

# Active Learning in Large Sciences Courses: Methods to Engage ALL Students

Bob Chen

School for the Environment

UMass Boston

HKU March 11, 2024



# Student-Centered

- What are you interested in learning in today's workshop?



# News of the Day

- <https://www.scmp.com/news/hong-kong/health-environment/article/3254006/flushing-food-waste-down-toilet-some-poor-families-worry-about-managing-extra-costs-hong-kongs-waste>
- <https://www.scmp.com/news/china/science/article/3253890/china-needs-10-times-its-solar-and-wind-power-be-carbon-neutral-study-finds>
- <https://www.scmp.com/magazines/post-magazine/article/3253213/its-losing-battle-against-abandoned-fishing-nets-hes-fighting-anyway-meet-hong-kongs-ghost-net>

# Solid Waste Pollution

Hong Kong society

+ FOLLOW

Get more with myNEWS

A personalised news feed of stories that matter to you

[Learn more](#) →

Hong Kong / Health & Environment

## Flushing food waste down the toilet? Poor families worry about extra costs of Hong Kong's rubbish charging scheme, call for grace period

- Society for Community Organisation poll finds quarter say they may flush food waste down toilet and more than half say will avoid taking out trash every day
- According to poll, 43 per cent of respondents call for one-year delay for certain underprivileged communities

[Listen to this article](#) ▶



Emily Hung

+ FOLLOW

Published: 8:03pm, 3 Mar, 2024

[Why you can trust SCMP](#)

### TOP PICKS

Japan's plan to become a world leader in AI

Paid Post: Jetro



News

Language barrier, living costs pose hurdles to mainland talent eyeing Hong Kong

3 Mar 2024



Listen



# Renewable Energy

China / Science

## China needs 10 times its solar and wind power to be carbon neutral, study finds

- It will take nearly 6 terawatts of the renewables for the country to achieve that goal by 2060, according to model simulation
- 80 per cent of solar and 55 per cent of wind power will have to be installed within 100km of major load centres to meet demand

[Listen to this article ▶](#)



Victoria Bela

[+ FOLLOW](#)

Published: 8:00pm, 3 Mar, 2024 -

[Why you can trust SCMP](#)



# Marine Plastics

## It's 'a losing battle' against abandoned fishing nets but he's fighting anyway: meet Hong Kong's 'ghost net hunter'

- Harry Chan is known as Hong Kong's 'ghost net hunter' for his work clearing the city's waterways of 'ghost nets' – fishing nets that have been abandoned
- He reveals why his parents almost sold him as a baby, business booms and busts, and how he fell in love with diving and beach clean-ups

[Listen to this article ▶](#)



Kate Whitehead

[+ FOLLOW](#)

Published: 7:15am, 27 Feb, 2024

[Why you can trust SCMP](#)



# Key Concepts in Ocean and Environmental Science

- **VII.) CONSERVATION OF MASS**

(Input/Output Models, Elemental Cycles, Hydrological Cycle, Stoichiometry, Equilibrium)

*“Mass is conserved as it is transferred from one pool to another”*

- **VI.) ENERGY FLOW AND TRANSFORMATION**

(Forms of Energy, Thermodynamics, Conservation of Energy, Energy Use, Motion)

*“Energy transformations drive physical, chemical, and biological processes. Total energy is conserved and flows to more diffuse forms”*

- **II.) HUMAN INTERACTIONS**

(Sustainability, Ocean Policy and Management, Human Health)

*“Currently, the human species is significantly affecting and is affected by earth systems, but has the ability to choose its relationship with the environment”*

# Course Objectives

- Student learning (rather than teaching)
- Conceptual understanding (rather than facts)
- Literate, engaged citizen who can gather information and hold an informed discussion



# 8 Key Concepts of Ocean and Environmental Science

## ➤ I.) WAYS OF KNOWING

- (Scientific Method, Observations, Technology, Informatics, Habits of Mind, Faith)
- “Reflection on how we know what we believe will help our understanding”

## ➤ II.) HUMAN INTERACTIONS

- (Sustainability, Ocean Policy and Management, Human Health)
- “Currently, the human species is significantly affecting and is affected by earth systems, but has the ability to choose its relationship with the environment”

## ➤ III.) ECOSYSTEMS

- (Biological Communities, Population Ecology, Habitats)
- “The survival and health of individuals and groups of organisms are intimately coupled to their environment”

## ➤ IV.) EARTH SYSTEM SCIENCE

- (System Properties, Oceanography, Atmospheric Science, Earth Science)
- “The Earth as a whole acts as a complex set of interacting systems with emergent properties”

## ➤ V.) EVOLUTION-BIODIVERSITY

- (Species Diversity, Natural Selection, Biogeography)
- “Evolution explains both the unity and diversity of life”

## ➤ VI.) ENERGY FLOW AND TRANSFORMATION

- (Forms of Energy, Thermodynamics, Conservation of Energy, Energy Use, Motion)
- “Energy transformations drive physical, chemical, and biological processes. Total energy is conserved and flows to more diffuse forms”

## ➤ VII.) CONSERVATION OF MASS

- (Input/Output Models, Elemental Cycles, Hydrological Cycle, Stoichiometry, Equilibrium)
- “Mass is conserved as it is transferred from one pool to another”

## ➤ VIII.) SPATIO-TEMPORAL RELATIONSHIPS

- (Geospatial Position, Mapping, Historical Trends, Coordinate Systems)
- “Choosing the appropriate reference frame is the key to understanding one’s environment.”

# Eliciting Pre-Conceptions: (Large) Introductory Courses

- **Individually**—Please write on your index card what you feel are the major barriers to effective teaching and learning in a large, diverse classroom setting (>50 students)
- In ***Pairs***—Please decide on the single most important hurdle to overcome for teaching in larger classrooms
- Report out your findings after breakouts

# Common Perceived Barriers

- (You can create these student-derived outlines in class and post on the web)
- 1) Interacting with each student
- 2) classroom management
- 3) Motivation for learning-diversity
- Content--leanrer

# Common Perceived Barriers

- Lack of student participation
- Lack of individual attention
- Loss of the bottom 25%
- Lack of attendance
- Too one-way (lecture), not discussion-based
- Tests must be multiple-choice or short answer—too hard to grade essay questions
- Hard to address diversity of learner
- Formative Assessment

# Index Card (1 Point)

- **Individually**, please write 3 ideas that you have to engage students in large (>50) classes
- In **Groups of 3-4**, each person, please share one (1) idea with your group
- One representative, please share with whole group (main room) one idea

# Strategies to Overcome Barriers

## ➤ I) Individual actions

- Writing on cards, handing in, counts for points
  - 30% of grade, increases engagement, attendance
  - Provides instantaneous assessment (pre-conceptions, conceptual progress) -- Don't have to read them all
  - Individual responsibility
  - Technology
- “You can't hide from good education”

## ➤ II) Peer Instruction

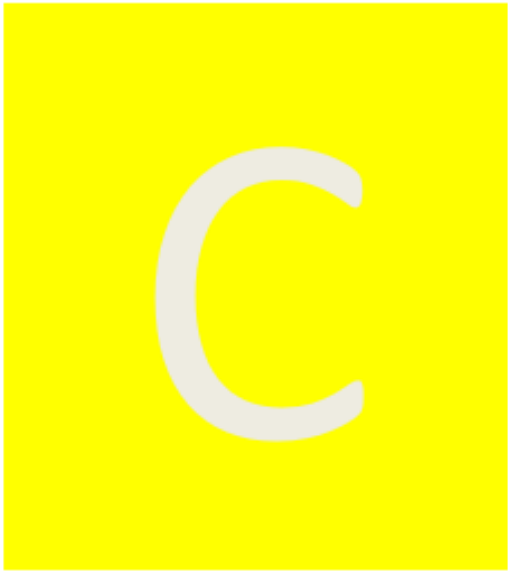
- Peer pressure to perform
- Establish learning community
- Manipulate group interactions to access bottom 25%, diversity of learner,
- “Collectively, this group of learners knows much more than the Instructor”

## ➤ III) Testing as teaching

- Critical thinking
- Tests reflect real world problem-solving
- Tests align with instructional goals; not simply about ranking students

# I) Individual Engagement: Technology

- Formative Assessment
- Engagement
- Democratic Learning
- Attendance
- i-clickers
- Poll Everywhere
- ABCD cards





# Learn about your Audience :

## Zoom Polling


What is your background?

- A) No PhD
- B) 1-4 years since PhD
- C) 4-7 years since PhD
- D) >7 years since PhD

# What is your experience teaching?

- A) No teaching experience
- B) 1-2 courses
- C) 3-5 courses
- D) >5 courses

# What is your area of expertise?

- A) Environmental Science
  - B) Engineering
  - C) Health Science/Biology
  - D) Other
- 
- The background features several sets of concentric circles in a lighter shade of blue, resembling ripples in water, positioned in the lower right quadrant of the slide.

# Content:



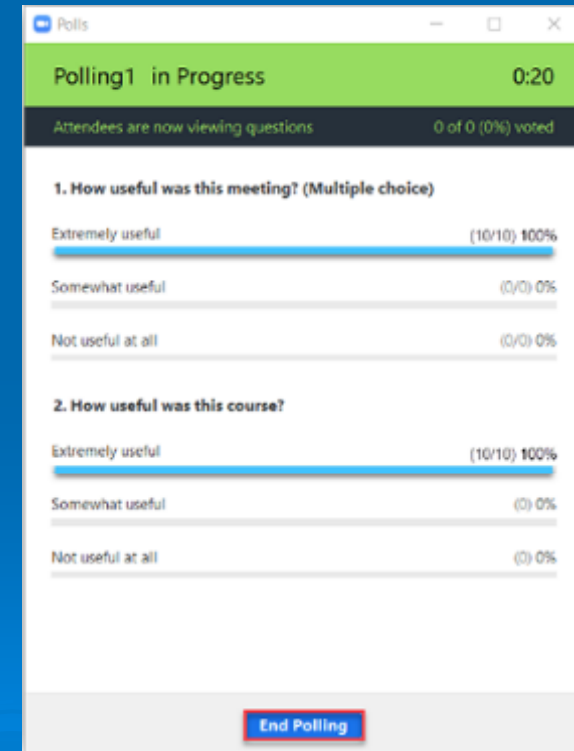
The water supply in Hong Kong comes from:

- A) Groundwater
- B) The Dongjiang
- C) Rainwater
- D) Desalination

# Formative Assessment:

## What do you think about Polling?

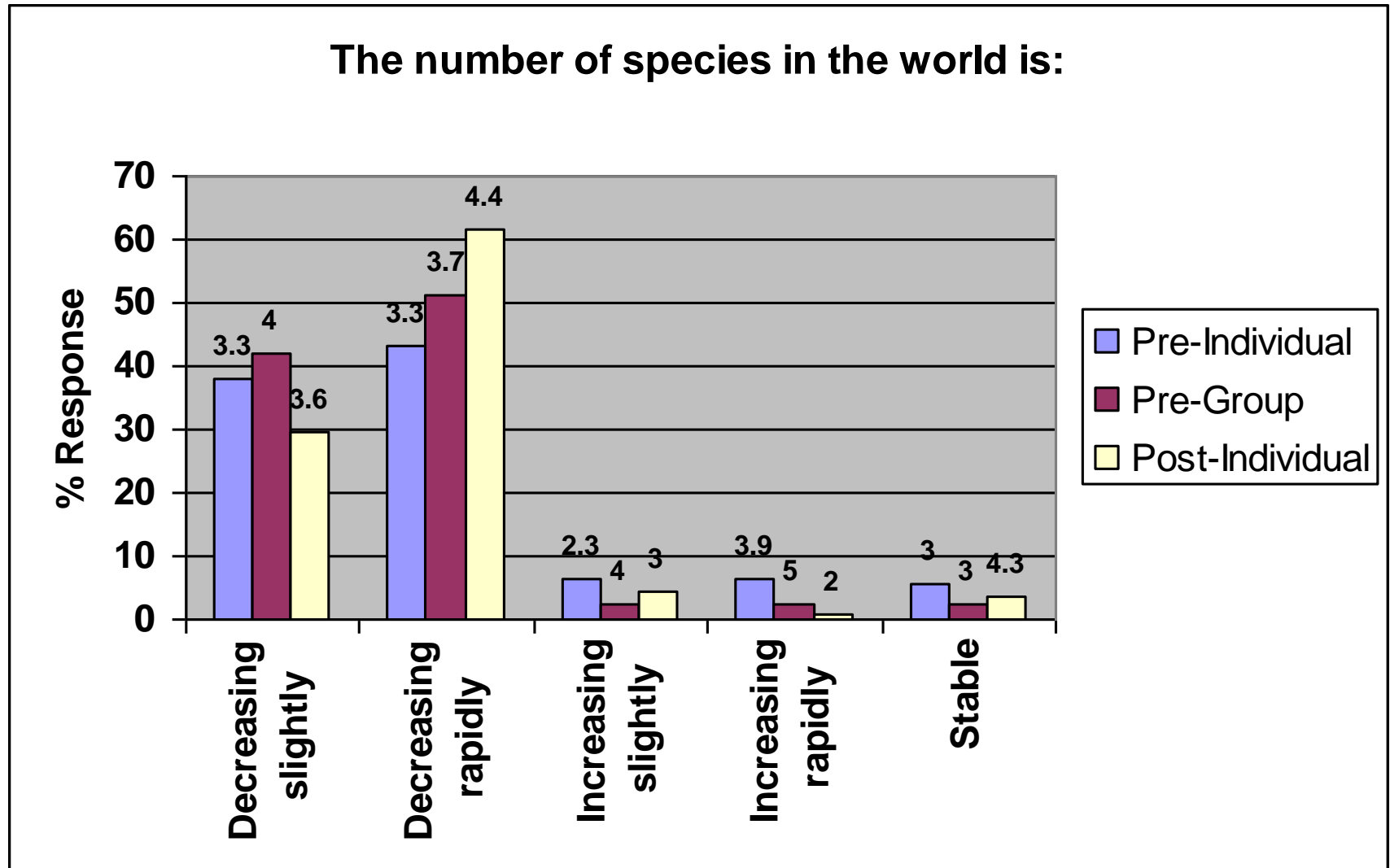
- A) I wouldn't use it
- B) I want to learn more
- C) I want to try it in my class
- D) I use i-Clickers, ABCD cards, or polling in every class that I teach



## II) Peer Instruction

- Data pre-test, post peer, post test shows 50% gains without instructor
- Lifelong learning will continue with peers, not in the classroom
- 50-90% of learning guided by an instructor for an entire semester can be accomplished with peers in 5 minutes
- Environmental/Ocean Science (and many of current subjects) is an interdisciplinary, collaborative science

# Factual



Confidence (1-5, 5 being highest)

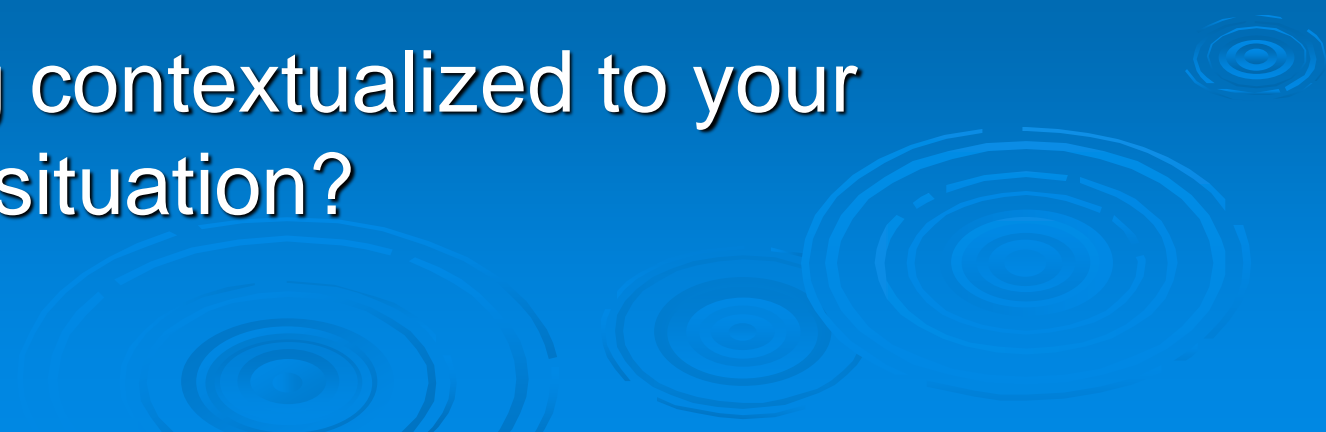
# Group Question



- How many acres of corn would you need to grow in order to produce enough ethanol fuel to drive a car to work for a year? Please show all work and write down your logic. What is the overarching “Big” concept? (6 points)
- Random (maybe related, maybe not) facts from the internet:
- One acre of fertile soil produces 250 - 300 bushels of corn or about 7,110 pounds (3,225 kg) of corn
- 1 bushel of corn, which weighs about 54 pounds, converts into about 18 pounds of ethanol
- 1 bushel of corn (about 35 liters) nets about 2.8 gallons (10 liters) of fuel -- that translates to between 330 - 420 gallons per acre.
- Gasoline is more efficient than ethanol. One gallon of gasoline is equal to 1.5 gallons of ethanol.



# Experiential Evidence

- Could you hide from this exercise?
  - What did you learn from your peers that would not have been possible from a lecture?
  - Do you know your peers better as a result?
  - Is learning contextualized to your individual situation?
- 

# Conclusions on Peer Instruction

- Peers can be a powerful influence
  - Increases confidence as well as content
  - Allows students to solve problems (do science)
- Effective in small groups even in a large class
- Group activities and evaluation is more “authentic”
  - Stresses collaborative interactions
- Even “good” teaching makes little difference in the collective understanding at the Undergraduate Level
- Large differences? In confidence, engagement & transferable skills

# III) Testing as Teaching

- Authentic assessment
- Critical thinking and interactions are more important than simple memorization of facts
- Solving problems in the real world is generally both an individual and a group enterprise
- Assessments should align with our learning goals

# Authentic Assessment

- Science (and learning in general) is a collaborative enterprise
- Assessment is rarely based on collaborative work
- Assessment should closely mirror the types of real-life situations that a student may encounter
  - Flexible (acknowledges diversity in learning styles)
  - Stresses transferable skills such as effective oral communication, group negotiation, and dynamic model construction
  - Uses collaborative tasks

# Collaborative Exams



## ➤ Part I

- Take-Home Exam Questions to be answered individually (using any non-human resources)

## ➤ Part II

- Add-on questions answered in small groups (3-4)

## ➤ Part III

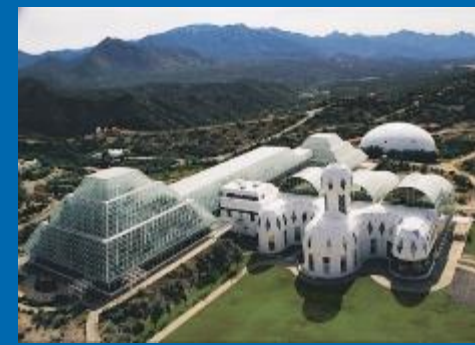
- Multiple Choice and Short Answer

## ➤ Grades

- 50% Part I, 30% Part II, 20% Part III

## ➤ Two Midterms and a Final-all same format

# Model of Collaborative Exam



## ➤ Individually solve this problem:

- Biosphere-2 failed to support human life for 2 years. How large a system would developed to support human life in an enclosed ecosystem indefinitely (e.g. 100 years)? need to be Explain how your ecosystem will support human life (Biosphere-2 did not). Please be as specific as possible regarding carbon, water, and energy cycles (10 points).

## ➤ Turn in one copy, save another

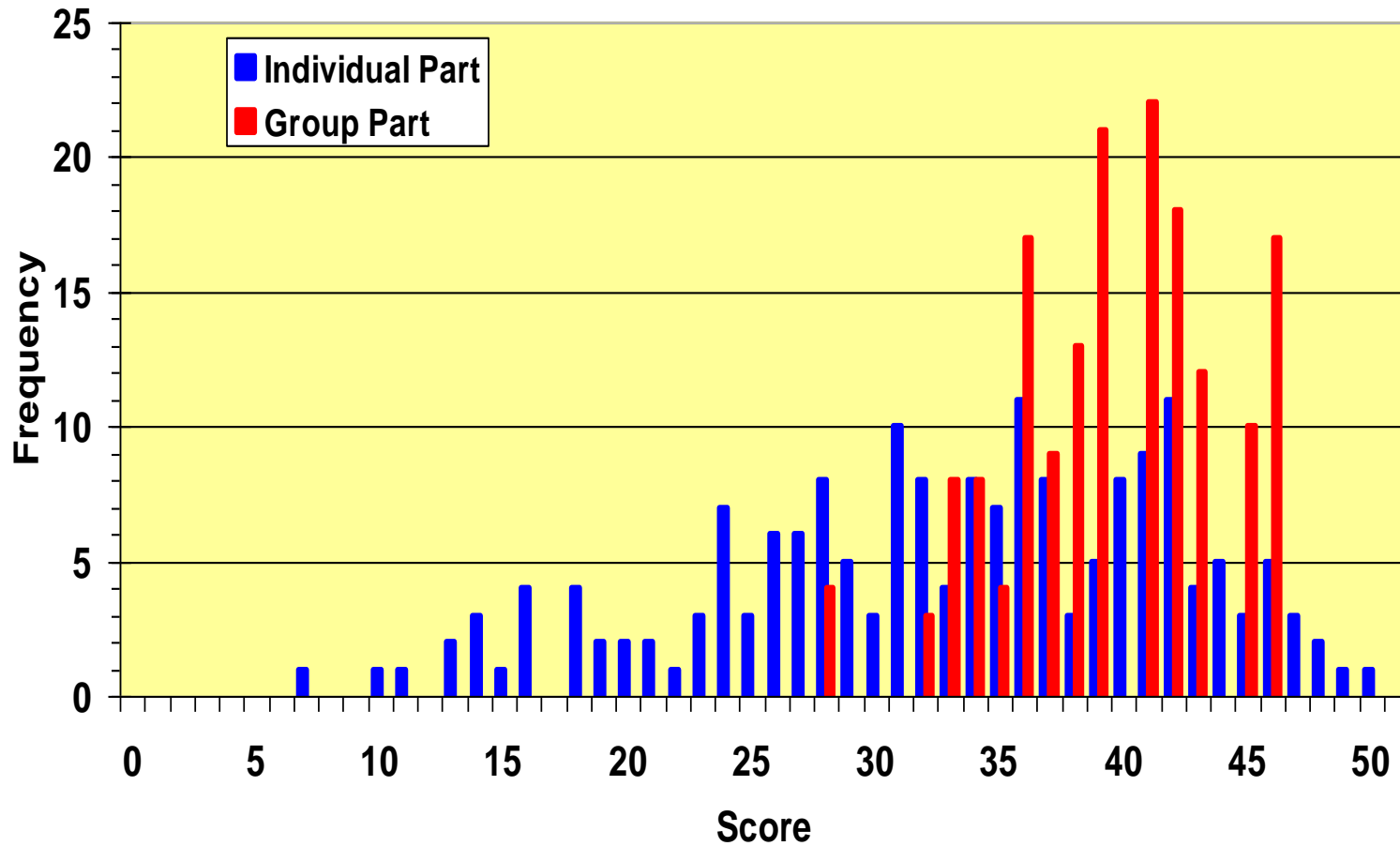
## ➤ As a group, solve this problem:

- Design a space station that will keep humans alive for 100 years. Explain how your space station will support human life. Please be as specific as possible regarding carbon, water, and energy cycles (6 points)

# Results of Individual/Group Take-Home Exam (Spring 2001)

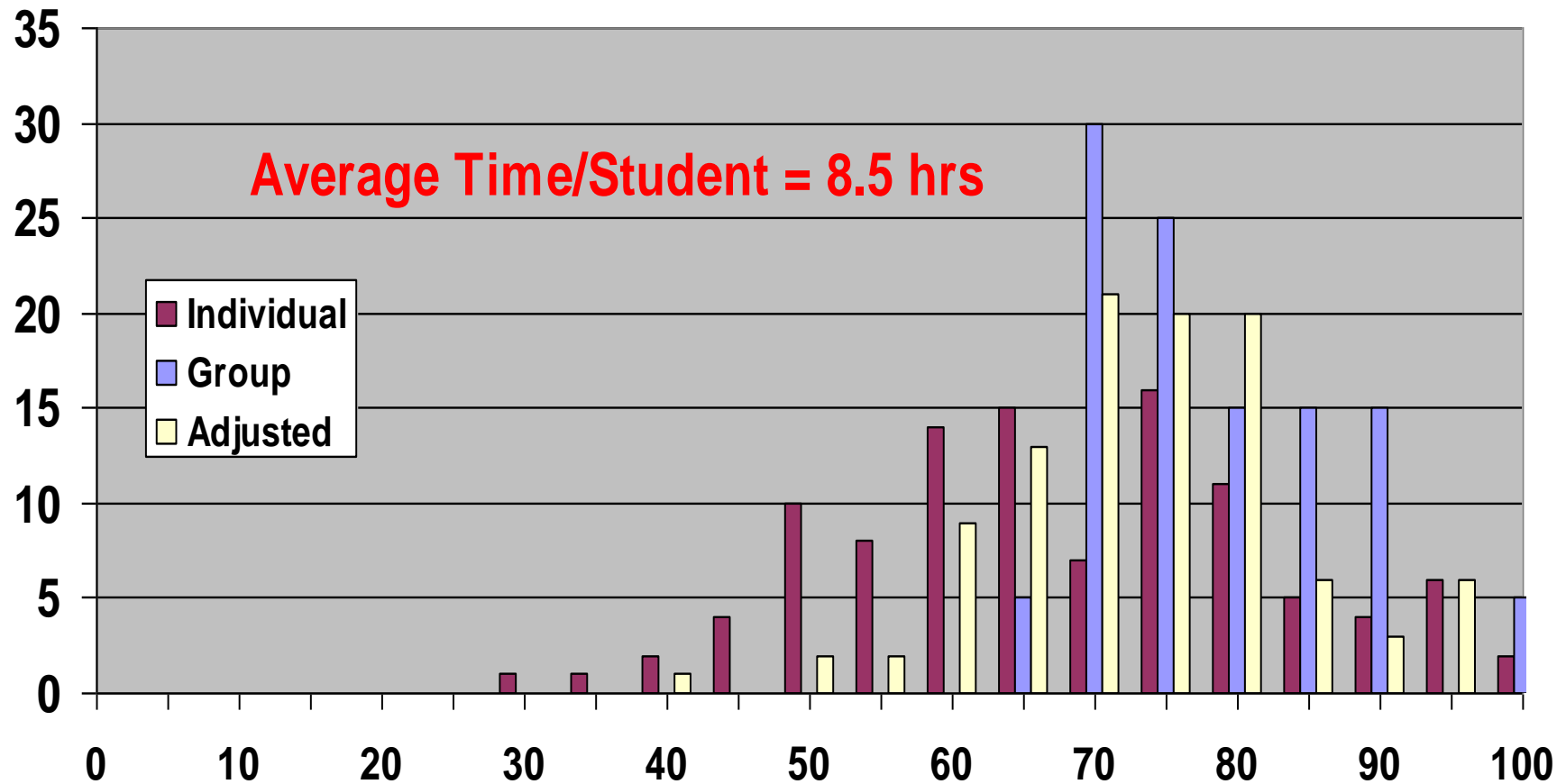
(Average Time Spent=9.5 Hours)

## Exam 2



# Repeatable Year After Year

Fall 2003 Mid-term ENVSTY101





# Student Comments

- “I work better when I am not in a timed-class environment”
- “I liked the group exam much more because it was a team effort and I actually learned more through group interaction”
- “It is easy to see when your own crystal clear logic produces an absolutely wrong answer because others see it differently”
- “I felt I was able to demonstrate my knowledge more in the second exam than the first exam”

# Benefits

- Students work on transferable skills
- Assessment is more than a measurement tool
- Students learn from each other (different points of view, alternative ways to solve the problem)
- Engages more diverse learning styles than traditional exams
- Content becomes personalized
- Students spend more time engaged in problem solving
- Students have more control of their assessment, no artificial time pressures

# Summary

- Individual Learning
  - Index Card
  - Clickers
  - News
- Peer Instruction
  - Index Cards
  - Group Exams
- Testing as teaching
  - Critical thinking
  - Big Concepts
  - Take Home Exams
    - Open internet
    - Research intensive
  - Group Exams



# Value to University

- Tuition = \$14,542 for 24 credits (\$603/cr)
- 3 Credit course = \$1800/student
- \$1800 \* 540 students
- = \$975,000
- > \$30,000/lecture
- = BIG grant

# Scholarship of Teaching

- Tenure and Promotion
  - What is considered “good” teaching?
  - What is your evidence?
- What is learning?
  - Applying new knowledge
  - Useful-Making Connections
- Disseminating your learning
  - Educational publications
  - Conference presentations
  - Discussions with colleagues