Module Descriptions

Module designation	**Multiple Representation of Chemistry**
Semester(s) in which the module is taught	7th /Fourth Year
Person responsible for the module	Prof. Dr. Utiya Azizah, M.Pd.
Language	Bahasa Indonesia (Regular Class) Bahasa Inggris (Internasional Class)
Relation to curriculum	Compulsory course
Teaching methods	Project-Based Learning, 2 workhours per week (2 x 170 minutes per week)
Workload (incl. contact hours, self-study hours)	1 CU for a bachelor's degree equals 170 minutes (50 minutes face-to-face, 60 minutes structured, 60 minutes independent learning) per week × 14 weeks, excluding mid and end-term exams. = 39.67 work hours per semester = 1.587 ECTS.
Credit points	2 Credit Units (CU) = 3.18 ECTS
Required and recommended prerequisites for joining the module	Learning Theories, Learning Planning, and ICT-based Learning Chemistry

Module objectives/intended learning outcomes	1. Understanding the fundamental principles of multiple representations in chemistry and their applications in media design: the focus and scope of chemistry, the nature of chemical concepts, the application of chemistry in everyday life contexts, the role of mental models in understanding abstract chemical concepts and their influence on deep learning, examples of deep learning in chemistry topics, multiple representations in chemistry and the meaning of the chemical triplet representation, the macroscopic, submicroscopic, and symbolic levels of representation with examples in chemistry topics, and the interconnections among the three levels of representation (macroscopic–submicroscopic, macroscopic–symbolic, submicroscopic–symbolic) with examples in chemistry topics, as well as the relationship between multiple chemical representations and 21st-century skills indicators (communication, collaboration, critical thinking, creativity, and digital literacy). 2. Able to evaluate the achievement of 21st-century skills through the implementation of chemistry learning or media based on multiple representations, grounded in a review of recent scientific articles 3. Able to develop media based on the interconnection of multiple representations in chemistry that provide a deep learning experience 4. Able to collaborate in utilizing digital technologies such as AI (artificial intelligence), virtual laboratories, VR (virtual reality), ChemDraw, and AR (augmented reality) to creatively visualize abstract concepts in chemistry 5. Able to demonstrate a responsible attitude and uphold digital ethics in developing media based on the interconnection of multiple representations in chemistry
Content	This course explores the three levels of chemical representation integratively, emphasizing mental models and their relation to 21st-century skills. It draws upon recent scientific studies as a basis for developing media that interconnect these representation levels through the creative, collaborative, and ethical use of digital technologies (AI, Virtual Lab, VR, ChemDraw, and AR) to enhance deep learning
Examination forms	Essay and Oral Presentation
Study and examination requirements	Study and Examination Requirements/Forms of Examination: 1. Group assignments / project (Conducting activities such as identifying and interconnecting the three levels of chemical representation, reviewing three recent scientific articles related to media development, creating chemistry learning media based on multiple representations, and exhibiting the developed media products) 2. Discussion and Presentation Assessment Recap (Project-Based Learning): - Participatory Activities: 30% - Project/Product Assessment: 70% - Total: 100%

Reading list	1. Johnson, E. B. 2002. Contextual Teaching and Learning: What It Is and Why It's Here To Stay. CA: Corwin/Sage. 2. Santrock, J. W. 2008. Educational Psychology. Third Edition. Boston: McGraw-Hill. 3. Johnstone, A.H. 2009. Multiple Representations in Chemical Education. International Journal of Science Education, 31(16): 2271–2273. 4. Treagust, D. F. dan Gilbert, J. K. 2009. Multiple Representations in Chemical Education. Dordrecht Netherlands: Springer Netherlands. 5. Anderson, A. 2019. Virtual Reality, Augmented Reality and Artificial Intelligence in Special Education: A Practical Guide to Supporting Students with Learning Differences. London: Routledge. 6. Bağcı, H. dan Koçyiğit, M. 2019. 21st Century Skills and Education. Newcastle upon Tyne: Cambridge Scholars Publishing. 7. Eilks, I. and Hofstein, A. 2015. Relevant Chemistry Education: From Theory to Practice. Rotterdam: Sense Publishers. 8. Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. 2024. Peraturan Menteri Pendidikan, Kebudayaan, Riset, dan Teknologi Nomor 12 Tahun 2024 tentang Kurikulum pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah. Jakarta: Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi. 9. Heal, J. dan Berlin, R. 2025. Mental Models: How Understanding the Mind Can Transform the Way You Work and Learn. London: John Catt Educational.