## Project Year
2016-2017

## Project Title
Virtual Laboratory Experiments in Materials Characterization

## Project Team
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## Audience
The virtual experiments will be targeted to students in *Materials Characterization* (510.403). The virtual labs can also be extended to any undergraduate or graduate course studying materials characterization, including online courses in the Advanced Academic Programs. It can also be used in specific cases (such as illnesses) when coming into the laboratory is not possible.

## Pedagogical Challenge
The study of materials involves understanding the chemistry, structure, and properties of a solid material. The best way to develop interpretive skills and knowledge about materials, after being exposed to the necessary theory, is actually going into the laboratory, running the experiment, analyzing the data, and coming up with a solution. Most materials are characterized by multiple techniques simultaneously to fully describe the material since information at different length scales is required for complete characterization. Ideally, the students would have access to the various techniques and run samples to understand the measurements. However, due to time, equipment, and financial limitations, it is not feasible for every student to do this. Even when the students run the characterization techniques, current equipment software often directly analyzes the data circumventing students gaining practice in the process.

## Solution
A virtual lab resource will allow students to successfully analyze data from “unknowns” (assembled model data sets on Blackboard) and identify the sample and salient characteristics of that sample from each data set. A set of data (including micrographs, plots, and data) will be available on Blackboard for at least 10 unknown samples. The students can then analyze the data in each unknown and identify the chemistry and structure of the sample. In addition, they will be able to discuss other features such as crystal size and shape, orientation, thermodynamic information, etc.

After they successfully identify the material, a solution will be available for each problem and a correlation of those features of the data that should be especially noted and are most pertinent in solving the problem. This is not a grant proposal to run a simulation of a sample. This grant will gather published data from the literature and the student is expected to analyze that data.

## Assessment Strategy
1. Successful completion of the virtual laboratory will lead to identification of the unknown in question. The number of students who can properly identify the “sample unknowns” will be used to determine

success. The goal is to have at least 10 “unknown samples” to allow the students to gain confidence and competence in the interpretation of data for a range of materials. Exam and homework scores will also be compared from the last 7 years to see if there is an improvement in test scores.
2. Feedback from students: We will ask the students to provide feedback regarding the data sets which will allow future improvements.

## Faculty Proposal

At present, there is a lack of “free” access to characterization techniques, which is an impediment in analyzing materials in a classroom setting. Oftentimes, the equipment is broken or time cannot be scheduled when needed during class, which means that the students may not have the equipment available for their work. Generally, each sample test takes 1-3 hours, which is even more challenging. Other techniques, such as TEM, are too expensive and time consuming to use for general classroom work.

By setting up a Virtual lab online, the students will have clean results (results from the literature that are not based on impurities and artifacts) that are then readily available for analysis. To address this, we are requesting funds to develop content/data (find experimental data from the literature which may be complemented by in-house testing) that will be uploaded to a Blackboard course site. To succeed, model samples with varying properties will be identified, such as quartz, teflon, alumina, protein, liquid crystal, etc. A set of data for each of the samples will be collected from the literature, or, if none is available, can be collected using available instrumentation. This data will likely include typical characterization techniques such as SEM, XRD, Optical Microscopy, XPS, Mass Spec., IR, AFM, EDS, Raman, Auger, TEM, etc. Each of these data sets will be put in a file on the Blackboard site and labeled “Unknown A”, “Unknown B”, etc. The “data” will be in the form of micrographs, plots, or numbers. Using the data for each sample, students will identify the sample in terms of chemistry and structure. If possible, we will have the students provide their answers online and mix up the unknown numbers so students can’t compare.

It is hoped that the data collected may be useful as a reference collection for standard samples. The successful completion of these online laboratory experiments should provide a strong background in data interpretation and technique sensitivity and allow the student to 1) decide which set of techniques will best characterize samples in the future, and 2) tackle characterization problems in the laboratory and in research with confidence.

The proposed project will develop an electronic teaching resource in a field of growing interest. To my knowledge, no such resource currently exists at Johns Hopkins or other universities. In particular, this resource will allow students to “obtain” reliable data, judge if a particular technique will give the desired result, and allow the students to successfully analyze data when experiments are limited. The benefit of this system is that once developed it allows rapid and inexpensive training of students in materials characterization that can be used in subsequent years and in other courses.