

# **Using CASPiE as an Introduction to Research for Pre-college Students**

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# Acknowledgements

## *National Science Foundation:*

1. Assuring STEM Credential Expansion through Nurturing Diversity; NSF DUE 0525582.
2. Undergraduate Research Center-Center for Authentic Science practice in Education (CASPiE); NSF CHE-0418902.

# STEP

The Science, Technology, Engineering, and Mathematics Talent Expansion Program (STEP) seeks to increase the number of students (U.S. citizens or permanent residents) receiving associate or baccalaureate degrees in established or emerging fields within science, technology, engineering, and mathematics (STEM).

*[www.nsf.gov](http://www.nsf.gov)*

# ASCEND

(Assuring STEM Credential Expansion through  
Nurturing Diversity)

- A multiyear program designed to enhance the experience of cohorts of UIC students in science, technology, engineering, and mathematics.
- Collaboration among two UIC College and academic support programs including:
  - African-American Academic Network (AAAN)
  - Latin American Recruitment and Educational Services
  - Minority Engineering Recruitment and Retention Program
  - Women in Science and Engineering (WISE)

# ASCEND

## *Objectives*

1. Increasing first to second and second to third year retention rates of each ASCEND cohort by 10%.
2. Increasing the four year graduation rate of the 2007 ASCEND cohort by 10%.
3. Provide support for incoming students in STEM disciplines

# Summer Pre-College Program

- Math Enrichment
- **Research Experience**
- Seminar

	Mon.	Tues.	Wed.	Thurs.
9:00-noon	<b>Math Enrichment Program</b>			
noon-1:00	<i>Lunch Break</i>			
1:00-3:00	<b>Research Experience</b>	<b>Seminar</b>	<b>Research Experience</b>	
3:00-4:00		<b>Peer Workshop</b>		

## Research Experience

- Research modules provide students with critical technical and general skills needed to conduct research
- Students complete a research based project associated with the module.
- Uses an innovative peer leader approach
- Introduces ASCEND scholars to important topics such as experiment design, keeping laboratory notebooks, research ethics, and issues involved in working with scientific literature.
- Provides students review of critical chemistry content.

# CASPiE Modules

Modules implemented during ASCEND summer '06  
pre-college program

1. Phytochemical Antioxidants with Potential Health Benefits in Foods, Jay Burgess, Associate Professor Purdue University.
2. Band Gap Tuning of Zinc Oxide Films for Solar Energy Conversion, Kyoung-Shin Choi, Assistant Professor, Purdue University.

# CASPiE Modules

- 4 weeks, two 3-hour meetings a week
- Implemented Peer-Led Team Learning throughout both modules. 1-hour peer workshop each week.
- Group poster presentation representing research findings.
- These two modules both have a strong quantitative aspect to them.
- One of the major concepts demonstrated in these modules is **dilutions**.

# Antioxidant Module

- 22 students, 5 groups
- Implemented with life science majors
- Research Question: How do fruits and vegetables vary in antioxidant activity with age, source, storage and preparation conditions?

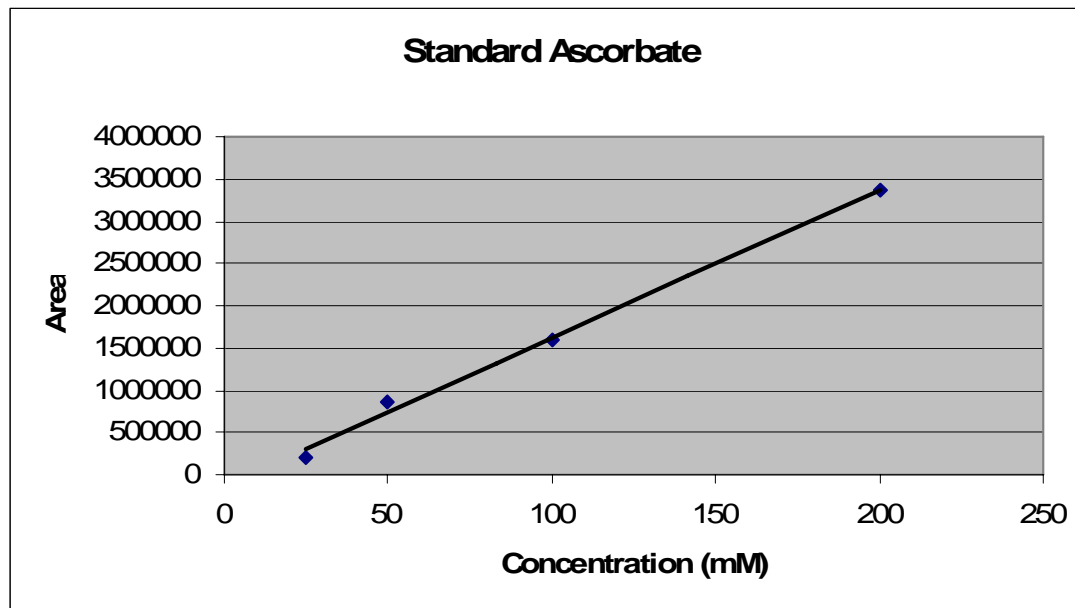
# Antioxidant Module

- Lab 1: Introductory Lab - Introduction to the module, making solutions, and spectral scanning of the Trolox Equivalent Antioxidant Capacity (TEAC) substrate.
- Lab 2: TEAC Measurement – Conduct the TEAC measurement with Trolox and the flavonoid epicatechin, and explore the equilibrium of the reaction.
- Lab 3: Ascorbate and Total Phenolic Measurement – Introduction to HPLC and the use of a standard curve to determine ascorbate and total phenolics concentrations in foods.
- Lab 4-6: Independent Research Project – Conduct experiments to test the chosen hypothesis and complete analysis – repeat tests as necessary.

# Antioxidant Module Student Results

“In this lab we used the HPLC method to examine ascorbate concentration from fruits. We used dilutions of 1%, 2%, and 10% for the natural and store bought lemon juice. We also used standards of ascorbate 500 $\mu$ M, 200  $\mu$ M, and 1 mM.”

## Standard Curve for Ascorbate after HPLC Analysis



# Antioxidant Module Student Results

## Data

Store bought Lemon Juice	Peak Area
10%	859262
2%	259209
1%	27040

Natural Lemon Juice	Peak Area
10%	87068
2%	3348
1%	1456

## Results

Peak Area = 17568(Concentration) – 145288

### Natural Lemon Juice

10% = 57.18 mM

2% = 23.02 mM

1% = 9.80 mM

### Store Bought Lemon Juice

10% = 13.22 mM

2% = 8.46 mM

1% = 8.35 mM

# Band Gap Module

- 14 students, 4 groups
- Implemented with all engineering and physical science majors.
- Research Question: Design synthetic conditions to prepare ZnO based solid structures with varying concentration of a 3d transition metal ion of your choice and then determine the maximum amount of the transition metal that can be incorporated into the ZnO lattice.

# Band Gap Module

- Lab 1: Synthesis of ZnO films via spray pyrolysis. Determination of optimum synthetic conditions for spray pyrolysis.
- Lab 2: Measurement of UV-Vis spectra of ZnO films and band-gap determination. Synthesis of  $\text{Zn}_{1-x}\text{M}_x\text{O}$  films using spray pyrolysis.
- Lab 3-4: Determination of the solubility of MO in ZnO, and study on the effect of compositions on optical properties of  $\text{Zn}_{1-x}\text{M}_x\text{O}$  films.
- Lab 5-6: Deposition of a series of  $\text{Zn}_{1-x}\text{M}_x\text{O}$  on conducting substrate for further photoelectrochemical characterization. Synthesis of a ZnO-based dye-sensitized solar cell and photocurrent measurement.

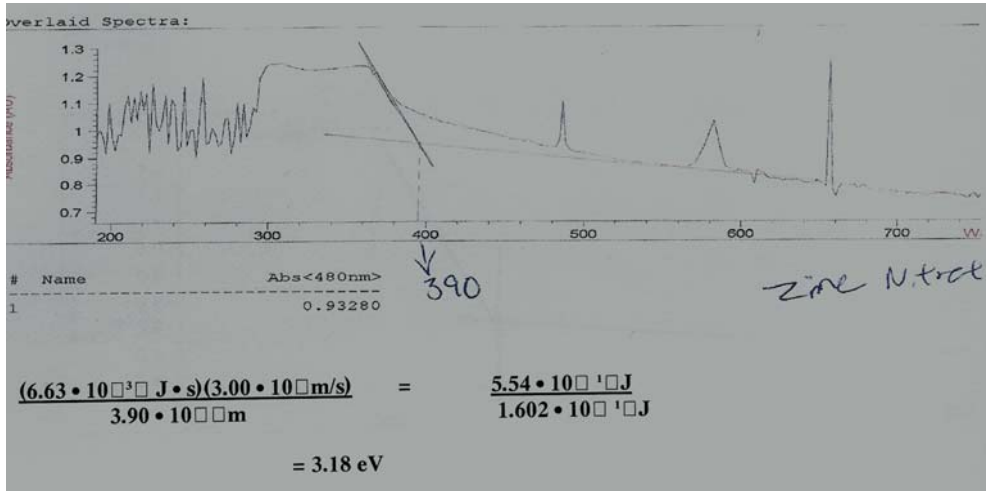
# Band Gap Module Student Results

**Introduction:** “We are trying to improve the efficiency of a solar cell by adding Copper to Zinc Oxide. We want to see whether the band gap of Zinc Oxide reduces or increases by adding Copper to the solution, and how that affects the ability of the cell to absorb more solar light.”

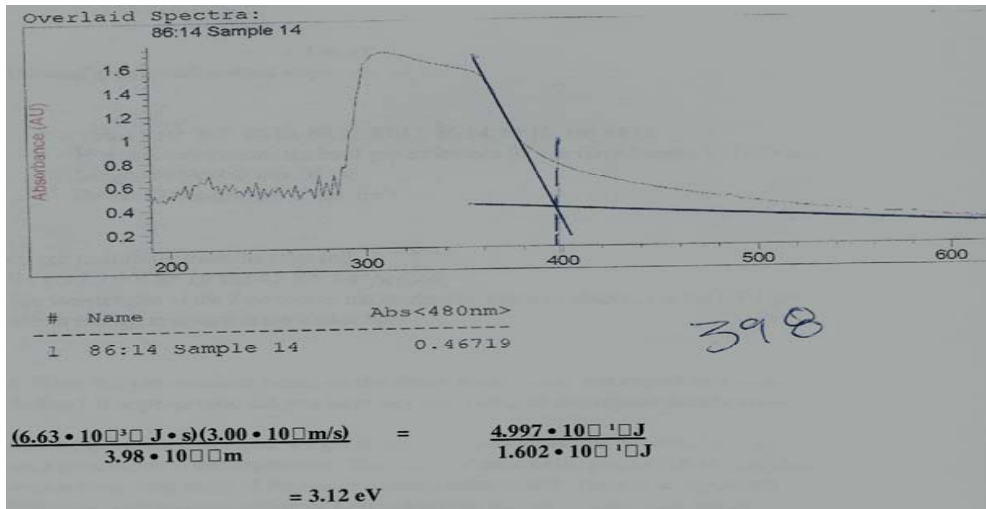
## Data

<b>Solid solutions</b>	<b>Engery calc from spectra</b>	<b>Solar cell overhead</b>	<b>Solar cell UV light</b>
Zinc Nitrate	3.18 eV	No reading	2.7 mV
Zinc-Cupric Nitrate (86.14)	3.12 eV	.01 mV close to nothing	4.5 mV

# Band Gap Module Student Results



**UV-Vis Spectra of  
0.1 M ZnO film.**



**UV-Vis Spectra of  
 $\text{Zn}_{.84}\text{Cu}_{.16}\text{O}$  film.**

# Band Gap Module Student Results

**Conclusion:** “As the experiment developed, we got closer to the conclusion that the metal of copper is not a good factor to this experiment. The results of most of the graphs that we analyzed were not matching many of the results of many other metals. There is no significant difference with the composition of Zinc and Copper enough to make solar energy.

# Advantages/Disadvantages

## Advantages

1. Research Experience
2. Improvement of Laboratory Skills
3. Group Work/Scientific Community
4. Increased Interest/Retention in Science degrees
5. Communication Skills

## Disadvantages

1. Prior Laboratory Skills
2. Mix of students' chemistry background and placement into general chemistry
3. Assessment – no grades
4. Group work – conflict of prior knowledge
5. College experience, work load

## ASCEND and CASPiE Summer '07

- Larger Group of Students
- Two Different Modules (More Conceptual)
  - Biodiesel, by Veronica Curtis-Palmer and Ana Fraiman at Northeastern Illinois University (Life Science)
  - Lipids: Chemistry, Biology, Food and Health, by Bruce A. Watkins at Purdue University (Engineering and Physical Science)