index.html
5- 6	**Unit Planning** In this session, student teachers explore "Understanding by Design" which is an approach to unit planning that focuses on deep understanding and meaningful, transferable learning rather than coverage of isolated content. They will learn how to identify and develop "Big (or enduring) Understandings" as the long-term learning goals of a unit. They will also explore and craft companion "essential questions" that promote inquiry and lead to these understandings. By the end of the session, student teachers will	• McTighe, J., & Wiggins, G. (2012). Understanding by design framework. *Alexandria, VA: Association for Supervision and Curriculum Development*. • Wiggins, G., & McTighe, J. (2011). *The understanding by design guide to creating high-quality units*. ASCD. • Wiggins, G., & McTighe, J. (n.d.). *Essential questions: Opening doors to student understanding*. Center for

	apply these principles by designing their own Big Understandings and essential questions for a selected topic. **Suggested Content Integration from Grades 9-12:** • Holozoic Nutrition Big Understanding: People have different dietary needs based on age, activity level, weight, and various health considerations. Essential question: How can a diet that is "healthy" for one person be unhealthy for another?	Learning. https://www.centerforlearning.org/wp-content/uploads/2015/04/ACD109EX.pdf
7- 8	**Complex Pedagogies I: Problem Based Learning and Phenomena-Based Learning** Student teachers read and discuss essential elements of phenomena-based learning (PhBL) and problem-based learning (PBL), and compare and contrast them with each other. (Chin & Chia, 2008; Saberi and Nouri, 2024). They identify the multilayered nature of PhBL and PBL that involve extended tasks, multiple steps, and integration of concepts, skills and real-world contexts. Student-teachers understand the relevance of other pedagogies that play a contributing role here, such as inquiry, argumentation, etc. Through the selected readings, student-teachers explore the essentials of developing effective PBL lessons, such as creating an effective problem scenario or case study, introducing the problem to students. (Chin & Chia, 2008; Sterling, 2007) Student teachers define what a "phenomenon" is in science and how to formulate one that anchors effective teaching and learning. They explore how PhBL holds the potential to engage students in learning about the natural world as scientists do, integrating all three dimensions of disciplinary content, SEPs, and CCCs (Amplify Science, 2018; Saberi & Nouri, 2024). **Suggested Content Integration from Grades 9-12** (*teacher educators should also integrate CCCs and SEPs within chosen content)***:** PBL: • Diseases and Immunity (Sterling, 2007) • Environmental Biology • Climate Change PhBL: • Reproduction and Inheritance (Grade 12)	• Amplify Science. (2018). What's so phenomenal about phenomena? An introduction to phenomenon-based learning. The Lawrence Hall of Science, University of California, Berkeley. Chin, C., & Chia, L. G. (2008). Problem-based learning tools. *The Science Teacher*, *75*(8), 44. • OpenSciEd. (2024). *B.3 inheritance & variation of traits*. https://openscied.org/instructional-materials/b-3-inheritance-variation-of-traits/ • Saberi, M., & Nouri, N. (2024). Promoting understanding of three dimensions of science learning plus nature of science using phenomenon-based learning. *Innovations in Science Teacher Education*. • Sterling, D. R. (2007). Modeling problem-based instruction. *Science & Children*, *45*(4).

	Exploring cancer as a phenomenon – Who gets cancer and why? (OpenSciEd., 2024) .	
9- 10	**Complex Pedagogies II: Project Based Learning (PjBL) and STEM/ STEAM** Student teachers experience and explore STEM/ STEAM and PjBL, both of which are multi-layered, based in real-world contexts and use inquiry amongst other pedagogies. Following on from their learnings in the previous sessions, student teachers reflect on and discuss where PjBL, STEM/STEAM, PBL and PhBL overlap and how they differ. PjBL: Through readings, student teachers explore how PjBL learning in biology centers on an extended, real-world project/task that culminates in a tangible product or presentation that requires 'application" of learning in science. (Colley, 2008) STEM: At the outset, student teachers connect with their own ideas about STEM and then engage in experiencing STEM. Through reading and discussion, they clarify their ideas on: • What is technology? • What is a prototype? • The role of the engineering challenge in the STEM unit. • The nature of engineering challenges as open-ended challenges that lead to multiple solutions • Integration of "engineering" into biology through the Engineering Design Process (EDP). • How and where is mathematics integrated in STEM? • How and where is art integrated in STEAM? (Bequette & Bequette, 2012) • Communication and Collaboration • Connections within science disciplinary content and with other disciplines As STEAM evolves from STEM, it involves blurring disciplinary boundaries to frame and solve problems—it involves thinking creatively and working on projects that aim at real-world inquiry integrating technology and design (Connor, Karmokar & Whittington, 2015). **Suggested Content Integration from Grades 9-12** (*teacher educators should also integrate CCCs and SEPs within chosen content)***:** • Environmental Biology/ Biodiversity/ Climate Change	• Bybee, R. W. (2013). *The case for STEM education: Challenges and opportunities*. National Science Teachers Association Press. • Honey, M., Pearson, G., & Schweingruber, H. (Eds.). (2014). *STEM integration in K–12 education: Status, prospects, and an agenda for research.* National Academies Press. • Moore, T. J., Stohlmann, M. S., Wang, H.-H., Tank, K. M., Glancy, A. W., & Roehrig, G. H. (2014). Implementation and integration of engineering in K–12 STEM education. In *Engineering in pre-college settings: Synthesizing research, policy, and practices*. Purdue University Press. • Williams, P. J. (2022). The integration of the engineering design process in biology-related STEM activity: A review of Thai secondary education. *ASEAN Journal of Science and Engineering Education*, *2*(1), 1-10. • Colley, K. (2008). Project-Based Science Instruction: A PRIMER. *Science Teacher*, *75*(8). • Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. Art education, 65(2), 40-47. https://doi.org/10.1080/00043125.2012.11519167 • Connor, A. M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for enhancing engineering and technology education. International Journal of Engineering Pedagogy, 5(2), 37–47.

	• Disease and Immunity • Biotechnology	
11-12	**Assessment Approaches to Teaching Biology** These sessions provide an overview of assessment approaches used in teaching biology across Grades 9-12. Building on Formative assessment (assessment for learning) in Biology Course 1, this session specifically examines summative assessments (assessment of learning) and helps student-teachers see how they serve different but interconnected purposes. Summative assessment is used to report progress, assign grades, and meet accountability demands. To align with science education standards, summative assessments must go beyond testing factual recall and instead measure deeper understanding, inquiry skills, problem-solving, and the ability to apply knowledge in new contexts. Through the readings, student- teachers explore how a variety of assessment approaches, such as performance tasks, portfolios, and enhanced/ adapted traditional tests, may be used (National Research Council, 2001, pp. 59–77). STs will also explore how to assess CCCs and SEPs which are integrated with the disciplinary content (Achieve, n.d.-a; Achieve, n.d.-b) Additionally, validity and reliability is discussed with respect to both formative and summative assessments. **Suggested Content Integration from Grades 9-12:** Any topic may be chosen to develop a summative assessment	• Achieve. (n.d.-a). *Task annotation project in science: Assessing three-dimensional performance—Crosscutting concepts*. https://www.nextgenscience.org/sites/default/files/TAPS%20CCCs.pdf • Achieve. (n.d.-b). *Task annotation project in science: Assessing three-dimensional performance—Science and engineering practices*. https://www.nextgenscience.org/sites/default/files/TAPS%20SEPs.pdf • National Research Council. (2001). The relationship between formative and summative assessment—In the classroom and beyond. In J. Coffey, P. Black, & J. M. Atkin (Eds.), *Classroom assessment and the national science education standards* (pp. 59–77). National Academies Press. https://doi.org/10.17226/9847 • Parry, D., Larsen, C., & Walsh, C. (2008). Summative assessment with formative feedback: An intervention in a small bioscience cohort. *Bioscience Education*, *11*(1), 1-3.
13	**Teaching and Learning Biology in Out-of-School Science Contexts** Student teachers, through selected readings, explore how out-of-school contexts may complement classroom instruction through providing authentic, experiential learning, real-world contexts, enhancing motivation and interest in science careers. These experiences may include: • Field studies in ecosystems (e.g., mangrove forests, marine environments) • Biodiversity surveys and ecological investigations • Museum, university centers, industry and science center programs • After-school STEM clubs and enrichment activities	• National Research Council. (2010). *Surrounded by science: Learning science in informal environments*. National Academies Press. https://doi.org/10.17226/12614 • Orion, N., & Hofstein, A. (1994). Factors that influence learning during a scientific field trip in a natural environment. *Journal of Research in Science Teaching*, *31*(10), 1097–1119. https://doi.org/10.1002/tea.3660311005 • Ballantyne, R., & Packer, J. (2009). Introducing a fifth pedagogy: Experience-based strategies for facilitating

	• Community-based environmental and conservation projects Student-teachers discuss strategies to successfully implement out of school learning, and engage learners in SEPs and CCCs, hands-on inquiry, Socio-Scientific Issues, observation, and data collection, fostering deeper understanding of important science concepts through providing guidance but not over-directing. Student teachers, in groups, design learning materials to direct learning through a meaningful interaction with the environment. **Suggested Content Integration from Grades 9-12** (*teacher educators should also integrate CCCs and SEPs within chosen content)***:** • Environmental Biology • Biodiversity and Classification • Forms and Functions of Plants	learning in natural environments. *Environmental Education Research*, *15*(2), 243–262. https://doi.org/10.1080/13504620802711282
14	**Biology Lab II** This session builds on Biology Lab I, in Biology Course I, where STs review safety in the lab, process skills and examine how laboratory experiences can be structured along a continuum from guided to open inquiry, with increasing student autonomy. Emphasis is placed on designing labs that require learners to apply SEPs—such as asking questions, planning investigations, analyzing and interpreting data, and engaging in argument from evidence—while making explicit connections to CCCs such as cause and effect, systems and system models, and structure and function. **Suggested Content Integration from Grades 9-12** (*teacher educators should also integrate CCCs and SEPs within chosen content)***:** • Environmental Biology • Metabolism: [SLO:B-11-I-07] Investigate the effect of pH on enzyme activity Compare the optimum pH of different enzymes like trypsin, pepsin and papain (Basehore et al., n.d.; Cordts et al., 2008) Student teachers will also discuss ethical implications of experimentation and investigations in biology, and engage in argumentation where science intersects with philosophy/ethics **Suggested Content Integration from Grades 9-12:** Diseases and Immunity (Grade 12): *Students discuss the ethical use of animals and humans in*	• Allchin, D. (2001). *Of rice and men*. SHiPS Resource Center. https://www.shipseducation.net/modules/biol/eijkman1.htm • Basehore, B., Bucks, M. A., & Mummert, C. M. (n.d.). *Enzyme lab*. Harrisburg Area Community College. Access the lab page • Cordts, M., Ridenour, N., & Hickey, M. K. (2008). *The properties of enzymes: A study of catalase*. Cornell Institute for Biology Teachers. https://blogs.cornell.edu/cibt/labs-activities/labs/catalase/ • Hofstein, A., & Lunetta, V. N. (2004). The laboratory in science education: Foundations for the twenty-first century. *Science Education, 88*(1), 28–54. https://doi.org/10.1002/sce.10106

	furthering the knowledge of biology through a case-study (see Allchin, 2001).	
- 15	**Microteaching, Feedback, and Debriefing** This session engages STs in microteaching as a structured opportunity to enact PCK through biology lessons and reflect on practice. STs teach short segments from previously developed mini-units/plans, receive focused peer and course facilitator feedback, and engage in guided debriefing. The session emphasizes reflective analysis of pedagogical decisions, and responsiveness to learners as key components of developing PCK.	• Albrechtsen, T.R.S., Kiær, K. (2025). A Pedagogy of Enactment: Creative Rehearsals and Feedback Literacy in Science Teacher Education. In: Svabo, C. Shanks, M., Zhou, C., Carleton, T. (eds) Creative Pragmatics for Active Learning in STEM Education. Contributions from Science Education Research, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-78720-1_11 • Gourlay, H. (2022). Becoming a science teacher: Is it merely a process of trial and error? *Research in Science Education, 52*(6), 1677–1698. https://doi.org/10.1007/s11165-021-10023-9 • Li, X., Li, F., Chen, X., & Wang, L. (2024). Using reflection and dialog feedback to promote the development of situated and dynamic pedagogical content knowledge. *Disciplinary and Interdisciplinary Science Education Research, 6*, 23. https://doi.org/10.1186/s43031-024-00114-8
16	**Synthesis of the course** Reflection on week 1-15 and key takeaways for teaching Biology.	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination presenting student-teachers with subject-specific scenarios and requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exam Development (30%)

Student-teachers design a subject-specific summative examination intended for secondary learners, complete with a marking rubric and examiner's rationale. Each item must be accompanied by a written justification explaining the targeted learning outcome, cognitive level (using Bloom's Taxonomy), and how it assesses conceptual understanding rather than rote recall.

This demonstrates advanced PCK by requiring student-teachers to think from both the teacher's and learner's perspective simultaneously.

Course Outline

Course: Chemistry Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh Chemistry Curriculum IX–XII (DCAR, 2024)
Developed by:	Unaeza Alvi, IBA Sukkur University

Course Description

The Chemistry course aims to enhance student teacher's Pedagogical Content Knowledge (PCK) which involves the blending of content and pedagogy into an understanding of how particular topics, problems are organized, represented and adapted to the diverse interests, abilities, contexts of learners and presented for instruction" first articulated by Shulman (1987) to its Refined Consensus Model in Science Education that explicates the multiple and complex layers of knowledge that shapes practice (Carlson & Daehler, 2019). The course also draws on a recent work on science teachers' PCK, referred to as CoRe (Content representation), the knowledge of important content, difficulties in teaching and learning, knowledge of students' thinking, and broader context and culture (Loughran et al. 2004 &2006). The course aims to develop a deeper understanding of the goals and purposes of teaching and learning Chemistry by grounding it, like science in general, in the history, philosophy, and the micro-macro nature of chemistry, the linkages between sub-fields, and their interdisciplinary linkages. Building on what chemistry is, how chemistry knowledge is constructed, organized, and linked, the student teachers will delve into the Grade 9-12 Chemistry Curriculum 2024 to undertake curriculum mapping and textbook analysis for informed curriculum implementation. The student teachers' understanding of students' thinking in chemistry will be strengthened through exploration of common alternative frameworks, complexities, and difficulties in learning chemistry, and the influence of context and culture. Student Teachers (STs) will also apply formative and summative assessment strategies to assess students' conceptual understanding and skills. Considering the policy-practice context, the needs assessment of the chemistry teachers, the NPST and contemporary research in chemistry education/STEAM. Selective, "Important and Big Ideas" in Chemistry and a range innovative and contextually relevant pedagogical, human centric techno-pedagogical approaches are modelled to address the alternative frameworks, learning difficulties and contemporary knowledge and skills and in order to make the ideas accessible to the learner. However, these topics are only suggestive, and teacher-educators may use any other topics from the Chemistry IX-XII curriculum, that integrate well with a given pedagogy.

Course Outcomes

1. Examine and broaden own conceptions of goals, purposes, the nature of science, nature of chemistry, sub-fields and inter-disciplinary linkages in chemistry to inform the teaching and learning of chemistry;
2. Analyze the Grade IX-XII Chemistry Curriculum and identify the domains, standards, benchmarks, students learning outcomes, cross-cutting themes for each topic/sub-topics and develop a vertical progression map portraying its scope and sequence;
3. Explore and identify students' common alternative frameworks, complexities and learning difficulties in chemistry;
4. Enhance/enrich pedagogical content knowledge in selected chemistry concepts from Classes IX-XII;
5. Demonstrate PCK-informed pedagogical reasoning by evaluating and selecting innovative and contextually relevant instructional approaches for teaching Chemistry concepts;
6. Practice teaching Chemistry in grades 9-12.

Learning and teaching approaches

The course is founded on the belief that the transformation of practices necessitates experiential learning, continuous reflection and the theoretical analysis of practice.

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, loud thinking, structured debriefs, and reflective dialogue. Teacher- educators will model a range of pedagogical strategies commonly used in middle and high school science classrooms—such as teaching and learning for conceptual change, construction of knowledge, teaching and learning of disciplinary literacy in Chemistry, Teaching using technology integration for visualization and Teaching Chemistry open and guided inquiry, through physical and virtual lab work, Teaching for standards-based curriculum planning and enactment, Teaching grounded in understanding of nature of science and chemistry, Teaching Chemistry using innovative and contextually/culturally relevant pedagogies and formative assessments — allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester outline

Week	**Session Title and Brief Description** [Pedagogy and suggested content/ concepts]	**Suggested Readings and Relevant Resources**
1	**Introduction to Chemistry and the Nature of Science** The session introduces student teachers to chemistry and its nature through colorful chemistry activities and its macro-micro complexity. This Nature of Science is experienced and discussed through hands-on activities "black box", active reading and role of the history of atomic theory/ phlogiston theory, comparing theories and laws.	• McComas, W. F. (2020). Principal elements of nature of science: Informing science teaching while dispelling the myths. In *Nature of science in science instruction* (pp. 35-65). Springer, Cham • Lederman, N. G., Abd-El-Khalick, F., Bell, R. L., & Schwartz, R. S. (2002). Views of Nature of Science Questionnaire: Toward Valid and Meaningful Assessment of Learners' Conceptions of Nature of Science. Journal of Research in Science Teaching, 39(6), 497-521. • Gabel, D. (1998). The complexity of chemistry and implications for teaching. In B. J. Fraser & K. G. Tobin (Eds.), International handbook of science education (Vol. 1, pp. 233–248). Kluwer. • Sindh Curriculum for Chemistry IX-XII,2024.
2 -3	**Curriculum Mapping and Textbook Analysis.** This session engages STs in critically examining the intended and enacted chemistry curriculum for Grades 9–12 through curriculum mapping and textbook analysis using a review tool/rubric developed from reading and analyzing case studies of teachers.	• Sindh Curriculum for Chemistry IX-XII,2024. • Alvi, U at al., (2008). Curriculum, Manual for teachers, teacher educators and textbook writers. Ministry of Education. Government of

	Drawing on the recent national and provincial curriculum documents and research on chemistry curriculum design, student teachers will explore how chemistry knowledge, skills, and the Nature of Science are prioritized and sequenced. Using scholarly frameworks for textbook analysis, they will interrogate how textbooks interpret curriculum goals, represent chemistry concepts, and position learners and teachers. Using concept mapping, the teachers will explore intradisciplinary connections and interlinkages between concepts. The session positions teachers as curriculum designers, foregrounding professional judgment in aligning curriculum intentions, textbook representations, and pedagogical decisions central to developing strong PCK in chemistry.	Pakistan. (Funded by UNESCO). • Roberts, D. A., & Östman, L. (Eds.). (1998). Problems of meaning in science curriculum. Teachers College Press. • Freire, M., Talanquer, V., & Amaral, E. (2019). Conceptual profile of chemistry: A framework for enriching thinking and action in chemistry education. International Journal of Science Education, 41(5). • Van Aalsvoort, J. (2004). Logical positivism as a tool to analyse the problem of chemistry's lack of relevance in secondary school chemical education. International Journal of Science Education, 26(9). • Millar, V., Park, W., & Dillon, J. (Eds.). (2025). The science curriculum: Issues, tensions and future prospects [Special issue]. International Journal of Science Education, 47(15–16) • Tsakeni, M. (2018). Opportunities for teaching sustainable development through the chemistry component of CAPS physical sciences. African Journal of Research in Mathematics, Science and Technology Education, 22(1), 125–136. • Said, Z., Mansour, N., Abu-Tineh, A., Cevik, M., & Al-Naimi, I. (2024). Mapping of K–12 science and mathematics curriculum against sustainable development goals and addressing sustainability gap. Cogent Education, 11(1), Article.
4	**Effective Chemistry Teaching and the Role of PCK and TPACK** This session focuses on effective chemistry teaching through the lenses of Pedagogical Content Knowledge (PCK) and Technological Pedagogical Content Knowledge (TPACK). Student teachers examine the historical development of the main models of PCK from Shulman (1987) to the Refined Consensus Model	• Shulman, L. S. (1987). Knowledge and teaching: Foundations of the new reform. Harvard Educational Review, 57(1), 1–23. • Hume, A., Cooper, R., & Borowski, A. (Eds.). (2019). *Repositioning pedagogical content knowledge*

	(Carlson & Daehler, 2019) and then conduct a self-audit of their CK/ PCK/ TPACK using the Secondary Chemistry Teacher Need Assessment Tool (Alvi, 2024). This session also provides an overview of general pedagogical and formative assessment approaches commonly used in teaching chemistry across Grades 9-12. Student teachers explore a range of instructional strategies grouped under the core pedagogical aims: Teaching for conceptual change; Enhancing Chemistry Language & Literacy, Teaching using technology; Teaching Chemistry through lab work, etc. Student-teachers examine how different formative assessment approaches can support student learning and understanding. The session emphasizes the purposes and limitations of various pedagogies and assessment strategies, encouraging STs to consider how these approaches influence engagement, conceptual understanding, and evidence of learning in chemistry classrooms. This overview prepares STs to later examine how pedagogical and assessment choices must be adapted and refined through topic-specific PCK. Through discussion and guided analysis, the session highlights how teachers select representations, and choose instructional and technological tools appropriate to chemistry topics. Emphasis is placed on using PCK and TPACK as analytic frameworks to support purposeful, context-sensitive chemistry instruction across Grades 9–12.	*in teachers' knowledge for teaching science*. Singapore: Springer Singapore. • Mishra, P., & Koehler, M. J. (2006). Technological pedagogical content knowledge: A framework for integrating technology in teachers' knowledge. Teachers College Record, 108 (6), 1017–1054. • Alvi, U. (2024). *TNA study report of teachers teaching English, Mathematics, Physics, Chemistry, and Biology at Grade 9–10 levels across Sindh, Pakistan* [Training needs assessment report]. Academia.edu. https://www.academia.edu/125072273/TNA_STUDY_REPORT_OF_TEACHERS_TEACHING_English_Mathematics_Physics_Chemistry_and_Biology_at_Grade_9_10_Levels_Across_Sindh_Pakistan • Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. Australasian Journal of Educational Technology, 33(3), 15. • Anderson, L. W., & Krathwohl, D. R. (2001). A Taxonomy for Learning, Teaching, and Assessing: A Revision of Bloom's Taxonomy of Educational Objectives. Longman. • Treagust, D. F., & Tsui, C.-Y. (2014). General instructional methods and strategies. In N. G. Lederman & S. K. Abell (Eds.), Handbook of research on science education (Vol. 2, pp. 303–320). Routledge.
5 & 6	**Learning Approaches and Alternative Framework** These sessions examine how children learn Chemistry and the alternative frameworks and misconceptions they commonly bring to the	• Driver, R., Squires, A., Rushworth, P., & Wood-Robinson, V. (2014). Making sense of secondary science:

	classroom. Student teachers analyze a video recording or a reading to identify students' alternative frameworks of any chemistry topic/subtopics, sources of alternative frameworks and nature of alternative frameworks. Student teachers then develop an interview tool, test and activities to elicit students' ideas/ alternative framework in chemistry and use these to elicit students' ideas in a real context. The session highlights the implications of misconceptions for instructional design, assessment, and the development of PCK in chemistry teaching. **Suggested Content Integration from Grades 9-12:** Physical & Chemical Propertices, Atom, Mixture, Compounds, Change of State, Mass of Gases, Conservation of Mass in Chemical Change, Role of Oxygen in combustion, Solution Chemistry, Symbols, Chemical Bonding, Electrochemistry, Chemical and Physical Change.	Research into children's ideas (2nd ed.). Routledge • Mondal, B. C., & Chakraborty, A. (2013). Misconceptions in chemistry: Its identification and remedial measures. Lap Lambert Academic Publishing. • White, R., & Gunstone, R. (2014). Probing understanding. Routledge. (Original work published 1992). • Development of the bonding representations inventory to identify student misconceptions about covalent and ionic bonding representations. Journal of Chemical Education, 91(3), 312–320 • Majeed, S., Ahmad, R., & Mazhar, S. (2023). An exploration of students' common misconceptions in the subject of chemistry at secondary level. Annals of Human and Social Sciences, 4(2), 265–272.
7, 8 & 9	**Teaching for Understanding and Conceptual Change**: This session focuses on teaching for understanding and conceptual change in chemistry through research-informed instructional strategies. Student teachers study Conceptual Change Model (Posner 1982) by experiencing dissonance through Cognitive Conflict Strategies such as Discrepant Events and Predict-Observe-Explain (POE). Some examples of –activities include: • Blow a Balloon-Rocket with Vinegar and Baking Soda • Invisible Fire • Elephant Toothpaste experiment • Floating of Eggs in Brine (POE) • What will happen, if you pour oil, honey and water in a bottle and shake the bottle.(POE). • Predict what can happen when all of these are connected together.(Lemon, wires, small LEDs, nails, (POE) Student-teachers also experience practical demonstrations, inquiry-based approaches, and models, analogies and modelling to deepen and challenge students' existing ideas and support deeper conceptual understanding,	• Krajcik, J., & Shin, N. (2023). Student conceptions, conceptual change, and learning progressions. In G. L. Norman,L.Z.Dana, &S.L.Judith (Eds.), Handbook of research on science education (1 ed.). Routledge. • Seimears, C. M., Graves, E., Schroyer, M. G., & Staver, J. R. (2012). How constructivist-based teaching influences students' learning science. The Educational Forum, 76(2), 265–271. • Anggoro, S., Widodo, A., Suhandi, A., & Treagust, D. F. (2019). Using a discrepant event to facilitate preservice elementary teachers' conceptual change about force and motion. Eurasia journal of mathematics, science and technology education, 15(8). • Coll, R. K. (2006). The role of models, mental models and analogies in chemistry teaching. In P. J. Aubusson, A. G.

	Suggested Content Integration from Grades 9-12 for: • **analogies** such as a ball rolling down to explain the shift from Bonding- Octet Rule to Lower Energy State in Bond Formation • **models and modelling** through developing the Model of Atom, Ionic, and Covalent Compounds. • **inquiry** into physical changes in state of matter, melting, boiling, freezing, evaporation, mass, volume, temperature changes, elevation in boiling point, and depression in freezing point.	Harrison, & S. M. Ritchie (Eds.), Metaphor and analogy in science education (pp. 65–77). Springer Netherlands.
10	**Enhancing Chemistry, Language, and Literary** This session explores disciplinary literacy in chemistry, emphasizing chemistry as a discipline with its own language, textual structures, and ways of constructing and justifying knowledge. Teachers examine why students often struggle to read and write chemistry texts and learn strategies to support comprehension by foregrounding how chemists use language, representations, and evidence to explain the matter and support scientific claims. Teacher Educators first help student teachers experience Directed Activities Related to Text (DARTS) (both Reconstruction DARTS & Analysis DARTS) and Writing Frames and then develop the same for given SLOs from the Chemistry curriculum. **Suggested Content Integration from Grades 9-12:** Periodic Table Atomic Structure, Chemical Bonding, Stoichiometry, Electrochemistry	• Uyanık, S., Yıldız, K., & Benzer, E. (2026). Investigation of pre-service science teachers' scientific text activities as a way of reading comprehension in science education. *International Journal of Science Education, 48*(6), 864–888. https://doi.org/10.1080/09500693.2025.2550036 • Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. McGraw-Hill Education • Rachmawati, D., Amirrachan, A. R., & Rachmawati, D. (2020). The use of small group discussion with directed activities related to texts (DARTs) technique in reading comprehension.. *Annual International Seminar on English Language Teaching, 16*, 35–50.
11 & 12	**Practical Lab I** This session focuses on the role of laboratory work in chemistry teaching as a site for inquiry, evidence generation, and conceptual understanding. Student teachers examine different types of chemistry labs (from confirmation inquiry to open inquiry), identification of chemistry apparatus, consider issues of lab safety, equipment safety and resource management, and analyse how practical work can be designed to support learning goals/ experimental skills rather than procedural completion. Emphasis is placed on aligning laboratory activities with content, pedagogy, and assessment and teacher's practical work pedagogical content knowledge. Student-	• Rutgers University Libraries. (n.d), Chemistry Laboratory Safety: Free Online Resources. https://libguides.rutgers.edu/chem_lab_safety/free_onlinettps://libguides.rutgers.edu/chem_lab_safety/free_online • EPA-United States Environment Protection Agency. (n.d). Tool Kit for Safe Chemical Management K-12 Schools, Toolkit for Safe Chemical Management in K-12 Schools | US EPA

	teachers will discuss and analyse the Aase study of a young teacher preparing for a chemistry lab (Wei & Liu, 2018) and list down the stages of lab preparations. **Suggested Content Integration from Grades 9-12:** • Melting/Boiling Points for Identification of Purity of Water, • Displacement Reaction • Combustion of candle/iron wool/metal in open and closed system. • Mixture Separation Techniques and Purification of Water • Volumetric Analysis-Titrations • Gravimetric Analysis	• Yoon, H., Woo, A. J., Treagust, D., & Chandrasegaran, A. L. (2014). The efficacy of problem-based learning in an analytical laboratory course for pre-service chemistry teachers. International Journal of Science Education, 36(1), 1–21. • Wang, T., Wang, W., & Wei, J. (2022). Challenges encountered by student teachers in an inquiry-based laboratory process. Journal of Chemical Education, 99(12), 3954–3963 • Wei, B., & Liu, H. (2018). An experienced chemistry teacher's practical knowledge of teach-ing with practical work: the PCK perspective. • Millar, R. (2010). Practical work. In J. Osborne & J. Dillon (Eds.), Good practice in science teaching: What research has to say (Vol. 2). Open University Press. • Hofstein, A., Navon, O., Kipnis, M., & Mamlok-Naaman, R. (2005). Developing students' ability to ask more and better questions resulting from inquiry-type chemistry laboratories. Journal of Research in Science Teaching, 42(7), 791–806.
13	**Lesson Planning for Chemistry Teaching** This session focuses on lesson planning for effective chemistry teaching in school contexts. Student-teachers plan lessons using different Lesson Templates such as 4A Lesson Plan for Constructivist Teaching, Inquiry Based Teaching Template, Conceptual Change Based Teaching Template for POE, Guided and Open Inquiry, while integrating various pedagogies introduced in this course. Student teachers examine case studies of a planned and un-planned teacher through the lens of (03) three questions when planning for teaching, namely: i) what is it that you want to teach your students? ii) how do you intend to teach/facilitate learning that you wish, desire or have decided to teach?	• Alvi, U. et al., (2008). Curriculum, Manual for teachers, teacher educators and textbook writers. Ministry of Education. Government of Pakistan. (Funded by UNESCO). • Alvi, U. (2026). The Toolkit of Lesson Plans for Teaching of General Science Grade IV-VIII and Specialized Sciences from Grades IX-XII. (59) Alvi Unaeza - Independent Researcher

	iii) how will the learning that has taken place be measured or how do you plan to establish the attainment of the intended learning? Student teachers examine the purposes and structure of lesson planning and explore both inductive (e.g., 5E) and deductive lesson planning frameworks. Emphasis is placed on PCK as the guiding framework while aligning learning outcome, instructional strategies, resources, and assessment with students' needs and content demands to support coherent, purposeful chemistry lessons.	
14	**ICT Integration/ Techno- Pedagogies** This session examines digital pedagogies that support Education 5.0, human centric and, meaningful learning in chemistry. Student teachers explore how technology can enable specific chemistry teaching approaches, such as modeling, simulation, data analysis, and visualization, that are difficult to achieve through traditional methods alone. The session emphasizes pedagogical purpose over tools, highlighting how digital resources can be strategically integrated to enhance conceptual understanding, metacognition, creativity, inquiry, sustainability, scientific reasoning and emotional intelligence. **Suggested content Integration from Grades 9-12:** • Quizlet for Vocabulary Introduction and Development for Periodic Table, Organic Chemistry • Digital Games for learning difficult chemistry topics/ concepts such as water at high and low temperatures, reversible and irreversible reactions, standard conditions and states, characteristics of material, industrial processes • Simulations for Chemistry atoms, elements, ions, isotopes, balancing chemical equations, structure of matter, state changes. • Virtual practical labs, chemistry industrial for Acid Based Titration, Identification of Unknown Salt, Industrial Preparation of Soap, Ammonia. • WEB elements for details about elements • ChemSpider for Modelling Tools	• Moore, E. B., Chamberlain, J. M., Parson, R., & Perkins, K. K. (2014). PhET interactive simulations: Transformative tools for teaching chemistry. *Journal of Chemical Education, 91*(8), 1191–1197 • Yuriev, E., Wink, D. J., & Holme, T. A. (2024). The dawn of generative artificial intelligence in chemistry education. Journal of Chemical Education, 101(8), 2957–2959 • Yaron, D., Karabinos, M., Lange, D., Greeno, J. G., & Leinhardt, G. (2010). The ChemCollective—Virtual labs for introductory chemistry courses. Science, 328(5978), 584–585. https://doi. Org/10.1126/science.1182435 • Yik, B. J., & Dood, A. J. (2024). ChatGPT convincingly explains organic chemistry reaction mech-anisms slightly inaccurately with high levels of explanation sophistication. Journal of Chemical Education, 101(5), 1836–1846.
15	**Microteaching, Feedback and Debriefing** This session engages student teachers in microteaching as a structured opportunity to enact	Albrechtsen, T.R.S., Kiær, K. (2025). A Pedagogy of Enactment: Creative Rehearsals and Feedback Literacy in Science Teacher Education. In: Svabo,

	PCK through chemistry lessons and reflect on practice. Student teachers teach short segments, receive focused peer and course facilitator feedback, and engage in guided debriefing. The session emphasizes reflective analysis of pedagogical decisions, use of representations, and responsiveness to learners as key components of developing PCK.	C., Shanks, M., Zhou, C., Carleton, T. (eds) Creative Pragmatics for Active Learning in STEM Education. Contributions from Science Education Research, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-78720-1_11
16	**Reflecting, Reviewing, Synthesizing, Connecting and Creating** Reflection on week 1-15 and key takeaways for teaching Chemistry	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination (90 minutes) presenting student-teachers with subject-specific scenarios requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exploring Student Conceptions — Elicitation, Analysis, and Remediation (30%)

Student-teachers design a theory-informed alternative framework/ misconceptions elicitation tool for a selected Grades 9–12 curriculum topic, then conduct interviews with 4–6 students to surface their existing conceptions. They analyse the data to identify patterns in student thinking and present findings and remediation strategies, supported by relevant literature, in the form of an oral presentation or a written report.

Course Outline

Course: Chemistry Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh Chemistry Curriculum IX–XII (DCAR, 2024)
Developed by:	Unaeza Alvi, IBA Sukkur University

Course Description

This course aims to strengthen student-teachers' Pedagogical Content Knowledge (PCK) by examining how chemistry content and pedagogical practices interact within secondary Chemistry classrooms in Sindh, Pakistan. The course begins by revisiting the purposes and goals of teaching Chemistry, anchored in the nature of science (NOS) in Chemistry (history, philosophy, contributions to material sciences, and interdisciplinary connections). This foundational orientation frames how chemistry knowledge evolves, is constructed, and validated by the chemistry community of practice, and its contribution to modern material sciences and understanding of chemical phenomena in everyday life and technological applications. Building on this, the course engages student teachers (STs) in a deep exploration of Cross-Cutting Concepts (CCCs) and Science, Engineering Practices (SEPS). The purpose of the CCCs is to unify the domains of science in terms of thinking tools that are transferable across them. The (SEPs) aim at different combinations of practices which tend to be iterative as opposed to linear. The (SEPs) aim to break away from a rigid and prescriptive "scientific method" and reflect a more authentic way of doing science, which involves different combinations of practices that tend to be iterative as opposed to linear. The SEPs are further enhanced by applying science, mathematics, and technology tools to solve complex problems through the design thinking approach of engineering, explored through aesthetic experiences and expressed through artistic creation (STEAM Design Thinking). The success of including the CCCs and SEPs in the curriculum rests on their integration across all disciplinary content throughout the Sindh Curriculum and in achieving the overarching interdisciplinary STEAM. Building on pedagogies introduced in Chemistry I, each session of the course models and analyses a range of pedagogies for teaching chemistry. This is modelled through selected examples across a range of content areas of chemistry that align with the pedagogy and demonstrate the integration of a variety of CCCs and SEPs. Content areas that have been included are Physical Chemistry, Atomic Structure, Chemical Bonding, Chemical Equations, Chemical Reactions, Energetics and Kinetics, Electrochemistry, Acids, Bases and Salts, Periodic Table, Environmental Chemistry, Industrial/Agriculture Chemistry, Climate Change, Organic Compounds, Polymer and Biochemistry. However, these topics are suggestive, and teacher educators may use other topics from the Chemistry 9-12 curriculum that integrate well with a given pedagogy. Finally, student teachers (STs) will also explore the purpose and multiple forms of summative assessment strategies to evaluate students' conceptual understanding, procedural knowledge and thinking skills with attention to when and how specific assessment strategies may be used effectively.

Course Outcomes

1. Examine the purpose, goals and nature of science (history, philosophy, contributions to material sciences and interdisciplinarity) in Chemistry and demonstrate how these foundations inform the teaching of Grades 9-12 chemistry concepts.
2. Integrate Crosscutting Concepts (CCCs) across chemistry pedagogical planning and teaching to help learners develop a coherent and scientifically based view of the world.
3. Integrate the Science and Engineering Practices (SEPs) across disciplinary content areas to help learners investigate chemical phenomena and design problems' solutions in authentic ways that reflect how scientists and engineers work
4. Design valid and reliable summative assessments tests and alternative assessments to assess students' conceptual, procedural knowledge and thinking, and experimental skills of core Chemistry Concepts.

5. Demonstrate PCK-informed pedagogical reasoning by selecting evidence-based and innovative pedagogies, for planning and teaching complex Chemistry concepts.
6. Practice theory-informed teaching of Chemistry in grades 9-12 and reflect on their practice.

Learning and Teaching Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, loud thinking, guided practice, structured debriefs, and reflective dialogue. Teacher educators will model a range of pedagogies that enhance learning in middle and high school science classrooms—such as project-based learning, problem-based learning, design thinking, inquiry-based learning, argumentation, integration of socio-scientific issues in learning science, STEM/ STEAM, integration with technology, Teaching Chemistry through lab work and out-of-school science contexts — allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's pedagogical decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester Outline

Week	Session Title and Brief Description [Pedagogy and suggested content/ concepts]	Suggested Readings and Relevant Resources
1	**Nature of Chemistry: a tentative, evolving, evidence-based human endeavor** Through activities based on selected readings, student- teachers discuss the essentials of science that should be taught in the chemistry classroom. They revisit key ideas related to the nature of science and scientific literacy by exploring the development of scientific knowledge through the lens of history. In doing so, they place science in context, making connections within and between chemistry, other disciplines and within broader societal contexts, its application in everyday life, technological advancements, and the role of values and ethics. In exploring how scientific knowledge evolves, student-teachers appreciate the development, uses and limitations of models in science, and appreciate that models are the products of intellectual processes rather than just tools for teaching and learning. Furthermore, student teachers will explore misconceptions about what is meant by “theory” and “law” in science and explain that scientific paradigm as a theoretical model. **Suggested Content Integration from Grades 9-12:** • Introduction to Chemistry, and its Interdisciplinary fields and applications. • Atomic Theory and Periodic Table • Periodic Table and Periodicity as Theoretical model.	• A. S. Cuthbert & A. Standish (Eds.), What Should Schools Teach?: Disciplines, subjects and the pursuit of truth (2nd ed.). UCL Press. https://doi.org/10.2307/j.ctv14t475s.18 • Erduran, S., & Scerri, E. (2002). The nature of chemical knowledge and chemical education. In Chemical education: Towards research-based practice (pp. 7–27). Springer. • Fensham, P. J. (2022). The future curriculum for school science: What can be learnt from the past? Research in Science Education, 52(Suppl 1), S81–S102. https://doi.org/10.1007/s11165-022-10090-6 • Corrigan, D., Buntting, C., Fitzgerald, A., & Jones, A. (Eds.). (2020). Values in science education: The shifting sands. Springer. https://doi.org/10.1007/978-3-030-26860-3. • Hentschel, K. (2009). Atomic models, J.J. Thomson’s “Plum Pudding” model. In D.

	• Explore the difference between Kinetic Particle Theory and Gas Laws. • Creating Models of Atomic Structure and Everyday Phenomenon in Chemistry Rusting, Salinity, Acid Rains, Energy and Matter Changes	Greenberger, K. Hentschel, & F. Weinert (Eds.), *Compendium of quantum physics* (pp. 18–21). Springer Berlin Heidelberg. https://doi.org/10.1007/978-3-540-70626-7_9 • Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Chemistry for Sindh: Grades IX–XII. • Robertson, B. (2009). Q: How does a scientific theory become a scientific law?. Science and Children, 46(5), 5 • Sterling, D. R. (2009). From Aristotle to today: Making the history and nature of science relevant. Science Scope, 32(5), 30–35 • Rodriguez, E. (2017). *Discovery of oxygen and combustion*. In *Encyclopaedia Britannica*. https://www.britannica.com/science/combustion/History-of-the-study-of-combustion
2	**Argumentation in Science** Building on scientific literacy in Chemistry Course I, student- teachers are introduced to Argumentation as a critical historical component of scientific literacy, that helps students construct, justify, and critique scientific claims using evidence/data and warrant and become encultured into the practices of science. Student-teachers explore core components of scientific argumentation (claim, data, and warrant) and processes that allows students to put forward an argument, examine how these discourse practices shapes the social setting and classroom culture and leads to the development of scientific thinking, thus promoting an open scientific discourse culture and developing a scientifically literate society, The teacher-educator models classroom strategies such as structured debate using claim-data-warrant (CDW) frameworks, counter arguments, backing/peer critique and rebuttals (CDWBR) to support engagement and deeper understanding of how students can be enculturated in scientific thinking and discourse through argumentation.	• Nolan, E., & Zeidler, D. L. (2014). Cultivating critical reflection through socioscientific perspectives. Science Education, 98(3), 422–450. https://doi.org/10.1002/sce.21104 • Namdar, B., & Karahan, E. (Eds.). (2024). Socioscientific issues focused teacher education: Place-based practices from Türkiye. Springer. • Chang, A. G., & Alvi, U. (2012). Addressing socio-scientific issues (SSIs) through argumentation. International Journal of Health and Education, 1(2), 30–48. • Högström, P., Gericke, N., Wallin, J., & Bergman, E. (2025). Teaching socioscientific issues: A systematic review.

	They also use argumentation to address multidisciplinary, ill defined, value laden socio-scientific issues and in making connections to philosophical complexities inherent in the nature of chemistry knowledge and practice, such as *Why does matter/material behave the way it does? What is the difference between reproducibility and repeatability? What do scientific mean by uncertainty or errors ? What do scientists mean by levels of confidence? What is the smallest unit of matter? How is every thought, feeling, emotion a chemical reaction?* **Suggested Content Integration from Grades 9-12:** • Industry (Grade IX-XII)-Chemical Processes, Compounds and Products-Petrochemical and Other Industry- Effect on Environment and Health (Biochemistry Grade XII)-Use in Testing and Genetic Engineering-Transgenic Crops • Medicine (Grade XII)- Reactions and Side Effects. • Agriculture (Grade XII)- Benefits and Risk of Using Pesticides on Health and Environment. • Polymers and Polymerization (IX-XII)-Plastics, Use and Disposal and its effects on Health and Environment	Science & Education, 34, 3079–3122. https://doi.org/10.1007/s11191-024-00542-y • Christopher, M., & Pinias, C. (2025). Exploring the balance between theory and practice of transformative science, technology, engineering, arts, and mathematics teacher education: A systematic literature review. Discover Education, 4(1), 386. https://doi.org/10.1007/s44217-025-00695-0 • Ghibaudi,E., Regis,A., & Roletto, E., (2013). What do chemists mean when they talk about elements? J. Chem. Educ. 2013, 90, 12, 1626–1631 https://doi.org/10.1021/ed3004275
3-4	**Cross-Cutting Concepts (CCCs) and Science and Engineering Practices (SEPs)** Student-teachers explore the CCCs and SEPs that have been adopted into the Sindh Curriculum (2024) from the Next Generation Science Standards through active reading and discussions (Sindh Curriculum for Chemistry (IX-XII), 2024; National Research Council, 2013; NGSS Lead States, 2013). Student-teachers describe CCCs as seven specific aspects of scientific knowledge or “thinking tools” that are applicable across science domains and support scientific reasoning, interpretation, critical thinking and science literacy. (NGSS Lead States, 2013; Nordine & Lee, 2023; Talanquer, 2019) using domain specific examples. They recognize that the success of including CCCs in the science curriculum depends on their explicit inclusion alongside the disciplinary content. Through readings and hands-on activities, student-teachers describe the 8 SEPs and how they help to make “how science is done” in more authentic ways (Bybee 2011, Murphy, 2023). Working with examples of integration, student-	• Bybee, R. W. (2011). Scientific and engineering practices in K-12 classrooms. *Science Teacher*, *78*(9), 34-40. • Government of Sindh, Education & Literacy Department, Directorate of Curriculum, Assessment & Research Sindh Jamshoro. (2024). Curriculum of Chemistry for Sindh: Grades IX–XII. • Mun, K., Shin, N., Lee, H., Kim, S.-W., Choi, K., Choi, S.-Y., & others. (2015). Korean secondary students’ perception of scientific literacy as global citizens: Using global scientific literacy questionnaire. International Journal of Science Education, 37(11), 1739–1766. https://doi.org/10.1080/09500693.2015.1045956

	teachers understand that the success of having SEPs in the curriculum is dependent on their explicit inclusion alongside disciplinary content. This allows student teachers to comprehend that doing chemistry is a process of becoming part of the community of practice. **Suggested Content Integration from Grades 9-12:** CCCs 1. Pattern: Inorganic Chemistry (Grade IX-XI)- Periodic Table, Periodicity and Groups 2. Cause and Effect: Industrial Chemistry (Grade IX-XII)- Increase in Petrochemical and Material Product- Increase in Environmental Pollution 3. Scale, Proportion and Quantity: Air Quality (Grade IX-XI)- Analyzing Air pollution data of different places, at different times and quantity of pollutants 4. Systems and System Models: Physical Chemistry (Matter IX) Phases of Matter (Grade XI)- Using sub-microscopic properties to describe macro properties of Matter. SEPs Planning and carrying out investigations, Analyzing and interpreting data, Constructing explanations 1. Organic Chemistry (Grade XI)- Synthesis of Compounds/ Determine Concentration of Sugar in Soft Drink and Fruit 2. Electrochemistry (X-XII) Conductance of Electrolyte	• Murphy, B. (2023). Science, Science, Everywhere. *Connected Science Learning*, *5*(2), 12318626. • National Research Council. (2013). *Appendix G: Crosscutting concepts*. In *Next Generation Science Standards: For states, by states*. The National Academies Press. https://www.nextgenscience.org/sites/ngss/files/Appendix%20G%20-%20Crosscutting%20Concepts%20FINAL.edited.pdf • NGSS Lead States. (2013). *Appendix F: Science and engineering practices in the Next Generation Science Standards*. Next Generation Science Standards. https://www.nextgenscience.org/sites/default/files/Appendix%20F%20%20Science%20and%20Engineering%20Practices%20in%20the%20NGSS%20-%20FINAL%20060513.pdf • Nordine, J., & Lee, O. (2023). On the nature and utility of crosscutting concepts. *Education Sciences, 13*(7), 640. https://doi.org/10.3390/educsci13070640 (harder)
5-6	**Unit Planning** In this session, student teachers explore "Understanding by Design" which is an approach to unit planning that focuses on deep understanding and meaningful, transferable learning rather than coverage of isolated content. They learn how to identify and develop "Big (or enduring) Understandings" as the long-term learning goals of a unit. Student teachers align the big understanding with a Domain/ Domains and Cross-Cutting themes, standards, benchmarks, topics, and sub-topics. They also explore and craft companion "essential questions" that promote inquiry and lead to these understandings. By the end of the session, student teachers apply these principles by then developing 8-10 lesson plans based on the pedagogies and assessments experienced in Chemistry Course I and II and	• McTighe, J., & Wiggins, G. (2012). Understanding by design framework. *Alexandria, VA: Association for Supervision and Curriculum Development*. • Wiggins, G., & McTighe, J. (2011). *The understanding by design guide to creating high-quality units*. ASCD. • Wiggins, G., & McTighe, J. (n.d.). *Essential questions: Opening doors to student understanding*. Center for Learning. https://www.centerforlearning.org/wpcontent/uploads/2015/04/ACD109EX.pdf

	corresponding Big Understandings and essential questions for a selected topic. **Suggested Content Integration from Grades 9-12:** • Matter Essential Question: If you could redesign any material from the inside out, what would you change, and what might you accidentally break? Big Understanding: The properties of any material — and therefore its usefulness, its limitations, and its behavior under stress — are determined by its composition and internal structure, meaning that by understanding and deliberately manipulating structures at the atomic or molecular level, humans can engineer materials to meet specific needs or solve specific problems. • Electrochemistry Essential Question: If you can use electricity to drive a chemical reaction, and a chemical reaction to produce electricity, what stops us from simply recycling energy forever — and why does that matter? Big Understanding: Electrical energy and chemical energy are interconvertible and it is humanity's ability to switch deliberately between these two directions that makes possible many things from aluminum production and electroplating to rechargeable batteries and hydrogen fuel cells.	• Bahl, B. S., Bahl, A., & Tuli, G. D. (2000). Essentials of physical chemistry S. Chand Limited, 2000 • Gallagher, R., Ingram, P., & Norris, R. (2016). Complete chemistry for Cambridge IGCSE (R) student book and workbook pack. Oxford University Press, USA
7-8	**Complex Pedagogies I: Problem Based Learning and Phenomena-Based Learning** Student teachers read and discuss essential elements of phenomena- based learning (PhBL) and problem-based learning (PBL) and compare and contrast them with each other (Chin & Chia, 2008; Saberi and Nouri, 2024). They identify the multilayered nature of PhBL and PBL that involve extended tasks, multiple steps, and integration of concepts, skills and real-world contexts. Student-teachers explore other pedagogies that play a contributing role here such as inquiry-based learning (Anderson 2002). Through the selected readings, student-teachers explore the essentials of developing effective PBL lessons, such as creating an effective problem scenario or case study introducing the problem to students (Chin & Chia, 2008; Sterling, 2007).	• Chin, C., & Chia, L. G. (2008). Problem-based learning tools. *The Science Teacher*, *75*(8), 44. • Saberi, M., & Nouri, N. (2024). Promoting understanding of three dimensions of science learning plus nature of science using phenomenon-based learning. *Innovations in Science Teacher Education*. • Sterling, D. R. (2007). Modeling problem-based instruction. *Science & Children*, *45*(4). • Yoon, H., Woo, A. J., Treagust, D., & Chandrasegaran, A. L. (2014). The efficacy of problem-based learning in an

	Student teachers further define what a "phenomenon" is in science and how to formulate one that anchors effective teaching and learning in PhBL. They explore how PhBL holds the potential to engage students in learning about the natural world as scientists do, integrating all three dimensions of disciplinary content, SEPs and CCCs (Amplify Science, 2018; Saberi & Nouri, 2024). **Suggested Content Integration from Grades 9-12** (teacher educators should also integrate CCCs and SEPs within chosen content): • PBL: Water Pollution (Grade XI-XII) • PhBL: Environmental Chemistry (Grade IX)- Photosynthesis as a natural process to reduce carbon dioxide	analytical laboratory course for pre-service chemistry teachers. International Journal of Science Education, 36(1), 1–21. • Anderson, R. D. (2002). Reforming science teaching: What research says about inquiry. *Journal of Science Teacher Education, 13*(1), 1–12. https://doi.org/10.1023/A:1015171124982 • Amplify Science. (2018). What's so phenomenal about phenomena? An introduction to phenomenon-based learning. The Lawrence Hall of Science, University of California, Berkeley.
9-10	**Complex Pedagogical Planning II: Project Based Learning (PjBL) and STEAM** Student teachers experience and explore STEM/ STEAM and PjBL both of which are multi-layered, based in real-world contexts. Following on from their learnings in the previous sessions, student teachers reflect on and discuss where PjBL, STEM/STEAM, PBL and PhBL overlap and how they differ. PjBL: Through readings, student teachers explore how PjBL learning in chemistry centers on an extended, real-world project/task that culminates in a tangible product (still/working models, research-based designs, research reports, poster presentation) that requires 'application" of learning in science (Colley, 2008). STEAM/ STEM: At the outset, student teachers connect with their own ideas about STEM/ STEAM and then engage in experiencing STEAM. Through readings ,discussion and working on a problem, they apply and clarify their ideas on: • What is technology? (Childers, G., & Hite, R. (2022)) • What is a prototype? • The role of the engineering challenge in STEM/ STEAM • The nature of engineering challenges as open-ended challenges that lead to multiple solutions • Integration of "engineering" into chemistry through the Engineering Design Process (EDP).	• Childers, G., & Hite, R. (2022). The role of emerging technologies in science teacher preparation. In J. A. Luft & M. G. Jones (Eds.), *Handbook of research on science teacher education* (pp. 218–230). Routledge. • Dayo ,N., Alvi U., & Mujtaba, M(2020) IEEE, Mechanics of Digital Mathematics Games for Learning of Problem-Solving: An Extensive Literature Review Mechanics. • Ojeogwu, J., & Mumba, F. (2025). Preparing pre-service teachers in engineering design integrated science teaching: A systematic review. Journal of Science Education and Technology. https://doi.org/10.1007/s10956-025-10247-8 • Pahl, G., & Beitz, W. (1996). *Engineering design: A systematic approach* (K. Wallace, L. Blessing, & F. Bauert, Trans. & Eds.). Springer-Verlag. • Lammi, M., & Becker, K. (2013). *Engineering design thinking and systems thinking in high school students engaging in engineering design. Journal*

	• How and where is mathematics integrated in STEM? • How and where is art integrated in STEAM? (Bequette & Bequette, 2012) • Communication and Collaboration • Connections within science disciplinary content and with other disciplines As STEAM evolves from STEM, it involves blurring disciplinary boundaries to frame and solve problems—it involves thinking creatively and working on projects that aim at real-world inquiry integrating technology and design (Connor, Karmokar & Whittington, 2015). **Suggested Content Integration from Grades 9-12** (*teacher educators should also integrate CCCs and SEPs within chosen content)*: • Polymer-Organic Compounds (Grade IX-XII)- Design a Waste Reduce-Reuse-Recycle System Acids, Bases and Salts (Grade XI- XII)- Generating Electricity from Fruits Waste • Environmental Chemistry II: Water (Grade IX-X)- Designing water quality testing for chemical, metals and purification systems	*of Technology Education, 24*(2), 55–73. • Kroes, P. (2012). *Technical artefacts: Creations of mind and matter: A philosophy of engineering design.* Springer Science+Business Media B.V. • Ojeogwu, J., & Mumba, F. (2025). Preparing pre-service teachers in engineering design integrated science teaching: A systematic review. Journal of Science Education and Technology. https://doi.org/10.1007/s10956-025-10247-8 • Bequette, J. W., & Bequette, M. B. (2012). A place for art and design education in the STEM conversation. *Art education*, *65*(2), 40-47. https://doi.org/10.1080/00043125.2012.11519167 • Connor, A. M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for enhancing engineering and technology education. International Journal of Engineering Pedagogy, 5(2), 37–47.
11-12	**Assessments Approaches to Teaching Chemistry** Building on Formative assessment (assessment for learning) in Chemistry Course 1, this session specifically examines summative assessments (assessment of learning) and helps student-teachers see how they serve different but interconnected purposes. Through analysis of different summative assessment tools, techniques, methods and readings, student-teachers explore the purposes, types and limitations of assessment approaches commonly used in assessing student learning in Chemistry across Grades 9-12, and consider how these approaches influence conceptual understanding, scientific thinking skills, scientific literacy, SEPs, CCCS and higher order thinking in chemistry classrooms. STs also explore how to assess CCCs and SEPs which are integrated with the disciplinary content. This overview prepares STs to examine how assessment choices must be adapted and refined through topic-specific PCK (Fensham, P. J. (2022).	• Fives, H., & DiDonato-Barnes, N. (2013). Classroom test construction: The power of a table of specifications. Practical Assessment, Research & Evaluation, 18(3), 1–7. https://doi.org/10.7275/cztt-7109 • Anderson, L. W., Krathwohl, D. R., Airasian, P. W., Cruikshank, K. A., Mayer, R. E., Pintrich, P. R., Raths, J., & Wittrock, M. C. (2001). *A taxonomy for learning, teaching, and assessing: A revision of Bloom's taxonomy of educational objectives*. Longman. • Haladyna, T. M., Downing, S. M., & Rodriguez, M. C. (2002). A review of multiple-choice item-writing guidelines for classroom assessment. Applied

	The student teachers apply and design multiple forms of summative assessments for assessing student learning in the context of chemistry: • TOS Development and Expert Validation (Fives, H., & DiDonato-Barnes, N. (2013) • SLO Based and Blooms Cognitive Taxonomy Based SRQs and CRQs item Development, Review and Analysis • Designing of Marking Keys, rubrics, test marking, tabulation, analysis, reporting and SLO based feedback • Rubrics (Chen, H. J., She, J. L., Chou, C. C., Tsai, Y. M., & Chiu, M. H. (2013). • Observation-assessments and tools • e-assessments and digital tools • Performance and Authentic Assessment Tasks and Tools **Suggested Content Integration from Grades 9-12:** Any topic may be chosen to develop a summative assessment	Measurement in Education, 15(3), 309–334. • Shan, Y., Zheng, C., & He, P. (2025). Assessing chemistry teachers' understanding of electrochemistry. *Science & Education*. Advance online publication. https://doi.org/10.1007/s11191-025-00680-x • Fensham, P. J. (2022). The future curriculum for school science: What can be learnt from the past? Research in Science Education, 52(Suppl 1), S81–S102. https://doi.org/10.1007/s11165-022-10090-6 • Lopez-Perez, K., Benjamin, S.-A., & Veige, M. K. (2026). Outsmarting ChatGPT in chemistry: Using student-formulated questions for critical AI evaluation. *Journal of Chemical Education*. • Chen, H. J., She, J. L., Chou, C. C., Tsai, Y. M., & Chiu, M. H. (2013). Development and application of a scoring rubric for evaluating students' experimental skills in organic chemistry: An instructional guide for teaching assistants. Journal of Chemical Education, 90(10), 1296–1302. https:// doi. org/ 10. 1021/ed101 111g • Chowdhury, F. (2018). Application of rubrics in the classroom: a vital tool for improvement in assessment, feedback and learning. International Education Studies, 12(1), 61. https:// doi. org/ 10. 5539/ ies. v12n1 p61. • Dmoshinskaia, N., Gijlers, H., & de Jong, T. (2020). Giving feedback on peers' concept maps in an inquiry learning context: The effect of providing assessment criteria. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-020-09863-2

		• Clark, T. M. (2023). Investigating the use of an artificial intelligence Chatbot with general chemistry exam questions. Journal of Chemical Education, 100(5), 1905–1916. https://doi.org/10. 1021/acs.jchemed.3c00027 • POrtiz-López, A., Olmos-Migueláñez, S., & Sánchez-Prieto, J. C. (2024). Toward a new educational reality: A mapping review of the role of e-assessment in the new digital context. *Education and Information Technologies, 29*, 7053–7080. https://doi.org/10.1007/s10639-023-12117-5
13	**Teaching and Learning Chemistry in Out-of-School Science Contexts and Informal Learning Spaces.** Student teachers, through selected readings, explore how out-of-school contexts and informal learning spaces may enrich the learning by providing experiential learning in authentic and real-world contexts thus enhancing career aspirations, ideas about the nature of science (NOS), attitudes towards science, understandings of scientific content, confidence for doing science and intellectual development (Sadler, Burgin, McKinney & Ponjuan 2010). These experiences may include: • Visits to lakes, ponds, dams, water treatment RO plants to explore water treatment and to test the quality of water and purification methods-pH, turbidity, aeration, coagulation other methods • University centres and industry to explore how science is done in modern settings and applied at large scale-Chemical Labs and Industries such as, Petrochemical, Cosmetics, Soap, Perfume, Polymer, Cement, Fertilizer, Food , Pharmaceutical, Fuel Industries. • Museum and science centre programs to explore history, major developments and explore chemistry through interactive exhibits and interactions. • After-school STEM clubs, fairs and enrichment activities to explore the different activities, modes of communication, representations, careers and applications.	• Sadler, T. D., Burgin, S., McKinney, L., & Ponjuan, L. (2010). Learning science through research apprenticeships: A critical review of the literature. Journal of Research in Science Teaching, 47(3), 235–256. https://doi.org/10.1002/tea.20326 • Sunday, E. S., Samuel, H. S., Rickson, N. H., Musa, J., & Etim, E. E. (2023). Impact of green chemistry education on students' learning and environmental awareness in chemistry. *Journal of Chemical Education*. • Blum, C., Bunke, D., Hungsberg, M., Roelofs, E., Joas, A., Joas, R., Blepp, M., & Stolzenberg, H.-C. (2017). The concept of sustainable chemistry: Key drivers for the transition towards sustainable development. *Sustainable Chemistry and Pharmacy*, *5*, 94–104. https://doi.org/10. 1016/j.scp.2017.01.001 • Eaton, D. (2000). *Cognitive and affective learning in outdoor education* University of Toronto.

	Student-teachers reflect on the experience and discuss strategies to successfully implement out of school learning, and how to engage learners in SEPs and CCCs, problem-based/ hands-on inquiry, attitudes towards science, exploration of Socio-Scientific Issuesto foster deeper understanding of important science concepts. Student teachers, in groups, design learning materials for a visit to any selected out-of-school science context for enriching students' authentic learning. **Suggested Content Integration from Grades 9-12** (*teacher educator should also integrate CCCs and SEPs within chosen content)*: • Environmental Chemistry (IX-XI)-Effects of Pollutants on Water Quality • Industrial Chemistry (IX-XI) • Agriculture (IX-XII)- Chemistry of Fertilizers, risk of using pesticides and effect of acid rain on soil.	• Engl, A., & Risch, B. (2016). Natural chemistry-outdoors. *Green Teacher, 109*(1), 39–42. • Gilbertson, K., Ewert, A., Siklander, P., & Bates, T. (2022). *Outdoor education: Methods and strategies*. Human Kinetics. • Haraldsson, K., Göranson, M., & Lindgren, E.-C. (2024). "It is easier to learn when you are out": An ethnographic study of teaching science subjects through outdoor learning at compulsory school. *Journal of Outdoor and Environmental Education*. https://doi.org/10.1007/s42322-024-00172-6
14	**Practical Lab II** This session builds on Chemistry Lab I, in Chemistry Course I, where STs will review safety in the lab, process skills and examine how laboratory experiences can be structured along a continuum from guided to open inquiry-to-problem based labs with increasing student autonomy. Emphasis is placed on designing labs that require learners to apply SEPs—such as asking testable questions,defining design problems, developing models, planning investigations (with controls and variables), collecting, recording, analysing, interpreting data, making calculations, identifying systematic and random errors, and engaging in argument from evidence—while making explicit connections to CCCs such as patterns, cause and effect, systems and system models, energy and matter flows/conservation, structure and function and stability and change. **Suggested Content Integration from Grades 9-12:** • Acid Based and pH (Grade IX-XI-XII) Quantitative Analysis-Acid-Base and pH-Volumetric Analysis-Titration Experiments • Separation Techniques (Grade IX-XII) Standard Mixture Separation Techniques • Analytical Chemistry Labs-Qualitative Analysis –Identification Tests (Grade IX)- Metals, Non-Metals, Gases,	• Rutgers University Libraries. (n.d), Chemistry Laboratory Safety: Free Online Resources. https://libguides.rutgers.edu/chem_lab_safety/free_onlineEPA-United States Environment Protection Agency.(n.d). Tool Kit for Safe Chemical Management K-12 Schools, https://www.epa.gov/schools/toolkit-safe-chemical-management-k-12-schools • Wang, T., Wang, W., & Wei, J. (2022). Challenges encountered by student teachers in an inquiry-based laboratory process. Journal of Chemical Education, 99(12), 3954–3963 • Wei, B., & Liu, H. (2018). An experienced chemistry teacher's practical knowledge of teaching with practical work: the PCK perspective. • Hofstein, A., Navon, O., Kipnis, M., & Mamlok-Naaman, R. (2005). Developing students' ability to ask more and better questions resulting from inquiry-type chemistry laboratories. Journal of Research in Science Teaching, 42(7), 791–806.

	Oxidizing and Reducing agents, Melting and Boiling Points, • Functional Groups Tests (Grade XI) Organic Analysis Tests for identification of functional groups • Thermometric Analysis • Spectroscopy (Grade XI &XII)-Analyze Spectra and Use to Identify Compounds.(Ibrahim, H. A., Ali, D. S., & Fadhil, G. F. (2025)	• Sugiarti, S., Sulastri, T., & Wijaya, M. (2021). Analysis of activity improvement and student learning outcomes on salt hydrolysis through discovery model learning. *Journal of Physics: Conference Series, 1899*(1), Article 012138. https://doi.org/10.1088/1742-6596/1899/1/012138. • Hofstein, A., & Hugerat, M. (2021). The chemistry laboratory: From theory to practice. In *Teaching and learning in the school chemistry laboratory* (pp. 46–90). Royal Society of Chemistry. https://doi.org/10.1039/9781839164712-00046 • Ibrahim, H. A., Ali, D. S., & Fadhil, G. F. (2025). Enhancing chemistry education with smartphone technology: A simplified protocol for teaching absorption spectrophotometry. *Instruments and Experimental Techniques, 68*(5), 912–917.
15	**Microteaching, Feedback and Debriefing** This session engages STs in microteaching as a structured opportunity to enact PCK through chemistry lessons and reflect on practice. STs teach short segments from previously developed unit plans, receive focused peer and course facilitator feedback, and engage in guided debriefing. The session emphasizes reflective analysis of pedagogical decisions, and responsiveness to learners as key components of developing PCK.	• Albrechtsen, T.R.S., Kiær, K. (2025). A Pedagogy of Enactment: Creative Rehearsals and Feedback Literacy in Science Teacher Education. In: Svabo, C. Shanks, M., Zhou, C., Carleton, T. (eds) Creative Pragmatics for Active Learning in STEM Education. Contributions from Science Education Research, vol 14. Springer, Cham. https://doi.org/10.1007/978-3-031-78720-1_11 • Gourlay, H. (2022). Becoming a science teacher: Is it merely a process of trial and error? *Research in Science Education, 52*(6), 1677–1698. https://doi.org/10.1007/s11165-021-10023-9 • Li, X., Li, F., Chen, X., & Wang, L. (2024). Using reflection and dialog feedback to promote the development of situated and dynamic

		pedagogical content knowledge. *Disciplinary and Interdisciplinary Science Education Research, 6*, 23. https://doi.org/10.1186/s43031-024-00114-8
16	**Synthesis of the course** The student teachers will reflect on the entire experience and articulate the role and responsibilities of a 21st Century Secondary Chemistry Teacher. Using the following questions and excerpts from the reading the student teachers will identify, discuss, present key roles. (i) What is the nature of chemistry? What is the purpose of teaching chemistry? What should be taught and Why? (ii) How should chemistry be taught? Why? (iii) How do students learn and how does learning takes place? (iv) How is learning assessed? (v) What is the role of students and teachers? (vi) What are the supporting and hindering factors?	• Valtonen, T., Sointu, E., Kukkonen, J., Kontkanen, S., Lambert, M. C., & Mäkitalo-Siegl, K. (2017). TPACK updated to measure pre-service teachers' twenty-first century skills. Australasian Journal of Educational Technology, 33(3), 15. • Alvi, U., & Gioko, M (2010). Science Subject Leadership in the Enhancement of Information Communication Technology (ICT) Integration in Project Based Learning (PBL) in Khaki, J., &Safdar, Q. (Eds). Educational Leadership in Pakistan: Ideals and Realities. Karachi: Oxford University Press.

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination presenting student-teachers with subject-specific scenarios and requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exam Development (30%)

Student-teachers design a subject-specific summative examination intended for secondary learners, complete with a marking rubric and examiner's rationale. Each item must be accompanied by a written justification explaining the targeted learning outcome, cognitive level (using Bloom's Taxonomy), and how it assesses conceptual understanding rather than rote recall.
This demonstrates advanced PCK by requiring student-teachers to think from both the teacher's and learner's perspective simultaneously.

Course Outline

Course: Mathematics Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh Mathematics Curriculum IX–XII (DCAR, 2024)
Developed by:	Dr. Munira Amirali, AKU IED

Course description

This course lays a strong foundation for understanding and applying interactive pedagogical strategies to teach, learn, and assess mathematics in Grades IX–XII. Designed to enrich teachers' pedagogical content knowledge, it equips them to foster logical reasoning, conceptual understanding, procedural fluency, and effective problem-solving in their mathematics classrooms. Throughout the course, teachers will examine the essential features of a range of interactive pedagogies, exploring how different strategies align with mathematical concepts to make informed instructional decisions. This course will enable teachers to support students in achieving desired learning outcomes.

Course outcomes

1. Develop an understanding of the national Mathematics curriculum as well as national professional standards for teachers in Pakistan, along with their implications for teaching mathematics at the secondary level;
2. Analyze key features, strengths, and limitations of a range of interactive pedagogical approaches for teaching mathematics in Grades IX–XII.
3. Apply pedagogical content knowledge to design mathematics lessons that promote conceptual understanding, logical reasoning, procedural fluency, and problem-solving skills.
4. Evaluate the alignment between instructional strategies, mathematical content, and desired student learning outcomes to make informed pedagogical decisions.
5. Develop inquiry-based, technology-integrated, and contextually relevant instructional plans aligned with specific mathematical concepts.
6. Plan and implement interactive teaching practices to facilitate effective teaching and learning in mathematics classrooms.

Learning and teaching approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher- educators will model a range of pedagogical strategies commonly used in middle and high school mathematics classrooms—such as lecture, inquiry & problem-based pedagogies, technology integration, and use of manipulatives — allowing student-teachers to experience these approaches as learners first. This course employs a blend of independent, peer, and collaborative learning strategies to model interactive mathematics pedagogy. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, reflect on task design, problem-solving approaches, and pedagogical implications. enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching. Teachers will be engaged in focused mathematical tasks from the Grades 9–12 curriculum, working individually and in groups to analyze, discuss, and refine their learning processes. The course also includes hands-on and minds-on activities, critical exploration of open virtual learning resources, and opportunities to design instructional materials. Through microteaching and reflective practice, participants will strengthen their capacity to implement innovative and effective mathematics teaching approaches.

Semester outline

Week	Session Title and Brief Description [Pedagogy and suggested content/ concepts]	Suggested Readings and Relevant Resources
1	**Foundational Understanding** • Exploring student-teachers' experiences with learning mathematics and their personal understanding of what mathematics is. • Overview of the course, nature of assignments • Develop an understanding of the national curriculum Mathematics (https://dcar.gos.pk/ ; https://ncc.gov.pk/) as well as National Professional Standards for Teachers in Pakistan (https://www.nacte.org.pk/assets/download/NationalProfessionalStandardsforTeachersinPakistan.pdf) and National Council of Teachers of Mathematics (NCTM) (and other contexts along with their implications for teaching mathematics.	• Nancy Protheroe, 'What Does Good Mathematics Instruction Look Like?' https://www.naesp.org/sites/default/files/resources/2/Principal/2007/S-Op51.pdf • Richard Skemp Relational and instrumental understanding https://nrich.maths.org/content/id/8068/Skemp.pdf
2 & 3	**Inquiry-Based Strategy: Problem Identification → Exploration → Pattern Recognition → Reasoning** Teacher-educators guide student-teacherss through a structured cycle of exploration in which they first identify a mathematical idea or pattern and then investigate it through guided tasks. For example, when exploring rational and irrational numbers, student-teachers examine numerical patterns, test hypotheses using number lines or geometric models, and justify their conclusions through logical reasoning. Similarly, when working with algebraic structures such as matrices or complex numbers, student-teachers observe patterns in operations and relationships before formalizing rules. This approach supports deep conceptual understanding, encourages mathematical curiosity, and strengthens student-teachers' ability to reason, justify, and construct mathematical meaning independently. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students through an Inquiry-Based Strategy • Real Numbers (IX) • Complex Numbers (X) • Sets and Functions (IX) • Loci (IX)	Vasuki, M., Celestin, M., & Kumar, A. D. (2016). Exploring the role of inquiry-based learning in mathematics education. *Journal of Engineering, Scientific Research and Applications, 2*(2), 193-206. https://www.researchgate.net/profile/A-Dinesh-Kumar-2/publication/391156838_Exploring_the_Role_of_Inquiry-Based_Learning_in_Mathematics_Education/links/680be9dfbd3f1930dd642693/Exploring-the-Role-of-Inquiry-Based-Learning-in-Mathematics-Education.pdf

	• Matrices and Determinants (X) • Probability (IX) • Relative and Expected Frequencies (IX) • Sequences and Series (XI) • Mathematical Induction (XI) • Binomial Theorem (XI) • Fundamental Law of Trigonometry (XI)	
4 & 5	**Exploring Students' Errors and Misconceptions in Mathematical Concepts & their Remediation** Teacher-educators guide student-teachers in systematically examining students' errors to uncover underlying misconceptions in mathematical concepts. Identifying student math errors is essential because misunderstandings in mathematics' abstract concepts can impede the development of problem solving, logical reasoning, and effective decision-making skills**.** Student-teachers analyze samples of student work, for example, errors in fractions, algebraic manipulation, or interpretation of graphs, to identify patterns in thinking rather than treating mistakes as isolated incidents. They then design targeted interventions such as concept-focused explanations, alternative representations, or guided practice to address these misconceptions. Through reflection and discussion, student-teachers develop the ability to anticipate common errors, respond constructively, and adapt instruction to support conceptual clarity. This approach strengthens diagnostic teaching skills, promotes responsive pedagogy, and enhances learners' deeper understanding of mathematics. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while exploring students' errors and misconceptions: • Linear Equations and Inequalities (IX) • Real Numbers (IX) • Complex Numbers (X) • Sets and Functions (IX) • Mathematical Induction (XI) • Fundamental Law of Trigonometry (XI) • Laws of Logarithms (XII)	• Baybayon, G. G., & Lapinid, M. R. C. (2024). Students' common errors in quadratic equations: Towards improved mathematics performance. *Infinity Journal*, *13*(1), 83-98. • Hoth, J., Larrain, M., & Kaiser, G. (2022). Identifying and dealing with student errors in the mathematics classroom: Cognitive and motivational requirements. Frontiers in psychology, 13, 1057730. • Sarwadi, H. R. H., & Shahrill, M. (2014). Understanding students' mathematical errors and misconceptions: The case of year 11 repeating students. Mathematics Education Trends and Research, 2014(2014), 1-10.
6 & 7	**Technology-Integrated Strategy: Using Excel & GeoGebra for Mathematical Modelling** Student-teachers incorporate digital tools such as Excel and GeoGebra to support dynamic exploration and visualization of mathematical relationships. In Excel, they input real-world or textbook data, generate graphs, and apply built-in statistical or algebraic functions to verify	• Viberg, O., Grönlund, Å., & Andersson, A. (2023). Integrating digital technology in mathematics education: a Swedish case study. *Interactive Learning Environments*, *31*(1), 232-243. https://www.tandfonline.com/d

	manual calculations. In GeoGebra, they manipulate sliders to observe how parameters influence the shape of linear, quadratic, or polynomial functions, investigate loci in conics, or visualize transformations in coordinate geometry. Technology enables learners to handle large datasets, test multiple representations quickly, and explore mathematical behaviour that may be difficult to observe manually. This strategy enhances computational fluency, promotes inquiry, and prepares students for data-driven and technology-rich environments. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in the Technology-Integrated Strategy: • Coordinate Geometry (IX) • Frequency Distribution (IX) • Relative and Expected Frequencies (IX) • Functions and Graphs (X) • Chords and Arcs of Circle (X) • Tangents and Angles in a Circle (X) • Complex Numbers (XI – Argand Plane) • Graphs of Trigonometric Functions (XI) • Functions and Graphs (XII) • Conics (XII) • Numerical Solution of Nonlinear Equations (XII) • Conics	oi/pdf/10.1080/10494820.2020.1770801 • Rakes, C. R., Stites, M. L., Ronau, R. N., Bush, S. B., Fisher, M. H., Safi, F., ... & Viera, J. (2022). Teaching mathematics with technology: TPACK and effective teaching practices. *Education Sciences*, *12*(2), 133. https://www.mdpi.com/2227-7102/12/2/133
8 & 9	**Planning for teaching and Formative Assessment** Engaging students in mathematical thinking requires creating an environment where ideas are shared, questioned, and reflected upon rather than simply answered. Using strategies such as KWL (Know–Want to Know–Learned) charts, Think–Pair–Share, Number Talks, student-teachers can activate prior knowledge, express their reasoning, compare solution strategies, and reflect on what they have learned. These approaches shift mathematics from a silent, answer-driven experience to one of dialogue and exploration, enabling students to build deeper conceptual understanding and confidence in expressing mathematical ideas. Also, different approaches to lesson planning - inductive-deductive, 5E model, and Assessment Techniques in Mathematics (Formative, Diagnostic) will be discussed. Student-teachers will select the SLOs and design a lesson plan, develop resources, design worksheets, etc., and seek peer and teacher-	• Thompson, C., Spenceley, L., Tinney, M., Battams, E., & Solomon, A. (2024). *The ultimate guide to lesson planning: Practical planning for everyday teaching*. Routledge. • Farrell, T. S. (2002). Lesson planning. *Methodology in language teaching: An anthology of current practice*, *11*(2), 30-39. • Moh'd, S. S., Uwamahoro, J., & Orodho, J. A. (2022). Analysis of Mathematics Lesson Planning Framed by the Teachers' Pedagogical Content Knowledge. *European Journal of Educational Research*, *11*(2), 1161-1182. • Iyanda, F. O., & Sam-Kayode, C. O. (2023). Investigating the

	educator feedback before implementing in the real classroom.	effects of inductive and deductive teaching strategies on students' learning in basic general mathematics: Implication for sustainable development. *International Journal of Research and Innovation in Applied Science*, *8*(12). DOI: https://doi.org/10.51584/IJRIAS.2023.81210
10 & 11	**Hands-On and Virtual Manipulatives Strategy: Concrete Exploration → Abstract Generalization** Student-teachers use concrete materials—such as geometric tools, paper folding, algebra tiles, string models for conics, or virtual manipulatives—to help students build intuitive understanding before formalizing mathematical ideas. For example, when teaching properties of circles, student-teachers construct chords, tangents, and arcs using a compass and ruler before identifying their properties. Similarly, dotted grids and area models help student-teachers reason about irrational numbers, while 3D models support the learning of vectors and spatial geometry. By physically manipulating objects or dynamically exploring virtual models, student-teachers bridge the gap between concrete experiences and abstract concepts. This strategy strengthens visualization, supports diverse learners, and anchors abstract mathematics in meaningful experiences. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in Hands-On and Virtual Manipulatives Strategy: • Geometrical Properties of Polygons, Triangles, Parallelograms (IX) • Construction of Triangles (IX) • Similar Figures (IX) • Practical Geometry of Circles (X) • Tangent of the Circle (X) • Vector in Space (XI – 3D models) • Conics (XII – string and pin models)	Durmuş et al. (2006). Virtual manipulatives in mathematics education: a theoretical framework [Academic]. *The Turkish Online Journal of Educational Technology, 5*(1), 117–118. https://files.eric.ed.gov/fulltext/EJ1102492.pdf
12 & 13	**Lecture-based Strategy** Student-teachers use direct instruction to introduce concepts that require formal derivations, precise definitions, or systematic	Macaranas, J. R. G. (2022). Appreciating the lecture method. *Philosophia: International Journal of Philosophy*, *23*(1), 218-224. https://www.researchgate.net/profile/Ju

	procedures. For instance, when teaching calculus, logarithms, or the binomial theorem, learners benefit from clear modelling of rules, step-by-step demonstrations, and structured examples that highlight underlying principles. The teacher provides explicit explanations, solves representative problems, and gradually scaffolds students toward independent work. Lecture-based instruction is also used to address common misconceptions—for example, misunderstandings about ratio and proportion or incorrect interpretations of limits. This strategy ensures procedural accuracy, builds fluency in symbolic manipulation, and supports learners in mastering mathematically demanding content. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in the Lecture-based Strategy: • Factorization (IX) • Real Numbers – Theoretical Properties (IX) • Algebraic Fractions (X) • Angle Between Lines (X) • Complex Numbers – Formal Operations (XI) • Matrices & Determinants – Algorithms (XI) • Division of Polynomial (XI) • Laws of Logarithms (XII) • Introduction to Differentiation (XII) • Integration (XII)	an-Macaranas/publication/358227941_Appreciating_the_Lecture_Method/links/62c6e46fcab7ba7426d8d5b1/Appreciating-the-Lecture-Method.pdf
14	**Pattern Seeking Strategy** Use digital platform (GeoGebra) to teach Linear, quadratic, and polynomial functions; Graphical representation of functions; Systems of equations and inequalities. Student-teachers are engaged in examining numerical, algebraic, or geometric patterns to help them derive general rules. For example, they explore sequences, experiment with expansions leading to the binomial theorem, or analyze changes in function graphs as parameters vary. By systematically observing regularities, testing conjectures, and articulating generalizations, they construct a deeper understanding of mathematical structure. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in the pattern-seeking strategy:	Taher, A. B., Mamouni, M. I., & El Wahbi, B. (2023). The generalization as a tool to develop the algebraic thinking process. *Journal of Hunan University Natural Sciences*, *50*(2), 159-166 https://jonuns.com/index.php/journal/article/viewFile/1304/1298

	• Sequences and Series (XI) • Binomial Theorem (XI) • Functions and Graphs – Parameter Variation (X, XII) • Trigonometric Functions – Periodicity and Symmetry (XI) • Real Numbers – Decimal Patterns (IX)	
15	Micro teaching, reflection and course tutor feedback	
16	Course overview Final examination	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination (90 minutes) presenting student-teachers with subject-specific scenarios requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exploring Student Conceptions — Elicitation, Analysis, and Remediation (30%)

Student-teachers design a theory-informed alternative framework/ misconceptions elicitation tool for a selected Grades 9–12 curriculum topic, then conduct interviews with 4–6 students to surface their existing conceptions. They analyse the data to identify patterns in student thinking and present findings and remediation strategies, supported by relevant literature, in the form of an oral presentation or a written report.

Course Outline

Course: Mathematics Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh Mathematics Curriculum IX–XII (DCAR, 2024)
Developed by:	Dr. Munira Amirali, AKU IED

Course description

This course deepens teachers' advanced pedagogical expertise for teaching mathematics in Grades IX–XII. Grounded in the history of mathematics and the contributions of Muslim mathematicians, it strengthens teachers' ability to use interactive pedagogical strategies for effective teaching, learning, and assessment. Emphasizing diagnostic assessment, error analysis, task design, and equitable teaching practices, the course supports the development of students' logical reasoning, conceptual understanding, procedural fluency, and problem-solving skills. Teachers will explore how learners construct and misconstrue mathematical ideas across number and operations, algebra, geometry, trigonometry, and statistics. Through inquiry-based discussions, analysis of student thinking, and reflective practice, participants will enhance their capacity to design rigorous, inclusive, and conceptually rich mathematics learning environments that promote meaningful and lasting learning outcomes.

Course outcomes

1. Explore major developments in the history of mathematics, from early civilizations such as the Egyptians and Babylonians, to support students' understanding of how mathematical ideas evolved over time.
2. Identify key contributions of Muslim mathematicians and incorporate these insights into mathematics instruction.
3. Analyze common student misconceptions across major mathematics domains (IX–XII)
4. Apply pedagogical content knowledge to design mathematics lessons that promote conceptual understanding, logical reasoning, procedural fluency, and problem-solving skills.
5. Develop inquiry-based, technology-integrated, and contextually relevant instructional plans aligned with specific mathematical concepts.
6. Plan and implement interactive teaching practices and assessment methods to facilitate effective teaching and learning in mathematics classrooms.

Learning and teaching approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher- educators will model a range of pedagogical strategies commonly used in middle and high school mathematics classrooms, such as misconception remediation, mathematical discourse, project-based learning, and CPA, allowing student-teachers to experience these approaches as learners first. This course uses dialogic, analytical, and practice-based approaches to strengthen mathematics teaching. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings. A blend of independent, peer, and group learning model interactive pedagogy as participants work on focused mathematical tasks from the Grades 9 -12 curriculum. Whole-class discussions, hands-on and minds-on activities, and exploration of virtual resources deepen reflection on task design and instructional decisions. Through microteaching, instructional rehearsals, and peer critique, teachers connect theory to practice, interpret student thinking, design equitable tasks, and refine instructional moves to meet diverse learners' needs.

Semester outline

Week	Session Title and Brief Description [Pedagogy and suggested content/ concepts]	Suggested Readings and Relevant Resources
1 & 2	**Revisiting key learning from Course I** **Course II Introduction** **Nature of Assignments** The session will begin by revisiting key learning from Course I to help student-teachers connect prior knowledge with the new focus of Course II. This will be followed by an introduction to the course structure, objectives, and expectations. Student-teachers will also engage in a discussion on their completed assignments, using this as an opportunity to reflect on learning and set goals for their continued professional growth**.**	Course Outline II
	History of Mathematics Explore key concepts of the school Mathematics curriculum by placing them into a wider historical context within and across various civilizations. Key developments in the history of mathematics, such as Egyptian unit fractions, Babylonian base-60 numeration, and Greek geometric reasoning, would build understanding of how mathematical ideas evolved.	• Liu, P. H. (2003). Connecting research to teaching: Do teachers need to incorporate the history of mathematics in their teaching? *Mathematics Teacher*, *96*(6), 416-421. • Dejić, M., & Mihajlović, A. M. (2014). History of mathematics and teaching mathematics. *Innovations in Teaching-Journal of Contemporary Teaching*, *27*(3), 15-30
3	**Muslim Mathematicians** Teacher-educators engage student-teachers in exploring the contributions of Muslim mathematicians such as Al-Khwarizmi, Omar Khayyam, and Al-Biruni. Student-teachers examine key ideas, such as the development of algebra, solutions of cubic equations, and advances in trigonometry, and connect them to concepts taught in secondary mathematics. Through guided inquiry and discussion, they recognize mathematics as a historically evolving discipline shaped by diverse cultures. This approach builds conceptual understanding, fosters appreciation of intellectual traditions, and supports meaningful integration of historical perspectives into mathematics teaching.	Maulidina, N., & Fahmy, A. F. R. (2022, October). Contribution Muslim scientists in the development of mathematics. In *Proceeding International Conference on Islam and Education (ICONIE),* 2(1). 1103-1110.
4 & 5	**Case-Based / Problem-Based Strategy: Analyzing Situational Cases Using Systematic Representation** Teacher-educators present student-teachers with authentic, context-rich cases such as attendance trends in a school, income variation in a community, or navigation tasks involving bearings and trigonometry to extract meaningful mathematical information. Student-teachers	• Boye, E. S., & Agyei, D. D. (2023). Effectiveness of problem-based learning strategy in improving teaching and learning of mathematics for pre-service teachers in Ghana. *Social Sciences & Humanities Open*, *7*(1),

	interpret the scenario, organize the given data using tables or graphs, identify patterns, and apply relevant mathematical tools such as probability rules, coordinate geometry concepts, or combinatorial reasoning. Through systematic case analysis, they learn to connect mathematical ideas with real situations, develop data literacy, and justify conclusions based on evidence. This strategy enhances problem-solving, promotes analytical reasoning, and strengthens students' confidence in applying mathematics beyond the classroom. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in a case-based / problem-based strategy: • Linear Equations and Inequalities (IX) • Coordinate Geometry (IX) • Trigonometry (IX) • Bearings (IX) • Measure of Central Tendency (IX) • Probability of Combined Events (X) • Permutation and Combination (XI) • Vector in Space (XI) • Scalar Triple Product (XI) • Application of Derivatives (XII) • Mechanics: Kinematics (XII) • Differential Equations (XII) Analytical Geometry: Concurrency of Lines (XII)		100453. https://www.sciencedirect.com/science/article/pii/S259029112300058X • Widyatiningtyas, R., Kusumah, Y. S., Sumarmo, U., & Sabandar, J. (2015). The impact of the problem-based learning approach on senior high school students' mathematics critical thinking ability. *Indonesian Mathematical Society Journal on Mathematics Education, 6*(2), 30-38.
6-7	**Concrete-Pictorial-Abstract (CPA) Approach** Building on course I, student-teachers will be engaged in further exploring different concepts suitable to explore using CPA approach. This approach enhances visualization, supports diverse learning needs, and grounds abstract mathematics in experiences that are accessible and conceptually rich. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in CPA Approach: • Geometrical Properties of Polygons, Triangles, Parallelograms (IX) • Construction of Triangles (IX) • Similar Figures (IX) • Practical Geometry of Circles (X) • Tangent of the Circle (X) • Vector in Space (XI – 3D models) • Conics (XII – string and pin models)		• Bandahala, D. E. (2024). Explicit instruction in teaching general mathematics and the application of concrete-pictorial-abstract approach. *International Journal of Multidisciplinary Research and Analysis*, *7*(10), 4832-4845. • Iyamuremye, E., & Burns, D. (2025). Concrete-Pictorial-Abstract instruction: Enhancing students' learning motivation and achievement in mathematics. *Cogent Education, 12*(1), 2558303.

8 & 9	**Summative & Alternate Assessments in Mathematics** Teacher-educators guide student-teachers in understanding and applying both summative and alternate forms of assessment in mathematics classrooms. Student-teachers design summative assessments such as tests or exams to evaluate learners' conceptual understanding and procedural fluency, while also exploring alternate assessments such as projects, portfolios, presentations, and math investigations that capture deeper understanding and problem-solving processes. For example, student-teachers may create tasks where learners explain their reasoning, model real-world situations, or present multiple solution strategies. Through analysis and reflection, they learn to align assessments with learning goals and use feedback to support student improvement. This approach promotes balanced assessment practices, values diverse ways of demonstrating learning, and strengthens student-teachers' ability to assess mathematics meaningfully.	• Brownlie, N., Burke, K., & van der Laan, L. (2024). Quality indicators of effective teacher-created summative assessment. *Quality Assurance in Education*, *32*(1), 30-45. • Zana, F. M., Sa'dijah, C., Susiswo, L. A., & Zulnaidi, H. (2024). Curriculum and teacher assessment practices in mathematics learning: Alignment with higher order thinking skills in Indonesian secondary schools. *Journal on Mathematics Education*, *15*(4), 1311-1334. • Orongan, R. C., Manual, A. A., Orongan, M. J. Q., Gamutan, L. V., & Vegafria, J. C. (2024, November). Analysis on teachers' summative assessment in basic secondary education. In *Proceedings of the 4th International Conference on Education and Technology (ICETECH 2023)* (p. 443). Springer Nature.
10 & 11	**Mathematical Discourse: Creating a "Talk-Productive" Classroom** Teacher-educators guide student-teachers in creating talk-productive mathematics classrooms by using structured discourse practices. Student-teachers learn to anticipate possible student responses, monitor their thinking during tasks, and strategically select and sequence responses to highlight key mathematical ideas before connecting them to formal concepts. They also focus on the purposeful use of mathematical vocabulary and the gradual introduction of formal terminology to support clarity and precision. For example, while teaching secondary-level topics, student-teachers encourage learners to explain their reasoning, compare solution strategies, and justify conclusions using appropriate language. Attention is also given to the increasing complexity of concepts in the national mathematics curriculum from Grades IX to XII and how discourse can support understanding. This approach strengthens communication, deepens conceptual learning, and equips student-teachers to facilitate meaningful mathematical discussions in diverse classrooms.	• Jacobs, J., Scornavacco, K., Harty, C., Suresh, A., Lai, V., & Sumner, T. (2022). Promoting rich discussions in mathematics classrooms: Using personalized, automated feedback to support reflection and instructional change. *Teaching and Teacher Education*, *112*, 103631. • Borger, L. C. (2025). Number talks to promote discourse in the algebra 1 classroom: A number talk curriculum development for a unit on quadratic expressions. Master's Theses/Capstone Projects. 136. https://digitalcommons.otterbein.edu/stu_master/136 • Thompson, P., Paatsch, L., & Nolan, A. (2025). Understanding the talk patterns in secondary school classrooms. *Language and Education*, *39*(2), 489–511. https://doi.org/10.1080/09500782.2024.2343292

12 & 13	**Project-Based Learning in Mathematics** Teacher-educators engage student-teachers in designing and implementing interdisciplinary projects that connect mathematics with other subjects such as science, social studies, or economics. Student-teachers develop projects where learners investigate real-world problems—for example, analyzing population growth using exponential functions, studying motion through graphs in physics, or examining budgeting and financial literacy in everyday contexts. Through sustained inquiry, data collection, and application of mathematical concepts, learners construct meaningful connections across disciplines. Student-teachers also guide learners in presenting their findings using mathematical representations and clear explanations. This approach promotes deeper understanding, enhances relevance of mathematics, and develops problem-solving, collaboration, and communication skills.	• Bohara, P. S. (2024). Supporting teachers in implementing project-based learning in teaching secondary mathematics: An action research. *Advances in Mobile Learning Educational Research*, *4*(2), 1122-1134. • Rehman, N., Huang, X., & Mahmood, A. (2025). Altering students' attitude towards learning mathematics through project-based learning: A mathematics project. *South African Journal of Education*, *45*(1), 1-14.
14	**Technology-Integrated Strategy: Using Geogebra, Desmos and Polypad for Exploring Mathematical Concepts such as Theorems, Exponential Functions** Building on course-I, student-teachers explore GeoGebra, Desmos and Polypad to support dynamic exploration and visualization of mathematical relationships in theorems, functions and other mathematical concepts. **Suggested Content Integration from Grades 9-12:** The suggested content below can be used while engaging students in Technology-Integrated Strategy: • Coordinate Geometry (IX) • Frequency Distribution (IX) • Relative and Expected Frequencies (IX) • Functions and Graphs (X) • Chords and Arcs of Circle (X) • Tangents and Angles in a Circle (X) • Complex Numbers (XI – Argand Plane) • Graphs of Trigonometric Functions (XI) • Functions and Graphs (XII) • Conics (XII) • Numerical Solution of Nonlinear Equations (XII) • Conics	• Chechan, B., Ampadu, E., & Pears, A. (2023). Effect of using Desmos on high school students' understanding and learning of functions. *Eurasia Journal of Mathematics, Science and Technology Education*, *19*(10), em2331. • Pllana, D., Baez, R., Sanchez, H., & Sandeep, N. (2024). Technology inspires mathematical creativity in high school. *Futurity Education*, *4*(3), 309-333. • Tay, M. K., & Wonkyi, T. M. (2018). Effect of using GeoGebra on senior high school students' performance in circle theorems. *African Journal of Educational Studies in Mathematics and Sciences*, *14*, 1-18. • Tuda, S., & Rexhepi, S. (2023). Exploring exponential functions using GeoGebra. *Brillo Journal*, *3*(1), 43-58. • Manana, S., & Simons, M. (2026). The Use of GeoGebra as an instrument to facilitate grade 11 learners' understanding of cyclic quadrilateral and tangent

		theorems: A case study. *Futurity Education*, *6*(1), 162-180. • Mendoza, J., Pati, R. C., Villena, J., Aduana, C. J., & Elipane, L. (2018). Integrating GeoGebra in teaching inscribed angle theorem and its proof: A lesson study. In *INTED2018 Proceedings* (pp. 8670-8675). IATED.
15	Micro teaching, reflection and course tutor feedback	
16	Course overview Final examination	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination presenting student-teachers with subject-specific scenarios and requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exam Development (30%)

Student-teachers design a subject-specific summative examination intended for secondary learners, complete with a marking rubric and examiner's rationale. Each item must be accompanied by a written justification explaining the targeted learning outcome, cognitive level (using Bloom's Taxonomy), and how it assesses conceptual understanding rather than rote recall.
This demonstrates advanced PCK by requiring student-teachers to think from both the teacher's and learner's perspective simultaneously.

Course Outline

Course: Social Sciences Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh Pakistan Studies Curriculum IX–XII (DCAR) National Curriculum of Pakistan for History, Geography, Sociology, Civics, Education
Developed by:	Rana Hussain, Ziauddin University

Course Overview

This 16-week course equips participants with targeted pedagogies for teaching Pakistan studies as a compulsory subject, and Civics, Sociology, World History, Education, and Geography to Grades IX- XII as electives. It focuses on how disciplinary knowledge is transformed into meaningful classroom instruction through inquiry, discussion, visual analysis, simulations, research, and field-based learning. Student-teachers critically examine curricula and textbooks, design lesson plans using deductive, inductive, and field-based approaches, and reflect on pedagogical choices. The course culminates in microteaching, where student-teachers apply selected pedagogies to teach short lessons, receiving feedback to strengthen instructional planning, delivery, and reflective teaching practice.
Each session in this course includes a choice of topics that may be used by teacher-educators to showcase/ model the pedagogical theme of that respective week. However, these are only suggestive, and teacher-educators may use any other topics from Pakistan Studies, Civics, Sociology, World History, Geography, Civics and Sociology, that integrate well with a given pedagogy.

Course Learning Outcomes

1. Analyze secondary-level social sciences curricula and textbooks to identify disciplinary aims, key concepts, and pedagogical implications for classroom teaching.
2. Apply a range of social science pedagogies—including inquiry-based learning, role-play, visual analysis, research, and field-based approaches—to design effective lesson plans for Grades IX–XII.
3. Demonstrate pedagogical reasoning by selecting appropriate teaching strategies to address social issues, diverse perspectives, and learners' contexts in Pakistan.
4. Practice teaching Social Science subjects in grades 9-12.

Teaching and Learning Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher- educators will model a range of pedagogical strategies commonly used in middle and high school social science classrooms—such as lecture, inquiry & discussion, roleplay, visuals tools, mapping skills, oral histories, and research — allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester Outline

Week	**Session Title and Brief Description** [Pedagogy and suggested content/ concepts]	**Suggested Readings and Relevant Resources**
1	This introductory session lays the foundation for teaching Pakistan Studies, World History, Geography, Civics, Sociology and Education. Together, these subjects equip students to understand how societies function, how people interact with their environments, and how social identities, inequalities, and public issues are shaped over time. These subjects help students interpret historical and contemporary realities, evaluate information and narratives, and make informed decisions as citizens in a changing society. In this introductory session, the curriculum of each subject will be discussed, especially the philosophy of each curriculum, by asking student-teachers to identify standards, benchmarks, learning outcomes, and 21st century skills for each subject in grades 9-12.	**Pakistan Studies** • Grades IX–X (2019): https://dcar.gos.pk/Sindh-Curriculum/Pakistan%20Studies%20Grade%20IX-X-2019-2020-Revised.pdf • Grades XI–XII (2021): https://dcar.gos.pk/Sindh-Curriculum/Advanced%20Pak%20Studies%20Grade%20XI-XII%20%202021%20with%20Notified.pdf **Civics** • Grades IX–X (2009): https://dcar.gos.pk/National_Curriculum/Civics%20IX-X-XI-XII.pdf • Grades XI–XII (2022): https://ncc.gov.pk/SiteImage/Misc/files/20-Civics.pdf **Sociology** • Grades XI–XII (2022): https://ncc.gov.pk/SiteImage/Misc/files/22-Sociology.pdf **Geography** • Grades IX–X (2009): https://examinationboard.aku.edu/learning-materials/Publication/SSC-H-Geography.pdf **World History** • Grades XI–XII (2022): https://ncc.gov.pk/SiteImage/Misc/files/17-History%20of%20the%20Modern%20World.pdf **Education** • Grades IX–XII (2022): https://ncc.gov.pk/SiteImage/Misc/files/78-%20Education.pdf • Smith, M. K. (2000). *Curriculum: Theory and practice*. The Encyclopedia of Pedagogy and Informal Education. https://infed.org/dir/welcome/curriculum-theory-and-practice/ • National Council for the Social Studies. (2023). *Powerful teaching and learning in social*

		studies: A position statement of the National Council for the Social Studies. https://www.socialstudies.org/position-statements/powerful-teaching-and-learning-social-studie • UNESCO International Bureau of Education. (2016). What makes a quality curriculum? (Current and critical issues in the curriculum and learning, Vol. 2). https://unesdoc.unesco.org/ark:/48223/pf0000243975
2 & 3	**Inquiry-Based Learning & Teacher Questioning** Inquiry-Based Learning in social sciences is an approach where students explore real social questions by examining sources, discussing perspectives, and constructing evidence-based explanations rather than memorizing facts. This pedagogy encourages critical thinking, questioning, and problem-solving, making it applicable to all social sciences subjects. It helps students develop research skills and think independently. Teacher questioning in social science pedagogy is a strategy where teachers use purposeful, open-ended questions to guide students to think critically about social issues, examine evidence, compare perspectives, and justify their ideas rather than simply recall facts. To model inquiry-based learning, teacher educators can use guiding questions, encourage student-teacher questioning, and provide resources for student-teachers to investigate and present their findings. **Suggested Content Integration from Grades 9-12:** Civics: • Domain E: Democracy and Democratic Process *(Grades XI-XII)* • Domain H: Conflicts and conflicts resolution *(Grades XI-XII)* Pakistan Studies • Constitutional and Political Developments in Pakistan *(Grades: IX—XII)*	• Aashamar, P. N., & Mathé, N. E. H. (2025). *Inquiry in social studies and social science: Linking teachers' perspectives and classroom practice*. *Nordic Journal of Comparative and International Education, 9*(4). https://doi.org/10.7577/njcie.6284 • Cambridge University Press & Assessment. (2023). *Inquiry-based learning: Make your classroom more inclusive.* https://www.cambridge.org/elt/blog/2023/01/08/inquiry-based-learning-make-your-classroom-more-inclusive/ • Edutopia. (2024). *7 strategies to captivate students in history class.* https://www.edutopia.org/article/captivate-students-history-class/ • Schools That Lead. (2025). *How to use inquiry-based learning in the classroom.* https://www.schoolsthatlead.org/blog/how-use-inquiry-based-learning/
4	**Role-Play and Simulation** Role-play and simulation in social science pedagogy involve students acting out real social, political, or historical situations to understand perspectives, decision-making, and the consequences of actions. This pedagogy enhances	• Stephens, J. M., Feinberg, J. R., & Zack, J. (2013). *Those who do: Social studies teachers' use of role play and simulations and the making of 21st century*

	students' understanding of different perspectives, and develops their empathy and communication skills.
	Teacher-educators can design scenarios, assign roles, and facilitate role-play and debriefing discussions with student-teachers.
	
	Suggested Content Integration from Grades 9-12:
	• Civics: Domain D Conflict and Conflict Resolution *(Grade XI)*
	• Education: Design and execute a roleplay to demonstrate the importance of education in fostering social cohesion in our society. *(Grade X)*
	• Pakistan studies
	  ○ Geography: (Economic Activities and & Resources and Economic development of Pakistan (*Grade IX-XII)*
	  ○ History: Nehru Report and fourteen points of Quaid-e-Azam as response *(Grade IX-XII)*
		citizens. In *The status of social studies* (pp. 259–275). Information Age Publishing.
		• Clapper, T. C. (2010). *Role play and simulation: Returning to teaching for understanding*. **Education Digest**, *75*(8), 39–43
		• Blea, C., & Bolick, C. M. (2013). Teaching social studies in middle and secondary schools (pp. 125-128). Pearson.

5 & 6	**Graphic Organizers** In social studies education, graphic organizers are visual tools that help students organize information, see relationships, and make sense of complex content. They are particularly useful because social studies involves multiple disciplines—history, geography, civics, economics—where students must connect events, ideas, causes, and consequences. Graphic organizers can help students summarize information, compare and contrast concepts, sequence events, analyze cause and effect, and categorize ideas. Some common types of graphic organizers in social studies include: • Timelines – for sequencing historical events and understanding chronology. • Venn diagrams – for comparing and contrasting ideas, cultures, or events. • Cause-and-effect charts – for analyzing relationships between actions, decisions, and outcomes. • Concept maps – for showing connections between ideas, such as the causes of a social movement or the branches of government. • T-charts – for weighing pros and cons or examining differing perspectives. This visual approach helps students understand relationships between concepts. It develops organizational and critical thinking skills.	• Romero, C., Cazorla, M., & Buzón, O. (2017). *Meaningful learning using concept maps as a learning strategy*. *Journal of Technology and Science Education, 7*(3), 313–332. https://doi.org/10.3926/jotse.276 • Novak, J. D., & Cañas, A. J. (2008). *The theory underlying concept maps and how to construct and use them*. Institute for Human and Machine Cognition. https://cmap.ihmc.us/docs/theory-of-concept-maps • Graduate Programs for Educators. (2025). *Effective graphic organizers for student learning*. GraduatePrograms.org. https://www.graduateprogram.org/blog/effective-graphic-organizers-for-student-learning/ • Athuraliya, A. (2024). *20 types of graphic organizers for teachers and students + free templates*. Creately. https://creately.com/guides/types-of-graphic-organizers/

	Teacher-educators can introduce various organizers, and guide student-teachers to create and present their organizers.
	
	Suggested Content Integration from Grades 9-12:
	Concept Maps:
	• Sociology:
	  o Domain D: Social institutions *(Grade XI- XII)*
	  o Domain E: Human societies *(Grade XI- XII)*
	• Geography: Population: Migration and types of migration *(Grade X)*
	
	Timelines:
	• Sociology: Classify various forms of human societies such as a] Hunting and gathering Societies b] Pastoral and horticultural Societies c] Agricultural Societies d] Industrial Societies e] Post Industrial or Information Societies *(Grade XI- XII)*
	• World History: Briefly outline independence attempts by various European countries, especially the Unification of Germany and Italy (1871), as a result of the ideology of nationalism that permanently changed Europe. *(Grades XI- XII)*
	• Pakistan Studies: Era of Political instability (1988 -1999) *(Grades XI- XII)*
	
	Cause-and-effect:
	• World History: Deconstruct the reasons for the French Revolution (1789) and its impact on the society and culture of Modern Europe. *(Grades XI- XII)*
	• Pakistan Studies *(Grades IX- X)*:
	  o Identify the causes and failure of the War of Independence 1857 and analyze it effects on Muslims in India.
	  o Explain the causes of separation of East Pakistan and analyze its impact on West Pakistan.
	• Geography: Discuss the likely causes and consequences of global warming and deforestation (use of fossil fuels, air pollution, agricultural change and CFC). *(Grade IX)*
	
	T-Charts:
		• Teacher Vision. (n.d.). Top 10 most popular graphic organizers examples. Teacher Vision. https://www.teachervision.com/graphic-organizer/top-10-most-popular-graphic-organizers

	• Geography: Explain the importance of rivers in Pakistan: advantages and disadvantages of flooding *(Grades IX- X)* • Sociology: Explain some advantages and disadvantages of each type of research model *(Grades XI- XII)* • Civics: Differentiate between facts and opinions in content. *(Grade IX)* • Pakistan Studies: Identify the causes of population growth and its density in Pakistan, and suggest solutions for controlling rapid growth. *(Grades IX- X)* **Venn Diagram:** • Civics: Identify at least one political party from any country outside Pakistan and compare it with the political Parties in the country. *(Grades XI- XII)* • Pakistan Studies: Compare and contrast the cultural values of colonial and pre-colonial Indian culture. *(Grades IX- X)* • Civics: Differentiate between global culture and Pakistani culture. *(Grade X)* • Education: Compare and contrast the effectiveness of face-to-face and online classes. *(Grade XI)*	
7	**Geographic Information Systems (GIS) Mapping** GIS Mapping in social science education is an instructional approach where students use digital maps and spatial data to analyze real social, economic, and environmental patterns, helping them connect geography with history, civics, and sociology through visual, data-driven inquiry. This pedagogy enhances students' spatial understanding and analysis. Teacher-educators can introduce GIS software, provide data sets, and guide student-teachers to create and present their maps. **Suggested Content Integration from Grades 9-12:** Pakistan Studies – Human Settlement & Migration Grades: IX–X (can be extended for Grade XI) human settlement, types of human settlement, migration and types of migration	• Edutopia. (n.d.). *Project-based learning for new teachers.* https://www.edutopia.org/article/project-based-learning-new-teachers/ • Baker, T. R., & Case, S. B. (2000). Let GIS be your guide. The Science Teacher, 67(7), 24–26 https://www.researchgate.net/publication/234709573_Let_GIS_Be_Your_Guide • Connor, G., & Ibáñez, J. (n.d.). Chapter 12: Human settlements. *Introduction to Human Geography*. Press books. https://louis.pressbooks.pub/humangeography/chapter/12human-settlements/
8	**Lecture-based Strategy in Social Sciences** Teachers use direct instruction to introduce concepts that require precise definitions, systematic frameworks, or structured analyses. In this approach, learners benefit from clear explanations, step-by-step breakdowns, and structured examples that highlight underlying principles. The teacher provides explicit	• Xia, L., Wang, L., & Huang, C. (2024). Implementing a social presence-based teaching strategy in online lecture learning. *European Journal of Investigation in Health, Psychology and Education, 14*(9), 2580–2597.

	explanations, analyzes representative case studies, and gradually scaffolds students toward critical thinking and independent interpretation. **Suggested Content Integration from Grades 9-12:** • Pakistan Studies: Political Science/ Civics: Political Systems *(Grades IX-X)* • History: Pakistan a new Country: Enlightenment 1947 till today *(Grades IX -XII-)*	https://doi.org/10.3390/ejihpe14090170 • Ali, M. (2011). *Pakistan in search of identity* (ISBN 9789350020999). Aakar Books. • Singer, A. (2021). *Does lecturing have a place in the social studies classroom?* Social Science Docket. University of Tennessee at Chattanooga. https://www.utc.edu/sites/default/files/2021-01/doeslecturinghaveaplaceinthesocialstudiesclassroom.pdf • Ijoyah, G. T. W., Moji, R. A., & Ijoyah, J. O. (2015). *Use of lecture method and concept mapping strategies in enhancing primary school pupils' achievement and retention in social studies at Makurdi, Nigeria*. International Letters of Social and Humanistic Sciences, 51, 5–10.

9	**Oral Histories**
	Oral history pedagogy in social studies education emphasizes learning from firsthand accounts and lived experiences to understand historical events, social change, and cultural memory. Students collect, record, and analyze interviews with their own ancestors, other individuals or communities, helping them appreciate multiple perspectives, voice, and context often absent from textbooks. This approach builds historical empathy, critical listening, and source evaluation skills while linking personal narratives to broader social processes.
	Teacher-educators can teach this pedagogy by modeling interviewing techniques, ethical practices, and transcription methods, and by guiding student-teachers to design and reflect on small-scale oral history projects in local contexts.
	
	Suggested Content Integration from Grades 9-12:
	Pakistan Studies:
	• History *(Grades XI- XII)*-
	    ○ Explore the features of Islamization under Zia's Martial-Law (1977 – 1988)
	    ○ Compare and contrast the impact of elections (1988, 1990, 1994 and 1997) on Pakistani Society.
		• Citizens Archive of Pakistan. (n.d.). *YouTube channel*. YouTube. https://www.youtube.com/@CitizensArchive
		• Oral History Association. (2023). *How can I use oral history as an educator?* Oral History Association. https://oralhistory.org/how-can-i-use-oral-history-myself-as-an-educator/
		• C-SPAN. (2021). *Lesson Plan: Oral Histories - A How-To*. C-SPAN Classroom. https://www.c-span.org/classroom/document/?19786
		• Facing History & Ourselves. (2022). Connecting the past to the present using oral history. Facing History & Ourselves. https://www.facinghistory.org/resource-library/connecting-past-present-using-oral-history
		• Voice of Witness. (2023). *Benefits of oral history*. Voice of Witness.

		https://voiceofwitness.org/benefits-of-oral-history/
10 & 11	**School/ College Based Instructional Planning:** In social science pedagogy, teaching can be framed through three broad approaches. 1. **Deductive learning** begins with established concepts, theories, or facts, which students then apply to examples and case studies. 2. **Inductive learning** starts from real data, events, or sources, guiding students to identify patterns and construct generalizations. 3. **Field-based learning** connects classroom knowledge to lived realities through community studies, surveys, site visits, and interviews. Accordingly, a few lesson plan templates will be shared. Teachers can choose any template and plan a lesson from Grades IX- XII in class.	• University of Alberta. (n.d.). *Inductive & deductive instruction*. https://sites.ualberta.ca/~obilash/inductivedeductive.html • Aitken, G., & Sinnema, C. (2008). Effective pedagogy in social sciences/tikanga ā iwi: Best evidence synthesis iteration. Ministry of Education. • National Council for the Social Studies. (2017). *Powerful, purposeful pedagogy in elementary school social studies: A position statement of the National Council for the Social Studies*. Social Education, 81(3), 186–189.

12 & 13	**Research**
	Research as pedagogy engages students in actively investigating social phenomena by collecting and analyzing their own data. Students formulate research questions, design instruments such as surveys or interviews, and gather information from peers, communities, or digital sources. They then organize, interpret, and discuss findings, linking evidence to social science theories. This approach develops critical thinking, analytical skills, and methodological understanding while promoting ownership of learning. By experiencing the full research process, students gain insight into how social knowledge is constructed, learn to evaluate sources critically, and connect theoretical concepts to real-world contexts.
	
	Suggested Content Integration from Grades 9-12:
	• Sociology: Conduct a mini-Survey Research on any social problem that they, being a member of the society, feel irritated or troubled about & write its results quantitatively (in numbers & percentages) *(Grade XII)* Education:
	  ○ Domain E: Society and education *(Grades XI- XII)*
	  ○ Domain F: Formal and Informal education *(Grades XI- XII)*
		• SurveyMonkey Inc. (n.d.). *3 types of survey research: Exploratory, descriptive, and causal (with examples)*. SurveyMonkey. https://www.surveymonkey.com/mp/3-types-survey-research/
		• Prasad, N., Kumar, V., & Kumar, S. (2024). *Survey research: Concept and development*. Department of Community Medicine, IGIMS, Patna, Bihar, India.
		• Siregar, T. (2025). *Classroom action research based learning innovations: Kemmis and McTaggart models* [Preprint]. *Preprints.org*. https://doi.org/10.20944/preprints202510.1440.v1

14	**Photographs and Videos** The use of images and videos, in teaching History has a great impact. An image adds weight to a	• Werner, W. (2002). Reading Visual Texts. *Theory & Research in Social*

	written text, a character or an event, but images are not just simple tools to help in the teaching process. In the contemporary multi-media world, they are part of social life and must be treated as such in the classroom (Werner W., 2002, pp. 401). History teachers who have studied the principles of modern education know that pupils and students can be stimulated in the use of images in history lessons, making the educational process more attractive and interactive. Today's students have access to devices that can record videos, photos that can be uploaded instantly; they then end up on school networks or platforms using video content. Teacher-educators can introduce a topic using a carefully selected image or short video, then guide student-teachers to observe, interpret, and question what they see using structured prompts. This would be followed by discussion and concept-building, where student-teachers connect visual evidence to social studies concepts and broader societal patterns. **Suggested Content Integration from Grades 9-12:** World History: Civilizations, The Independence Movement, Renaissance, Reformation and Enlightenment	*Education*, *30*(3), 401–428. https://doi.org/10.1080/00933104.2002.10473203 Videos: • Beginning To Now. (2023). *The ENTIRE History of Human Civilizations | Ancient to Modern (4K Documentary) [Full Movie]* [Video]. YouTube. https://www.youtube.com/watch?v=ha1NneZGm7A • History central. (2025). *The Birth of Two Nations: India and Pakistan Gain Independence (1947)* [Video]. YouTube. https://www.youtube.com/watch?v=O4gFMQnBp4w
15	**Microteaching** Student-teachers select different topics from a subject and plan a 10-15 minutes micro teaching. The selection of topic and the pedagogy will be based on the student-teachers' own understanding and comfort level.	• Koross, R. (2016). Micro teaching an efficient technique for learning effective teaching skills: Pre-service teachers' perspective (IRA International Journal of Education and Multidisciplinary Studies, 4(2), 289). Research-Advances.org. https://doi.org/10.21013/irajems.v4.n2.p7 • Remesh, A. (2013). *Microteaching, an efficient technique for learning effective teaching*. Journal of Research in Medical Sciences, *18*(2), 158–164. **PMCID:** PMC3724377.
16	**Course Overview**	

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination (90 minutes) presenting student-teachers with subject-specific scenarios requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Oral History as Pedagogical Resource (30%)

Student-teachers select a learning objective from the Grades 9–12 curriculum and record oral history interviews with experienced community members or practitioners to gather authentic, contextually grounded accounts related to that topic. They then critically analyse the recordings and transform it into a pedagogical resource by designing a learning activity, assessment task, or teaching material that meaningfully integrates oral history as a culturally responsive teaching strategy for secondary learners.

Course Outline

Course: Social Sciences Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh Pakistan Studies Curriculum IX–XII (DCAR)
	NCP History, Geography, Sociology, Civics Curriculum
Developed by:	Rana Hussain, Ziauddin University

Course Overview

This 16-week course equips participants with targeted pedagogies for delivering Pakistan studies as a compulsory subject, and Civics, Sociology, History, Education, and Geography to Grades IX - XII as electives. It focuses on how disciplinary knowledge is transformed into meaningful classroom instruction through variety of instructional approaches, including Cooperative Learning, Case Study Analysis, Debate and Discussion, Project –Based Learning, and Service Learning. The curriculum emphasizes moving beyond isolated facts toward "Big Understandings"—conceptual, transferable, and enduring ideas that help students make sense of complex social, historical, and political phenomena. Through micro-teaching, collaborative analysis, and social action projects, participants will learn to design inquiry-driven units and assessments that promote disciplinary understanding and active citizenship. The course culminates in microteaching, where student-teachers apply selected pedagogies to teach short lessons, receiving feedback to strengthen instructional planning, delivery, and reflective teaching practice.

Each session in this course includes a choice of topics that may be used by teacher-educators to showcase/ model the pedagogical theme of that respective week. However, these are only suggestive, and teacher-educators may use any other topics from Pakistan Studies, Civics, Sociology, World History, Geography, Civics and Sociology, that integrate well with a given pedagogy.

Course Outcomes

1. Apply a range of social science pedagogies— Cooperative Learning, Case Study Analysis, Debate and Discussion, Project –Based Learning, and field-based approaches— to design effective lesson plans for Grades IX–XII.
2. Analyze secondary-level social sciences curricula and textbooks to identify disciplinary aims, key concepts, and pedagogical implications for classroom teaching. Create formative and summative assessments that measure critical thinking, civic engagement, and content mastery.
3. Practice teaching Social Science subjects in grades 9-12.

Teaching and Learning Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher-educators will model a range of pedagogical strategies commonly used in middle and high school social science classrooms—such as Cooperative Learning, Case Study Analysis, Debate and Discussion, Project –Based Learning, Reflective Journaling, Service Learning — allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching.

Semester Outline

Week	Session Title and Brief Description [Pedagogy and suggested content/ concepts]	Suggested Readings and Relevant Resources
1	**Theoretical underpinnings of social studies** In this introductory session, student-teachers differentiate between the purpose, content and method of the four social studies teaching traditions, identifying the theory(ies) that underpin each: 1. Social Studies Taught as Citizenship Transmission 2. Social Studies Taught as a Social Science 3. Social Studies Taught as Reflective Inquiry 4. Social Studies Taught as Personal Development Although some aspects of each tradition may be found in most middle schools and high schools, one usually dominates. Student-teachers will write a short reflection, identifying which teaching tradition(s) they have been using in their classroom and which teaching tradition(s) they would like to now adopt and why.	• Barr, R. D., Barth, J. L., & Shermis, S. S. (1977). Defining the social studies (Bulletin No. 51). National Council for the Social Studies. • Miller, J. P., & Young, J. (1979). Social education in the classroom: The dynamics of the hidden curriculum. Theory and Research in Social Education, 7(1), 21–42. • Button, L. J. (2021). *Philosophical foundations of curriculum*. In *Curriculum Essentials: A Journey*. Pressbooks. https://oer.pressbooks.pub/curriculumessentials/chapter/philosophical-foundations-of-curriculum/
2	**Case Study Pedagogy** This is a learner-centered instructional method where students actively solve real-world problems presented through narratives known as "cases". Students learn by closely examining realistic social situations to understand how social, political, economic, or cultural processes operate in practice. Rather than studying concepts in isolation, learners analyze a specific case to explore causes, consequences, perspectives, and possible solutions. To model this pedagogy, a teacher educator can give student-teachers documents, data, narratives, media reports, or testimonies, to identify key issues, apply social science concepts, compare viewpoints, and justify conclusions. Case studies help students connect theory to real-world contexts, develop analytical and decision-making skills, and understand the complexity of social phenomena where multiple factors interact. **Suggested Content Integration from Grades 9-12:** • Civics: Conflict and conflict resolution *(Grade IX)* • Education: Benefits and challenges of transformative, social and experiential learning *(Grade XII)*	• Abdul Latif Jameel Poverty Action Lab. (n.d.). *Case study 1: Education in Pakistan* [PDF]. J-PAL. https://www.povertyactionlab.org/sites/default/files/research-resources/Case1_ReportCards_Pakistan_.pdf • Harris, C. (2021). *EMERALD pedagogical guidelines: Teaching cases* (Pedagogical Guidelines). Norwegian University of Science and Technology. https://www.ntnu.edu/documents/1297014369/1326993163/Case+Study+Pedagogy+EMERALD+final.pdf/3fbcb542-9cba-f1b0-9a2d-8ef898b5ffb8?t=1708963071926

	• Sociology: Corruption in Pakistani society, Role of technology in the evolution of societies *(Grade XII)* • Geography: Environmental challenges in Pakistan and their potential solutions *(Grade IX)*	
3	**Debate and Discussion** This pedagogy engages students in structured dialogue around social, political, historical, and ethical issues. Learners examine evidence, articulate arguments, listen to opposing viewpoints, and justify positions using social science concepts. This pedagogy promotes critical thinking, civic reasoning, and democratic dispositions by helping students understand complexity, multiple perspectives, and the role of dialogue in resolving disagreement. It develops critical thinking, argumentation, and communication skills, encourages civic engagement and public speaking. To model this pedagogy, a teacher-educator can pose a compelling social issue, guiding students to prepare evidence-based arguments, and facilitate structured dialogue that examines multiple perspectives and informed conclusions. **Suggested Content Integration from Grades 9-12:** • Civics: Institutions that facilitate government Legislature, Executive, Judiciary, Presidential and parliamentary system *(Grade X)* • Education *(Grade XI)*: o Argue the benefits and drawbacks of having more than one mode of education. o Discuss purpose of schooling in current era. • Sociology: Critically analyze the role of each agent of Socialization in the development of personality. *(Grade XII)* • Geography: Explain the importance of population planning. *(Grade X)*	• Brown, Z. (2015). The use of in-class debates as a teaching strategy in increasing students' critical thinking and collaborative learning skills in higher education. *Educational futures, 7*(1), 39–45. British Education Studies Association. • Pace, J. L. (2021). Hard questions: Learning to teach controversial issues. Rowman & Littlefield.
4	**Big Understandings in Social Sciences** In social studies education, big understandings are the broad, enduring ideas that help students make sense of complex social phenomena. They focus on the deeper meaning and significance of historical, political, economic, or cultural events, helping students understand patterns and relationships that extend beyond a single lesson. Big understandings are conceptual, transferable, and enduring; for example, students might learn	Perkins, D. N. (2014). Future wise: Educating our children for a changing world. Jossey-Bass

	that "democratic societies rely on citizen participation to function effectively" or that "economic systems influence people's choices and quality of life." In this session, student-teachers develop big understandings from various social science domains using the Perkins (2014) framework: • **big on ethics** means it helps students reflect on values, responsibility, and moral implications • **big on action** means it motivates students to apply what they know in real-life situations • **big on insight** means it provides deep conceptual understanding that helps students see patterns, relationships, and connections across ideas within a discipline • **big on opportunity** means it opens pathways for further learning, exploration, and creative problem-solving.	
5	**Critical Analysis of Social Studies Textbooks** Student-teachers will work in small groups to critically examine selected middle or high school social science textbooks using criteria such as content accuracy, visual-spatial content, bias, inclusion of multiple perspectives, the suggested learning activities and suggested assessment items of textbook chapter(s). Each group will focus on one subject for one grade (9-12) to identify how well the textbook addresses the learning outcomes and 21st century skills in the corresponding subject curriculum. In the second half, students will research primary and secondary sources—including speeches, archival documents, articles, oral histories, and diverse narratives—to enrich a given chapter. The session will conclude with presentations proposing how these additional sources could strengthen the syllabus.	• Nayyar, A.H., & Salim, A. (2008). The subtle subversion: The state of curricula and textbooks in Pakistan. Sustainable Development Policy Institute: Islamabad • Zaidi, S.M.A. (2011). Polarisation of social studies textbooks in Pakistan. The Curriculum Journal, 22(1), 43-59. Available at https://www.researchgate.net/publication/254251925_Polarisation_of_social_studies_textbooks_in_Pakistan • Jalbani, L. N., & Khan, N. (2022). *Analyzing social studies national curriculum and textbooks for the concept of global citizenship: A content analysis*. Journal of Education and Educational Development, 9(1), 68–88. https://doi.org/10.22555/joeed.v9i1.42 • Crystal Springs Books. (n.d.). Textbook Evaluation Form. https://people.uncw.edu/robertsonj/SEC300/textbook_evaluation.pdf
6 & 7	**Unit Planning in Social Sciences**	Lattimer, H. (2008). *Challenging history: Essential questions in the*

	Based on the preceding sessions, student-teachers use their big understandings as the foundation for unit planning by structuring the entire unit around the enduring idea they want students to grasp. Based on this, student-teachers pull out an overarching essential question—a provocative, open-ended question that frames the unit and encourages students to explore, investigate, and reflect. From there, inquiry questions are developed for each lesson or sub-topic; these are smaller, focused questions that guide learning and help students build the knowledge and skills needed to reach the big understanding. By the end of the unit/ chapter, these inquiry questions converge, allowing students to synthesize their learning and articulate the big understanding by themself. This approach ensures that the unit is cohesive, inquiry-driven, and centered on deeper, transferable knowledge rather than isolated facts.	*Social Studies classroom*. Social Education, 72(6), 326–329. https://www.socialstudies.org/system/files/publications/articles/se_7206326.pdf

8 & 9	**Project –Based Learning**
	In this approach students work on real real-world issues over a longer period, gather and analyze information, and present solutions or interpretations through meaningful products or actions (a report, campaign, exhibition, policy proposal, etc.). It develops students' problem-solving, collaboration, and communication skills. It applies knowledge to real-world problems, develops critical thinking and problem-solving skills.
	
	Suggested Content Integration from Grades 9-12:
	• Civics *(Grades IX- X)*:
	  o Domain A: Citizenship Education
	  o Domain F: Rights and responsibilities Sociology: Analyze the impact of (any three institutions) on crimes such as a] Child abuse b] Gender abuse c] Terrorism d] Corruption in Pakistani society. *(Grades XII)*
	• Geography: Natural calamity, Environmental challenges in Pakistan and their potential solutions *(Grades X-XII)*
		• PBLWorks. (n.d.). *What is PBL?* https://www.pblworks.org/what-is-pbl
		• Valenzuela, J. (2023). *Project-based learning for new teachers*. Edutopia. https://www.edutopia.org/article/project-based-learning-new-teachers/
		• Cleaver, S. (2026). *Project based learning: What it is, how it works, & examples.* Discovery Education. https://www.discoveryeducation.com/blog/teaching-and-learning/project-based-learning/
		• Petrov, G., Emmert Goodnight, J., & Coombs, G. (2026). *Projectbased and problembased learning*. Edward Elgar Publishing

10 & 11	**Assessments in Social Sciences** At the middle and secondary school level, social sciences can be assessed using a balanced mix of formative and summative assessments that capture knowledge, skills, and dispositions. These include written assessments such as short-answer questions, essays, source-based questions, and document analysis to assess conceptual	• Asante, G., Kojo Brany, N., Senyo Osafo, S., & Boateng, G. (2023). Social Studies Teachers' Authentic Assessment Practices, Tools and Challenges in Assessing Students' Learning Outcomes. Universal Journal of Social Sciences and

	understanding and reasoning. Performance-based assessments—such as projects, case studies, debates, presentations, role-plays, and simulations—allow students to apply concepts to real-world issues. Visual and media analysis, maps, timelines, and portfolios support assessment of analytical and interpretive skills. Quizzes, reflections, and exit tickets are commonly used for formative feedback, while research tasks and examinations help evaluate cumulative learning and critical thinking. In this session, student-teachers will apply their knowledge and skills from the 'Educational Assessment & Evaluation' B.Ed. core course to develop a range of assessments in Social Science subjects, as listed above.	Humanities, 3(1), 23–34. DOI: 10.31586/ujssh.2023.696 • Ghosh, R., Singha, J., & Gardia, A. (2025). Formative assessment strategies in social science education: A conceptual framework for achieving the goals of National Education Policy 2020. Asian Journal of Education and Social Studies, 51(5), 395–407. https://doi.org/10.9734/ajess/2025/v51i51927 • Dey, N. (2018). *Assessment and evaluation in social sciences (Unit-5)*. Indira Gandhi National Open University. http://egyankosh.ac.in/handle/123456789/46717 • Leaman, H., & Kistler, S. L. (2009). *Improving learning through performance assessment in a social studies methods course for preservice elementary teachers*. SRATE Journal, 18(2), 70–75. https://files.eric.ed.gov/fulltext/EJ948680.pdf
12 & 13	**Cooperative Learning** Cooperative learning in social science is a pedagogical approach where students work in small, diverse teams to achieve shared academic goals, fostering both content mastery and social skills. It promotes positive interdependence, individual accountability, and active participation, essential for understanding complex social issues, history, and civics. Key techniques include jigsaw, think-pair-share, fishbowl, four corners, reciprocal teaching and gallery walk. **Suggested Content Integration from Grades 9-12:** • Civics: A: State, Forms of Government & Constitution *(Grade X1)* • Education: Benefits and drawbacks of on-site and distance learning *(Grade XII)* • Sociology: Role of technology in the evolution of societies *(Grades X-XII)*	• Mahuri, G. (2024). Cooperative learning as one of the solutions for teaching social sciences. *EduInspire Journal, Volume*(Issue), page range • Gillies, R. M. (2016). *Cooperative learning: Review of research and practice*. University of Queensland. https://r.gillies@uq.edu.au • Tsay, M., & Brady, M. (2010). A case study of cooperative learning and communication pedagogy: Does working in teams make a difference? *Journal of the Scholarship of Teaching and Learning, 10*(2), 78–89.
14 &15	**Service Learning** Service-learning is an experiential pedagogical approach combining academic curriculum with community service to foster civic responsibility, critical thinking, and social skills. By engaging in real-world, community-identified projects,	• Weber State University. (n.d.). *Principles of good practice for service-learning pedagogy*. Center for Community Engaged Learning. https://www.weber.edu/WSUIm

	students learn through doing and reflection, applying classroom knowledge to authentic problems. It promotes active citizenship, empathy, and personal growth.
	
	Suggested Content Integration from Grades 9-12:
	• Civics:
	  o Engage with communities at local levels in the campaigns of active citizenship like tree plantation, cleanliness and welfare of their society *(Grade XII)*
	  o Standard 8- Community Service (Grade X)
	• Geography: Suggest practices to reduce the pollution. *(Grades XI-XII)*
	• Pakistan Studies *(Grades XI- XII)*:
	  o Fundamental Rights protected under the 1973 constitution of Pakistan
	  o Health & Philanthropy
	  o Poverty
	  o Social Movements
		ages/ccel/docs/BestPractices.pdf
		• Howard, J. (n.d.). *Principles of good practice for service-learning pedagogy*. Reprinted by permission of the author. Updated from Howard, J. (1993), *Community service learning in the curriculum*, in J. Howard (Ed.), *Praxis I: A faculty casebook on community service learning* (pp. 3–12). OCSL Press. https://www.weber.edu/WSUImages/ccel/docs/BestPractices.pdf
		• Koslowsky, J., Lorenzen, F., Anjos, S., Magalhães Silva, J., & Matraka, A. (Eds.). (2023). *Understanding service learning*. Deutsche Schule Athen.
		• https://ec.europa.eu/programmes/erasmus-plus/project-result-content/fd6e8e80-9dc9-48a3-aba8-d06f61ed355e/Service_Learning.pdf

16	**Microteaching** Student-teachers select different topics from a subject and plan a 10-15 minute micro teaching. The selection of topic and the pedagogy will be based on the student-teachers' own understanding and comfort level.	• Koross, R. (2016). Micro teaching an efficient technique for learning effective teaching skills: Pre-service teachers' perspective (IRA International Journal of Education and Multidisciplinary Studies, 4(2), 289). Research-Advances.org. https://doi.org/10.21013/irajems.v4.n2.p7 • Remesh, A. (2013). *Microteaching, an efficient technique for learning effective teaching*. Journal of Research in Medical Sciences**,** *18*(2), 158–164. PMCID: PMC3724377.

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination presenting student-teachers with subject-specific scenarios and requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exam Development (30%)

Student-teachers design a subject-specific summative examination intended for secondary learners, complete with a marking rubric and examiner's rationale. Each item must be accompanied by a written justification explaining the targeted learning outcome, cognitive level (using Bloom's Taxonomy), and how it assesses conceptual understanding rather than rote recall.

This demonstrates advanced PCK by requiring student-teachers to think from both the teacher's and learner's perspective simultaneously.

Course Outline

Course: English Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh English Language Curriculum IX–XII (DCAR, 2024)
Developed By:	Dr. Kiran Hashmi, Institution of Business Management

Course Description

This course prepares student teachers to teach reading, writing, speaking, and listening at the secondary level in alignment with the Sindh English Language Curriculum for Grades IX–XII. It introduces foundational TESOL concepts, including English as a second and foreign language, and the realities of multilingual classrooms in Pakistan. Student teachers develop an understanding of curriculum competencies, benchmarks, and SLOs and learn how these guide classroom practice. The course focuses on skill-based pedagogy, purposeful use of text types, and the integration of vocabulary and grammar as tools for meaning making across language skills. Through modelling, guided practice, and microteaching, student teachers build confidence in planning and delivering curriculum-aligned English lessons. Advanced TESOL practices and technology-integrated instruction are addressed in Pedagogy of English II.

Course Learning Outcomes

1. Interpret and apply all five competencies of the DCAR English Curriculum when planning and delivering lessons in reading, writing, speaking and listening.
2. Use curriculum aligned text types to teach SLO categories for Grades IX to XII, including vocabulary and grammar that support comprehension and communication.
3. Plan and implement skill based and integrated language lessons that develop comprehension, coherent writing, clear speaking and purposeful listening.
4. Use modelling, scaffolding, formative assessment and feedback strategies to support learning in multilingual secondary classrooms.
5. Demonstrate reflective teaching practice through observation, self evaluation and microteaching.

Learning & Teaching Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher-educators will model a range of pedagogical strategies commonly used in high school English classrooms- drawing on communicative language teaching, task-based learning, genre-based instruction and process writing, while remaining practical for multilingual classrooms- allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching. Student teachers will work with SLOs, design tasks linked to text types, and plan lessons in pairs or small groups.

Semester Outline

Week	**Session Title and Brief Description** [Pedagogy and suggested content/ concepts]	**Suggested Readings and Relevant Resources**
1	**TESOL Foundations, Linguistic Diversity, and Curriculum Orientation**	• DCAR English Curriculum IX–XII (2024) — *local PDF*

	Themes: • TESOL terms (ESL/EFL/EAL, goals) • multilingual Pakistan + teacher role • curriculum structure (competencies, benchmarks, SLOs) Disciplinary Content: • Curriculum document analysis (pp. 8–15) Before lesson planning, student teachers must understand how the curriculum is constructed and what skills it prioritizes. In this session, student teachers map all five competencies (including grammar as an enabling competency) to classroom practices.	https://dcar.gos.pk/Sindh-Curriculum/English%20Language%20Curriculum%20Grade%20IX-XII%2021%20JUNE%202024.pdf • Coleman, H., Capstick, T., & others. (2012). *Language in education in Pakistan: Recommendations for policy and practice.* British Council. https://www.teachingenglish.org.uk/sites/teacheng/files/Language%20In%20Education%20in%20Pakistan.pdf • British Council. (2022). *ELT learning and assessment in Pakistan.* https://www.teachingenglish.org.uk/sites/teacheng/files/2022-04/ELT%20learning%20and%20assessment%20in%20Pakistan_April%202022_new2.pdf • Richards, J. C. (2013). *Curriculum approaches in language teaching: Forward, central, and backward design. RELC Journal, 44*(1), 5–33. https://doi.org/10.1177/0033688212473293
2	**Teaching Reading: Introduction to Purposeful Reading** Teacher-educators can model purposeful reading by engaging student-teachers in pre-reading prediction activities, guided reading of a selected text, and post-reading reflection and discussion. Through think-alouds, they can demonstrate how readers use both bottom-up processes (e.g., decoding vocabulary and grammar) and top-down processes (e.g., activating prior knowledge and making inferences) to construct meaning. Student-teachers can analyze curriculum benchmarks and SLOs related to reading and design reading lessons that incorporate appropriate pre-, while-, and post-reading strategies for narrative, descriptive, expository, argumentative, and visual texts. Disciplinary Content: • Relevant benchmarks and SLOs for Competency 1 (Reading) across all prescribed text types in the curriculum, including narrative, descriptive,	• Grabe, W. (2009). *Reading in a second language: Moving from theory to practice*. Cambridge University Press. • Nation, I. S. P., & Macalister, J. (2010). *Language curriculum design*. Routledge. https://www.wgtn.ac.nz/lals/about/staff/publications/paul-nation/2010-Macalister-Nation-Language-Curriculum.pdf • DCAR Competency 1 Benchmarks https://dcar.gos.pk/Sindh-Curriculum/English%20Language%20Curriculum%20Grade%20IX-XII%2021%20JUNE%202024.pdf

	expository, argumentative, and visual texts (Grades IX–XII).	
3	**Teaching Text Structure & Organization** Teacher-educators can model the teaching of text structure by guiding student-teachers to analyze how ideas are organized within different texts and how organizational patterns support meaning. Using sample texts, they can demonstrate strategies for identifying sequencing, coherence, cohesion, and patterns such as chronological order, general-to-specific organization, and compare–contrast. Student-teachers can examine the use of cohesive devices and sentence structures within texts and design learning activities that help secondary students recognize and apply these organizational features while reading. Disciplinary Content: Relevant benchmarks and SLOs for this competency in the curriculum	• Grabe, W. (2009). *Reading in a second language: Moving from theory to practice*. Cambridge University Press. https://www.researchgate.net/publication/303223565_Reading_in_a_Second_Language_Moving_from_Theory_to_Practice • UNESCO. (2016). *If you don't understand, how can you learn? Teaching reading in multilingual contexts*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000245838 • Williams, J. P. (2005). *Teaching text structure to improve reading comprehension*. https://files.eric.ed.gov/fulltext/ED588183.pdf • Duke, N. K., & Pearson, P. D. (2002). Effective practices for developing reading comprehension. https://files.eric.ed.gov/fulltext/ED463217.pdf
4	**Teaching Reading Comprehension & Critical Thinking** The teacher educator models reading comprehension instruction using an authentic Grade 9–12 text and explicitly demonstrates literal, inferential, and evaluative questioning through think-alouds. The QAR (Question-Answer-Relationship) strategy is introduced as the teacher educator analyses sample questions and guides student-teachers to classify and design their own SLO-aligned questions. Student-teachers work in pairs to explore how vocabulary and grammar (modals, tenses) shape meaning and support inference. The teacher educator consistently links activities to curriculum SLOs requiring higher-order thinking. Finally, student-teachers plan and microteach a short reading lesson segment, focusing on scaffolding questioning techniques and promoting critical engagement with texts in secondary English classrooms. Disciplinary Content: • Explicit alignment with SLOs requiring higher-order thinking (analysis, inference, evaluation) across multiple text types	• Raphael, T. E. (1986). Teaching question answer relationships (QAR). https://files.eric.ed.gov/fulltext/ED284274.pdf • Harvey, S., & Goudvis, A. (2007). *Strategies that work: Teaching comprehension for understanding and engagement* (2nd ed.). Stenhouse. https://www.heinemann.com/shared/companionResources/E00709/strategiesthatwork_excerpt.pdf

5	**Teaching Literary Texts** The teacher educator models how to teach short stories and poems by demonstrating a reader-response approach, encouraging student-teachers to construct meaning through personal and contextual interpretation. A shared literary text is used to explore theme, imagery, and figurative language through guided close reading and discussion. The teacher educator explicitly shows how interpretive and critical questions move beyond appreciation toward analysis aligned with curriculum expectations. Student-teachers work collaboratively to design discussion prompts and annotate texts, focusing on how literary devices shape meaning. Finally, they plan and microteach a short literary lesson segment that integrates reader-response strategies with SLO-based interpretive and critical objectives. Disciplinary Content: • Links literary analysis with curriculum expectations for interpretive and critical engagement, not only appreciation.	• Rosenblatt, L. M. (1978). *The reader, the text, the poem: The transactional theory of the literary work*. Southern Illinois University Press. https://www.academia.edu/40653719/Rosenblatt_Reader_Response_Theory • Paran, A. (2008). The role of literature in instructed foreign language learning and teaching. *TESOL Quarterly*. https://files.eric.ed.gov/fulltext/EJ1137651.pdf
6	**Teaching Summary & Paraphrasing Skills** The teacher educator models how to teach summarizing and paraphrasing using an authentic Grade 9–12 text, explicitly demonstrating how to distinguish main ideas from supporting details. Think-aloud strategies are used to show how a summary is condensed while retaining key meaning. Student-teachers practise identifying topic sentences and reorganizing information into concise summaries. The teacher educator demonstrates paraphrasing by rewriting sentences using different vocabulary and structures without changing meaning. Finally, student-teachers design a short classroom activity aligned with SLOs that develop students' academic writing and comprehension skills. Disciplinary Content: • SLO 2.3 (Summary writing)	• Brown, A. L., & Day, J. D. (1983). Macrorules for summarizing texts. https://files.eric.ed.gov/fulltext/ED262177.pdf • Purdue OWL. (n.d.). *Paraphrasing exercises*. Purdue University. https://owl.purdue.edu/owl/research_and_citation/using_research/paraphrase_exercises/index.html
7	**Teaching Writing: Process Approach** The teacher educator models the process approach to writing by demonstrating how writers move through pre-writing, drafting, revising, and editing using a mentor text. Student-teachers analyse the mentor text to identify genre features, structure, and language patterns, including relevant grammar and vocabulary. The teacher educator demonstrates think-aloud writing to show decision-making during drafting and revision. Student-teachers then plan a writing task for Grades 9–12, designing scaffolds such as graphic organizers and peer feedback checklists.	• Graham, S., & Perin, D. (2007). *Writing next: Effective strategies to improve writing of adolescents*. https://ies.ed.gov/ncee/wwc/Docs/PracticeGuide/508_WWCPG_SecondaryWriting_122719.pdf • British Council. (n.d.). *Process writing in the classroom*. https://www.teachingenglish.org.uk/sites/teacheng/files/Process_writing.pdf

	They practise revising sample drafts to improve clarity and coherence. Finally, they microteach a writing mini-lesson aligned with genre-specific SLOs. Disciplinary Content: • Relevant benchmarks and SLOs for this competency in the curriculum (example: Descriptive/narrative writing (Benchmark 2.2)	
8	**Teaching Writing in Various Genres** The teacher educator models genre-based writing instruction by contrasting descriptive, narrative, and expository texts from Grades 9–12 curricula. Student-teachers analyse mentor texts to identify structural features, coherence, transitions, and organization patterns such as compare–contrast. The teacher educator explicitly demonstrates how grammar and vocabulary choices vary across genres to achieve purpose and effect. Through guided practice, student-teachers design graphic organizers and paragraph frames for each genre. They then practise writing short samples and revising for coherence and structure. Finally, they plan a genre-based writing lesson aligned with SLOs and microteach a segment focusing on one organizational pattern. Disciplinary Content: Relevant benchmarks and SLOs for this competency in the curriculum (e.g. SLO 2.2.12.2.2 and 2.2.3)	• Oshima, A., & Hogue, A. (2007). *Introduction to academic writing* (4th ed.). Pearson. https://edisciplinas.usp.br/pluginfile.php/4595129/mod_resource/content/1/Oshima_Hogue%20-%20Introduction%20to%20Academic%20Writing%20%284th%20edition%29.pdf • British Council. (n.d.). *Teaching narrative writing*. https://www.teachingenglish.org.uk/sites/teacheng/files/Narrative_writing.pdf • Reading Rockets. (n.d.). *Expository text structures*. https://www.readingrockets.org/sites/default/files/Expository%20Text%20Structures.pdf
9	**TESOL Strategies for Multilingual Classrooms** The teacher educator models TESOL strategies by demonstrating a scaffolded lesson where language support gradually shifts from teacher to student through clear stages of the Gradual Release of Responsibility (GRR). Student-teachers practise designing CCQs and ICQs to check comprehension and task understanding in multilingual Grade 9–12 classrooms. The teacher educator highlights how to balance teacher talk and student talk, and how wait time improves learner confidence and participation. Through role-play, student-teachers experience differentiation for mixed-proficiency groups and explore strategic use of Urdu/Sindhi to support meaning-making without direct translation. Finally, they design a TESOL-informed mini-lesson aligned with secondary English SLOs. These strategies cut across all language skills and are essential for effective teaching in multilingual Pakistani classrooms. Placing them mid-semester allows student teachers to apply them	• Harmer, J. (2015). *How to teach English* (2nd ed.). Longman. https://www.drnishikantjha.com/papersCollection/How_to_Teach_English_Harmer.pdf • UNESCO. (2016). *Teaching in multilingual classrooms*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000245838

	immediately in subsequent lessons and microteaching. Disciplinary Content: No new SLOs — strategies support existing ones	
10	**Teaching Persuasive/ Argumentative Writing** The teacher educator models how to teach persuasive and argumentative writing using authentic Grade 9–12 texts that present competing viewpoints. The session explicitly demonstrates claim–evidence–reasoning (CER) by deconstructing sample paragraphs and showing how arguments are built and evaluated. Student-teachers identify persuasive techniques, tone, and credibility markers in mentor texts and discuss how these influence readers. The teacher educator models how to integrate research-based support and guide students in selecting relevant evidence. Student-teachers then design argumentative writing tasks with structured scaffolds such as CER organizers and debate prompts, followed by microteaching a short lesson aligned with curriculum SLOs. Disciplinary Content: • Higher-grade persuasive /argumentative writing	• Graham, S. (2018). Teaching argument writing. https://files.eric.ed.gov/fulltext/ED572044.pdf • University of North Carolina Writing Center. (n.d.). *Argumentation*. https://writingcenter.unc.edu/wp-content/uploads/sites/487/2012/06/Argument.pdf
11	**Teaching Oral Communication (Part I)** The teacher educator models oral communication teaching through interactive role-plays that demonstrate asking and responding, and expressing preferences in meaningful Grade 9–12 contexts. Student-teachers analyse how functional language is used in interpersonal communication and practise designing short dialogue tasks. The teacher educator explicitly demonstrates how to scaffold speaking through sentence starters, prompts, and structured pair work to support fluency and confidence. Attention is given to turn-taking, active listening, and classroom interaction patterns that maximise student talk time. Finally, student-teachers design and microteach a short speaking activity aligned with communicative competence and relevant curriculum SLOs. Disciplinary Content: • Relevant benchmarks and SLOs for this competency in the curriculum (e.g. Competency 3 SLO categories 3.2.1–3.2.5)	• Brown, H. D. (2007). *Teaching by principles: An interactive approach to language pedagogy* (3rd ed.). Pearson. https://octovany.files.wordpress.com/2013/12/ok-teaching-by-principles-h-douglas-brown.pdf • Nation, I. S. P., & Newton, J. (2009). *Teaching ESL/EFL listening and speaking*. Routledge. https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/b3b65fa2-4a17-4fd8-9f58-2f558b5756fa/content
12	**Teaching Oral Communication (Part II)** The teacher educator models how to teach public speaking by demonstrating a structured oral	• Goh, C. C. M., & Burns, A. (2012). *Teaching speaking: A holistic approach*. Cambridge

	presentation, explicitly showing how cue cards support fluency without over-reliance on reading. Student-teachers analyse the structure of effective presentations, including introduction, main points, and conclusion, and identify functional language and vocabulary used for coherence and impact. The teacher educator demonstrates strategies for scaffolding presentations through modelling, rehearsal, and peer feedback. Attention is given to managing anxiety, voice control, and audience engagement. Finally, student-teachers design and microteach a short presentation task aligned with secondary-level communicative SLOs. Disciplinary Content: • Presentation SLO categories (3.3.1–3.3.5)	University Press. https://core.ac.uk/download/pdf/228252044.pdf • British Council. (2018). *Presentation skills*. https://www.teachingenglish.org.uk/sites/teacheng/files/Presentation_skills.pdf
13	**Teaching Listening** The teacher educator models listening instruction using authentic audio texts and demonstrates how to design tasks for gist and detail listening at Grades 9–12 level. Student-teachers experience pre-, while-, and post-listening stages and analyse how task design supports comprehension. The teacher educator explicitly demonstrates note-taking strategies such as keyword listening, chunking, and guided templates. Attention is given to scaffolding listening tasks through prediction and focused questions aligned with SLOs. Student-teachers then design listening activities and practise microteaching a short segment, ensuring clear instructions, appropriate task sequencing, and strategies that build learners' listening confidence and comprehension skills. Disciplinary Content: • Relevant benchmarks and SLOs for this competency in the curriculum Rationalization: Listening is not taught directly in most schools; student teachers need explicit methods.	• Field, J. (2008). *Listening in the language classroom*. Cambridge University Press. • Nation, I. S. P., & Newton, J. (2009). *Teaching ESL/EFL listening and speaking*. Routledge. https://scholarspace.manoa.hawaii.edu/server/api/core/bitstreams/b3b65fa2-4a17-4fd8-9f58-2f558b5756fa/content
14	**Translanguaging for supporting multilingual learners** The teacher educator introduces translanguaging as a pedagogical strategy and contrasts it with traditional TESOL approaches, highlighting how it draws on learners' full linguistic repertoire rather than limiting classroom language use. Through demonstration lessons, the teacher educator shows how Urdu/Sindhi can be used strategically to support concept development, clarify meaning, and build bridges to English without over-translation. Student-teachers analyse classroom scenarios to decide when	• García, O., & Wei, L. (2014). *Translanguaging: Language, bilingualism and education.* Palgrave Macmillan. https://www.researchgate.net/publication/265758908_Translanguaging_in_Education

	translanguaging supports or hinders learning. They design tasks that use bilingual scaffolds such as key-term glosses, discussion prompts, and peer explanation. Finally, they microteach a short segment focused on supporting low-proficiency learners through purposeful language integration. Disciplinary Content: No new SLOs — strategies support existing ones	
15	**Microteaching: Language Skills** The teacher educator facilitates microteaching sessions where student-teachers design and deliver integrated English lessons that combine reading, writing, listening, or speaking skills. The teacher educator models how to use structured observation tools to focus feedback on specific pedagogical skills such as questioning, scaffolding, and student talk time. Student-teachers observe peer lessons using clear criteria and provide evidence-based feedback. The teacher educator guides reflective feedback cycles that include self-assessment, peer review, and revision of lesson plans. Emphasis is placed on linking practice to curriculum SLOs and refining instructional decisions based on feedback for improved teaching effectiveness. Disciplinary Content: • Any skill-based SLO selected by student teachers	• British Council. (n.d.). *Microteaching and classroom practice*. https://www.teachingenglish.org.uk/professional-development/teachers/planning-lessons-and-courses/articles/microteaching • Allen, D. W. (1967). *Microteaching: A description*. https://files.eric.ed.gov/fulltext/ED450118.pdf • Brookhart, S. M. (2008). *How to give effective feedback to your students*. ASCD. https://files.eric.ed.gov/fulltext/ED506427.pdf
16	**Final Portfolio & Reflection** • Portfolio presentation (compilation of lessons, tasks, materials, and reflections) • Reflective review • Course synthesis	Wolf, K. (1996). Developing an effective teaching portfolio. *Educational Leadership*. https://files.eric.ed.gov/fulltext/EJ1277601.pdf

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination (90 minutes) presenting student-teachers with subject-specific scenarios requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Analysing Translanguaging Practice in the Secondary Classroom (30%)

Student-teachers listen to a provided secondary-level classroom audio recording and analyse the teacher's language use through a translanguaging lens. They identify instances where Urdu/ Sindhi were used strategically to support concept development, where it was over-relied upon, and missed opportunities for supporting comprehension, participation, and English language development, particularly for low-proficiency learners. Citing specific instances from the recording and drawing on course readings on translanguaging and TESOL literature, they write a brief evidence-based critique explaining what the teacher does well, what could be improved, and how alternative translanguaging strategies could better support English language learning in a multilingual classroom.

Course Outline

Course: English Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh English Language Curriculum IX–XII (DCAR, 2024)
Developed By:	Dr. Kiran Hashmi, Institution of Business Management

Course Description

This course strengthens advanced pedagogical practice for teaching English at the secondary level by focusing on technology-integrated instruction, assessment-informed teaching, and inclusive TESOL practices in multilingual classrooms. Building on the foundations developed in Course 1, the course shifts from teaching individual language skills to designing, evaluating, and refining instruction where pedagogy, technology, language use, and assessment work together to support learning. Student-teachers learn to design lessons and units where teaching strategies, language use, classroom interaction, and assessment work together to support learning. Assessment is treated as a supportive part of teaching, used to guide feedback, improvement, and reflection rather than as an end in itself. The course prepares teachers to respond flexibly to learner needs while remaining aligned with curriculum standards and classroom realities.

Course Outcomes

1. Design technology-supported English language lessons aligned with curriculum competencies and SLOs.
2. Apply TESOL strategies such as translanguaging, task-based learning, and differentiation in multilingual classrooms.
3. Integrate grammar and vocabulary meaningfully through texts, tasks, and digital resources.
4. Develop curriculum-aligned assessment tools and use formative feedback to support learning.
5. Analyse learner performance and adapt materials and instruction accordingly.

Learning & Teaching Approaches

The teaching and learning approaches in this course will be grounded primarily in teacher modelling, guided practice, structured debriefs, and reflective dialogue. Teacher-educators will model a range of pedagogical strategies commonly used in high school English classrooms- technology-supported instruction, assessment design, designing digital and print teaching and learning materials, adapting tasks for diverse proficiency levels- allowing student-teachers to experience these approaches as learners first. Each modelled pedagogy will be followed by a systematic debrief, during which student-teachers will analyze the teacher-educator's instructional decisions, classroom interactions, and learning outcomes. Through guided reflection, students will explicitly connect their observations from the modelled strategy with assigned course readings, enabling them to bridge theory and practice. This cycle of modelling, debrief, and reflection is intended to deepen pedagogical understanding and support thoughtful application in future classroom teaching. Student teachers will work with SLOs, design tasks linked to text types, and plan lessons in pairs or small groups.

Semester Outline

Week	**Session Title and Brief Description** [Pedagogy and suggested content/ concepts]	**Suggested Readings and Relevant Resources**
1	**Advanced TESOL Orientation and Progression from Course 1** The teacher educator briefly revisits key TESOL principles from Course 1 through applied classroom examples, helping student-teachers connect prior knowledge to more advanced	• Richards, J. C., & Rodgers, T. S. (2014). *Approaches and methods in language teaching* (3rd ed.). Cambridge University Press.

	instructional decision-making. The session explicitly contrasts teaching language skills with designing coherent instruction, positioning student-teachers as instructional designers rather than task deliverers. Through guided analysis of lesson sequences, the teacher educator models how Communicative Language Teaching (CLT) and task-based learning function as design principles for integrated lessons. Student-teachers examine sample lesson plans to identify stages of progression, scaffolding, and communicative intent. Reflection activities are used to develop professional judgement, with emphasis on adapting instruction for diverse classroom contexts.	(Selected sections on CLT and task-based learning) • Hall, G. (2016). *Exploring English language teaching: Language in action*. Routledge. (Chapter 1: What is ELT?) • Farrell, T. S. C. (2015). *Reflective practice in English language teaching*. Routledge. (Chapter 2: Reflective teaching)
2	**Designing Technology-Integrated English Lessons** The teacher educator models how technology is used as pedagogy by demonstrating a lesson where digital tools meaningfully support language learning rather than functioning as add-ons. Student-teachers evaluate different low-tech and high-tech tools for their pedagogical value in teaching English in Grades 9–12, especially in resource-constrained classrooms. The teacher educator guides them in analysing how each tool supports specific language skills and learning outcomes. Through guided design tasks, student-teachers plan tech-supported lesson components such as interactive reading, audio-based listening, or collaborative writing. Emphasis is placed on adapting digital strategies for public-sector classrooms with limited access and connectivity.	• British Council. (n.d.). *Integrating technology in language teaching*. https://www.teachingenglish.org.uk/article/integrating-technology-language-teaching • UNESCO. (2023). *Technology in education: A toolkit*. UNESCO. https://unesdoc.unesco.org/ark:/48223/pf0000371024
3	**Designing and Assessing Listening skills** The teacher educator models how listening functions as meaningful input by demonstrating a complete listening lesson using an authentic audio or video text. Student-teachers analyse how pre–while–post listening tasks are sequenced to build comprehension and engagement. The teacher educator explicitly demonstrates how to select and adapt listening materials aligned with secondary SLOs and classroom realities. Attention is given to formative assessment techniques such as quick checks, prediction tasks, and comprehension prompts during listening. Student-teachers design listening tasks that integrate speaking follow-ups, showing how listening naturally feeds into oral language practice. The teacher educator also models the use of simple digital tools like audio clips and mobile recordings to support accessible listening instruction in diverse classrooms.	• Field, J. (2008). *Listening in the language classroom*. Cambridge University Press. (Chapter 1: Understanding listening) • Nation, I. S. P., & Newton, J. (2009). *Teaching ESL/EFL listening and speaking*. Routledge. (Chapter on teaching listening) • British Council. (2023). *Teaching listening*. https://www.teachingenglish.org.uk/professional-development/teachers/knowing-subject/articles/teaching-listening • Nation, I. S. P., & Newton, J. (2009). *Teaching ESL/EFL listening and speaking*. Routledge. https://scholarspace.manoa.haw

		aii.edu/server/api/core/bitstreams/b3b65fa2-4a17-4fd8-9f58-2f558b5756fa/content • British Council. (2023). *Teaching listening.* https://www.teachingenglish.org.uk/professional-development/teachers/knowing-subject/articles/teaching-listening • Hughes, A., & Hughes, J. (2020). *Testing for language teachers* (3rd ed.). Cambridge University Press. (Chapter on Testing Listening)
4	**Designing and Assessing Reading Tasks** The teacher educator models how to design reading tasks by demonstrating text adaptation strategies for different proficiency levels and classroom contexts. Student-teachers analyse how scaffolding supports comprehension through simplified texts, glossing, and visual aids. The teacher educator explicitly demonstrates how to design comprehension questions that progress from literal to inferential and evaluative levels, aligned with SLOs. Attention is given to formative assessment through summaries, response writing, and structured discussion tasks. Student-teachers design integrated reading-to-writing and reading-to-speaking activities that extend comprehension. The teacher educator links practice to the idea that reading supports overall language development, drawing on principles of vocabulary learning in context.	• Hughes, A., & Hughes, J. (2020). *Testing for language teachers* (3rd ed.). Cambridge University Press. (Chapter on testing reading) • Duke, N. K., & Pearson, P. D. (2002). Effective practices for developing reading comprehension.
5	**Designing and Assessing Speaking Tasks** The teacher educator models communicative speaking instruction by demonstrating structured tasks such as dialogues, discussions, and short presentations aligned with secondary SLOs. Student-teachers analyse interaction patterns (pair work, group work, whole-class discussion) to understand how they increase learner talk time and engagement. The teacher educator explicitly demonstrates how to provide language scaffolds such as sentence frames, discourse markers, and classroom language support to enable participation. Attention is given to formative assessment of speaking through rubrics, observation checklists, and peer feedback strategies. Student-teachers design speaking tasks and practise microteaching, integrating digital tools like audio and video recordings to support reflection and performance improvement.	• Goh, C. C. M., & Burns, A. (2012). *Teaching speaking: A holistic approach*. Cambridge University Press. (Chapter on designing speaking tasks) • Nation, I. S. P., & Newton, J. (2009). *Teaching ESL/EFL listening and speaking*. Routledge. (Chapter on speaking activities) • Hughes, A., & Hughes, J. (2020). *Testing for language teachers*. Cambridge University Press. (Chapter on assessing speaking)

6	**Designing and Assessing Writing Tasks** The teacher educator models how to design writing instruction by demonstrating genre-based tasks aligned with curriculum SLOs and communicative purposes. Student-teachers analyse mentor texts to identify genre features and examine how writing varies across purposes and audiences. The teacher educator explicitly demonstrates the writing process through planning, drafting, revising, and editing, using writing frames and model texts to scaffold learning. Attention is given to formative assessment through rubrics, checklists, and peer feedback strategies that guide improvement. Student-teachers design writing tasks and assessment tools, and explore how digital platforms can support drafting, collaboration, and iterative revision in secondary classrooms.	• Hyland, K. (2019). *Second language writing*. Cambridge University Press. • British Council. (n.d.). *Teaching writing.* https://www.teachingenglish.org.uk/article/teaching-writing • Hughes, A., & Hughes, J. (2020). *Testing for language teachers*. Cambridge University Press. (Chapter on assessing writing)
7	**Teaching and Assessing Grammar and Vocabulary through Tasks** The teacher educator models how grammar and vocabulary can be taught through meaningful communication rather than isolated exercises. Student-teachers analyse authentic texts and learner language samples to identify opportunities for language noticing and contextualized instruction. The teacher educator demonstrates how to design noticing tasks that draw attention to grammatical patterns and vocabulary use within reading, writing, listening, and speaking activities. Attention is given to integrating vocabulary development into skills lessons and promoting deeper word knowledge through context. Student-teachers design short diagnostic checks and formative assessment tasks that assess grammar and vocabulary use in authentic language production rather than through decontextualized testing.	• British Council. (n.d.). *Teaching grammar communicatively.* https://www.teachingenglish.org.uk/professional-development/teachers/knowing-subject/articles/teaching-grammar • Hughes, A., & Hughes, J. (2020). *Testing for language teachers*. Cambridge University Press. (Chapter on Grammar and Vocabulary) • Ellis, R. (2003). *Task-based language learning and teaching*. Oxford University Press. (Chapter on focus on form) • Nation, I. S. P. (2013). *Learning vocabulary in another language*. Cambridge University Press. (Chapter on vocabulary teaching)
8	**Translanguaging and Multilingual Strategies** Translanguaging supports multilingual classrooms by using students' first languages to boost comprehension and participation while developing English skills. It helps teachers design inclusive tasks and assess understanding across languages. The teacher educator examines translanguaging as a pedagogical approach and contrasts it with direct translation through classroom examples and case studies. Student-teachers analyse multilingual classroom scenarios to identify how strategic use of learners' first languages can support comprehension, participation, and	• García, O., & Wei, L. (2014). *Translanguaging: Language, bilingualism and education.* Palgrave Macmillan. https://doi.org/10.1057/9781137385765 • Creese, A., & Blackledge, A. (2010). Translanguaging in the bilingual classroom: A pedagogy for learning and teaching? *The Modern Language Journal, 94*(1), 103–115.

	English language development. The teacher educator models how to design translanguaging-supported tasks that encourage learners to draw on their full linguistic repertoire while working toward English learning goals. Attention is given to inclusive participation and equitable classroom interaction. Student-teachers design assessment tasks that capture understanding across languages and evaluate how multilingual strategies can be used effectively in diverse secondary classrooms.	https://doi.org/10.1111/j.1540-4781.2009.00986.x • British Council. (2020). *Using learners' first language in the classroom.* https://www.teachingenglish.org.uk/professional-development/teachers/knowing-subject/articles/using-learners-first-language • García, O., & Wei, L. (2014). *Translanguaging*. Palgrave. (Chapter 1)
9	**Differentiation and Inclusive Classroom Practices** The teacher educator models differentiation strategies through examples of mixed-ability secondary English classrooms and demonstrates how the same learning objective can be achieved through varied levels of support. Student-teachers analyse lesson tasks and adapt them for learners with different proficiency levels while maintaining common curriculum expectations. The teacher educator explicitly demonstrates how to design tiered activities, flexible grouping structures, and scaffolded supports that preserve cognitive challenge. Attention is given to supporting struggling learners without reducing content complexity. Student-teachers then redesign existing English tasks and justify their instructional decisions, focusing on inclusion, participation, and equitable access to learning.	• 1. Tomlinson, C. A., & Doubet, K. J. (2012). *Differentiating instruction as a pathway to student success.* https://rutamaestra.santillana.com.co/wp-content/uploads/2020/01/Classrooms-2nd-Edition-By-Carol-Ann-Tomlinson.pdf • Tomlinson, C. A. (2014). *The differentiated classroom: Responding to the needs of all learners* (2nd ed.). ASCD. https://files.ascd.org/staticfiles/ascd/pdf/siteASCD/publications/books/differentiated-classroom2nd-sample-chapters.pdf • TESOL International Association. (2018). The 6 principles for exemplary teaching of English learners. TESOL Press. https://www.tesol.org/professional-development/education-and-events/on-demand-facilitated/tesol-me/tesol-me-the-6-principles-for-exemplary-teaching-of-english-learners/
10	**Designing Assessment Tools** The teacher educator introduces the principles of validity, reliability, practicality, fairness, and transparency through the analysis of authentic classroom assessment examples. Student-teachers evaluate existing assessment tasks and rubrics to determine how well they align with curriculum SLOs and language learning objectives. The teacher educator models the process of designing summative assessment tasks and developing clear scoring rubrics for language skills. Attention is given to creating assessment tools that are manageable and appropriate for secondary	Hughes and Huges (2020) Chapter 1-5 Brookhart, S. M. (2013). *How to create and use rubrics for formative assessment and grading.* ASCD. https://www.ascd.org/books/how-to-create-and-use-rubrics-for-formative-assessment-and-grading

	classrooms. Student-teachers use AI tools to generate draft questions, tasks, and rubrics, then critically review and revise these materials to improve alignment, quality, fairness, and educational value.	
11	**Analysing Learner Errors and Performance** The teacher educator introduces the distinction between errors and mistakes through the analysis of authentic learner language samples from secondary classrooms. Student-teachers identify patterns in learner performance and discuss what these reveal about language development and learning needs. The teacher educator models how error analysis informs instructional decisions by demonstrating how assessment evidence can be used to plan targeted remedial instruction. Attention is given to responding to learner errors as opportunities for learning rather than as deficits requiring correction alone. Student-teachers analyse samples, diagnose learning needs, and design follow-up activities that address identified difficulties while supporting continued language development.	• Ahmad, N., & colleagues. (2024). *Analyzing linguistic errors in English essay writing at secondary school level in Pakistan*. https://historymedjournal.com/index.php/medicine/article/view/1120 • Corder, S. P. (1981). *Error analysis and interlanguage*. Oxford University Press.
12	**Materials Development and Adaptation** The teacher educator models how to evaluate English language teaching materials by analysing textbook activities for alignment with SLOs, learner proficiency, and communicative purpose. Student-teachers critique existing materials and identify gaps in cognitive demand, language support, and contextual relevance. The teacher educator demonstrates task redesign by modifying textbook activities to improve clarity, scaffolding, and interaction. Attention is also given to designing supplementary materials such as worksheets, visual aids, and task cards that support diverse learners. Student-teachers adapt a textbook unit and justify their design choices based on pedagogical principles and classroom realities in secondary English teaching.	Tomlinson, B. (2011). *Materials development in language teaching* (2nd ed.). Cambridge University Press. (Chapter on materials adaptation)
13	**Designing Integrated Instructional Units** The teacher educator models how to design integrated instructional units by unpacking a multi-lesson English unit and showing how skills, tasks, and assessment are coherently sequenced. Student-teachers analyse unit samples to identify pedagogical alignment across reading, writing, listening, and speaking activities. The teacher educator demonstrates how learning outcomes (SLOs), materials, and classroom tasks are aligned to ensure progression and continuity. Attention is given to building thematic or skill-based coherence across lessons while maintaining flexibility for classroom realities. Student-	• Edutopia. (n.d.). *Developing a successful unit plan.* https://www.edutopia.org/article/developing-successful-unit-plan • British Council. (n.d.). *Lesson plans*. TeachingEnglish. https://www.teachingenglish.org.uk/teaching-resources/teaching-secondary/lesson-plans

	teachers design a short integrated unit plan and justify how their sequencing supports cumulative language development and meaningful classroom practice.	
14	**Professional Ethics and Teacher Growth** The teacher educator discusses professional ethics in teaching through real classroom dilemmas and guided ethical decision-making scenarios relevant to secondary English classrooms. Student-teachers analyse cases involving fairness, classroom interaction, assessment integrity, and teacher responsibility, linking decisions to professional codes of conduct. The teacher educator also demonstrates how reflective teaching supports continuous professional growth by modelling structured reflection tools such as journals and lesson evaluations. Student-teachers develop reflective teaching plans that identify areas for improvement and set actionable goals for classroom practice. Emphasis is placed on ethical responsibility, professional identity, and sustained development as reflective English language teachers.	Richards, J, C., Farrell, T, S, C, S. (2005). *Professional development for language teachers : strategies for teacher learning*. Cambridge: Cambridge University Press.
15	**Microteaching (Technology-Integrated and Assessment-Informed Lesson Delivery)** The teacher educator facilitates microteaching sessions where student-teachers deliver short, technology-integrated lessons based on previously designed plans and materials. Student-teachers demonstrate classroom interaction strategies, manage learner participation, and implement digital tools to support instruction. The educator models how formative assessment is embedded during teaching through questioning, observation, and quick checks for understanding. Attention is given to real-time instructional decision-making and adapting teaching based on learner responses. Student-teachers observe peer lessons using clear criteria and provide evidence-based feedback. The teacher educator guides reflective feedback cycles that include self-assessment, peer review, and revision of lesson plans. Emphasis is placed on linking practice to curriculum SLOs and refining instructional decisions based on feedback for improved teaching effectiveness. Disciplinary Content: Any skill-based SLO selected by student teachers	• Farrell, T. S. C. (2015). *Reflective practice in English language teaching.* Routledge. • British Council. (n.d.). *Microteaching and classroom practice.* https://www.teachingenglish.org.uk/professional-development/teachers/planning-lessons-and-courses/articles/microteaching
16	**Final Portfolio and Reflective Synthesis** • Portfolio presentation (compilation of lessons, tasks, materials, and reflections)	• Wolf, K. (1996). Developing an effective teaching portfolio.

	• Professional synthesis	*Educational Leadership, 53*(6), 34–37. • Seldin, P., Miller, J. E., & Seldin, C. A. (2010). *The teaching portfolio: A practical guide to improved performance and promotion/tenure decisions* (4th ed.). Jossey-Bass.

Assessment:

1. Lesson Planning + Microteaching (40%)

Student-teachers design a detailed single-lesson plan aligned to secondary curriculum standards in their subject specialization, incorporating subject-specific pedagogical strategies, learning objectives, and formative assessment strategies. They then deliver a 15–20 minute microteaching segment to the course instructor and peers, followed by a structured self-reflection and peer feedback session evaluating pedagogical choices and content accuracy.

2. Timed PCK Exam (30%)

A closed-book, timed examination presenting student-teachers with subject-specific scenarios and requiring them to demonstrate pedagogical content knowledge. Items include short-answer and case-based questions addressing common student misconceptions, instructional decision-making, content representation, and curriculum sequencing. The exam assesses the integration of content knowledge with appropriate and context-sensitive teaching strategies and prepares student-teachers for a similar pattern of testing in the secondary license test.

3. Exam Development (30%)

Student-teachers design a subject-specific summative examination intended for secondary learners, complete with a marking rubric and examiner's rationale. Each item must be accompanied by a written justification explaining the targeted learning outcome, cognitive level (using Bloom's Taxonomy), and how it assesses conceptual understanding rather than rote recall.
This demonstrates advanced PCK by requiring student-teachers to think from both the teacher's and learner's perspective simultaneously.

Course Outline

Course: Urdu Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindh Urdu Language Curriculum IX–XII (DCAR, 2019)
Developed By:	

This course is under development and will be published soon.

Course Outline

Course: Urdu Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindh Urdu Language Curriculum IX–XII (DCAR, 2019)
Developed By:	

This course is under development and will be published soon.

Course Outline

Course: Sindhi Specialization Course I

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 1)
Reference Document:	Sindhi Language Curriculum IX–XII (DCAR, 2019)
Developed By:	

This course is under development and will be published soon.

Course Outline

Course: Sindhi Specialization Course II

Credit Value:	3 Credits
Course Type:	Pedagogy (Specialization Course 2)
Reference Document:	Sindhi Language Curriculum IX–XII (DCAR, 2019)
Developed By:	

This course is under development and will be published soon.