# Student Learning in a Collaborative Virtual Computer Laboratory: Bridging Theory and Practice

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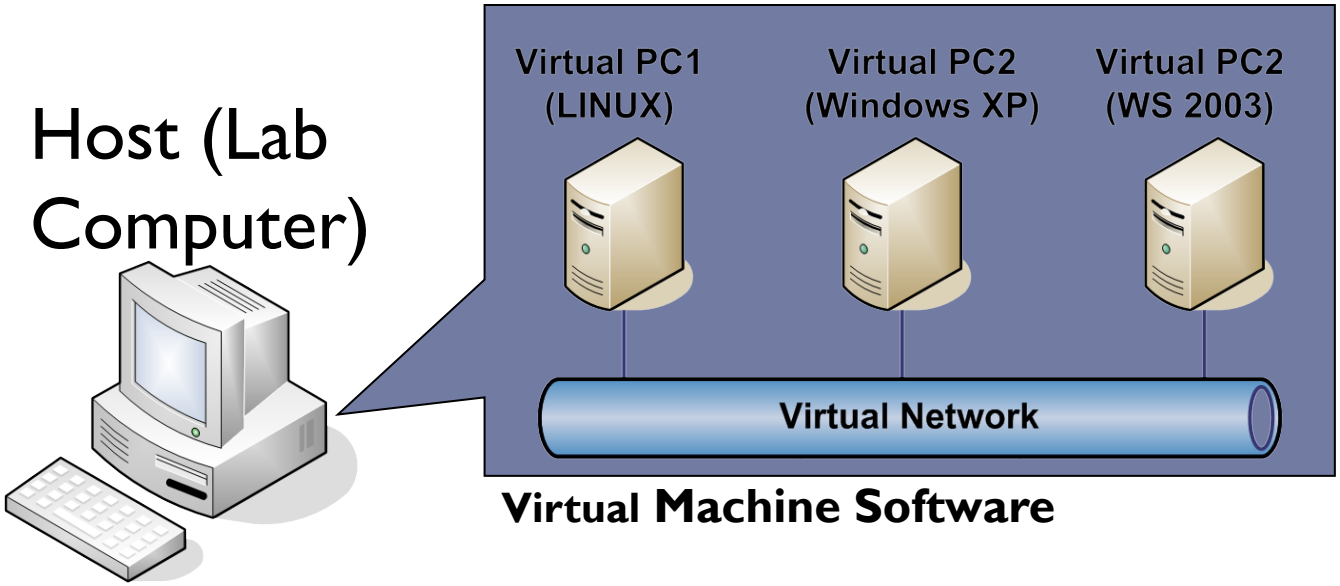
# Challenges in Information Security Education

- Hands-on learning is really important, but there are many challenges:
  - Restrictions imposed by the campus IT policies
  - Need for specialized computer labs and equipment
  - Financial / Personnel
- Distance education
  - Hands-on learning?
  - Teamwork?

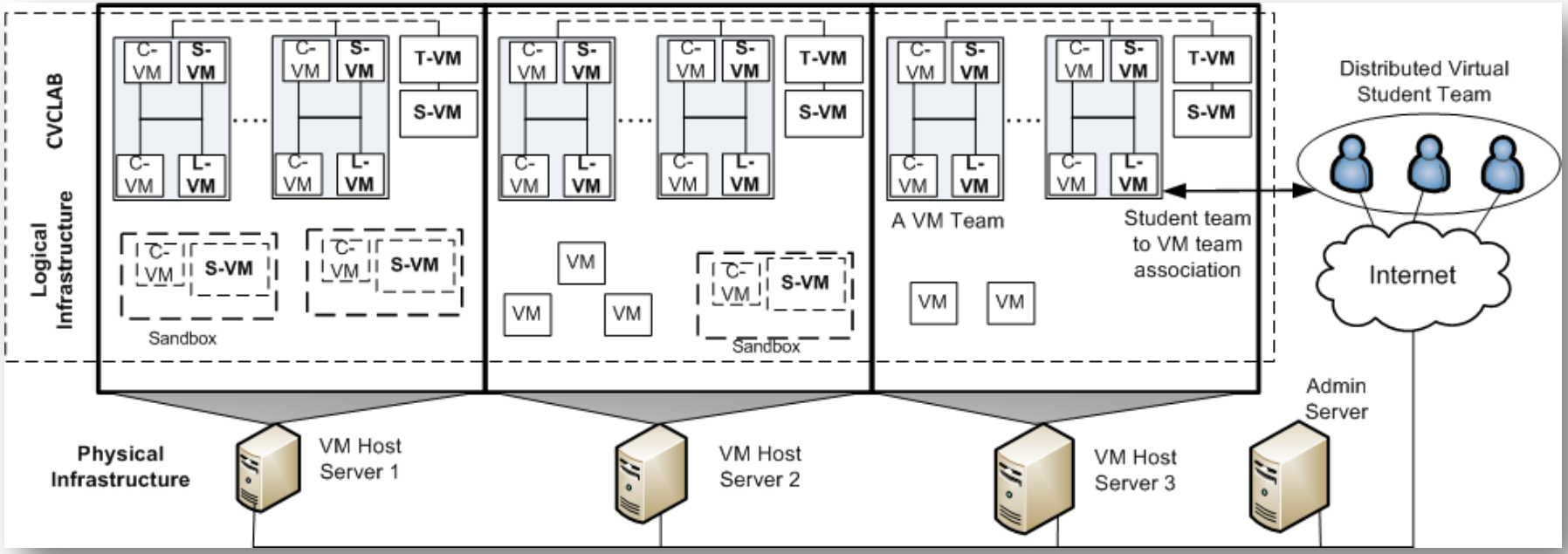
# A Solution-Virtual Computers

- Virtual computers are software emulators of fully functional operating systems (OS).
- Multiple OS can be simultaneously run on a single host.



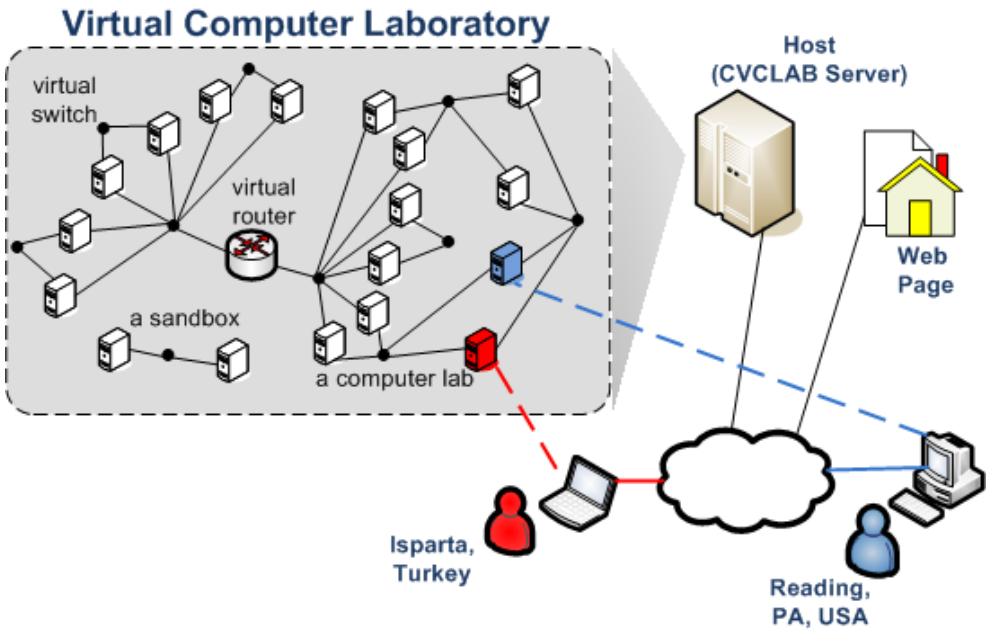
# The Collaborative Virtual Computer Labratory (CVCLAB)- Penn State Berks

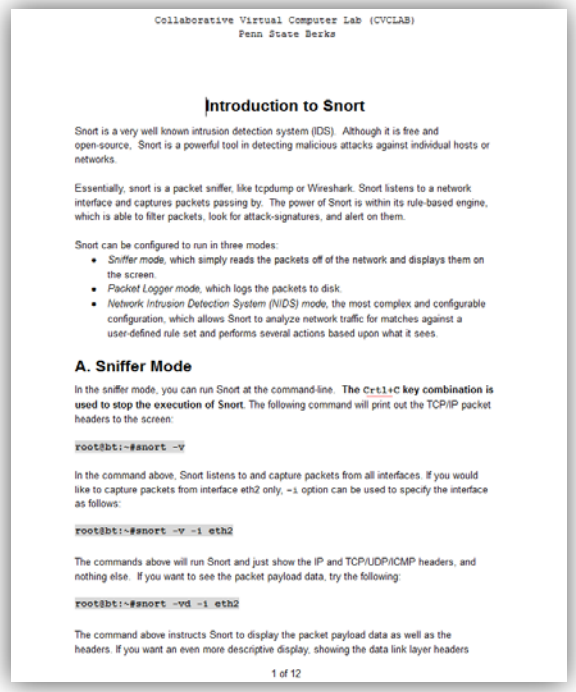
- The CVCLAB aims to provide students with an open learning environment in which they can experiment with high risk operations without any concern.
- http://ist.bk.psu.edu/cvclab



# Collaborative Work in the CVCLAB

- Students attempt to create a product of their learning by being engaged in a common activity in the CVCLAB.
- Students depend on one another for a successful completion of the activity.



Collaborative Virtual Computer Lab (CVCLAB)
Penn State Berks

**Introduction to Snort**

Snort is a very well known intrusion detection system (IDS). Although it is free and open-source, Snort is a powerful tool in detecting malicious attacks against individual hosts or networks.

Essentially, snort is a packet sniffer, like tcpdump or Wireshark. Snort listens to a network interface and captures packets passing by. The power of Snort is within its rule-based engine, which is able to filter packets, look for attack-signatures, and alert on them.

Snort can be configured to run in three modes:

- *Sniffer mode*, which simply reads the packets off of the network and displays them on the screen.
- *Packet Logger mode*, which logs the packets to disk.
- *Network Intrusion Detection System (NIDS) mode*, the most complex and configurable configuration, which allows Snort to analyze network traffic for matches against a user-defined rule set and performs several actions based upon what it sees.

**A. Sniffer Mode**

In the sniffer mode, you can run Snort at the command-line. **The `Ctrl+C` key combination is used to stop the execution of Snort.** The following command will print out the TCP/IP packet headers to the screen:

```
root@bt:~#snort -v
```

In the command above, Snort listens to and capture packets from all interfaces. If you would like to capture packets from interface eth2 only, `-i` option can be used to specify the interface as follows:

```
root@bt:~#snort -v -i eth2
```

The commands above will run Snort and just show the IP and TCP/UDP/ICMP headers, and nothing else. If you want to see the packet payload data, try the following:

```
root@bt:~#snort -vd -i eth2
```

The command above instructs Snort to display the packet payload data as well as the headers. If you want an even more descriptive display, showing the data link layer headers

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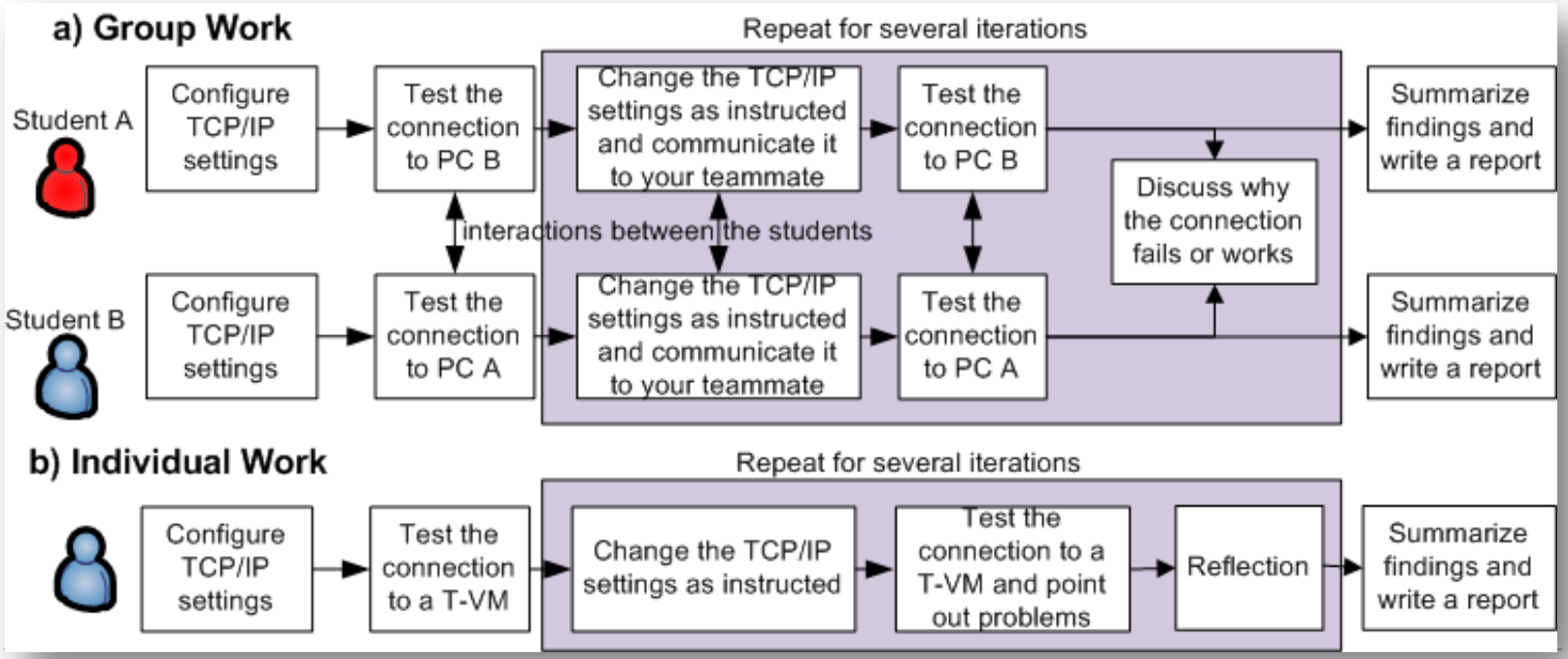
# Research I-
# Impact of Collaborative Learning

- Claim: Virtual computer labs (VCLs) should support collaborative learning to enhance student learning.
- Research Questions:
  - Does collaborative work have a positive impact on student learning in VCLs?
  - What are the differences in learning outcomes of students when they engage a collaborative activity in VCLs?

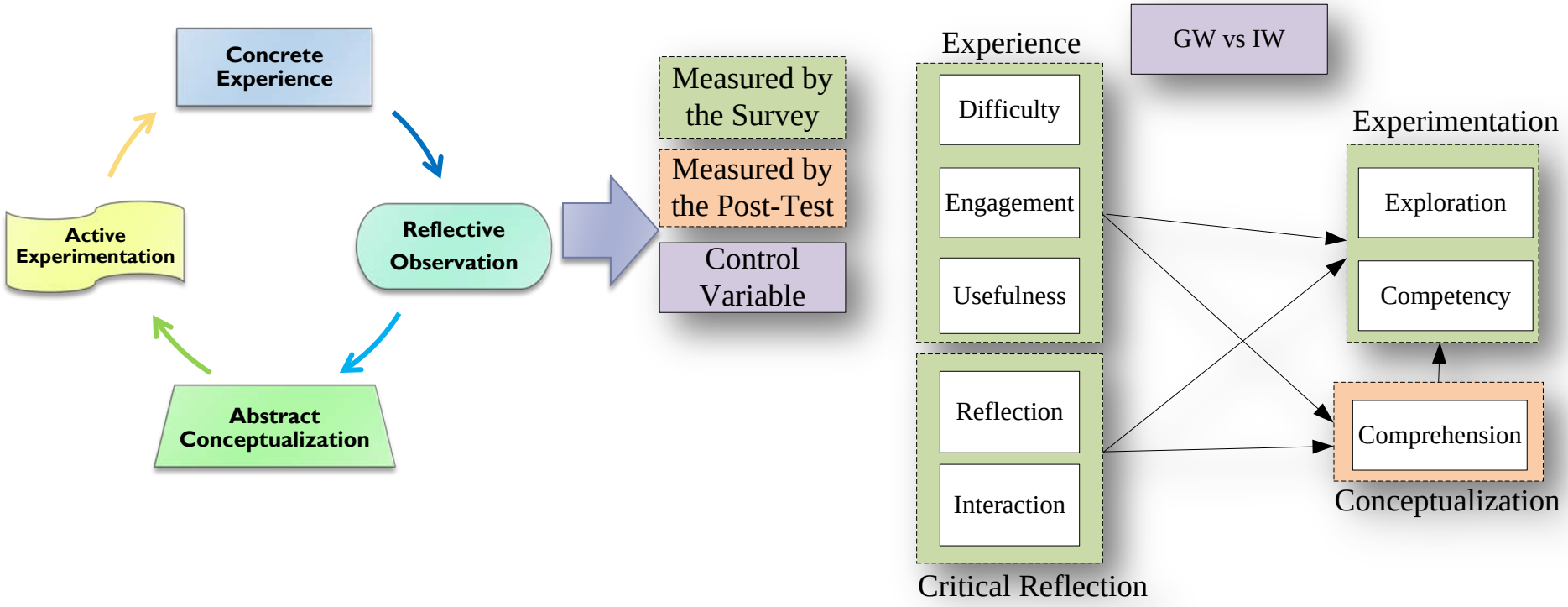
# Research Plan

- Two versions: **Treatment**-Group Work (GW) and **Control**-Individual Work (IW)
- The exact same tasks, but the GW version requires students to work together.



# Research Model

- Seven constructs mapped against the four stages of Kolb's Theory of Experiential Learning Cycle
- Measurement Instruments: a survey and a quiz (post-test)



# The Survey Instrument

- Designed to measure students' self-reported perceptions about the activity and their learning.
- Each construct is measured by three questions.
- Operationalized with a seven-point Likert scale, ranging from "Strongly Agree" (1) to "Strongly Disagree" (7)
- Two open-ended questions

# Experimental Setup and Data Collection

- Two Activities:
  - Computer Networking (NT): 45-60 minutes
  - Database Administration (DB): 120 minutes
- Two introductory level courses with two sections
  - Each section completed a version of an activity

| Activity | Control IW | Treatment GW |
|---|---|---|
| Activity NT | 13 | 16 |
| Activity DB | 22 | 24 |
| **Total** | **35** | **40** |

# Survey Validation (Partial Survey)

- Internal consistency of the constructs (Cronbach's Alpha >0.707)
- Convergent validity

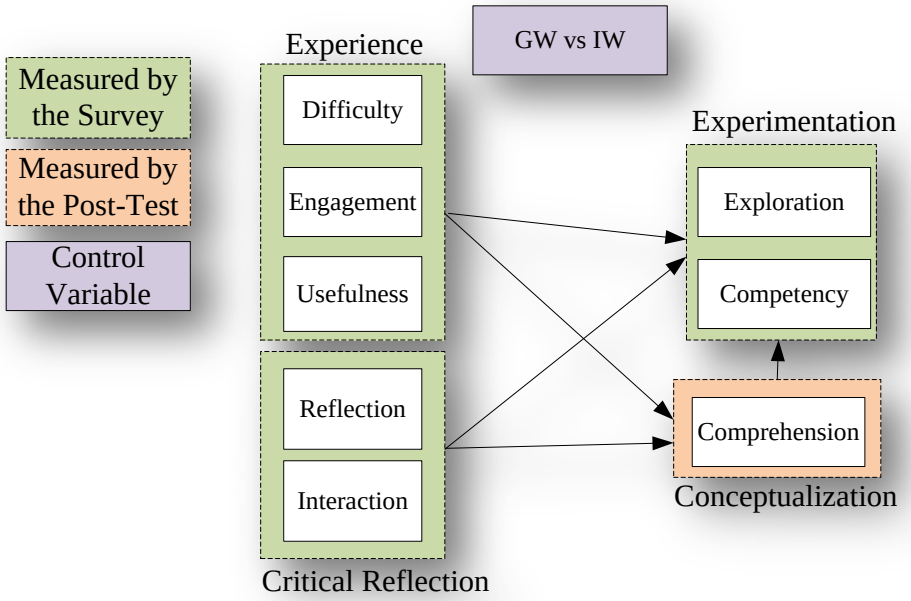
| Constructs (Cronbach's alpha) and Related Survey Questions | CR1 | CR2 | EP1 | EP2 |
|---|---|---|---|---|
| **CR1: Interaction (.825)** | 1.00 | 0.61 | 0.57 | 0.76 |
| I learned new concepts/skills by interacting with other students. | **0.81** | 0.42 | 0.50 | 0.62 |
| Interacting with other students helped me complete the activity. | **0.86** | 0.65 | 0.46 | 0.72 |
| The activity encouraged me to ask questions to others. | **0.88** | 0.50 | 0.50 | 0.61 |
| **CR2: Reflection (0.852)** | 0.61 | 1.00 | 0.60 | 0.69 |
| Review questions were helpful to reinforce what was performed in the activity. | 0.55 | **0.89** | 0.54 | 0.61 |
| Provided opportunities to reflect back what was learned in the activity. | 0.55 | **0.88** | 0.47 | 0.64 |
| Promoted helpful discussions about what was performed in the activity. | 0.48 | **0.82** | 0.53 | 0.56 |
| **EP1:Competency (0.915)** | 0.57 | 0.60 | 1.00 | 0.57 |
| The activity helped me improved my problem solving skills. | 0.68 | 0.66 | **0.92** | 0.62 |
| The activity improved my technical skills and competency in the subject area. | 0.45 | 0.45 | **0.93** | 0.42 |
| I felt a sense of accomplishment after completing the activity. | 0.46 | 0.55 | **0.92** | 0.55 |
| **EP2:Exploration (0.893)** | 0.76 | 0.69 | 0.57 | 1.00 |
| I will be able to use what I learned in the activity in other courses or the future. | 0.68 | 0.56 | 0.38 | **0.87** |
| The activity increased my curiosity and interest in this area. | 0.64 | 0.69 | 0.51 | **0.91** |
| The activity encouraged me to learn more about this topic. | 0.71 | 0.61 | 0.62 | **0.89** |

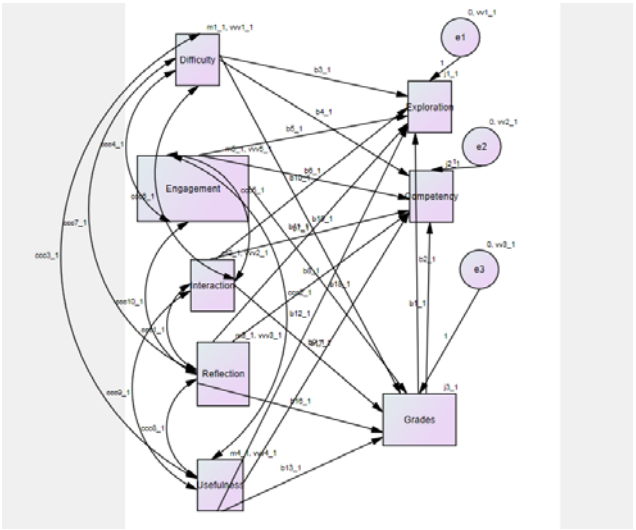
# Comparisons of the Constructs: IW vs GW

- The construct means were compared across the treatment and control groups using *t*-test.

| Construct | Activity DB | | | Activity NT | | |
|---|---|---|---|---|---|---|
| | IW | GW | p-value | IW | GW | p-value |
| Difficulty | 2.90 | 2.91 | 0.95 | 4.29 | 3.50 | 0.07 |
| Engagement | 2.30 | 2.52 | 0.54 | 3.50 | 3.00 | 0.29 |
| Usefulness | 2.14 | 2.48 | 0.19 | 3.14 | 2.79 | 0.46 |
| Interaction | 2.18 | 2.36 | 0.46 | 3.18 | 3.00 | 0.69 |
| Reflection | 2.55 | 2.33 | 0.45 | 3.67 | 3.09 | 0.23 |
| **Comprehension** | **76.91** | **90.47** | **0.00** | 35.00 | 42.50 | 0.46 |
| **Competency** | **2.74** | **1.79** | **0.02** | **4.67** | **2.85** | **0.03** |
| Exploration | 2.20 | 2.25 | 0.88 | 3.39 | 3.13 | 0.61 |
| Overall Activity Rating | 2.85 | 2.91 | 0.80 | 4.58 | 3.75 | 0.08 |
| Overall CVCLAB Rating | 2.85 | 2.91 | 0.85 | 4.00 | 3.25 | 0.15 |

# Structural Equation Modelling




| GW -Treatment | | | IW -Control | | |
|---|---|---|---|---|---|
| **Structural Model Connection** | **Coefficient** | **p-value** | **Structural Model Connection** | **Coefficient** | **p-value** |
| Exploration← **Interaction** | 0.438 | 0.007 | Exploration←**Interaction** | 0.584 | 0.000 |
| Competency← **Interaction** | 0.424 | 0.009 | Comprehension←**Difficulty** | -15.908 | 0.008 |
| Exploration← Difficulty | 0.428 | 0.014 | Comprehension←Usefulness | 14.758 | 0.033 |
| Comprehension← **Interaction** | -14.92 | 0.020 | Exploration←**Difficulty** | 0.379 | 0.045 |
| Competency← Comprehension | -0.007 | 0.056 | Exploration←Reflection | 0.383 | 0.061 |

# Discussions (Group Work)

- Students who indicated a higher level of interaction also felt stronger about their perceived learning.
  - They were more likely to indicate that their competency increased as a result of the activity (Competency).
  - They were more encouraged to apply their new skills to other problems (Exploration).
  - They were more likely to perform better in the post-test (Comprehension).

# Discussions: (IW – Control Group)

- The Interaction construct had a positive impact on the Exploration construct.
- A major factor was the perceived Difficulty of the activity.
- A larger variance of responses.

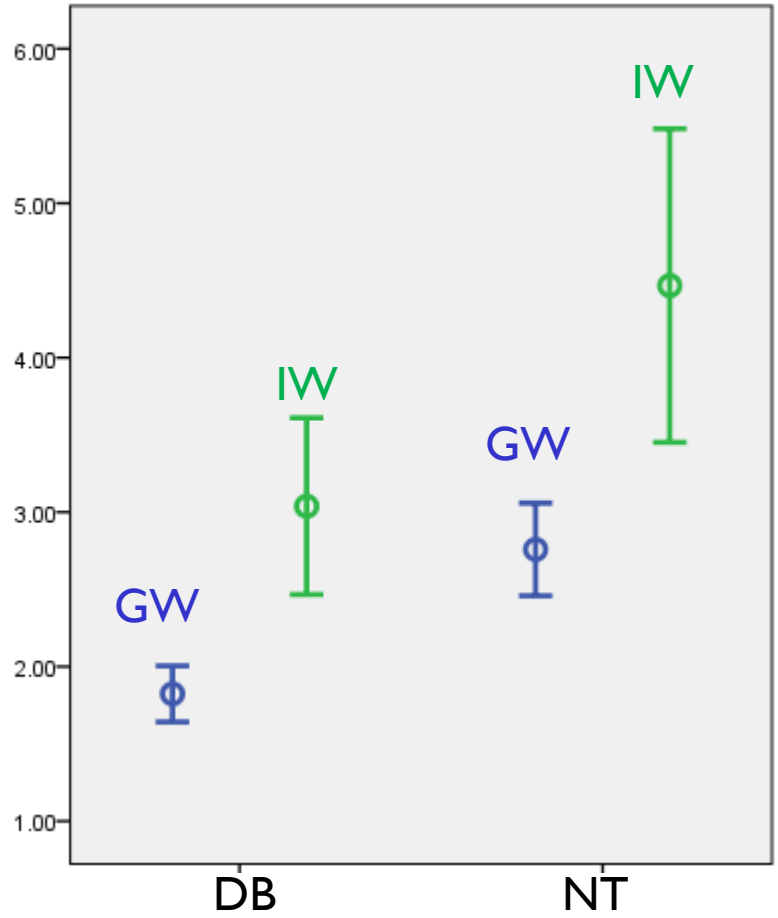
# Discussions

- Students who engaged collaborative learning in the CVCLAB felt more competent about their learning and more confident about applying their new skills to other areas.
- Why?
  - GW students considered the activities to be more relevant to the real-world.
  - Peer-to-peer learning.
- Virtual Computer Labs should be designed to provide students with opportunities to collaborate and interact with one another.

# Impact of Peer-to-Peer Learning (Spring, Fall 2012)

**Learned new concepts by interacting with other students (90% CI)**

(1-Strongly Agree,…,7-Strongly Disagree)



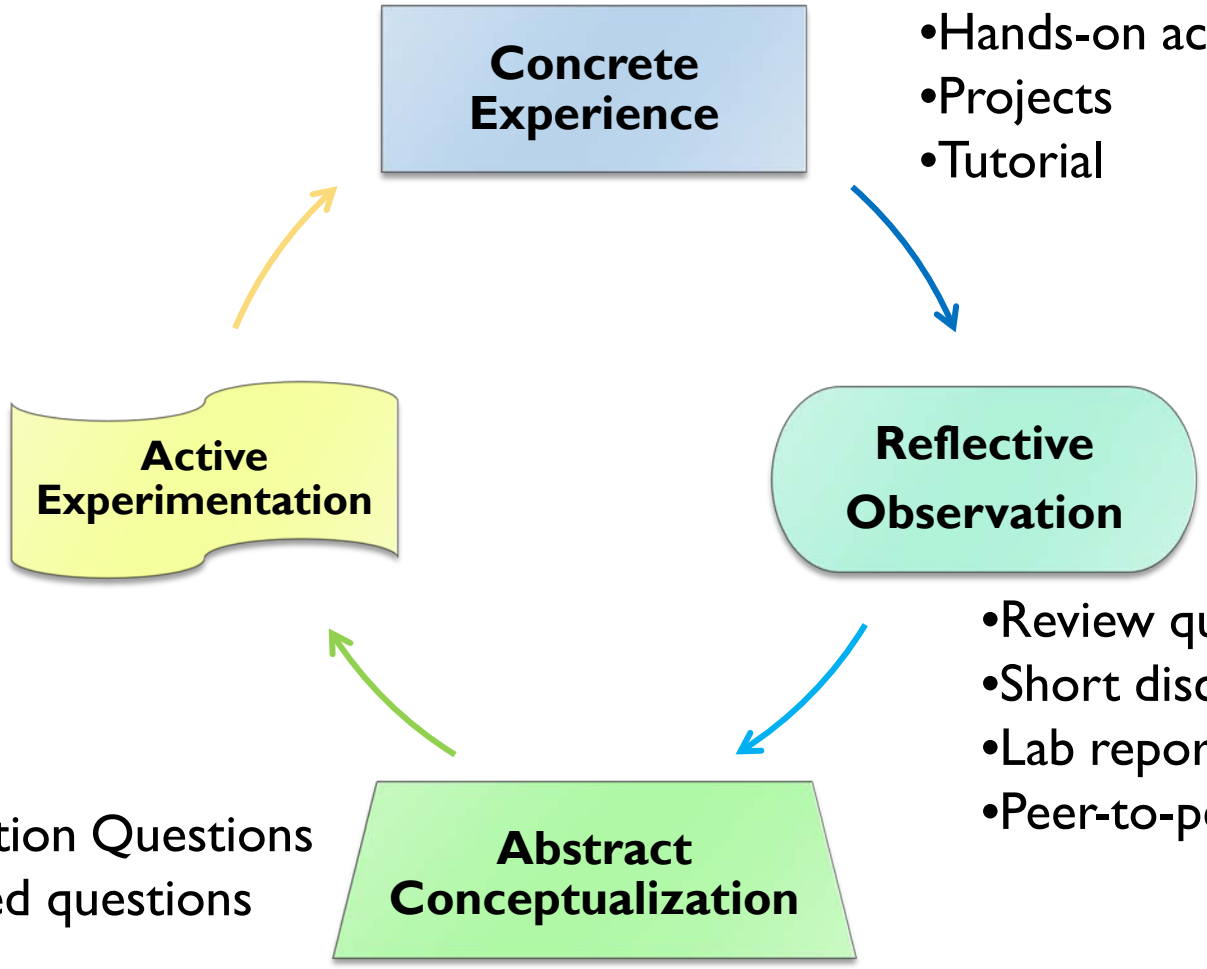
# Limitations & Further Research

- Limited sample size (additional data in Fall 2012, Spring 2013)
- Only two activities
- Focus on out of classroom and online activities (Spring 2013)
- Better ways to promote group work in online learning

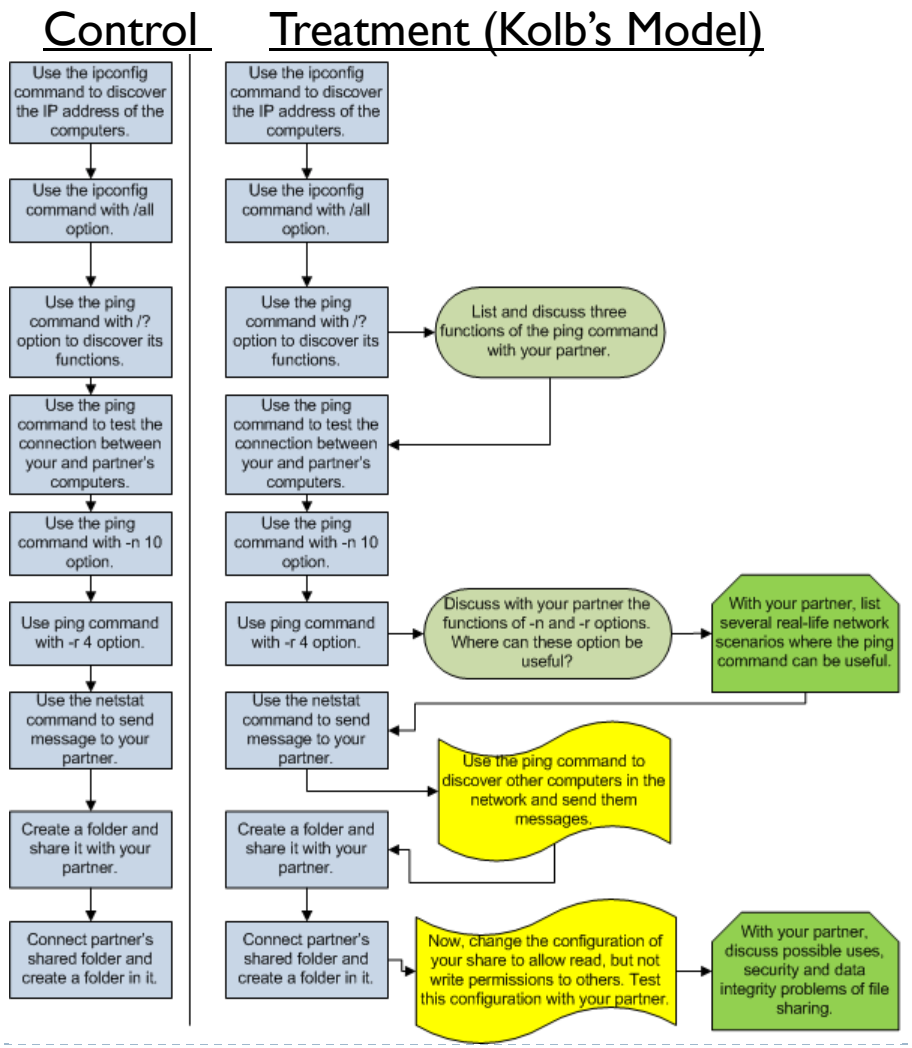
# Research II-
# Impact of Hands-on Activity Design

- Claim: Activities designed as step-by-step instructions that guide students through challenging tasks do not achieve complete learning.
- Research Question:
  - What are the best pedagogies to design hands-on activities for virtual computer laboratories?

# Kolb's Theory of Experiential Learning Cycle (Kolb, 1984)

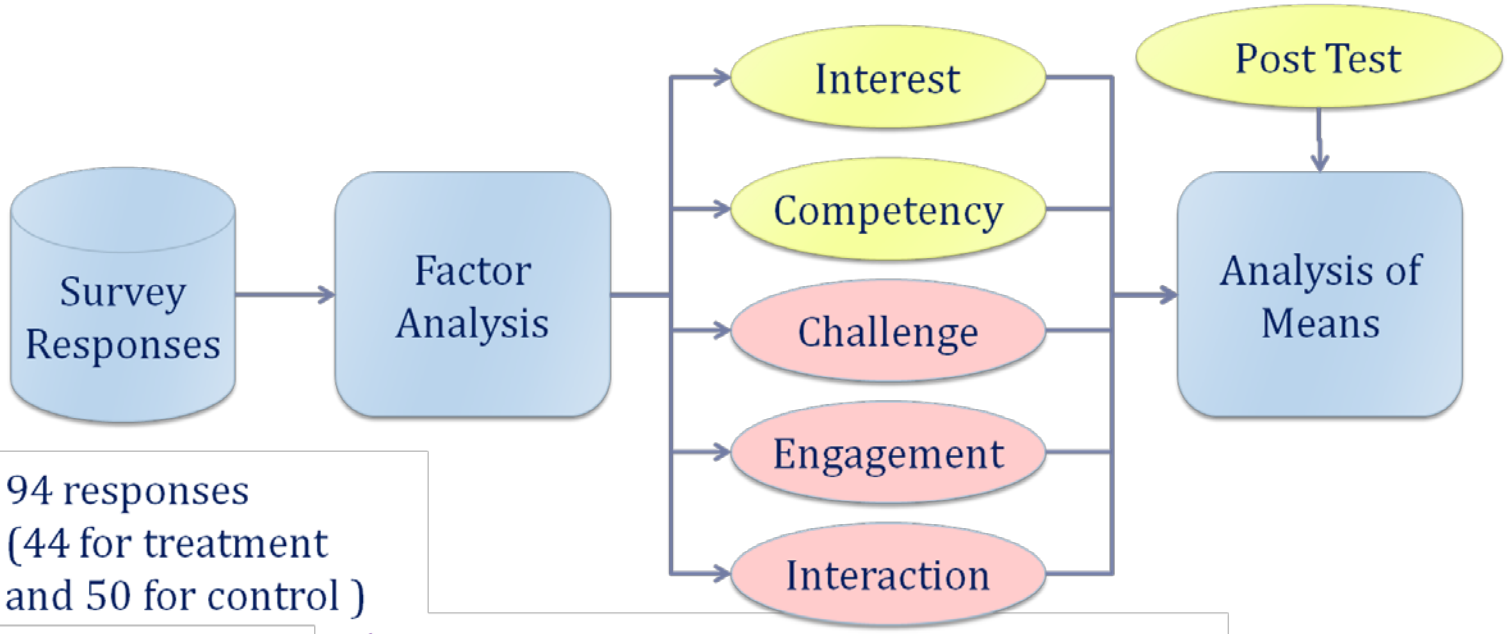


# Research Plan & Experimental Setup




| Class | Treatment | Control |
|---|---|---|
| IST 110-I | | 19 |
| IST 110-II | 15 | |
| IST 110-III | | 19 |
| IST 110-IV | 17 | |
| MIS 204 | | 5 |
| IST 220-I | 12 | |
| IST 220-II | | 7 |
| **Total** | **44** | **50** |

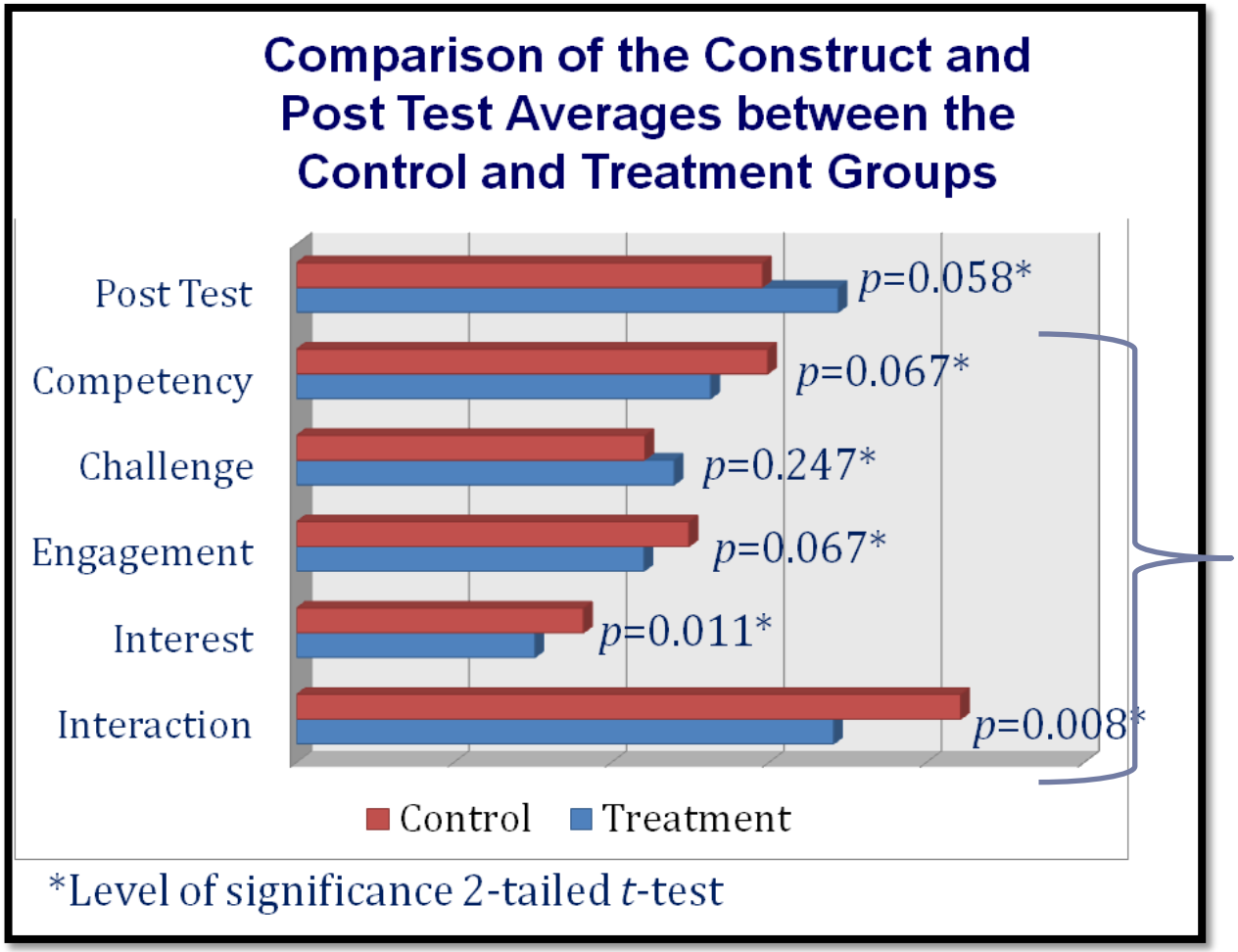
# Data Analysis




94 responses
(44 for treatment
and 50 for control )

- ✓ All factor loadings ≥ 0.71
- ✓ All Cronbach's Alpha values ≥ 0.74

# Results


Comparison of the Construct and Post Test Averages between the Control and Treatment Groups
Post Test
Competency
Challenge
Engagement
Interest
Interaction
p=0.058*
p=0.067*
p=0.247*
p=0.067*
p=0.011*
p=0.008*
Control
Treatment
*Level of significance 2-tailed t-test
The Smaller, The Better

# Discussions

- We can foster more comprehensive learning by including all stages of Kolb's Experiential Learning Cycle in hands-on activities.
- Design activities based on an inquiry-based framework rather than a cookbook methodology.

# Ongoing Research

- Data collection
- Outside of the classroom
- Online courses