Development of Virtual laboratories - Handout 2

Resource – Guidelines for Virtual labs – Electronics Engineering	**Version 1.0, April 2016** **Version 1.5 March 2018**
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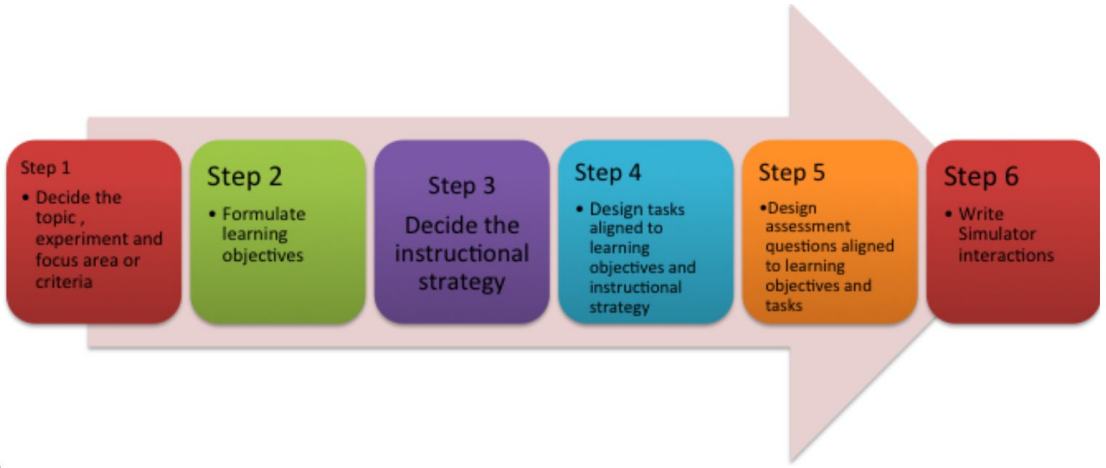

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Guidelines to design experiments for development of effective virtual laboratories

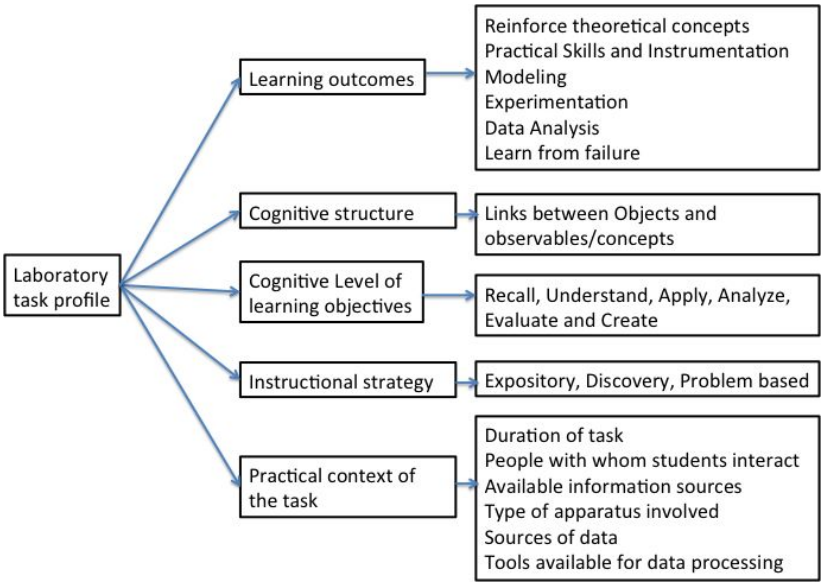
These guidelines cover the five important steps in the design of experiments for effective virtual laboratories. These steps are as follows:

a. Selection of topic, experiment and focus area or criteria
b. Formulate learning objectives
c. Selection of instructional strategy
d. Design tasks aligned to learning objectives and instructional strategy
e. Design assessment questions aligned to learning objectives and tasks

Step 4 – d. Guidelines for designing tasks aligned to learning objectives and instructional strategy

As seen from the figure that laboratory tasks depend on five dimensions namely

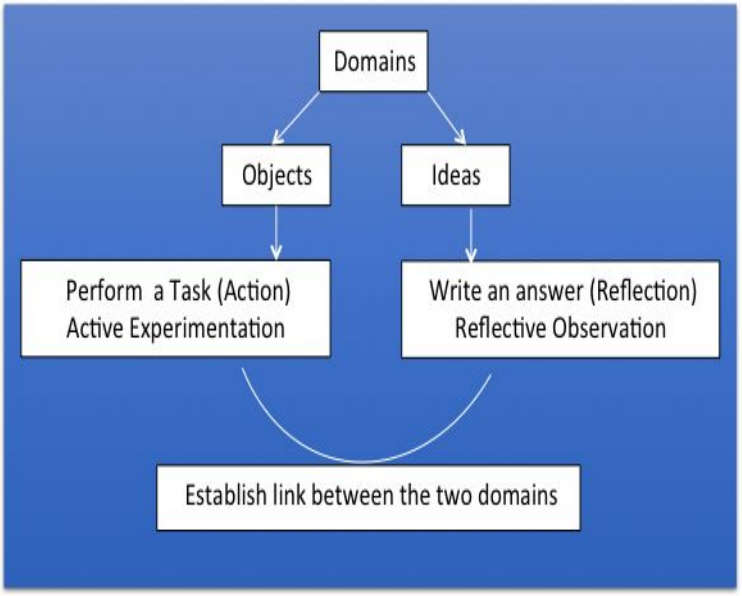
1. Learning objective
2. Cognitive level of learning objectives
3. Instructional strategy
4. Cognitive structure of the tasks
5. Practical context



We have covered the first three dimensions the learning objectives, cognitive level and instructional strategy in the previous section. The next important dimension is the cognitive structure of the tasks.

4. Cognitive structure of the tasks

Labwork includes a wide variety of tasks, designed to promote quite different kinds of learning. The fundamental purpose of any labwork task is to help students to make links between two domains: the domain of real objects and observable things, and the domain of ideas. When the labwork task is implemented we can observe what the students actually do on the task, and we can attempt to assess what they actually learn.



In the electronics engineering virtual laboratories as in case of traditional laboratories the students have to work in two domains – the object domain and the ideas domain. The following table gives the various objects and observables in the context of electronics engineering virtual laboratories.

Objects	**Observables/Concepts**
Components	Symbolic representation
Linear: Resistor, Capacitor, Inductor	Real life image
Non-linear: PN Diode, Zener Diode, BJT, FET, LED, Transformer,	Specifications
	Purpose/Function
Equipment	Symbolic representation
Ammeter, Voltmeter, CRO, Multimeter,	Real life image
DC Regulated Power Supply, Signal Generator, Function Generator	Ranges
	Parameters
	Resolutions
	Procedures for operation
	Purpose/Function
Circuits	Layout
	Purpose/Function
Plots/Graphs	Parameters plotted on the axes
	Scales used on the axes
	Nature of graph/plot
Equations	Variables/parameters
	Values of Variables/parameters

	Units of variables/parameters
Models	Parameters
	Purpose/Function
Simulations	Properties

The following table gives the details of the various tasks that can be assigned in the virtual laboratory for the course Basic and Advanced Electronics.

Objects	**Tasks with objects**	**Observables**	**Tasks with observables**
Components	Select (Drag and drop)	Specifications	Select
	Observe		Reason out for selection
	Connect in circuit		Report observations
	Rotate		Reason out for observation
	Double click		Determine value of
	Right click		Choose between
			Reason out for the choice
			Explore relation between
		Purpose/Function	Determine
			Choose between
			Reason out for the choice
Equipment	Select (Drag and drop)	Ranges	Select
	Observe		Reason out for selection
	Connect in circuit		Report observations
	Rotate		Reason out for observation
	Double click		Determine value of
	Right click		Choose between
			Reason out for the choice
			Explore relation between
		Parameters	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Determine value of
			Choose between
			Reason out for the choice
			Explore relation between
		Resolutions	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Determine value of
			Choose between
			Reason out for the choice
			Explore relation between

		Procedures for operation	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Determine value of
			Choose between
			Reason out for the choice
			Explore relation between
		Purpose/Function	Determine
			Choose between
			Reason out for the choice
Circuits	Construct	Layout	Select
	Observe		Reason out for selection
			Identify pattern
			Explore relation between
			Report observations
			Reason out for observation
			Choose between
			Reason out for the choice
		Purpose	Select
			Reason out for selection
		Function	Select
			Reason out for selection
			Choose between
			Reason out for the choice
Plots/Graphs	Construct	Parameters plotted on the axes	Select
	Display		Reason out for selection
	Observe		Report observations
			Reason out for observation
			Determine value of
			Choose between
			Analyse the relation between
			Reason out for the choice
			Explore relation between
		Scales used on the axes	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Determine value of
			Choose between
			Reason out for the choice
			Explore relation between
			Analyse the relation between

		Nature of graph/plot	Report observations
			Reason out for observation
			Determine value of
			Explore relation between
			Analyse the relation between
			Identify pattern
			Test a prediction
Equations	Select	Variables/parameters	Select
	Make		Reason out for selection
	Observe		Report observations
			Reason out for observation
			Determine value of
			Explore relation between
			Analyse the relation between
			Identify pattern
			Test a prediction
			Choose between
			Reason out for the choice
		Values of variables/parameters	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Determine value of
			Explore relation between
			Identify pattern
			Test a prediction
			Choose between
			Reason out for the choice
		Units of variables/parameters	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Determine value of
			Explore relation between
			Identify pattern
			Test a prediction
			Choose between
			Reason out for the choice
Model	Make	Parameters	Select
	Observe		Reason out for selection
	Select		Report observations
			Reason out for observation
			Determine value of
			Explore relation between
			Identify pattern
			Test a prediction

			Choose between
			Reason out for the choice
		Purpose	Select
			Reason out for selection
			Report observations
			Reason out for observation
			Choose between
			Reason out for the choice
			Test a prediction
Simulations	Select	Properties	Select
	Observe		Reason out for selection
			Report observations
			Reason out for observation
			Choose between
			Reason out for the choice
			Test a prediction

5. Practical context of task -- Duration of task

The duration of the task depends on the nature of the tasks. The average duration of the tasks assigned to the students in the electronics engineering virtual laboratories in order to achieve the learning outcomes selected in our context is arrived after the evaluation of the lab work. This is discussed in the various studies.

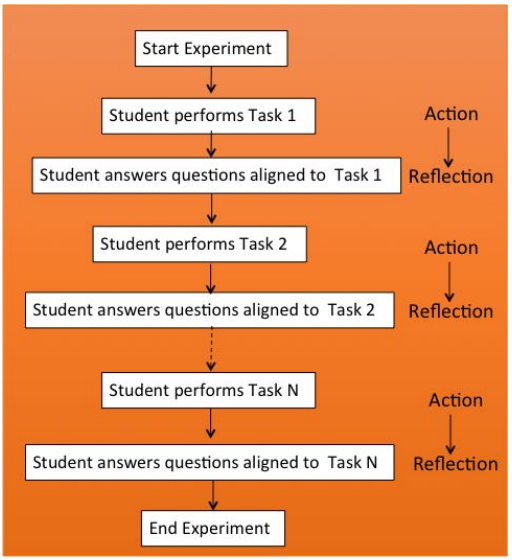
Task profile	Learning outcome criteria						Level of technical skills			Instructional style				Cognitive structure				
	R	I	E	DA	M	LFF	L	M	H	E	I	D	P	A	B	C	D	E
Duration of task	15	20	25	20	20	25	15	20	25	15		20	25	25	20	15	15	10

Guidelines for the Task Design based on Instructional strategy

Components of experiment	**Expository Instruction**	**Inquiry Instruction**	**Discovery Instruction** (Guided-inquiry)	**Problem-Based Instruction**
Broad goal/ Objective	Given	Given	Given	Given
Background Theory	Given	Given	Given	Given
Procedure	Given	Not given but decided by students	Given or decided by students	Given or decided by students
Circuit/System Design	Given	Not given but decided by students	Not given but decided by students	Given or decided by students
Information about what data to be collected	Given	Not given but decided by students	Not given but decided by students	Not given but decided by students
Data Analysis and Results	Given	Not given but decided by students	Not given but decided by students	Not given but decided by students
Interpretation of results	Not given but mostly known to the students	Not given but decided by students	Not given but decided by students	Not given but decided by students
Conclusion	Not given but mostly known to the students	Not given but decided by students	Not given but decided by students	Not given but decided by students

Step 4 – d. Guidelines for designing assessment questions aligned to learning objectives and tasks

After a comprehensive literature analysis we recommend that the type of assessment method, which should be followed in the virtual laboratories, is the Formative assessment or assessment for learning. This methodology can be followed as shown in the figure.



The assessment questions you ask should be aligned to the learning objectives and the tasks assigned to the students. The following table gives the list of assessment questions you can ask aligned to the tasks and learning objectives.

Tasks	**Assessment Questions**
Select (Drag and drop)	Why did you select?
	What will happen if you select sth else?
Observe	What is the value of?
	What is the purpose of?
Connect in circuit	How did you connect (series/parallel)?
	Why this type of connection?
Rotate	--
Double click	What is the value of specification xx?
	Can you change the value?
	Why did you change?
	What will happen if?
Right click	--
Construct/ Make	How did you construct?
	What type of analysis will you carry out?
	What function will xx circuit or system perform?
	Can it do yyy?
Display	What do you observe?
Reason out for selection	Why did you select the component/equipment/simulation property/plot/
Report observations	What is the nature of ?
	State the type of
Reason out for observation	Why did you get this output/result/plot?
Determine value of	How did you find out?
Explore relation between	What is the relation between the parameters?
Identify pattern	How are the parameters related?
Test a prediction	What will happen if?
	What output do your expect to obtain?

Choose between	Which of the given xx will you choose for yyy function/purpose?
Reason out for the choice	Why did you choose xxx?
	What will happen if you choose yyy instead of xxx?

The following table gives the list of assessment questions aligned to the focus area/criteria you wish to fulfill through the virtual lab experiment.

Learning objective focus area	Assessment Questions
Practical Skills	1. State the equipment you used to construct the circuit. 2. State the purpose of each of the equipment used in the circuit. 3. Which equipment you will choose to measure xxxx? 4. Why did you choose this equipment? 5. State the components you used to construct the circuit. 6. State the purpose of each of the components used in the circuit. 7. Which component you will choose for xxxx? 8. Why did you choose this component? 9. What will happen if x is chosen instead if y? 10. What type of input have you applied to the circuit? 11. State the specifications of applied input. 12. Why have you applied this input? 13. How will you observe the output? 14. How will you measure the input? 15. How will you measure the output? 16. Write the value of the input parameter. 17. State the value of output parameter. 18. What will be the headings of your observation table? 19. How many readings have you taken? 20. Did you enter all the reading correctly?
Practical Skills	1. How did you connect the equipment -Series/Parallel? 2. Why did you connect it in series/parallel? 3. What will happen if you reverse the connection? 4. What will happen if you reverse the component? 5. Is it possible to connect two or more components back to back? 6. Will you get the desired output if you connect the circuit with two or more components? 7. Observe the given circuit and state the types of connections?
Experimentation	1. State the equipment you used to construct the circuit. 2. State the purpose of each of the equipment used in the circuit. 3. Which equipment you will choose to measure xxxx? 4. Why did you choose this equipment? 5. State the components you used to construct the circuit. 6. State the purpose of each of the components used in the circuit. 7. Which component you will choose for xxxx? 8. Why did you choose this component? 9. What will happen if x is chosen instead if y? 10. What type of input have you applied to the circuit?

	11. State the specifications of applied input. 12. Why have you applied this input? 13. How will you observe the output? 14. How will you measure the input? 15. How will you measure the output? 16. Write the value of the input parameter. 17. State the value of output parameter. 18. What will be the headings of your observation table? 19. How many readings have you taken? 20. Did you enter all the reading correctly? 21. How did you connect the equipment -Series/Parallel? 22. Why did you connect it in series/parallel? 23. What will happen if you reverse the connection? 24. What will happen if you reverse the component? 25. Is it possible to connect two or more components back to back? 26. Will you get the desired output if you connect the circuit with two or more components? 27. Observe the given circuit and state the types of connections? 28. What type of analysis will you carry out for the circuit? 29. Why would you carry out this analysis? 30. What simulation properties will you select for this analysis? 31. Why would you choose these simulation properties? 32. What will happen if you choose yy analysis instead of xx? 33. What will happen if you choose yyy simulation properties instead of xxx? 34. If the circuit is modified what analysis will you carry out? 35. Why this type of analysis for the modified circuit? 36. What simulation properties will you choose for the modified analysis? 37. What parameter did you plot on the X/Y axes? 38. Why did you choose these parameters for the plots? 39. What is the nature of graph obtained? 40. What will happen if you plot x parameter on Y-axis and y on X-axis? 41. Can you plot x parameter on Y-axis and y on X-axis? 42. What is the scale selected for the two axes? 43. Why did you select these scales? 44. Can you change these scales?
Data Analysis	1. What type of analysis will you carry out for the circuit? 2. Why would you carry out this analysis? 3. What simulation properties will you select for this analysis? 4. Why would you choose these simulation properties? 5. What will happen if you choose yy analysis instead of xx? 6. What will happen if you choose yyy simulation properties instead of xxx? 7. If the circuit is modified what analysis will you carry out? 8. Why this type of analysis for the modified circuit? 9. What simulation properties will you choose for the modified analysis? 10. What parameter did you plot on the X/Y axes?

	11. Why did you choose these parameters for the plots? 12. What is the nature of graph obtained? 13. What will happen if you plot x parameter on Y-axis and y on X-axis? 14. Can you plot x parameter on Y-axis and y on X-axis? 15. What is the scale selected for the two axes? 16. Why did you select these scales? 17. Can you change these scales? 18. What will happen if you change these scales? 19. Can you plot multiple graphs on the same plot? 20. How many graphs can you plot? 21. How do you find the value of the parameter plotted on the X-axis? 22. How do you find the value of the parameter plotted on the Y-axis? 23. What is the unit of the parameter on the X-axis? 24. What is the unit of the parameter on the Y-axis?
Modeling	1. State the equipment you used to construct the circuit. 2. State the purpose of each of the equipment used in the circuit. 3. Which equipment you will choose to measure xxxx? 4. Why did you choose this equipment? 5. State the components you used to construct the circuit. 6. State the purpose of each of the components used in the circuit. 7. Which component you will choose for xxxx? 8. Why did you choose this component? 9. What will happen if x is chosen instead if y? 10. What type of input have you applied to the circuit? 11. State the specifications of applied input. 12. Why have you applied this input? 13. How will you observe the output? 14. How will you measure the input? 15. How will you measure the output? 16. Write the value of the input parameter. 17. State the value of output parameter. 18. What will be the headings of your observation table? 19. How many readings have you taken? 20. Did you enter all the reading correctly? 21. How did you connect the equipment -Series/Parallel? 22. Why did you connect it in series/parallel? 23. What will happen if you reverse the connection? 24. What will happen if you reverse the component? 25. Is it possible to connect two or more components back to back? 26. Will you get the desired output if you connect the circuit with two or more components? 27. Observe the given circuit and state the types of connections? 28. What type of analysis will you carry out for the circuit? 29. Why would you carry out this analysis? 30. What simulation properties will you select for this analysis? 31. Why would you choose these simulation properties?

	32. What parameter did you plot on the X/Y axes? 33. Why did you choose these parameters for the plots? 34. What is the nature of graph obtained? 35. Obtain the equation for the graph obtained. 36. What is the difference between the theoretical equation and the derived equation?Why is there a difference in the two equations?
Learn from failure	1. State the equipment you used to construct the circuit. 2. State the purpose of each of the equipment used in the circuit. 3. Which equipment you will choose to measure xxxx? 4. Why did you choose this equipment? 5. State the components you used to construct the circuit. 6. State the purpose of each of the components used in the circuit. 7. Which component you will choose for xxxx? 8. Why did you choose this component? 9. What will happen if x is chosen instead if y? 10. What type of input have you applied to the circuit? 11. State the specifications of applied input. 12. Why have you applied this input? 13. How will you observe the output? 14. How will you measure the input? 15. How will you measure the output? 16. Write the value of the input parameter. 17. State the value of output parameter. 18. What will be the headings of your observation table? 19. How many readings have you taken? 20. Did you enter all the reading correctly? 21. How did you connect the equipment Series/Parallel? 22. Why did you connect it in series/parallel? 23. What will happen if you reverse the connection? 24. What will happen if you reverse the component? 25. Is it possible to connect two or more components back to back? 26. Will you get the desired output if you connect the circuit with two or more components? 27. Observe the given circuit and state the types of connections? 28. What type of analysis will you carry out for the circuit? 29. Why would you carry out this analysis? 30. What simulation properties will you select for this analysis? 31. Why would you choose these simulation properties? 32. What parameter did you plot on the X/Y axes? 33. Why did you choose these parameters for the plots? 34. What is the nature of graph obtained? 35. What modification is required in the circuit to obtain the desired output? 36. How did you find out the modifications required? 37. Did you get the desired result after carrying out the modifications?