

Linking Evidence and Promising Practices in STEM Undergraduate Education

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What's the Problem?

- An educated citizenry/general public awareness of STEM
- Pipeline
 - Attracting K-12 students into STEM?
 - Recruiting college students into STEM majors?
 - Retention in the major?
- Enhance the preparation of STEM students for their professions


- Improve STEM college student learning outcomes: Which ones?
 - Knowledge (content, retention, application, synthesis)
 - Skills (communication, problem-solving, commitment to lifelong learning)
- Curriculum

Improving College Student Learning in STEM

- Improving teaching
- Improving student learning
- Improving student learning productivity

What We Know about Improving College STEM Teaching and Learning

- Pedagogical effects
 - Traditional (e.g., clear lesson plans and expectations for students)
 - Innovative (PBL, cases, studio instruction, etc.)
- Student engagement (Kuh)
- Active and Collaborative Learning (Pascarella & Terenzini)
- Student learning communities
- In-class and out-of-class effects on cognitive development
- Faculty professional development

The background of the slide is a deep blue color with a subtle, wavy texture that resembles water. A bright, horizontal reflection of light, likely from the sun, stretches across the upper portion of the image, creating a gradient from white to light blue. The text is centered in the upper half of the slide.

What We Know About Current Instructional Practices in STEM (1999, all 4-year institutions)

	All	STEM	Hum./ F.A.	Soc. Sci.	Prof.
% male	72	87	67	74	62
Hours/wk. teaching	8.9	8.1	9.7	8.4	9.1
% used active/collab. instr.	30	19	40	19	38
% time, research	20	25	17	22	18
% P.I.	23	42	07	21	20
Publications (2 yr.)	5.5	6.7	4.4	5.7	5.2
Belief research should be main criterion P&T	2.26	2.32	2.21	2.41	2.17

Fairweather, J., and Paulson, K. "The Evolution of Scientific Fields in American Universities: Disciplinary Differences, Institutional Isomorphism." In Cultural Perspectives in Higher Education, ed. J. Valimaa and O. Ylijoki (pp. 197-212). Dordrecht: Springer, 2008.

The Nature of Evidence in Reforming STEM Undergraduate Education

- Assumptions:
 - STEM faculty/administrators require empirical evidence to convince them of the success of educational reforms.
 - The quality of empirical evidence will be judged according to the scientific standards in STEM rather than those of educational research.
 - An implicit “If we demonstrate it works they will use it” model
 - The reality of educational innovation: Evidence is a necessary but not sufficient condition for reform.
 - The typical story: A “one-off” pedagogical reform
 - Dancy & Henderson’s “Barriers”
 - ECSEL
 - CIRTL
- Generalizability of results across STEM fields?

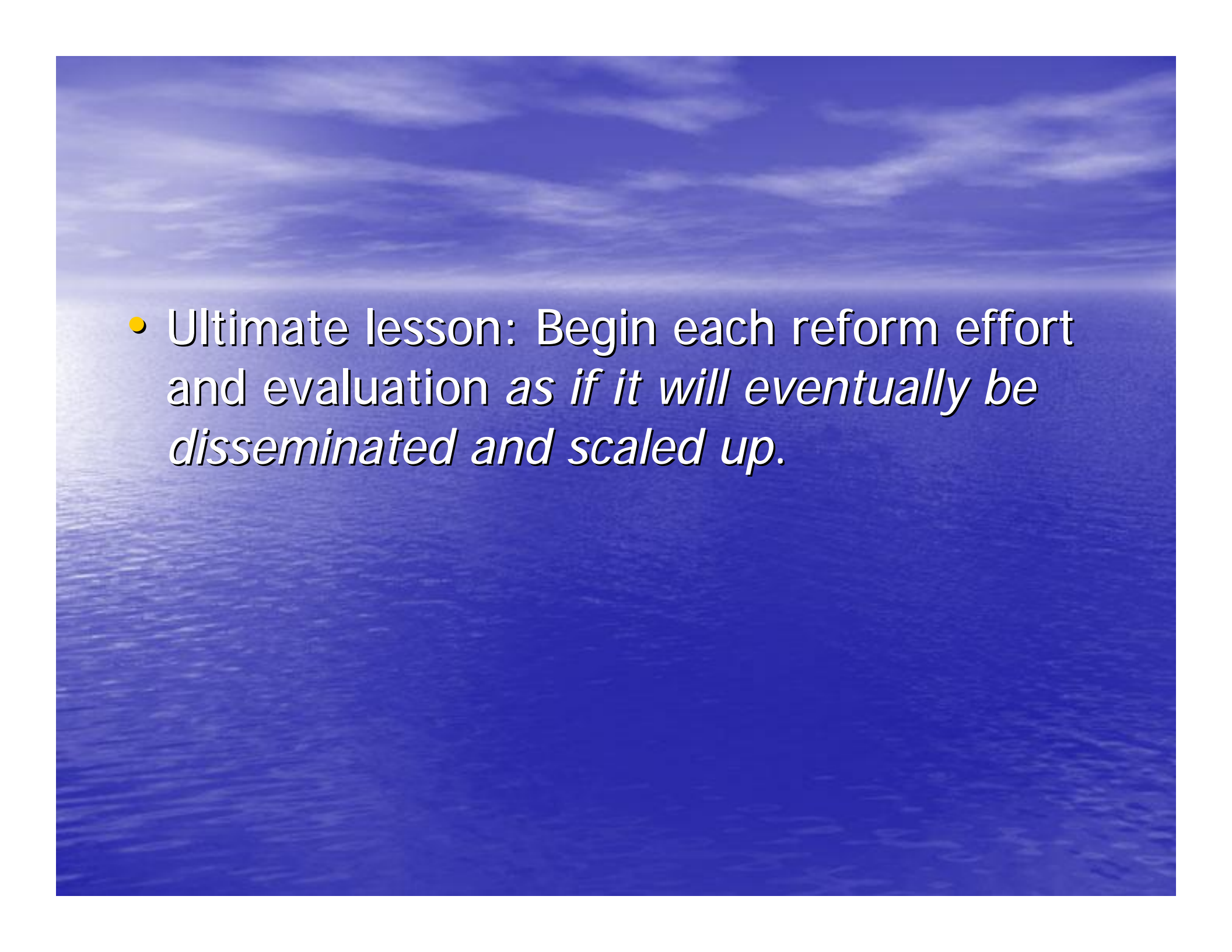
Evaluation Practices

- Most evaluation focuses on in-class events
- Pre-post “gold standard” used occasionally; self-reports are more common
- Another “gold standard”: Linking learning objectives, instructional approaches, and evaluation tools
- The behavioral modification dilemma
- The role of face validity
- Pros and cons of meta-analysis
- Longitudinal studies, in-depth studies, systemic reform studies: The exceptions, not the rule

Evaluation Recommendations

- The usefulness of any evaluation tool ultimately depends on both rigor *and* ease of use: Transforming a classroom research tool into a tool for all faculty members
- Distinguish between what's required for any effective teaching/learning (e.g., clear expectations) from what's required to promote innovative pedagogies (e.g., studio work).
- Negative student ratings and educational innovations
- Case study evaluations must provide sufficient detail about the setting for others to see its applicability
- Determining useful effect sizes and levels of significance

- Distinguish between evaluations meant to
 - Help a faculty member implement an innovation (formative assessment)
 - Help a faculty member document summative effects of a classroom innovation
 - Prepare results for a national research audience
 - Convince other faculty members to try the new instructional approach
- Curriculum reform requires more than evidence of impact (political environment, cost-effectiveness) [GE Fund story]

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- Ultimate lesson: Begin each reform effort and evaluation *as if it will eventually be disseminated and scaled up.*

Teaching and the Faculty Position

The background of the slide is a deep blue gradient with a subtle, textured pattern of water ripples, creating a serene and professional atmosphere.

The Relative Importance of Teaching and Research in Faculty Rewards



Trends in the Relative Value of Teaching and Research in Faculty Salaries

Research Questions

- What is the relative value of teaching and research in faculty pay in 1993 and 1999?
- Has the relative value of teaching and research in faculty pay changed between 1993 and 1999?

Study Variables

- Criterion
 - Basic Salary (Log) in constant 1998 dollars
- Behaviors
 - Department Chair
 - Hours spent teaching in the classroom per week
 - Type of students taught
 - Use of active/collaborative instruction
 - Total referred publications, career
 - Principal investigator

- Institutional Controls
 - Source of control (institution): public/private
 - Institutional wealth (expenditures per pupil)
- Individual Controls
 - Program area/discipline
 - Length of contract (9/12 months)
 - Years since attained highest degree
 - Minority/non-minority
 - Male/Female
 - Highest degree Ph.D. (yes/no)

Semi-log Regressions on LOG (Basic Salary) (standardized coefficients)

	Research		Doctoral		Comprehensive		Liberal Arts	
	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>
CLASSHR	-.19***	-.13***	-.20***	-.22***	-.08**	-.24***	-.06	-.18*
TYPESTS	.10***	.05**	.11***	.11***	.07***	.11***	.06**	.12***
COLLABORATE	.03	-.02	-.01	.02	-.01	.03	-.02	.02
TOTPUBS	.24***	.36***	.35***	.29***	.21***	.10**	.21***	.30***
PI	.08***	.05*	.01	-.04	.01	-.01	.01	.05
ADJUSTED R²	.59	.54	.58	.52	.47	.41	.67	.52
N	1135	1877	1314	767	2981	1837	699	.480

Bold = statistically significant

Fairweather , J. Beyond the Rhetoric: Trends in the Relative Value of Teaching and Research in Faculty Salaries. Journal of Higher Education 76 (2005): 401-422.

Estimated effect on faculty pay (in constant 1998 dollars) of hours spent in the classroom and career publications at the mean, by type of institution and year

	<u>Research</u>		<u>Doct oral</u>		<u>Comprehen sive</u>		<u>Liberal Arts</u>	
	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>
CLASSHR								
Effect	-.011	-.009	-.010	-.014	-.004	-.016	-.003	<u>-.008</u>
0% Return	22.9	29.4	38.8	31.3	36.3	29.2	25.9	48.4
% Cases	2.7%	0.9%	0.8%	0.7%	0.7%	1.3%	2.2%	0.5%
TOTPUBS								
Effect	.002	.003	.004	.003	.002	.001	.003	.004
0% Return	426	276	180	134	340	140	245	88
% Cases	0%	0.2%	0.7%	2.4%	0.1%	0.3%	0.2%	1.6%

Bold = $p < .001$, Underline = $p < .001$, otherwise not significant

Fairweather, J. Beyond the Rhetoric: Trends in the Relative Value of Teaching and Research in Faculty Salaries. *Journal of Higher Education* 76 (2005): 401-422.

Estimated effect on faculty pay (in constant 1998 dollars) of an additional hour spent in the classroom and an additional career publication at the mean, by type of institution and year

	Research		Docto ral		Compre hensive		Liberal Arts	
	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>	<u>92-3</u>	<u>98-9</u>
CLASSHR	-\$728	-\$758	-\$580	-\$614	-\$208	-\$540	-\$138	-\$474
TOTPUBS	\$119	\$211	\$206	\$157	\$111	\$ 68	\$131	\$190

The Complete Faculty Member

- Research Question:
 - What percentage of the American faculty are productive in both teaching and research?

The Highly Productive Researcher

- Above the median [for discipline and type of institution] on refereed publications OR
- In the second quartile of publications AND
 - Principal investigator where project dollars amount was in top quartile OR
 - Principal investigator (any \$ amount) and top quartile of conference presentations OR
 - Principal investigator and above median in both research dollars and conference presentations.

The Highly Productive Teacher

- Above the median [for discipline and type of institution] in student contact hour production OR
- In the second quartile of student contact hour production AND the top quartile of both independent study contact hours and dissertation/thesis committee service.

Productivity Groups

- Group 1: Above the median in both teaching and research productivity
- Group 2: Above the median in research productivity while showing some evidence of active/collaborative instruction
- Group 3: Above the median in both research and teaching productivity while showing evidence of the use of active/collaborative instruction.

Percent of Faculty in High Performing Productivity Groups, By Type of 4-Year Institution (NSOPF-93)

<u>Type of Institution</u>	Group 1: High Teaching & High Research	Group2 : High Research, Used Active Instruction	Group 3: High Teaching & High Research + Used Active Instruction
	<u>Percent</u>	<u>Percent</u>	<u>Percent</u>
All 4-year	22.0	12.3	6.0
Research	21.7	9.7	4.6
Doctoral	21.5	10.7	4.0
Comprehensive	22.8	15.6	7.9
Liberal Arts	20.4	13.9	8.1
Other	23.8	8.9	4.5

Fairweather, J. The Mythologies of Faculty Productivity: Implications for Institutional Policy and Decision-making. *Journal of Higher Education* 73 (2002): 26-48.

Intervention Strategies: Factors Affecting Success

- Focusing on current versus future faculty (CIRTL)
- Understand the implicit change model
 - Non-linear cybernetic models vs. traditional linear models of reform
 - Structural impediments to reform
 - Role of professional societies and accreditation
 - Role of resources available on campus (professional development among them)
- “Preaching to the choir” and what it means for reform
- Enhancing learning productivity may require different strategies than improving individual classroom teaching and learning