Features of Basic Electronics Virtual lab

Guidelines on how to design effective experiments

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Broad Goal of the presentation

Help engineering instructors to design effective virtual lab experiments

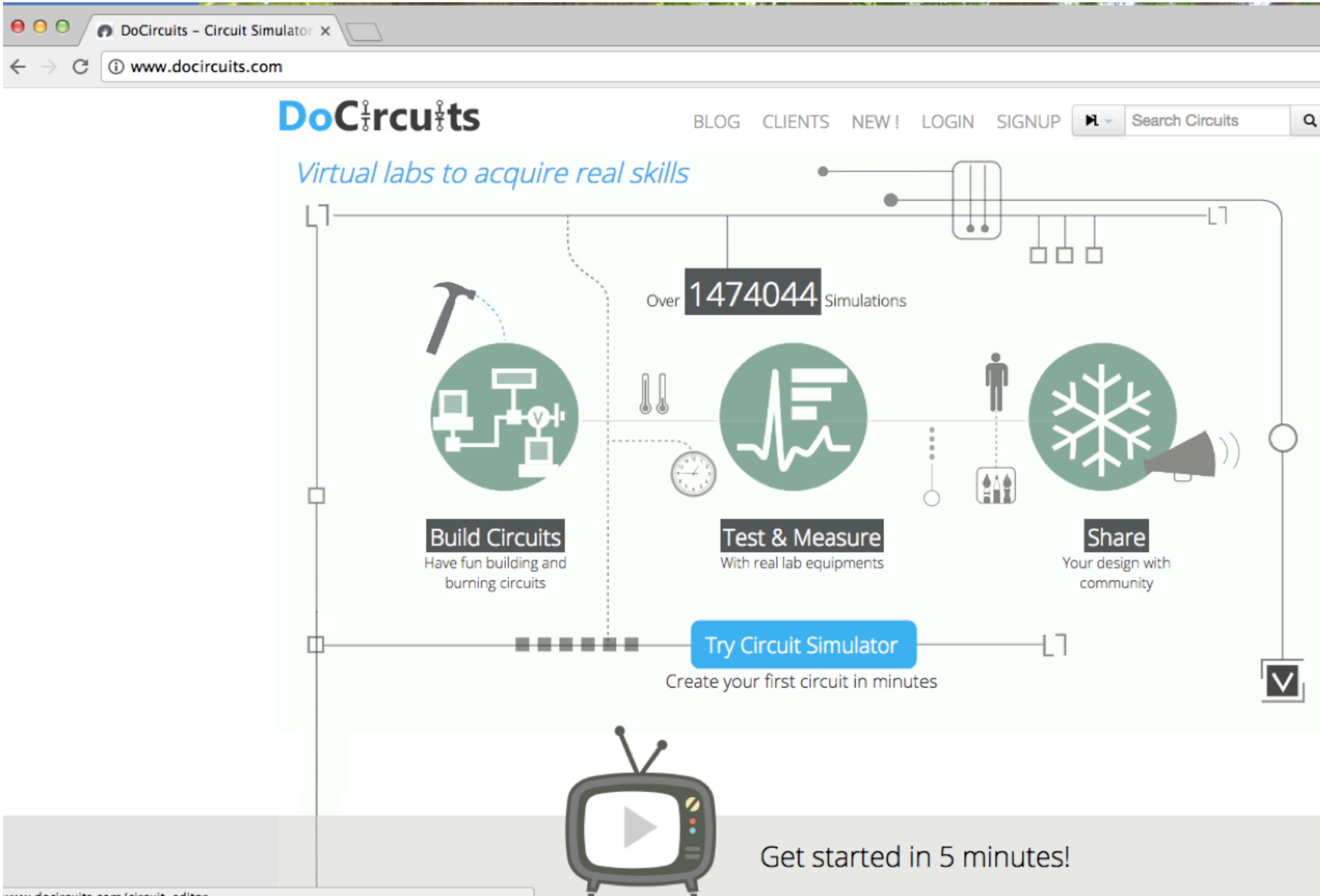
Objectives

- The engineering instructors should be able to understand the various features of the Circuit Simulation Virtual lab
- The engineering instructors should be able to design effective experiments utilizing these features
- The experiment designs should incorporate the various experiment design guidelines proposed in the SDVIcE tool

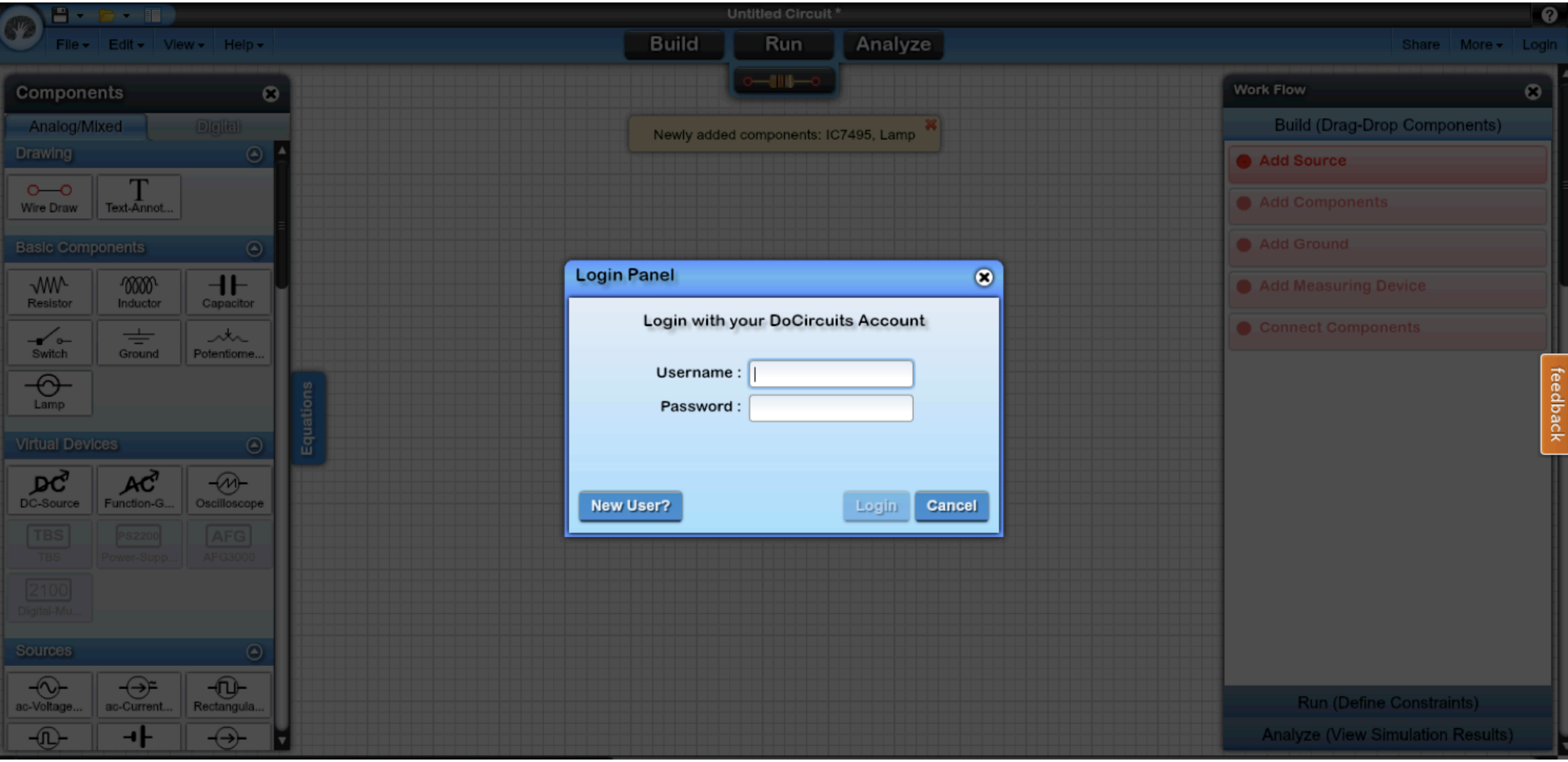
Sample Circuit Simulation Virtual lab

- In this presentation the DoCircuits Virtual lab is considered as the sample example but there are numerous such virtual labs available online.
- You may select any one of the labs for your experiment design
- The labs available online along with their URL are
- https://www.circuitlab.com/editor/#?id=7pq5wm
- http://www.partsim.com/simulator

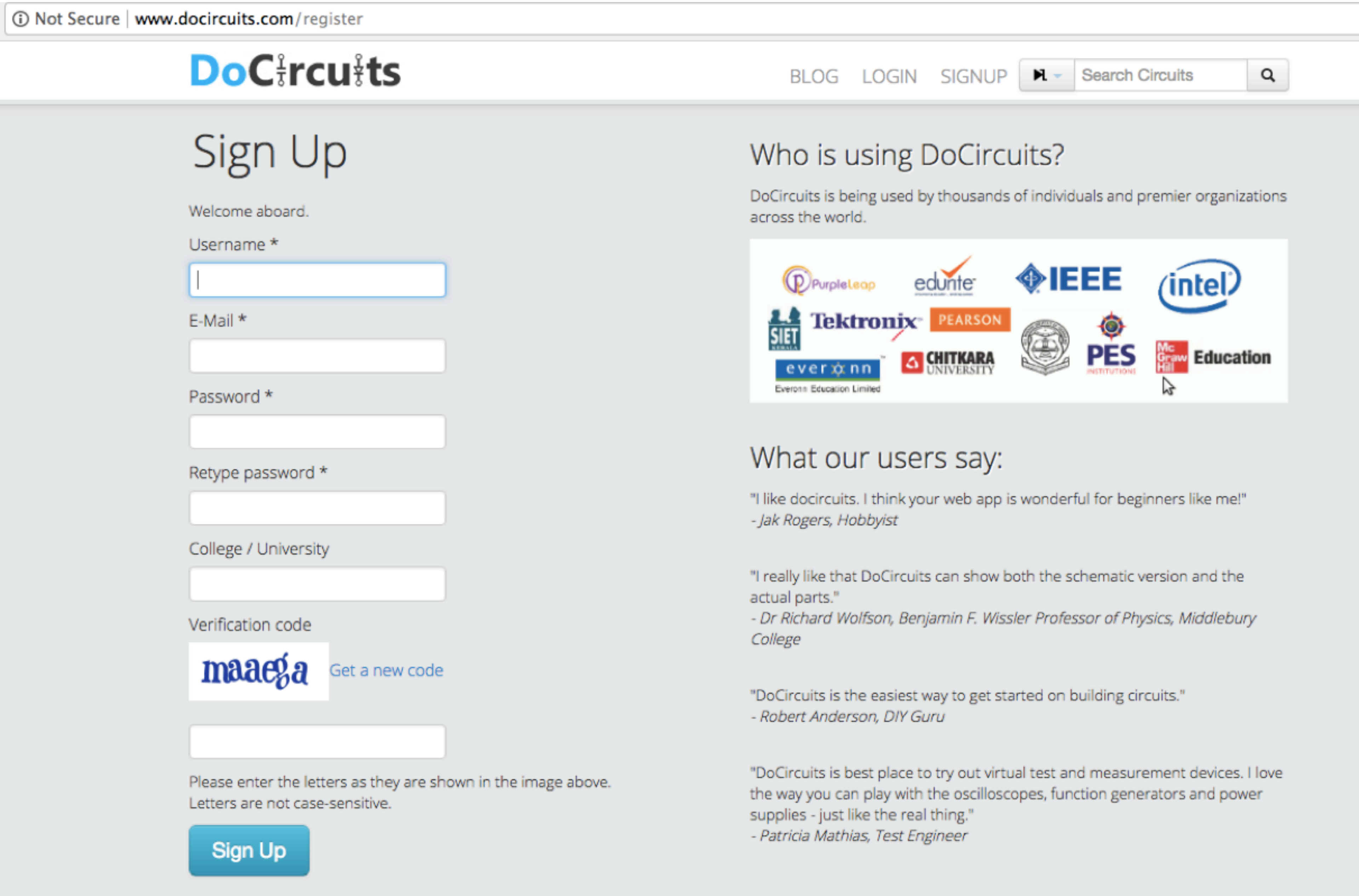
Landing page of the Circuit Simulation vlab



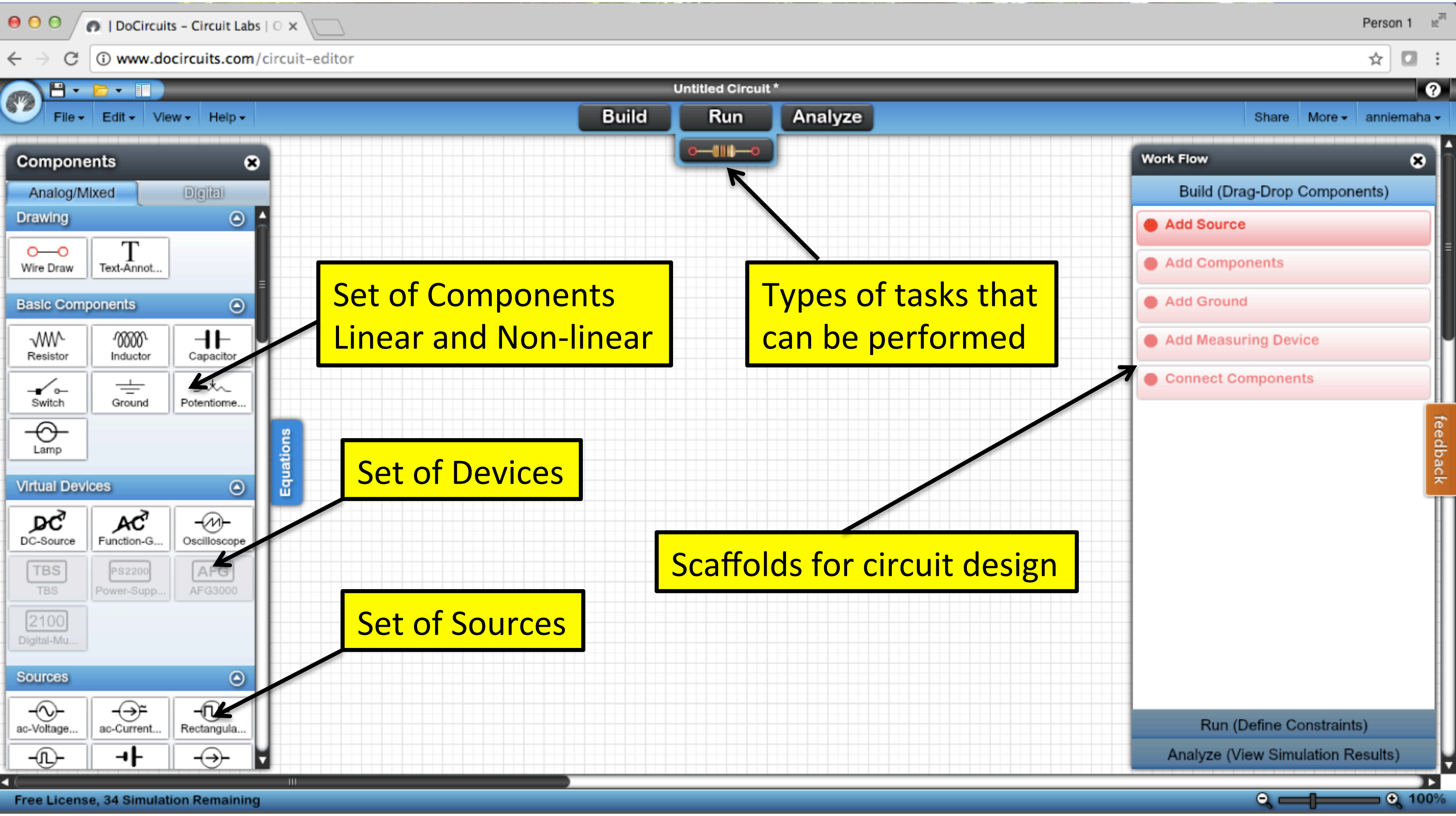
After you select the vlab you need to register with a username and password



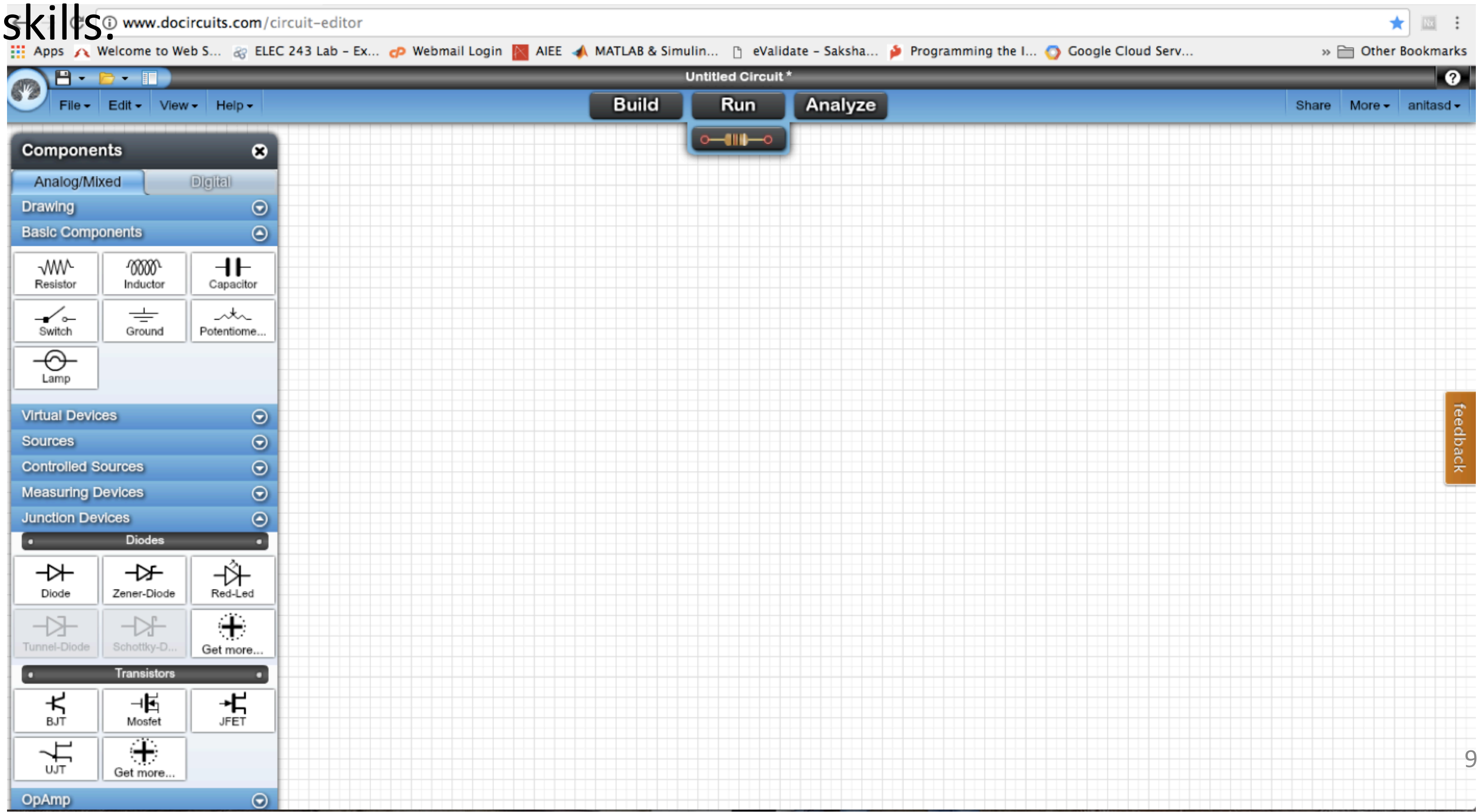
This is the Sign Up registration form



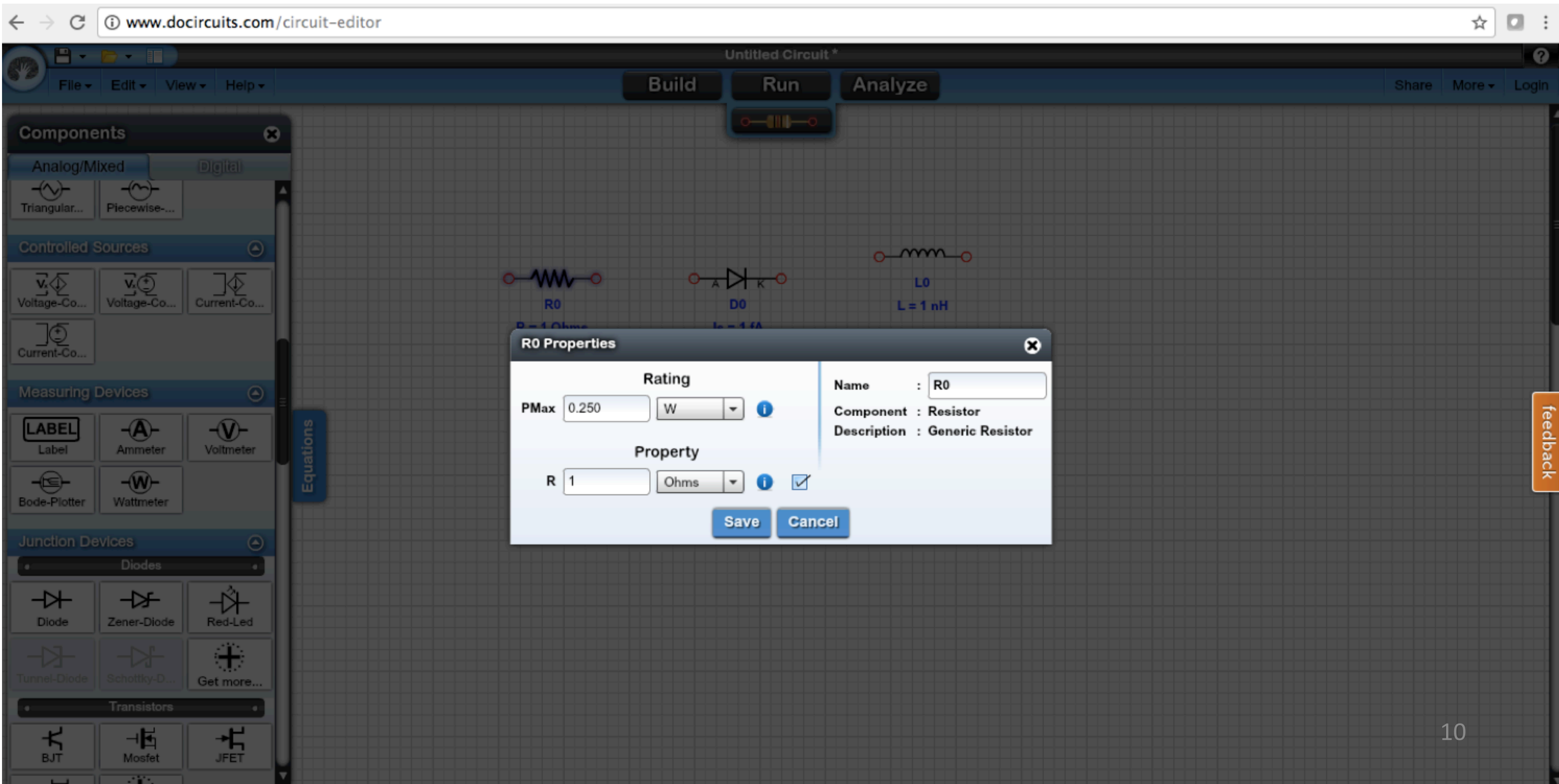
The Simulators have the components as seen in the figure



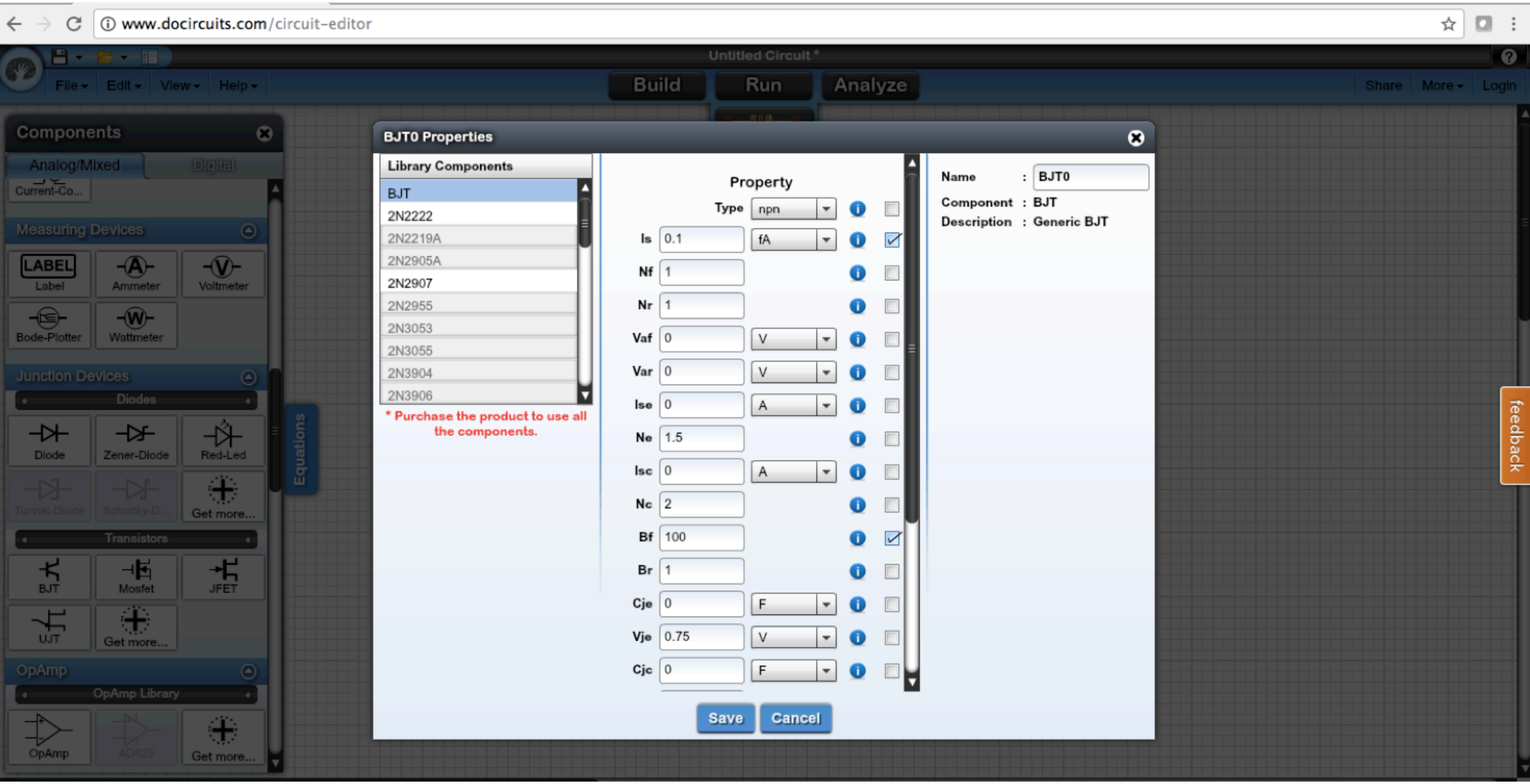
Feature 1: A library of a variety of components and types of instruments are available for the students. This provides them an opportunity to play around with them. This is one of the most important feature as although there are a variety of components and equipment in physical lab too there are constraints and we do not allow the students to play around. This helps in the development of practical skills.



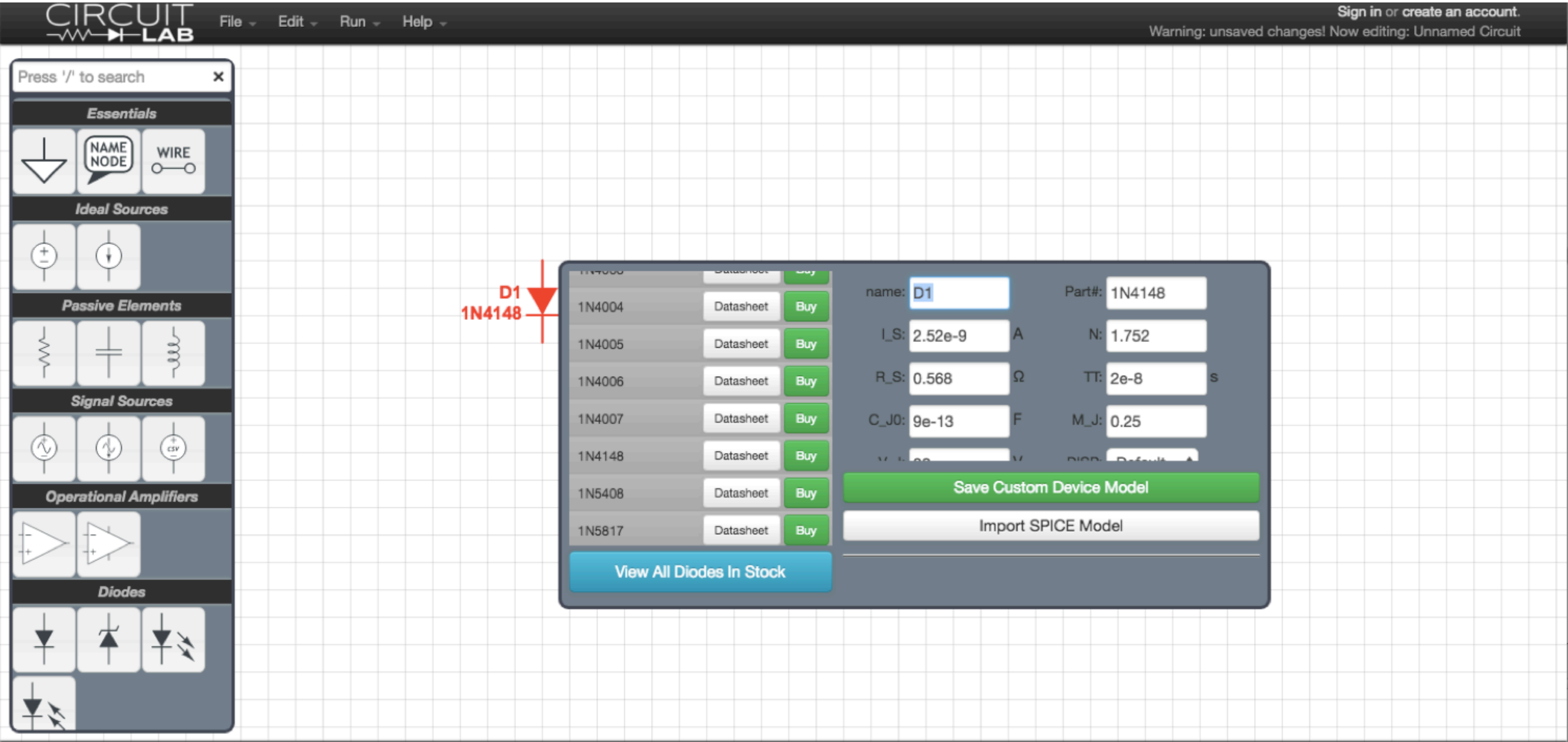
Feature 2: Students can vary the properties or specifications of all the components. In physical labs although this is possible the students are not provided the opportunity of selecting the different components due to various constraints. This helps the students in understanding the concept of specifications. You can design experiments so as to make students vary the specifications and analyse the effect on the results.



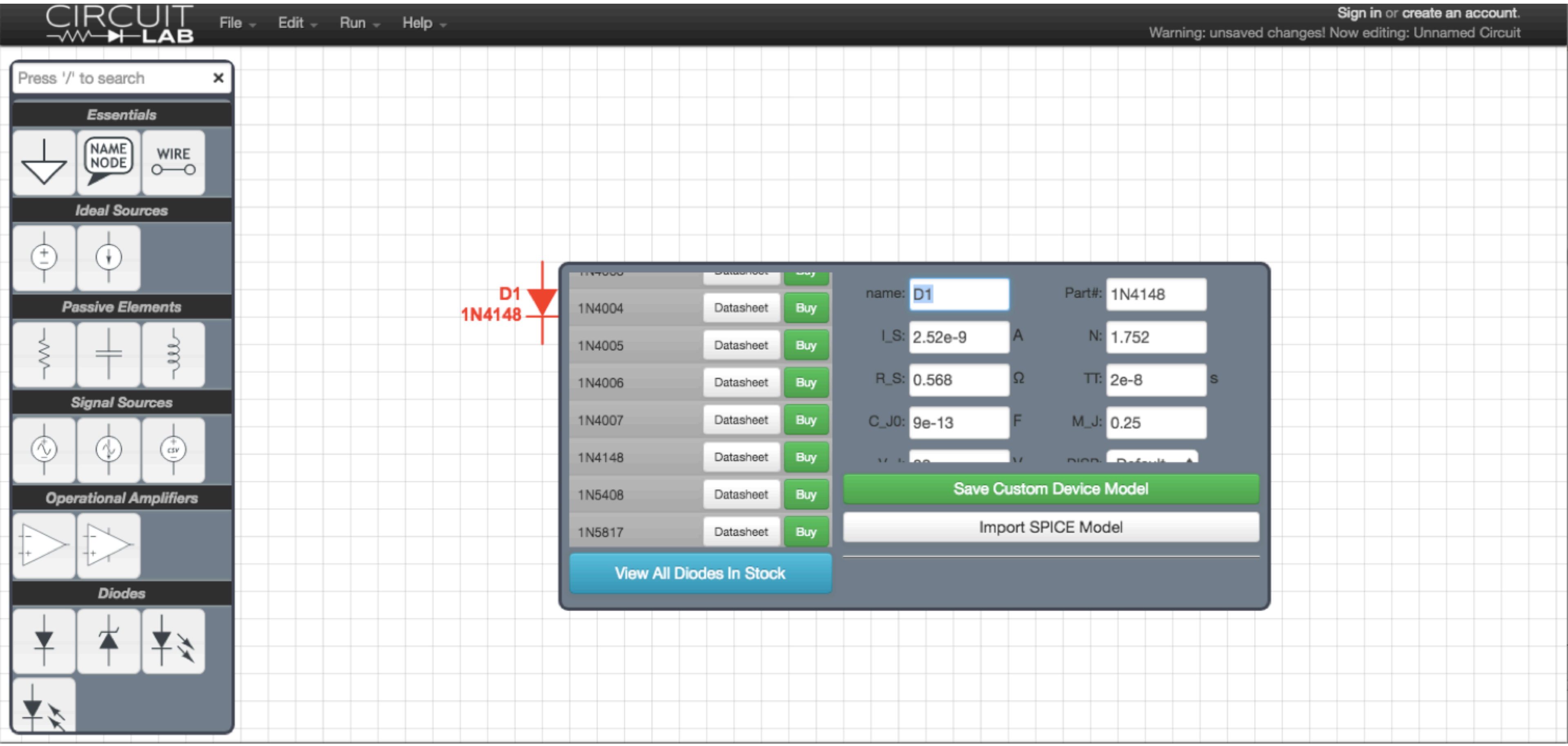
Feature 2: As seen in the figure the students can vary the values of specifications such as temperature, junction capacitance etc. You can design experiments to enable students understand the effect of these on the V-I characteristics of the diode. This helps in the development of higher order objectives such as analysis and evaluation.



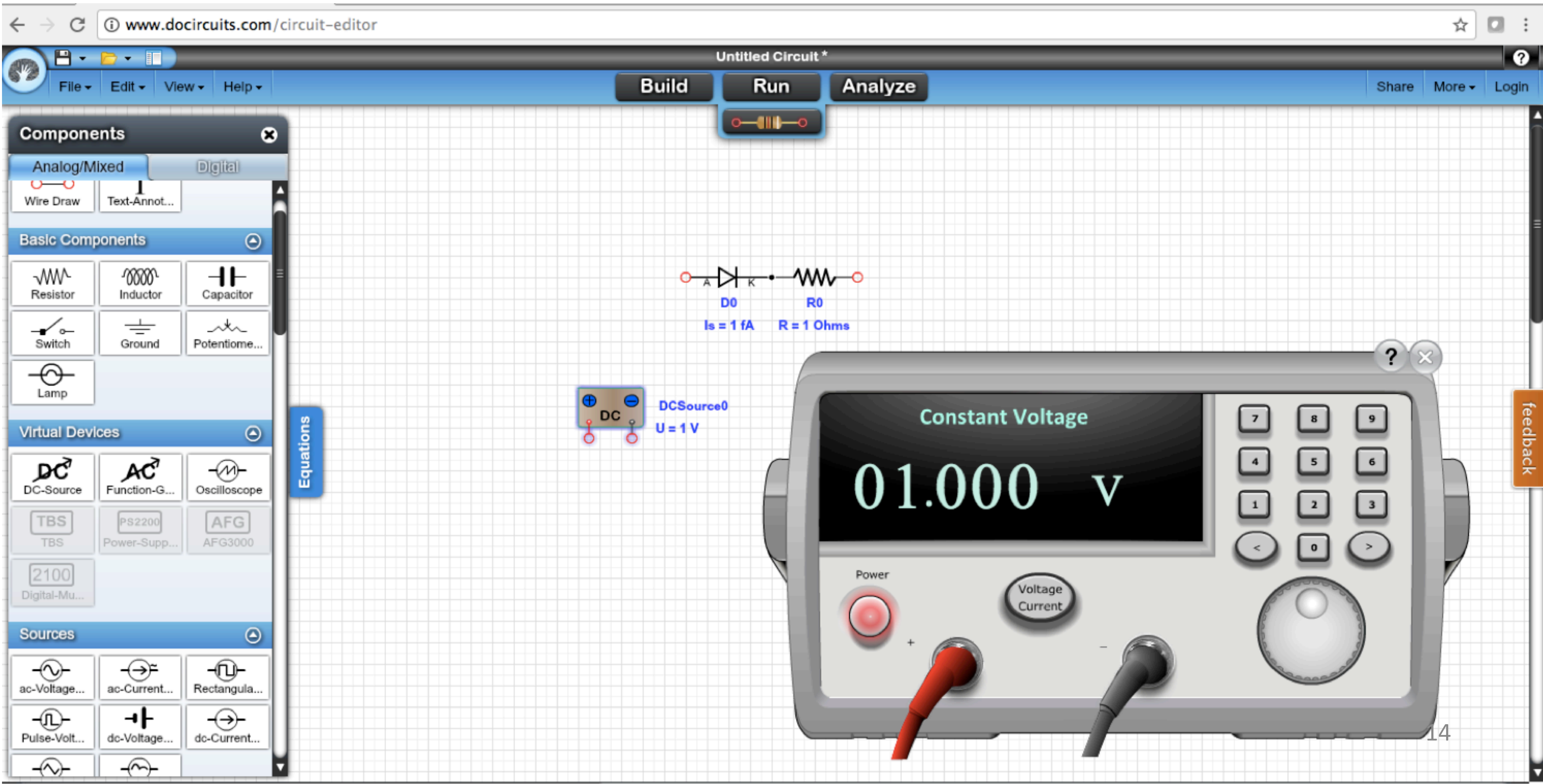
Feature 3: As seen in the figure whenever a particular component is selected the entire specifications are visible. Also as the students selects the components one by one they can compare the specifications. You can ask questions in the experiment design related to the reasons for the selection of a particular component. This helps in the development of higher order objectives such as evaluation.



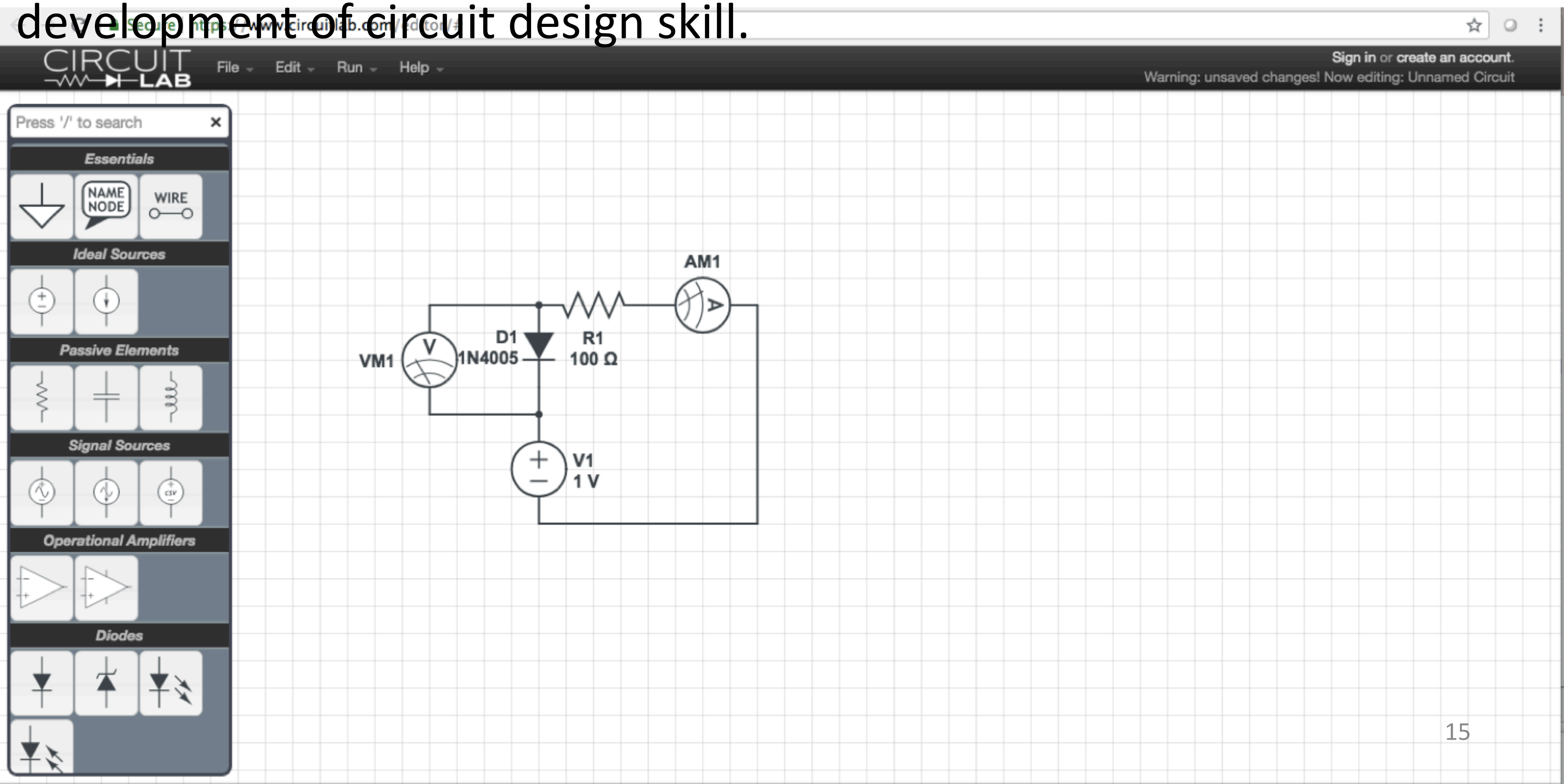
Feature 3: As seen in the figure there is a link provided for the entire datasheet of the component. They can refer to them as and when they want. This is also provided in the physical lab but not so many copies are normally kept that each student can refer separately.



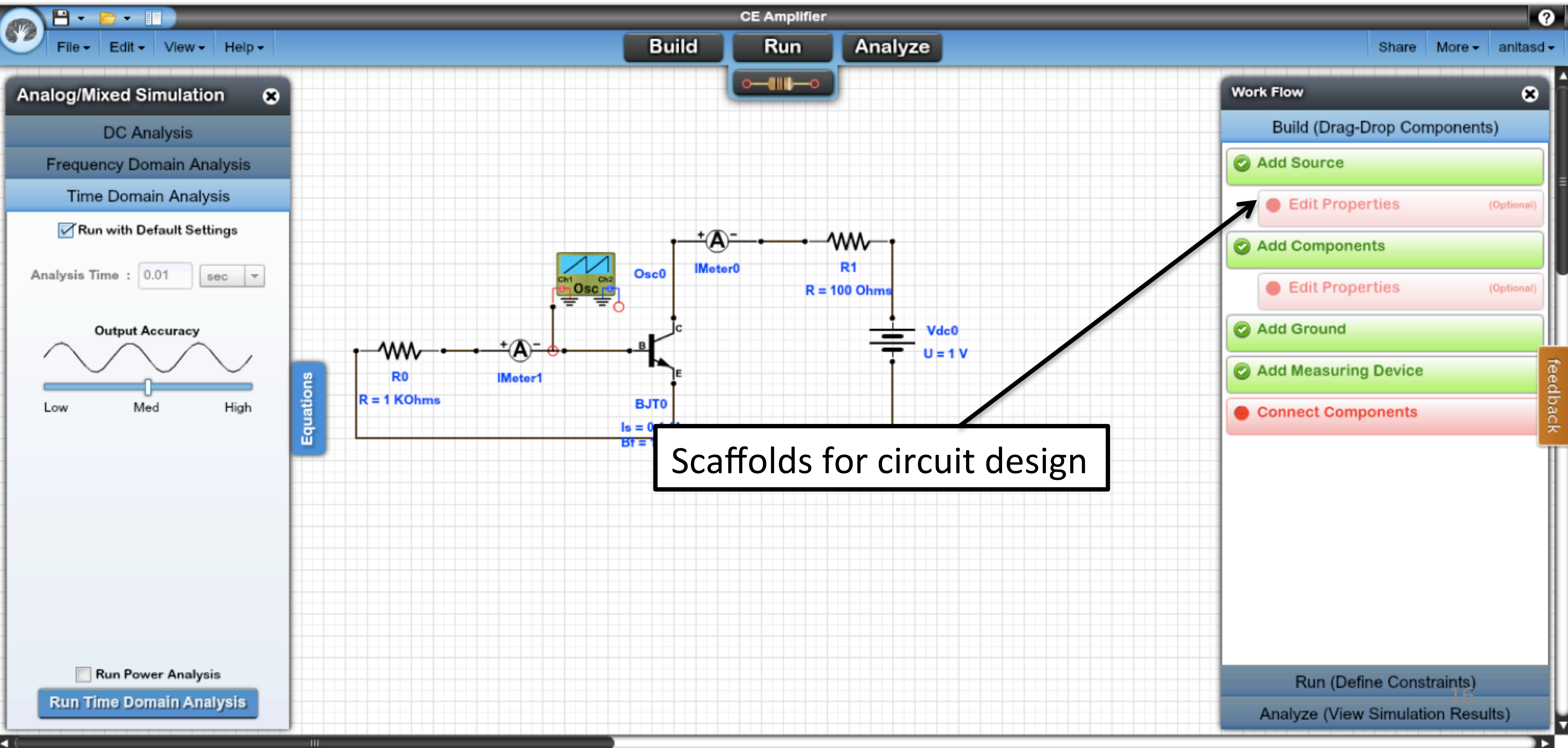
Feature 4: The students can get the feel of operating a real equipment as the image is real life and the various functions and adjustments are exactly same as in actual. The students are not distracted due to non-functioning of the equipment as in physical lab. You can design experiments with the objective of developing the students practical skills such as operating equipment, taking measurements etc.



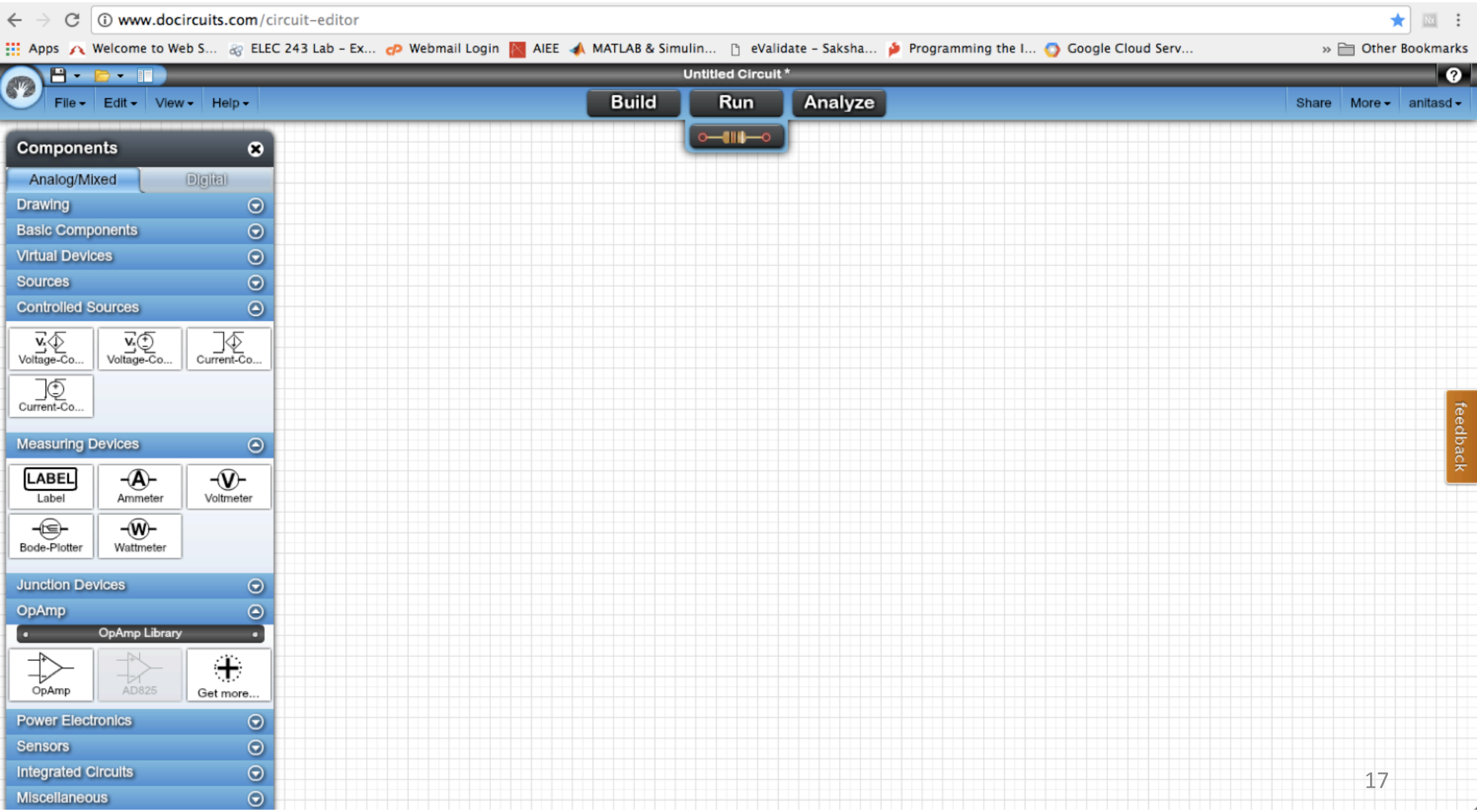
Feature 5: The students can drag and drop any component and equipment and construct the circuits multiple times with minimum time. In case of physical labs it takes a lot of time for the students to assemble the circuit on a breadboard. You can design experiment in which the students understand and analyse the different variations of the same circuit or compare multiple designs. This feature helps in the development of circuit design skill.



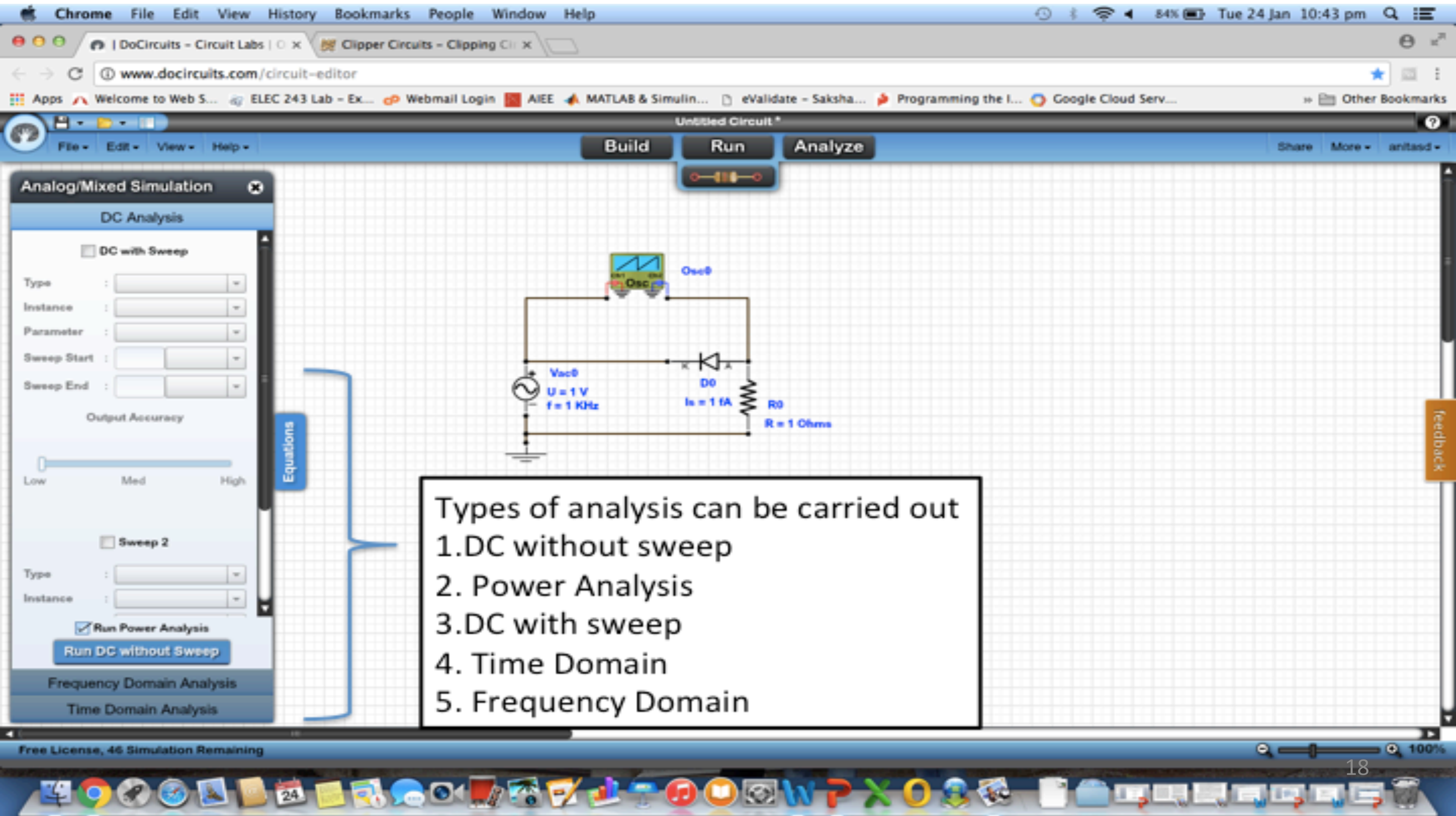
Feature 6: In some of the circuit simulators If students do not complete the circuit construction correctly, an explanation is provided in the form of a concise informative message. Scaffolds provided for completion of circuit construction help students and keep them motivated and engaged.



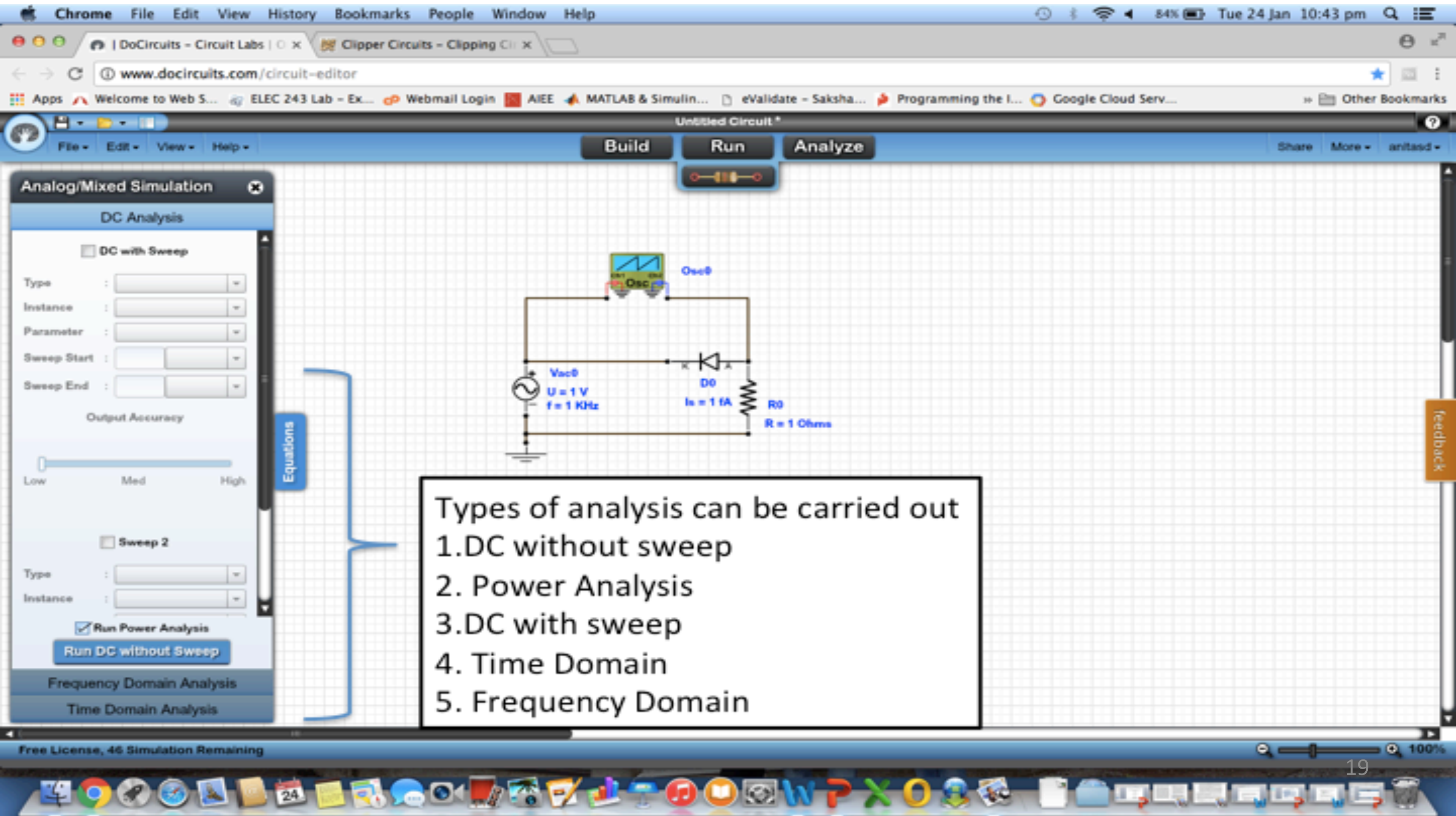
Feature 7: The circuit simulator requires less setup time and Students can perform more experiments and thus gather more information in the same amount of time it would take to do the physical experiment.



Feature 8: After the students construct the circuit they can carry out five types of analysis – DC without sweep, Power Analysis, DC with sweep, Time Domain and Frequency Domain. This provides results of lengthy investigations instantaneously and accurately. This helps in the development of anaytical and manipulative skills.

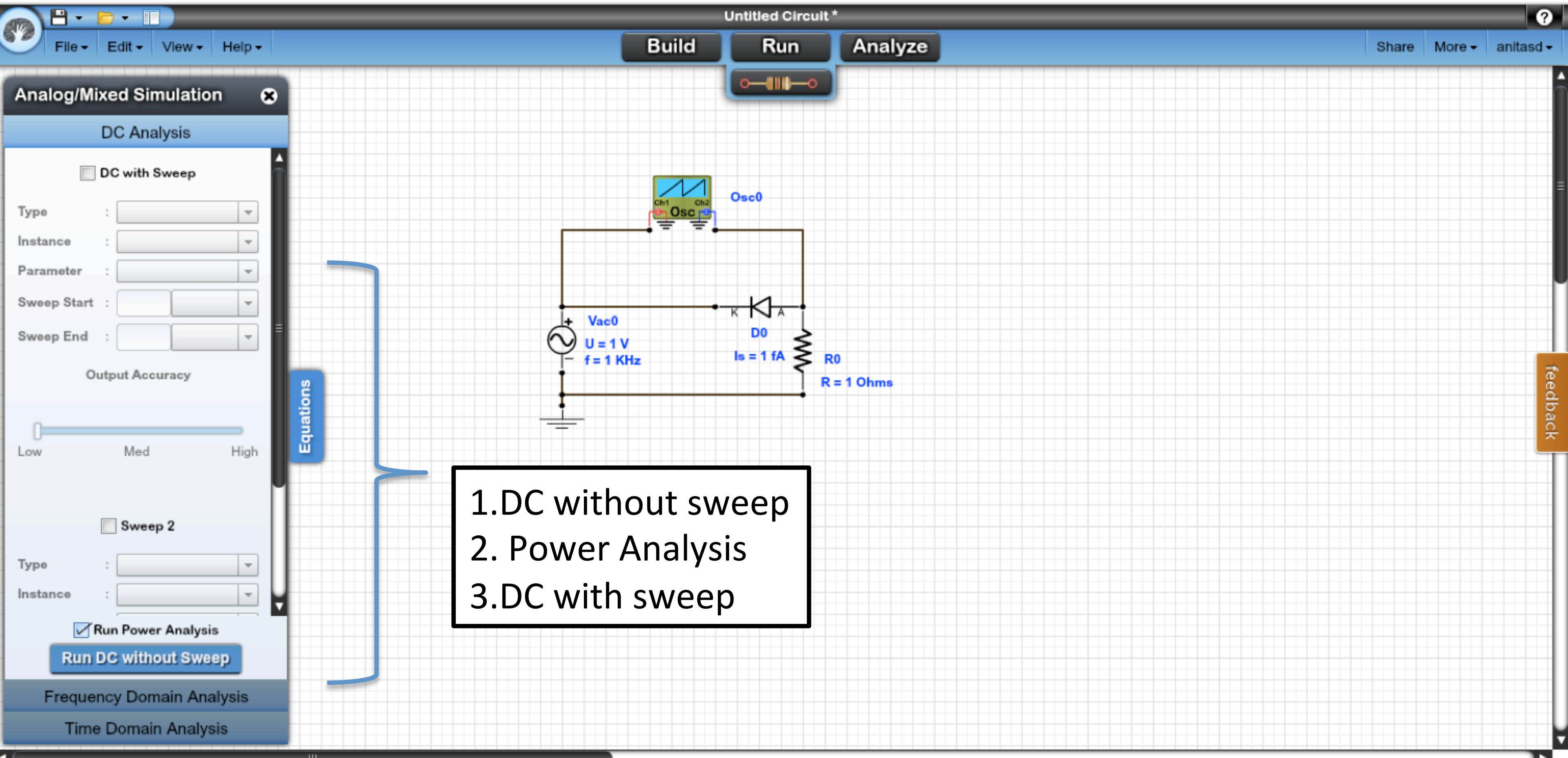


Feature 8: After the students construct the circuit they can carry out five types of analysis – DC without sweep, Power Analysis, DC with sweep, Time Domain and Frequency Domain. You can design experiments in which students can carry out the analysis of the same circuit multiple times by changing a particular component or changing the specification of a particular component.



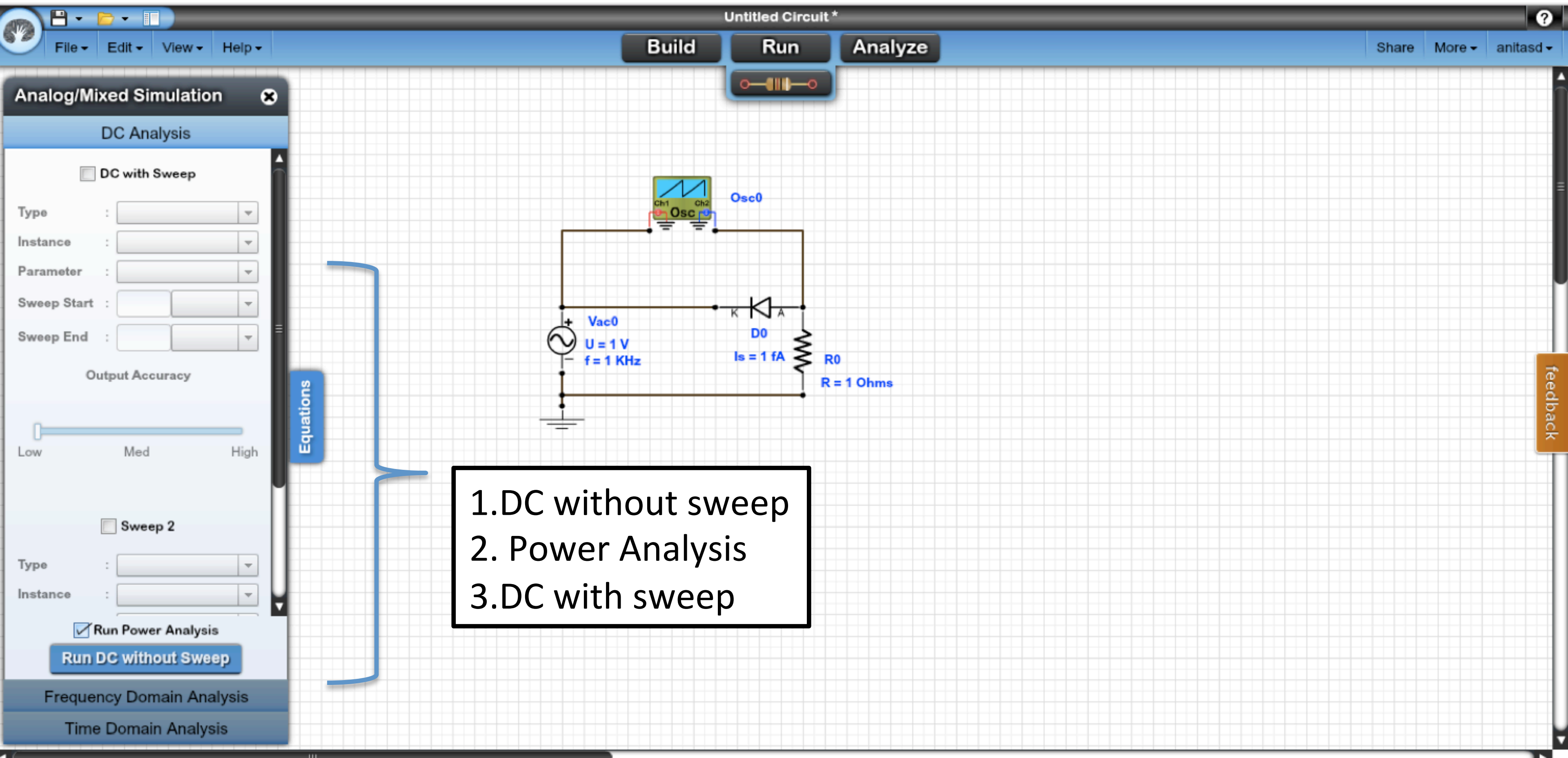
Feature 9: The various DC Analyses that are possible are

1. DC without sweep – This helps the students to measure the voltages at various locations in the circuit and currents through different components. You can design experiment so that the students analyse the change in these values depending on the change in the circuit components or component specifications. This develops their analytical, manipulative and investigative skills



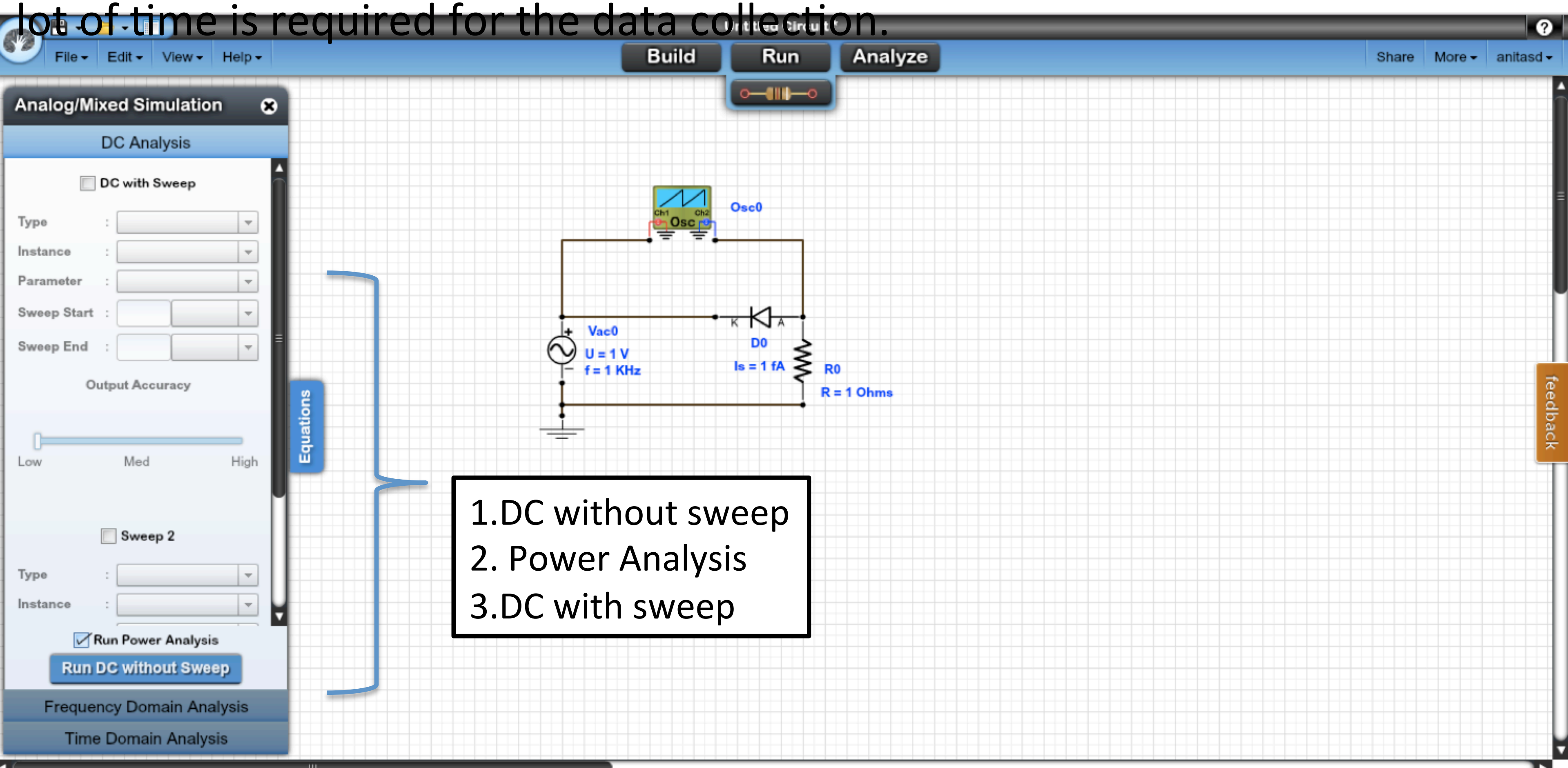
Feature 9: The various DC Analyses that are possible are

2. Power Analysis – This helps the students to measure the power in the circuit. You can design experiment so that the students analyse the change in these values depending on the change in the circuit components or component specifications. This develops their analytical, manipulative and investigative skills. This is difficult in the physical labs as the equipment for power analysis are normally not available.

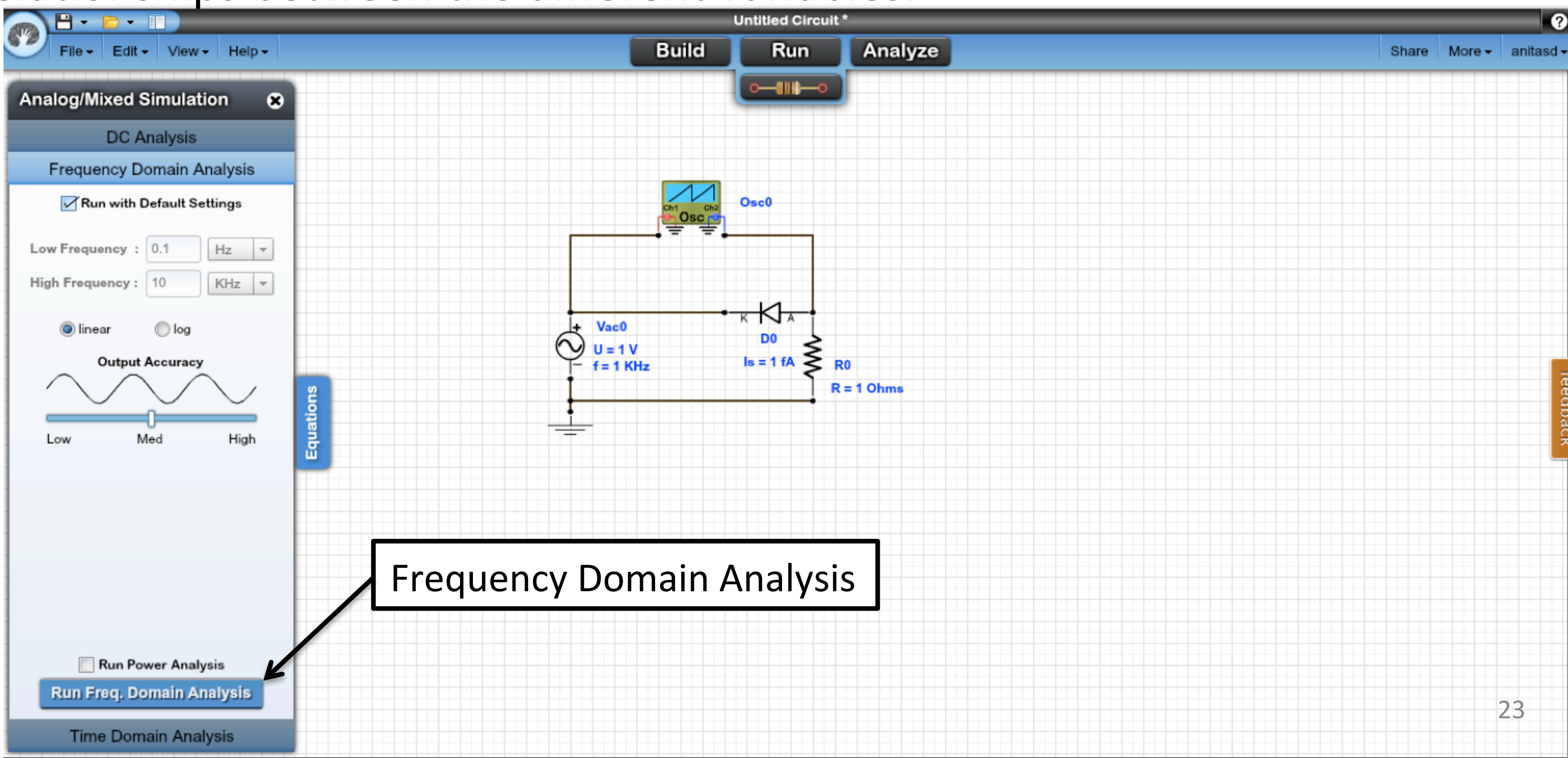


Feature 9: The various DC Analyses that are possible are

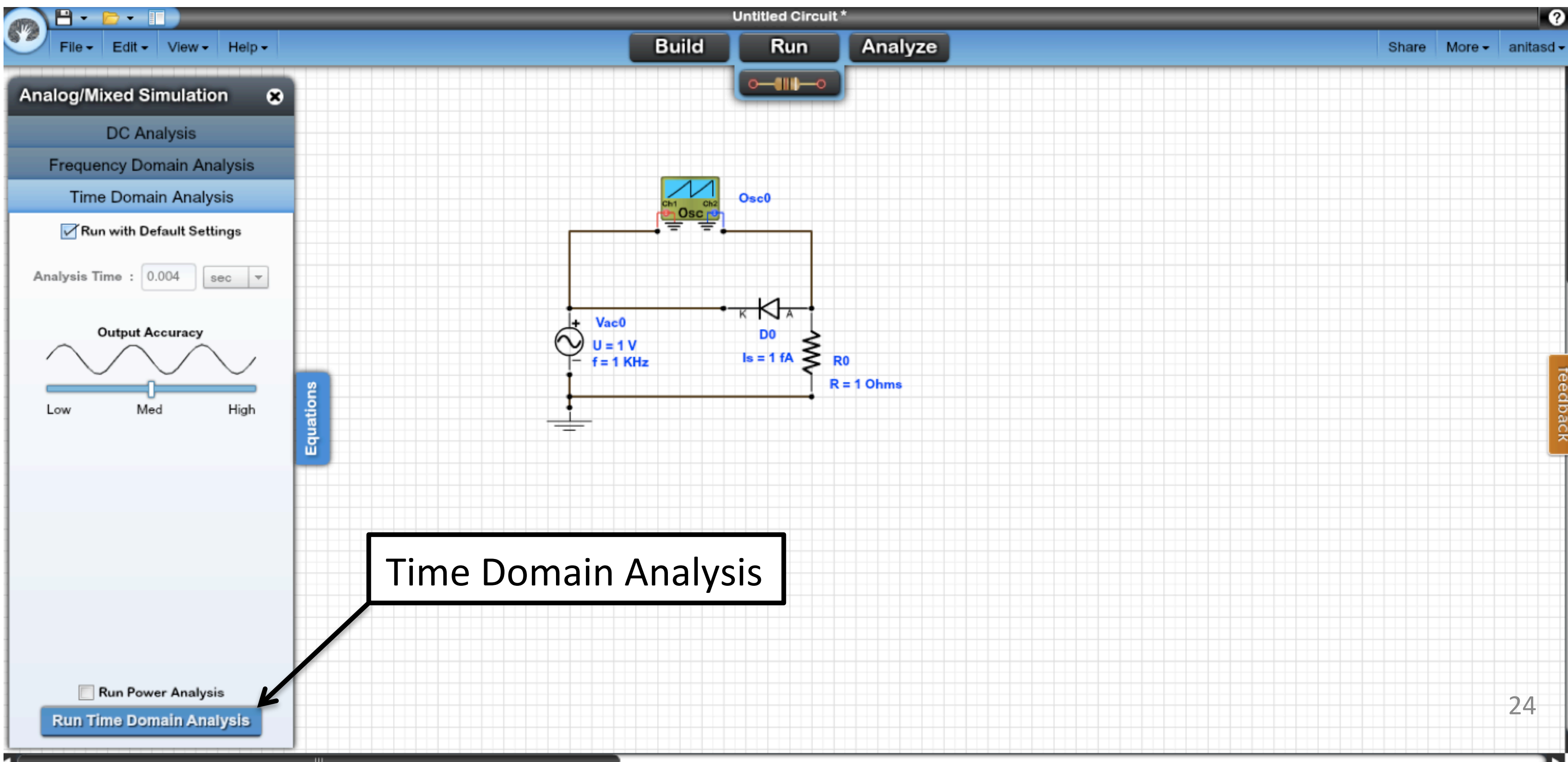
3. DC with sweep – This feature helps in obtaining the various plots of the continuous change in the value of a particular parameter with respect to another such as the V-I Characteristics of diode, Input Characteristics of BJT etc. The plots can be obtained instantaneously and accurately. You can design experiments in which the students plot the graphs of the different variables and carry out analysis immediately. This is not possible in the physical labs as lot of time is required for the data collection.



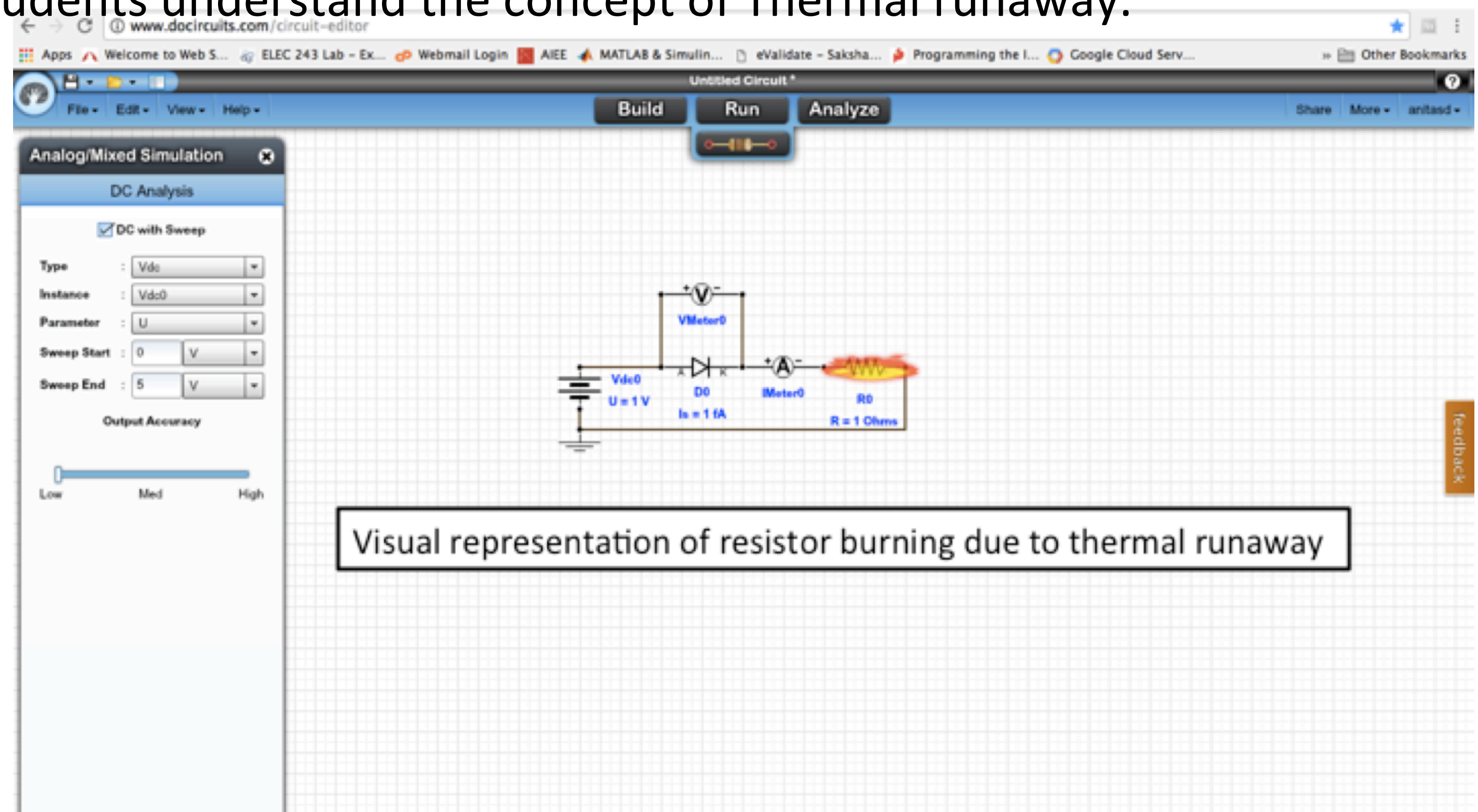
Feature 10: The students can carry out Frequency Domain Analysis. The plots of the variables in the frequency domain can be obtained instantaneously and accurately. This reduces the time required as in case of the physical labs where the students initially gather the data for the plot, then plot the graph using paper and pencil and then they can analyse it. In the virtual lab as the graphs are obtained within no time you can design experiments in which the emphasis is on analysing the graphs, improving students understanding of the relationships between the different variables.



Feature 10: The students can carry out Time Domain Analysis. The plots of the variables in the frequency domain can be obtained instantaneously and accurately. This reduces the time required as in case of the physical labs where the students initially gather the data for the plot, then plot the graph using paper and pencil and then they can analyse it. In the virtual lab as the graphs are obtained within no time you can design experiments in which the emphasis is on analysing the graphs, improving students understanding of the relationships between the different variables.

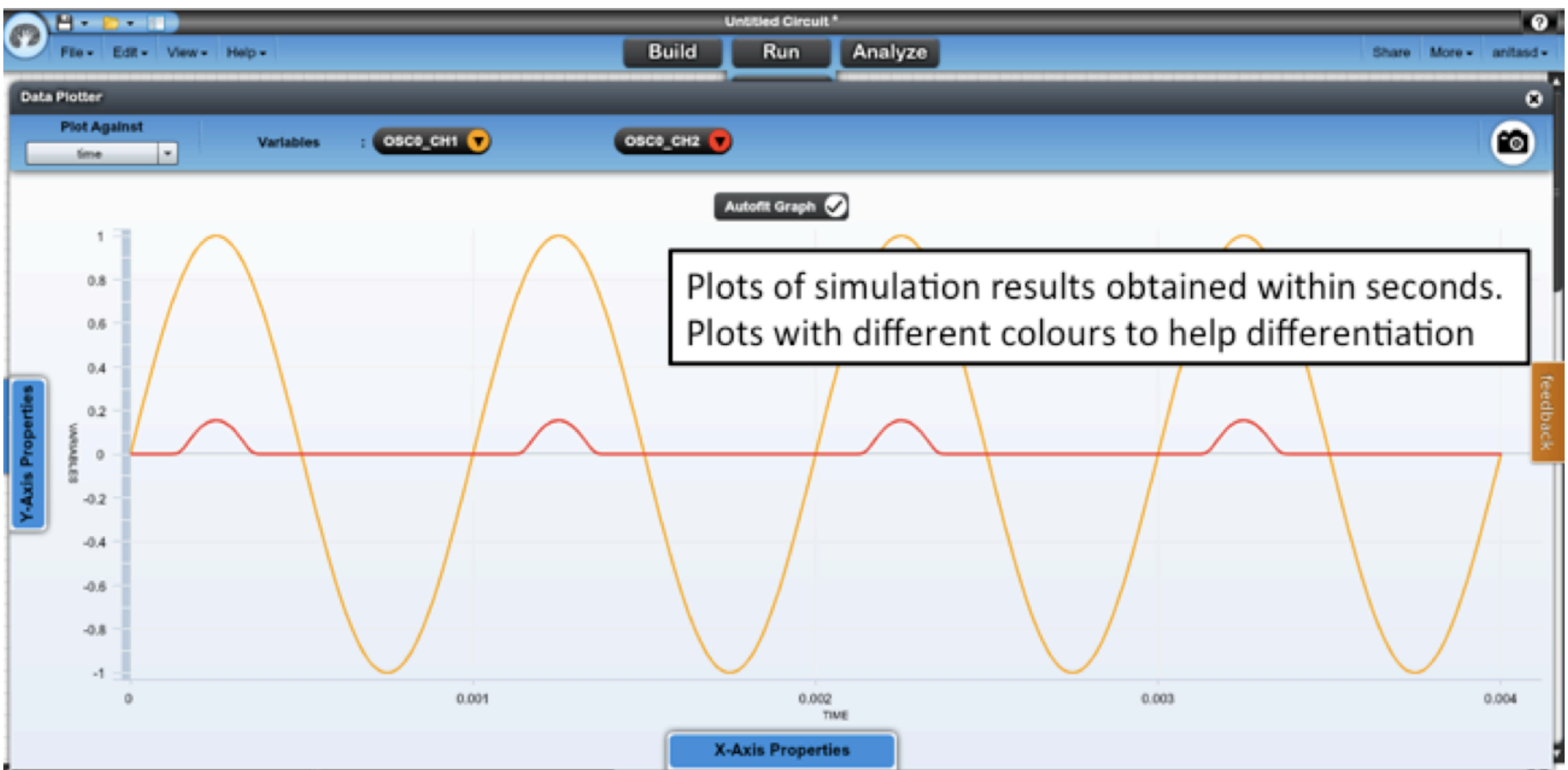


Feature 11: A very important feature is the visual of the component burning when the current flowing through it exceeds the power rating of the component as shown in the figure. This is not allowed in physical labs as it damages the component. This is a very important part of students learning as they get to learn from failure. You can design experiments in which the students are given a circuit with higher currents and then make them adjust the values of the parameters in order to rectify the problem. This helps the students understand the concept of Thermal runaway.

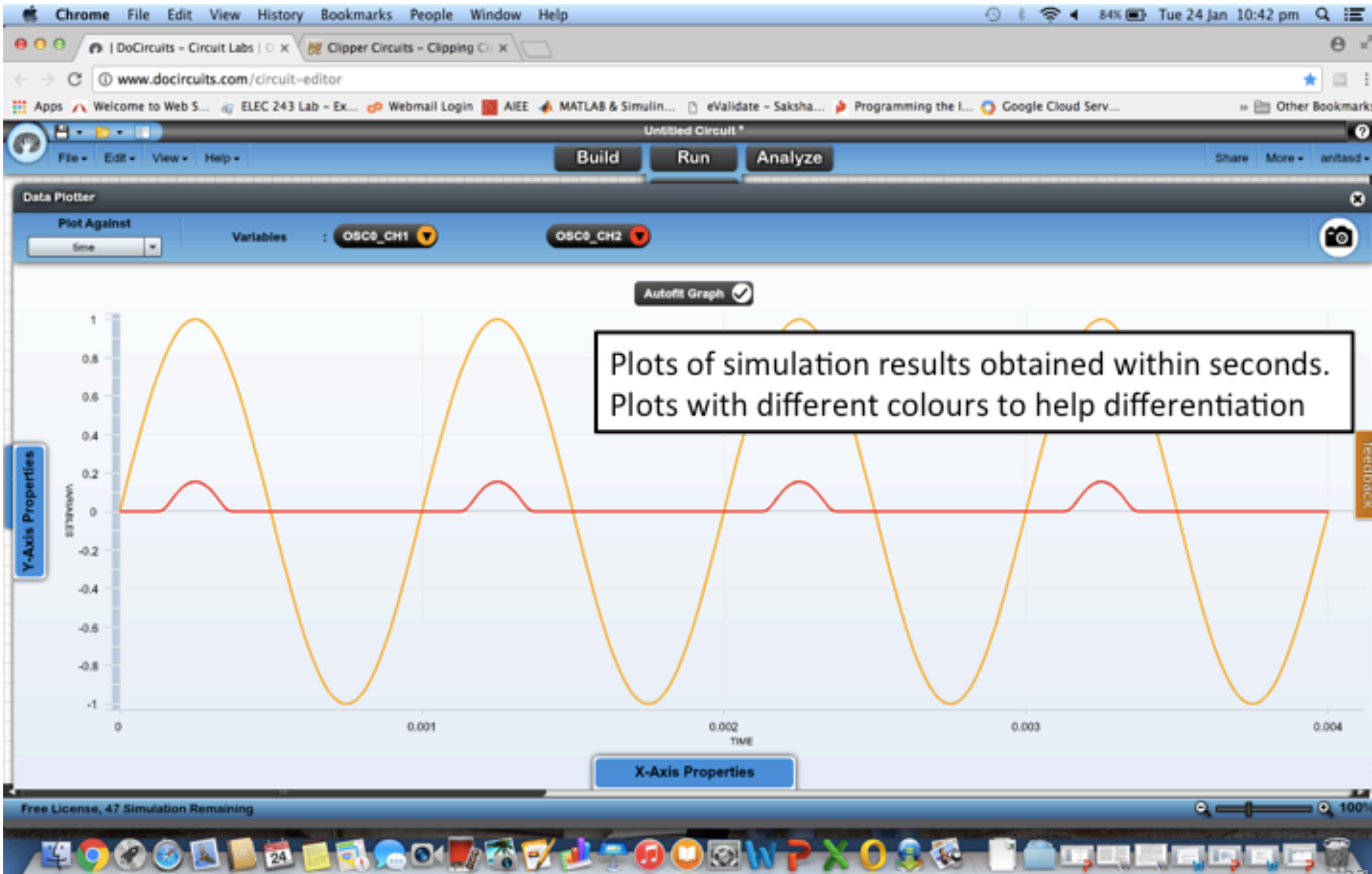


Visual representation of resistor burning due to thermal runaway

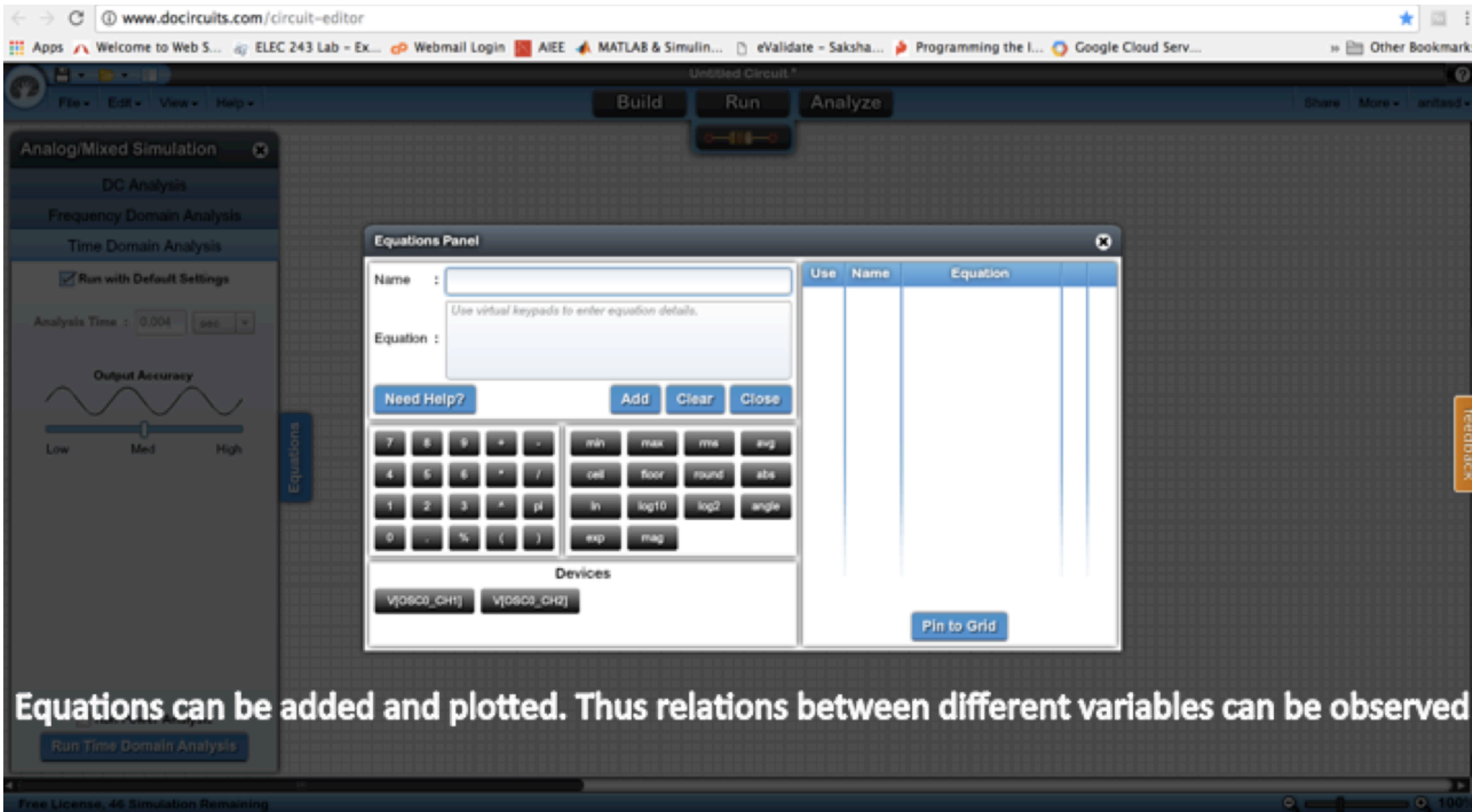
Feature 12: Facilitates recording measurements and plotting of data (e.g., semi-log graphing of the transfer function of a low-pass filter). As can be seen from the figure the graphs of three variables can be seen simultaneously. This feature can help students understand and analyse the relationships between the different variables. You can design experiments at higher cognitive levels such as anlyse and evaluate.



Extract valid information from a complex visualization when they draw what they observed in an experiment



Feature 13: Students can also directly link unobservable processes to symbolic equations and observable phenomena, which encourages them to make abstractions over different representations. This feature allows the students to plot the graphs of equations. You can design experiments in which the students can see the relations of variables for example the Vdc,Vrms,Vac simultaneously



Design experiments with learning objectives at higher cognitive levels

- Students should be able to analyze the plot and identify linear and non-linear regions in the V-I characteristics of diode.
- Students should be able to identify the most suitable diode for a particular application.

- In order to achieve this learning objective you can use different instructional strategies
- The next slide gives the design of an experiment for the instructional strategy

Instructional Strategy - Discovery

- Focus question: Determine if the given PN junction diode is suitable to function as a rectifier or switch?

- Procedure: To carry out this analysis what procedure will you follow? What circuit will you use? What are the observations necessary to carry out the experiment? What data will you gather? How will you represent the data? What type of data analysis will you carry out? What can you infer from the analysis of the data? Do the results answer the focus question? What can you conclude from the results?

Instructional Strategy - Discovery

- This learning objective can be achieved using the vlab as it has the necessary features so that students can carry out the tasks and answer the assessment questions

Tasks to be performed by the students and corresponding vlab feature

Task	Vlab feature
What circuit will you use?	Students can construct their own circuit using various components
What are the observations necessary to carry out the experiment?	Students can decide the simulation properties
What data will you gather?	Students can observe the graph and find out values of parameters from the graph
How will you represent the data?	Students can decide the axes for plotting the various parameters
What type of data analysis will you carry out?	Students can decide the type of analysis to be carried out and based on that can decide the simulation properties
What can you infer from the analysis of the data?	As students are given the theoretical background and can observe various waveforms and circuit diagrams simultaneously they can draw inferences

Instructional Strategy - Structured Problem Solving

- Measure the forward voltage drop of a silicon rectifying diode, such as a model 1N4001. How close is the measured forward voltage drop to the "ideal" figure usually assumed for silicon PN junctions? What happens when you increase the temperature of the diode? What happens when you decrease the temperature of the diode?

Tasks to be performed by the students and corresponding Vlab feature

Task	Vlab feature
Measure the forward voltage drop of a silicon rectifying diode, such as a model 1N4001.	Students can construct their own circuit using various components
How close is the measured forward voltage drop to the “ideal” figure usually assumed for silicon PN junctions?	Students can decide the type of analysis to be carried out and based on that can decide the simulation properties
What happens when you increase the temperature of the diode?	Students can change the internal properties of the components , observe the graph and find out values of parameters from the graph
What happens when you decrease the temperature of the diode?	Students can change the internal properties of the components , observe the graph and find out values of parameters from the graph

Instructional Strategy - Problem-based

- Procedure: In PBL the problem needs to be solved in a group. So students may be asked to form groups and work together towards the solution. They may use the online resources to arrive at the solution.
- Design the circuit for using PN junction diode as a switch. Compare your design with that of your peers. Are all the designs same? Which of the designs do you think are optimum? Why?

Tasks to be performed by the students and corresponding DoC vlab feature

Task	Vlab feature
Design the circuit for using PN junction diode as a switch.	Students can construct their own circuit using various components. Scaffolds are provided while they are constructing the circuit. They can carry out various analysis and so find out if the circuit is working and check the results of the analysis from the graphs obtained.
Compare your design with that of your peers.	Students can save their circuits and share it with peers. They can analyse the circuits and the outputs for various circuit designs and compare the results.
Are all the designs same?	Students can share their designs with their peers and so compare the various designs
Which of the designs do you think are optimum? Why?	Students can analyse all the waveforms as there is a provision of saving the waveforms that is the outputs of the various circuits.

Conclusion

The Vlab has the following features

- The library of components and equipment is large
- More specifications of components can be varied
- Scaffolds provided to students while they are constructing the circuit
- Type of analysis that can be carried out is
- Graphs that can be plotted can be seen in different colours
- More number of graphs can be plotted together
- The scales for both axes can be adjusted
- Graphs of parameter equations can be plotted together so students can compare the natures of various parameters
- If the current flowing through a particular component is more than the power rating of the component it is shown as a visual of a burning component.

Conclusion

As the Vlab has these important features you can design experiments with learning objectives at higher cognitive levels, use different instructional strategies and assign tasks with different cognitive structures

Conclusion

The various examples illustrate how learning objectives at higher cognitive levels can be achieved using the Vlab

Design your own experiment for the Vlab

- Now that you have understood the features of vlab and how experiments with learning objectives at higher cognitive levels, various instructional strategies, various cognitive structures can be designed using vlab go ahead and design your own experiment.