

Transforming How We Teach Power Engineering



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ONR/NSF/UMN Faculty Workshop

Reforming Electric Energy
Systems Curriculum

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Progression of UMN Initiatives

- Updated technical learning objectives
 - Developed textbooks to address objectives
 - Designed new lab activities & equipment
 - Hosted workshops, webinars, continuing ed
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- *Designing in-class activities*
 - Outlining graduate-level courses
 - Integrating research & teaching



Industry Involvement
Faculty Mentoring

Motivation...

Video clip from "Minds of Our Own"
University graduates struggle with batteries & bulbs



Motivation...

How do you encourage deep, lasting learning?

- Response 1: Bill motivates students by discussing common, real-life applications of the technical content (e.g., power supplies for the students' personal electronic devices)
- Response 2: Bruce engages the students with pictures and movies of power system disasters, while discussing the technical details behind how these disasters occurred
- Response 3: Paul wraps a story around an important concept, which humans are naturally inclined to pay attention to and remember
- Response 4: Another audience member uses open-ended design problems to encourage deeper understanding of technical content
- Response 5: Another audience member uses hands-on but not "cookbook" activities, so students experience applications of the technical knowledge but don't mindlessly follow a written set of procedures

Transforming How We Teach

For student learning, move from:

- "Covering it"
- Transferring instructors' notes into students' notes



Move to:

- Active engagement, "minds-on" more than "hands-on"
- Relevant, real-world problems of student interest
- Collaborative peer interactions
- Face-to-face, meaningful faculty interactions
- Higher-level critical thinking and problem solving

Transforming How We Teach

For instructors, move from:

- Fear of teaching unknown content
- Hiding behind the podium, sticking with "safe" material
- Telling
- Ineffective use of time

Move to:

- Well designed, evaluated class activities
- More enjoyable student interactions
- Support from highly qualified colleagues
- Rapid proficiency, success in new teaching methods
- Improved student enrollment, retention, grades



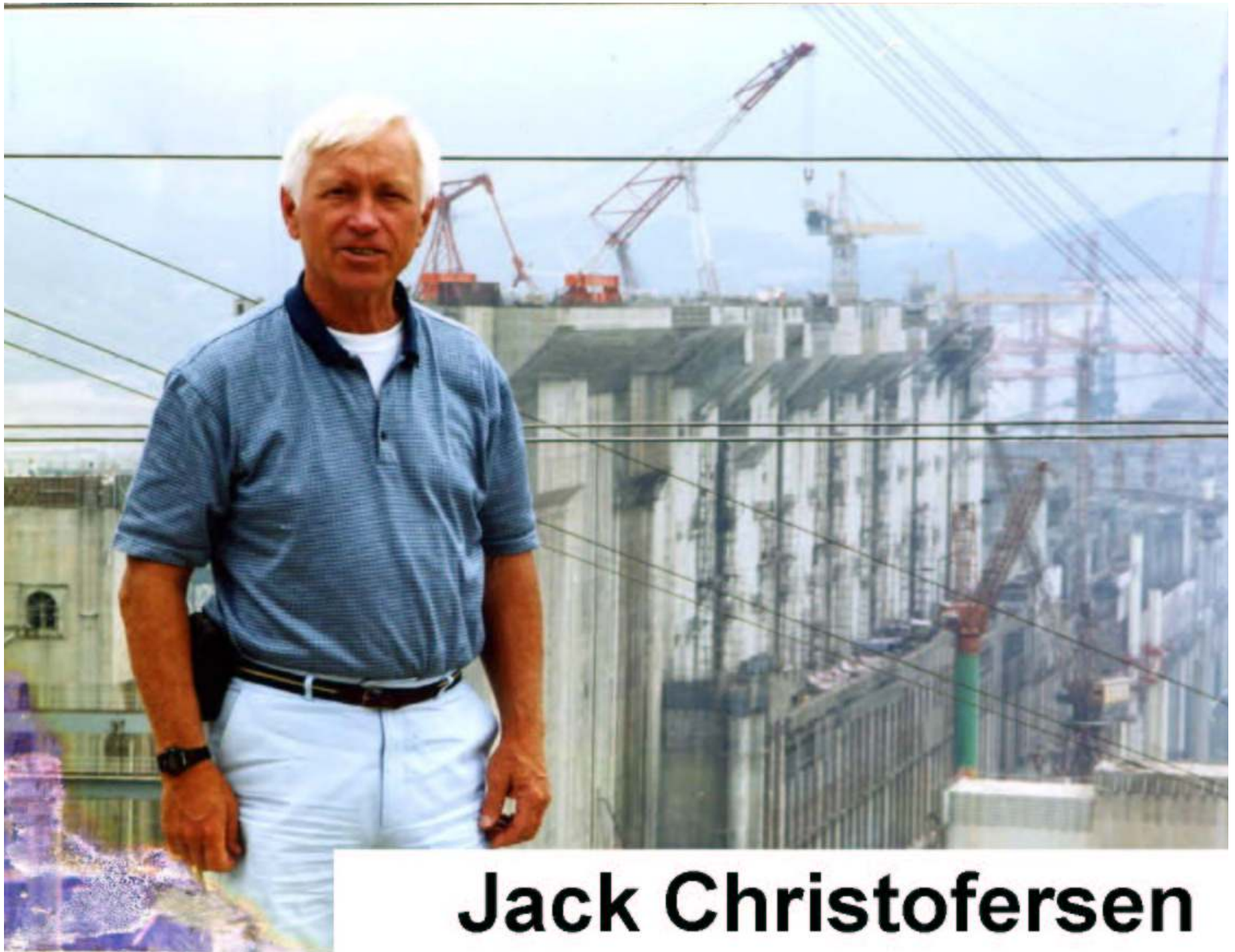
Step 1: Recording Experts' Stories

Save institutional knowledge in case studies

Example contributors:

- Chris Henze - Designed charger for 1st electric car
- Jim Hendershot - Designed numerous motors & generators
- Jack Christofersen - 40 yrs working on T&D
- Pratap Mysore - 30 yrs working on protection systems

Jack is writing his first case...



Jack Christofersen

Reforming Electric Energy Systems Curriculum



**Ned Mohan's Reform School
3 Gorges Project 22,500 MW
2nd largest civil engineering project**

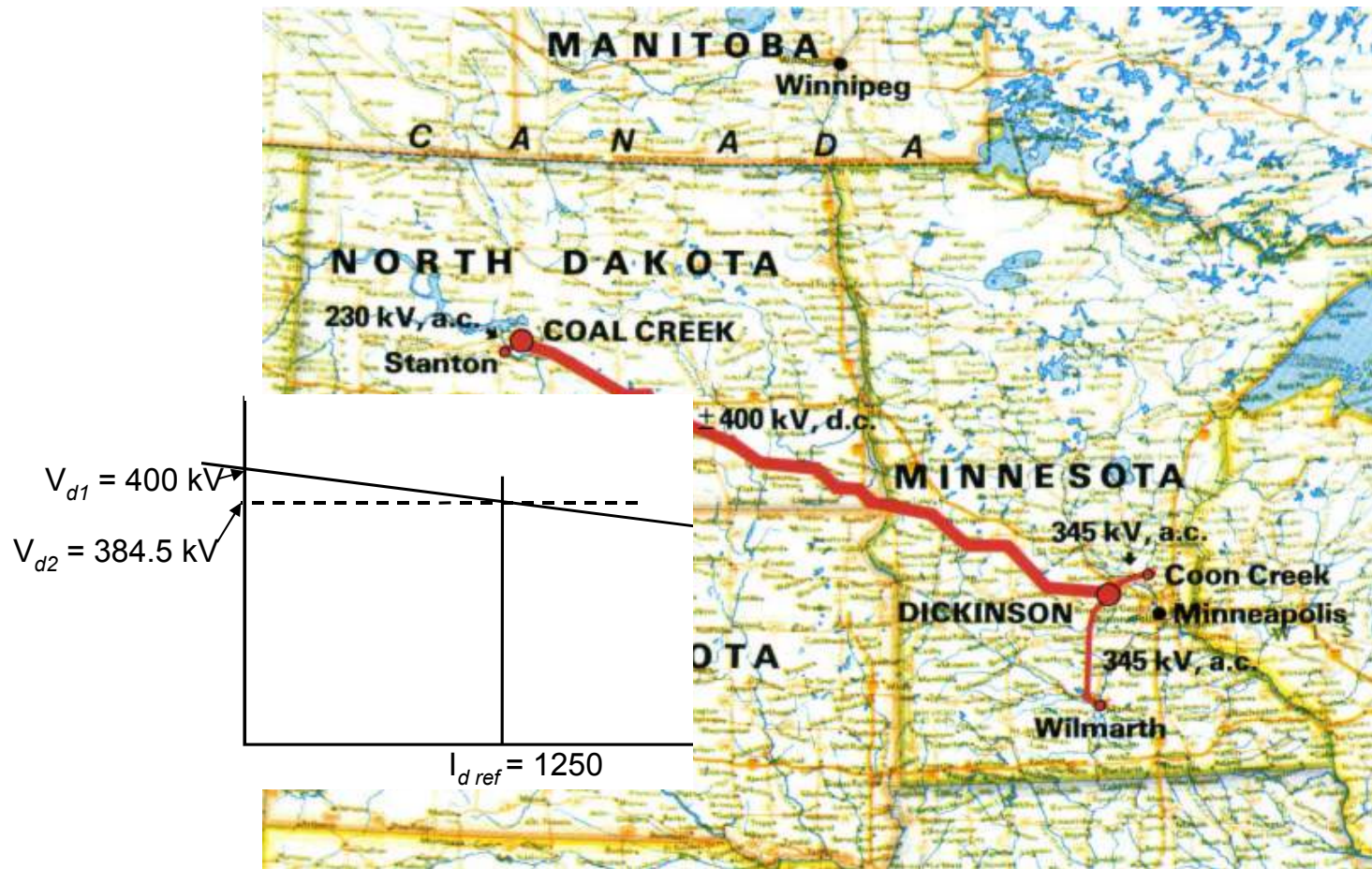


Fig. 1 CU Transmission System [2]

**An early thyristor valve system commissioned in 1979.
 Real-world case studies from
 initial design, permitting and commissioning to
 present life extension projects after operating over 30 years.**

The primary applications for HVDC:

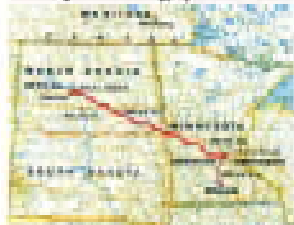
- **The economic alternative for transmitting power over long distances.**
- **Transmitting power underground or undersea at transmission voltage levels with distances over 30 km.**
- **The only alternative for power transfer between asynchronous systems.**

HVDC was chosen for the CU Project because of the long distance and system stability.

- **Definition of HVDC Terminal Components**
- **CU One-line Diagram and Project Specifications**
- **Performance Review**
 - **Transmission Line and Electrode**
 - **Electric and Magnetic Fields**
 - **Converter Configuration**
 - **Thyristor Valve**
 - **Bipolar and Monopolar**
- **National Electrical Safety Code (NESC)**

Hope to see you during the Poster Session

California High-Speed Rail Authority
February 4-7, 2010
Relieving Electrical Energy Systems Constraints



The HV Project

California High-Speed Rail Authority and related project and system risks.

The primary applications for HV are:

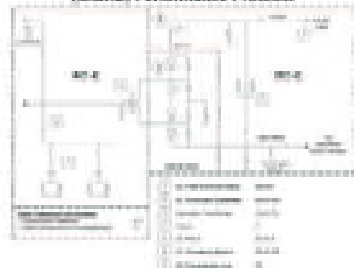
- The economic alternative for transporting power over long distances.
- Transporting power underground as a solution to transmission voltage limits over distances over 100 km.
- The only alternative for access to remote areas with transmission systems.
- HVDC uses electricity for the HV Project because of the long distances and system capacity.

The HV Project

An introduction to High Voltage (HV) Current Transmission

- Definition of HVDC Terminal Components
- Role for Storage and Regulated Operation
- Multiple System
- Transmission Line and Structure
 - Basics
 - Electric Fields
- Electrical Safety Analysis and Standards
 - Electrical Safety
 - Electrical Safety Standards
 - Electrical Safety Code (IEEE)

Definition of HVDC Terminal Components (IEEE) Performance Protocol



HVDC System Components

AC System Components (IEEE) are all those those associated with the system including the HVDC system. It includes all equipment in the system, including those in the HVDC system, such as the HVDC converter, transformer, filter, reactor, and capacitor bank. It also includes all equipment in the system, including those in the HVDC system, such as the HVDC converter, transformer, filter, reactor, and capacitor bank. It also includes all equipment in the system, including those in the HVDC system, such as the HVDC converter, transformer, filter, reactor, and capacitor bank.

The equipment located in the HVDC system and associated equipment is not used as a transmission line and the HVDC system is not used.

DC System Components (IEEE) are those components associated with the HVDC system, including those in the HVDC system, such as the HVDC converter, transformer, filter, reactor, and capacitor bank.

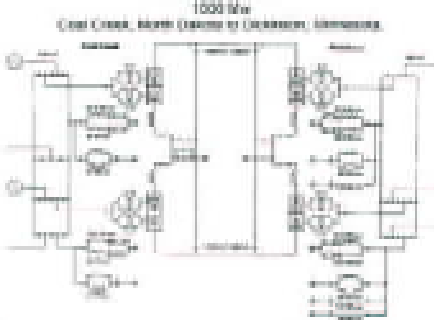
The HVDC system is not used as a transmission line and the HVDC system is not used.

The HVDC system is not used as a transmission line and the HVDC system is not used.

California High-Speed Rail Authority
February 4-7, 2010
Relieving Electrical Energy Systems Constraints

Notes:
The HVDC system is not used as a transmission line and the HVDC system is not used. The HVDC system is not used as a transmission line and the HVDC system is not used. The HVDC system is not used as a transmission line and the HVDC system is not used.

One-line Diagram



Performance Review



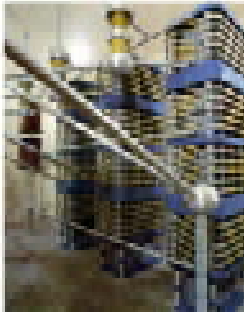
Transmission Structure
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Transformer

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WOLFE 2010

Electric Fields

Natural electric fields may range from 100 V/m up to 40 V/m in the surface. Being lightning strikes and corona produced space charge (static induction).

- Conductor surface gradient
 - HVDC systems range from 15 kV/cm to 20 kV/cm
 - Conductor shape, location, size and material
 - HV system calculation
 - 21.8 kV/cm in Missouri
 - 24.1 kV/cm in North Dakota

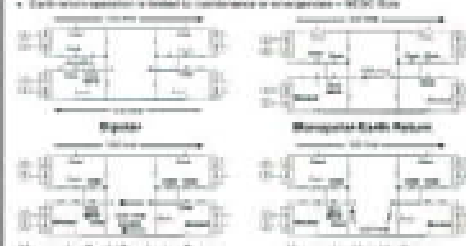
- Necessary to have construction permit - system used
 - Calculated at one meter above ground level
 - Does not consider electric field caused by ice

Magnetic Fields

Affected by the Earth's 60 to 100 milligauss magnetic field.

Calculations using Magnetic Fluxes Administration Criteria and Field Values Program (Paul Gregory (June 1991))

- Shielded configurations - single and complex magnetic fields
- Magnetic field when not perpendicular when transferring from leader to return
- Earth return system is related to transmission wire separation - 4000 ft



Coal Creek Station located near the location



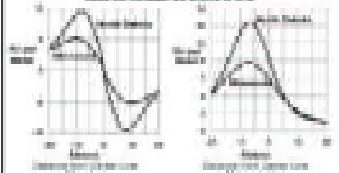
Monopolar earth return leader
The HVDC system is not used as a transmission line and the HVDC system is not used. The HVDC system is not used as a transmission line and the HVDC system is not used.

Natural Electric Field Study

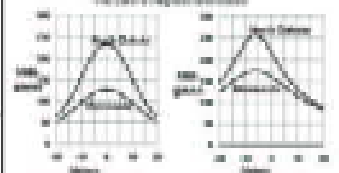
Location	Year of Study	Field (V/m)	Field (kV/m)
San Francisco, CA	1990	100	0.1
San Francisco, CA	1991	100	0.1
San Francisco, CA	1992	100	0.1
San Francisco, CA	1993	100	0.1
San Francisco, CA	1994	100	0.1
San Francisco, CA	1995	100	0.1
San Francisco, CA	1996	100	0.1
San Francisco, CA	1997	100	0.1
San Francisco, CA	1998	100	0.1
San Francisco, CA	1999	100	0.1
San Francisco, CA	2000	100	0.1
San Francisco, CA	2001	100	0.1
San Francisco, CA	2002	100	0.1
San Francisco, CA	2003	100	0.1
San Francisco, CA	2004	100	0.1
San Francisco, CA	2005	100	0.1
San Francisco, CA	2006	100	0.1
San Francisco, CA	2007	100	0.1
San Francisco, CA	2008	100	0.1
San Francisco, CA	2009	100	0.1
San Francisco, CA	2010	100	0.1

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Calculated Electric Field



Calculated Magnetic Field



Calculations 1000 MVA 1000 meters one meter above ground level at cross sectional elevation 100 ft in Missouri and 10 ft in North Dakota.

Notes

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PROTOCOL FOR REPORTING THE OPERATIONAL PERFORMANCE OF HVDC TRANSMISSION SYSTEMS

Working Group
14.04

March 2010



Step 2: Develop In-Class Activities

- Instructors identify core, important concepts in each case
- Instructors coordinate with engineering education specialist to outline each activity
- Support materials for teachers & students are developed
- Ned records on-line 30-minute video modules (lecture material to support case)

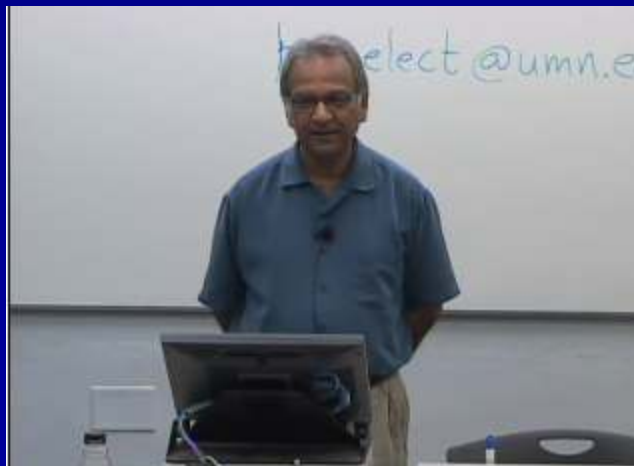
Step 3: Assess In-Class Activities

- Materials tested at UMN and NAU
- Implementation and results of each activity professionally assessed & revised
- Timeline:
 - Power Electronics, Fall 2010
 - Power Systems, Fall 2011
 - Electric Drives, Fall 2012



Step 4: Dissemination

- Spring/summer dissemination workshops after each assessment
- New instructors additionally supported by:
 - Ned's video modules
 - Weekly teleconferences with resource faculty



Possible Follow-on Activities

- Implementation, assessment, and revision at several other institutions
- Collection & distribution of other outstanding in-class activities, homework assignments, simulations, tricks & techniques, etc.
 - Emphasis on integrating research and contemporary issues into the curriculum
- More intensive training sessions

Resources

Annenberg / Corporation for Public Broadcasting. (1997.) *Minds of Our Own*. (Videocassette) Author.

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