



**Universitas Negeri Surabaya**  
**Faculty of Mathematics and Natural Sciences**  
**Chemistry Masters Study Program**

**Document Code**

**SEMESTER LEARNING PLAN**

<b>Courses</b>	<b>CODE</b>	<b>Course Family</b>	<b>Credit Weight</b>			<b>SEMESTER</b>	<b>Compilation Date</b>																																																																																																				
Catalyst	4710203007	Compulsory Study Program Subjects	T=3	P=0	ECTS=6.72	2	January 30, 2024																																																																																																				
<b>AUTHORIZATION</b>	<b>SP Developer</b>		<b>Course Cluster Coordinator</b>			<b>Study Program Coordinator</b>																																																																																																					
	Dr. I Gusti Made Sanjaya, M.Si.		.....			Prof. Dr. Nuniek Herdyastuti, M.Si.																																																																																																					
<b>Learning model</b>	Case Studies																																																																																																										
<b>Program Learning Outcomes (PLO)</b>	<b>PLO study program which is charged to the course</b>																																																																																																										
	<b>Program Objectives (PO)</b>																																																																																																										
	<b>PO - 1</b>	Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment																																																																																																									
	<b>PO - 2</b>	Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science																																																																																																									
	<b>PO - 3</b>	Has data analysis capabilities based on chemical instruments																																																																																																									
	<b>PO - 4</b>	Compile and communicate ideas, thoughts and scientific arguments responsibly regarding catalysts and catalysis and are based on academic ethics.																																																																																																									
	<b>PLO-PO Matrix</b>																																																																																																										
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<b>PO Matrix at the end of each learning stage (Sub-PO)</b>																																																																																																											
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<b>Short Course Description</b>	The Catalyst course examines the theory and implementation of catalysts and catalysis related to the chemical meaning, types, analysis, performance evaluation, synthesis, characterization and use cycle of catalysts in everyday life, industrial needs or green chemistry needs.																																																																																																										
<b>References</b>	<b>Main :</b>																																																																																																										

<ol style="list-style-type: none"> <li>1. Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</li> <li>2. Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</li> <li>3. Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</li> <li>4. Punekar, N. S. 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</li> <li>5. Twigg, M. V. and Spencer, M. S. 1994. Catalyst Characterization: Physical Techniques for Solid Materials. New York: Plenum Press.</li> </ol>							
<b>Supporters:</b>							
1. Artikel-artikel jurnal terkait katalis ataupun kataalisis							
<b>Supporting lecturer</b>	Dr. I Gusti Made Sanjaya, M.Si. Prof. Dr. Sari Edi Cahyaningrum, M.Si. Dr. Dina Kartika Maharani, S.Si., M.Sc.						
Week-	Final abilities of each learning stage (Sub-PO)	Evaluation		Help Learning, Learning methods, Student Assignments, [ Estimated time]		Learning materials [ References ]	Assessment Weight (%)
		Indicator	Criteria & Form	Offline ( offline )	Online ( online )		
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)

1	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	<p>1.- Evaluate the use of catalysts in irreversible reactions and reversible reactions</p> <p>2.- Detailing the performance of homogeneous catalysts, heterogeneous catalysts and enzymes</p>	<p><b>Criteria:</b> Non test</p> <p><b>Form of Assessment :</b> Participatory Activities</p>		<p>discussion and question and answer</p>	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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3	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	<p>Develop problems related to the implementation of catalysts and catalysis to solve authentic problems in everyday life or industrial environments</p>	<p><b>Criteria:</b> Assessment of project problems</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		<p>discussion and question and answer</p>	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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4	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	<p>Planning projects related to catalyst development or catalyst implementation to solve authentic problems in everyday or industrial environments</p>	<p><b>Criteria:</b> Project plan assessment</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		<p>discussion and question and answer</p>	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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5	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	Carrying out projects related to developing catalyst prototypes or implementing catalysts to solve authentic problems in everyday or industrial environments	<p><b>Criteria:</b> Assessment of the project implementation process related to the development of catalyst prototypes</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		discussion and question and answer	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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7	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	Carrying out projects related to developing catalyst prototypes or implementing catalysts to solve authentic problems in everyday or industrial environments	<p><b>Criteria:</b> Assessment of the project implementation process related to the development of catalyst prototypes</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		discussion and question and answer	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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8	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	<p>Successfully developed homogeneous, heterogeneous, or enzymatic catalyst prototypes</p>	<p><b>Criteria:</b> Assessment of homogeneous, heterogeneous, or enzymatic catalyst prototypes</p> <p><b>Forms of Assessment :</b> Participatory Activities, Project Results Assessment / Product Assessment, Practices / Performance</p>		<p>performance of project results related to prototypes related to catalysts or catalysis</p>	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	10%
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9	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	Characterizing project prototypes related to catalysts or catalysis	<p><b>Criteria:</b> Assessment of the results of characterization of project prototypes related to catalysts or catalysis</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		practice, discussion and question and answer	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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12	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p> <p>3. Compile the results of scientific thoughts and arguments responsibly regarding catalysts and catalysis and are based on academic ethics.</p>	Prepare project results reports related to catalysts or catalysis	<p><b>Criteria:</b> Assessment of project results reports related to catalysts or catalysis</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		presentations, discussions and questions and answers	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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13	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p> <p>3. Compile the results of scientific thoughts and arguments responsibly regarding catalysts and catalysis and are based on academic ethics.</p>	Prepare project results reports related to catalysts or catalysis	<p><b>Criteria:</b> Assessment of project results reports related to catalysts or catalysis</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>		presentations, discussions and questions and answers	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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14	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p> <p>3. Communicate ideas, thoughts and scientific arguments responsibly regarding catalysts and catalysis and are based on academic ethics.</p>	Communicate project results related to catalysts or catalysis	<p><b>Criteria:</b> Assessment of communication of project results related to catalysts or catalysis</p> <p><b>Form of Assessment :</b> Participatory Activities, Practice/Performance</p>	presentations, discussions and questions and answers	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <hr/> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <hr/> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	5%
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16	<p>1. Mastering theoretical concepts, principles and methods in terms of structure and properties of matter, energy, dynamics as well as principles of synthesis, analysis, characterization of chemical compounds, as well as contemporary handling of their impacts on people's lives and the environment</p> <p>2. Able to solve scientific problems through an inter or multidisciplinary approach that is beneficial for society and science</p>	Produce project output related to catalysts or catalysis with good character	<p><b>Criteria:</b> Assessment of projects for making homogeneous, heterogeneous or enzymatic catalysts with good characteristics</p> <p><b>Forms of Assessment</b> : Participatory Activities, Project Results Assessment / Product Assessment, Practices / Performance</p>	performance of catalyst or catalysis project results in solving daily environmental or industrial problems	<p><b>Material:</b> - Catalysts and Catalysis <b>Literature:</b> <i>Can Li and Yan Liu. 2014, Bridging Heterogeneous and Homogeneous Catalysis: Concepts, Strategies, and Applications. Germany: Wiley-VCH Verlag GmbH &amp; Co.</i></p> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Bhaduri, S. and Mukesh, D. 2014. Homogeneous catalysis : mechanisms and industrial applications, Second edition. United States of America: John Wiley &amp; Sons, Inc.</i></p> <p><b>Material:</b> - Types of catalysts <b>References:</b> <i>Schmal, M. 2016, Heterogeneous Catalysis and its Industrial Applications. Switzerland: Springer International Publishing.</i></p> <p><b>Material:</b> - Enzyme catalysts <b>References:</b> <i>Punekar, NS 2018. ENZYMES: Catalysis, Kinetics and Mechanisms. Singapore: Springer Nature Singapore Pte Ltd.</i></p>	20%
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#### Evaluation Percentage Recap: Case Study

No	Evaluation	Percentage
1.	Participatory Activities	50%
2.	Project Results Assessment / Product Assessment	10%
3.	Practice / Performance	40%
		100%

#### Notes

- 1. Learning Outcomes of Study Program Graduates (PLO - Study Program)** are the abilities possessed by each Study Program graduate which are the internalization of attitudes, mastery of knowledge and skills according to the level of their study program obtained through the learning process.
- 2. The PLO imposed on courses** are several learning outcomes of study program graduates (CPL-Study Program) which are used for the formation/development of a course consisting of aspects of attitude, general skills, special skills and knowledge.

3. **Program Objectives (PO)** are abilities that are specifically described from the PLO assigned to a course, and are specific to the study material or learning materials for that course.
4. **Subject Sub-PO (Sub-PO)** is a capability that is specifically described from the PO that can be measured or observed and is the final ability that is planned at each learning stage, and is specific to the learning material of the course.
5. **Indicators for assessing** ability in the process and student learning outcomes are specific and measurable statements that identify the ability or performance of student learning outcomes accompanied by evidence.
6. **Assessment Criteria** are benchmarks used as a measure or measure of learning achievement in assessments based on predetermined indicators. Assessment criteria are guidelines for assessors so that assessments are consistent and unbiased. Criteria can be quantitative or qualitative.
7. **Forms of assessment:** test and non-test.
8. **Forms of learning:** Lecture, Response, Tutorial, Seminar or equivalent, Practicum, Studio Practice, Workshop Practice, Field Practice, Research, Community Service and/or other equivalent forms of learning.
9. **Learning Methods:** Small Group Discussion, Role-Play & Simulation, Discovery Learning, Self-Directed Learning, Cooperative Learning, Collaborative Learning, Contextual Learning, Project Based Learning, and other equivalent methods.
10. **Learning materials** are details or descriptions of study materials which can be presented in the form of several main points and sub-topics.
11. **The assessment weight** is the percentage of assessment of each sub-PO achievement whose size is proportional to the level of difficulty of achieving that sub-PO, and the total is 100%.
12. TM=Face to face, PT=Structured assignments, BM=Independent study.