

Experiential Learning through STEM: Recent Initiatives in the United States

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1. Focus on recent US STEM, especially using experiential learning methods
2. Many recent local initiatives, often partnering schools (2- and 4-year postsecondary) with other institutions
3. Initiatives funded by federal government (eg NSF); industry; state and local governments
4. Many focus on “experiential learning,” ie integrating formal instruction with learning-by-doing
5. Initiatives arise from concern that US falling behind in global technological competition
6. And from fact that educational system failing many young people (high economic inequality, related to high geographic inequality, lowers economic mobility through education)
7. Premise: well-aligned system of experiential education through STEM can benefit:
 - a. Opportunity for young people
 - b. Labor force for industry
 - c. Economic development for communities, country→ -ie “win-win-win”

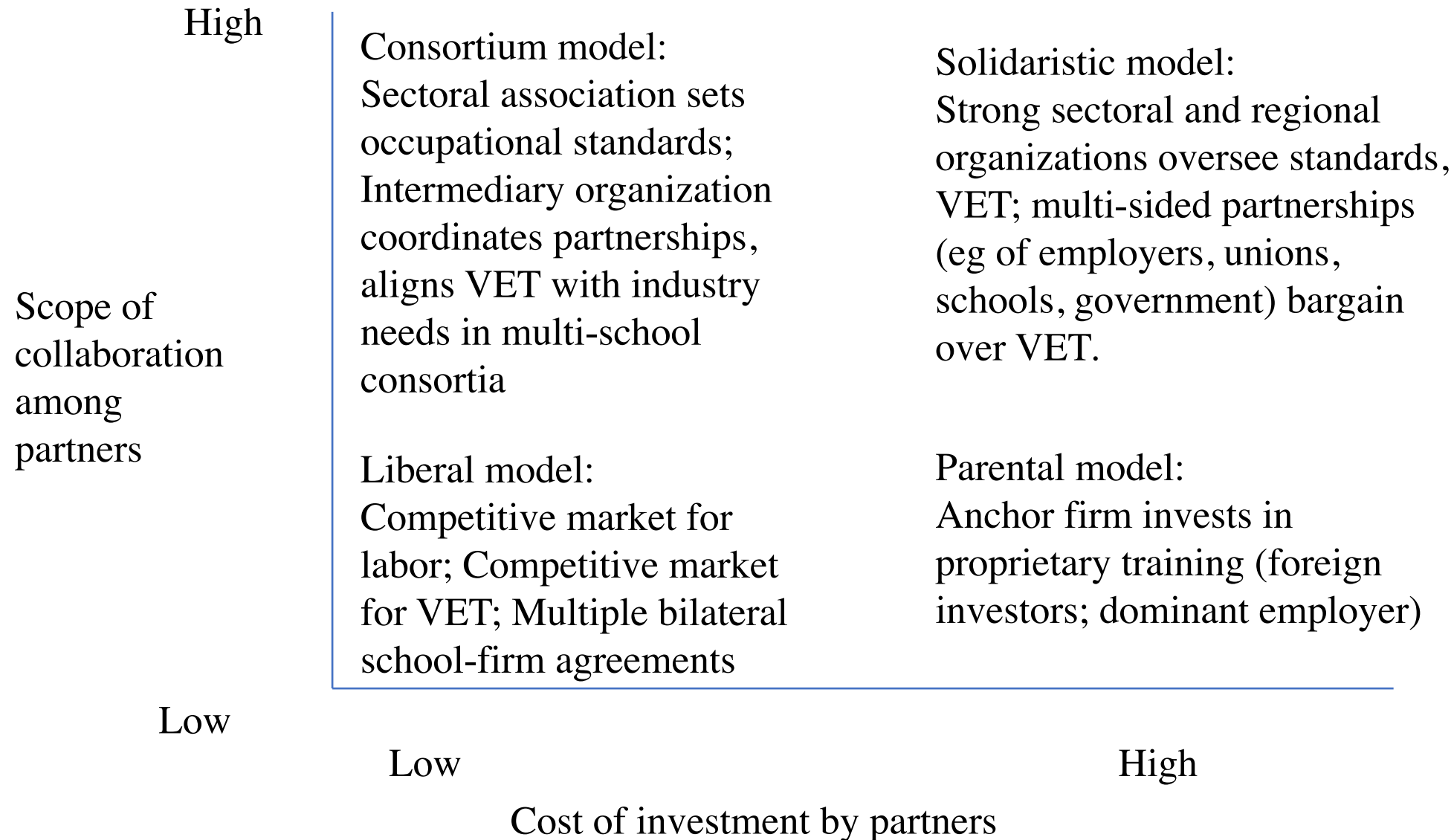
1. Obstacles:
 - a. Expense (organizing, sustaining new models of education)
 - b. Bureaucratic routine
 - c. Pursuit of short-term successes at expense of longer-term investments
 - d. Conceptual confusion over “STEM” -- broad vs. narrow definitions

2. Impetuses for institutional interventions :
 - a. Market failures (labor market fails to reward full benefit of learning-bydoing (Arrow 1962)
 - b. Resistance by schools (eg teachers, administrators must meet state standards for credit hours)
 - c. Parents may resist departure from familiar methods of instruction

3. Long history of experiential learning in US. Cf John Dewey and Progressive Movement:
 - a. Child-centered education; “*experientia docet*”
 - b. Learning by doing as citizenship education
 - c. Bringing knowledge from community into school, carry understanding back to community
 - d. Cultivating capacity to apply knowledge to solve problems, teamwork, initiative
 - e. Recognizing self as part of larger society

4. But Dewey’s ideas were not implemented in most public schools

1. "Dual education" methods (ie apprenticeships) not widespread in US
(of US labor force = 164 million workers, <600,000 [0.37%] are in apprenticeships)
2. US often relies on partnerships among schools and employers for TVET among firms, schools, and governments. Community colleges have close relations with local employers
3. We classify these along two dimensions:
 - a. Level of coordination on TVET across firms operating in same labor market
 - b. Cost of resources committed to cooperative arrangements on part of partners
4. Theory: greater investment in TVET by firms yields greater control over content of training; therefore firms sacrifice control over content when sharing TVET spending with other firms
5. Yields two-by-two matrix:



1. Most of the projects studied in this paper fall into **consortium** or **parental** category
2. Larger questions:
 - a. Do these initiatives yield educational and occupational benefits for students?
 - b. Do they raise level of preparedness for workforce?
 - c. Do they have benefits for society (eg higher income levels, lower inequality)?
3. Ultimate goal: assess initiatives to determine effectiveness in meeting these objectives
4. Unfortunately, data too limited to allow assessment
5. This paper's goals more modest: classifying initiatives, observing common organizational patterns
6. 2 sources of evidence:
 - a. analysis of 11K NSF grants in last 5 years to support STEM education projects in the US
 - b. case studies and meta-analysis of case studies

1. NSF grants, 2017-2022: N = 11,406. Total of \$8.7 billion spent.
2. We coded all abstracts containing keywords:
“education,” “learning,” “employment,” “pathways,” “jobs,” “workforce”
3. Grant recipient and intended beneficiary institutions sorted by category: post-secondary (2-year + 4 year); other, eg museums
4. We searched for references to:
 - a. curriculum development
 - b. employer engagement
 - c. do students from outside vocational track participate?
 - d. is there an evaluation component?
 - e. is there an explicitly experiential component?
 - f. employer partnership?
 - g. are intermediary organizations involved?
 - h. is a specific target population mentioned (eg women, minorities, rural population)
 - i. establishment pathway from school to employment?
 - j. are there support services?
 - k. teacher development?
 - l. workforce development focus?

| Grant attributes | Grant category (target) | | | | |
|-----------------------------------------------------|-------------------------|--------------|---------------|--------------|----------------|
| | SECONDARY+ | 2-YR+ | 4-YR+ | UNSPECIFIED | Full Sample |
| All grants | 27.08% | 6.71% | 61.95% | 4.26% | 100.00% |
| % Curriculum development | 36.87% | 42.48% | 20.78% | 11.32% | 26.19% |
| % Employer consortium | 0.42% | 0.78% | 0.06% | 0.00% | 0.20% |
| % Engages students outside vocational tracks | 35.58% | 25.23% | 33.82% | 26.13% | 33.39% |
| % Evaluation component | 29.59% | 36.99% | 27.50% | 28.81% | 28.76% |
| % Explicitly Experiential | 27.94% | 28.76% | 24.26% | 13.37% | 25.09% |
| % Grantee is a school | 89.16% | 94.25% | 95.95% | 5.35% | 90.14% |
| % High Industry Engagement | 21.40% | 20.92% | 18.99% | 15.43% | 19.62% |
| % Industry partnerships | 4.56% | 7.32% | 2.02% | 0.62% | 3.01% |
| % Intermediary Organizations | 0.42% | 0.65% | 0.31% | 1.65% | 0.42% |
| % Local industry-driven | 11.59% | 13.07% | 5.93% | 5.97% | 7.94% |
| % Mentions Target Population | 60.89% | 72.29% | 52.90% | 47.53% | 56.14% |
| % Pathways strategy | 38.62% | 41.83% | 27.06% | 35.80% | 31.55% |
| % Rural-serving | 9.91% | 5.62% | 3.11% | 4.73% | 5.19% |
| % Supportive services | 2.98% | 2.75% | 2.52% | 2.88% | 2.67% |
| % Teacher development | 53.09% | 36.86% | 19.93% | 23.66% | 30.20% |
| % Workforce development focus | 65.68% | 84.31% | 61.69% | 55.14% | 64.01% |

General observations on NSF-funded projects:

- a. Most projects target specific populations (eg disadvantaged groups)
- b. Few cite intermediary organizations or support services
- c. Few cite evaluation components
- d. Little attention to community-wide benefits
- e. $\sim 1/3$ cite pathways elements, eg dual enrollment
- f. $\sim 1/3$ engage students outside vocational tracks
- g. $< 1/4$ mention explicitly experiential elements

Analysis of case studies:

1. Searched for papers, reports, websites, project announcements, scholarly papers (2014-2022) related to: STEM education; STEM and experiential learning; STEM education and workforce development.
2. Questions:
 - a. Experiential learning component?
 - b. Cooperation with industry
 - c. Partnerships between schools and other organizations
 - d. Reference to intermediary organizations
 - e. Targeted population?
 - f. Fields of study
 - g. Reference to expanding career opportunity
 - h. Reference to evaluation component

Observations on case studies:

1. Many projects seek to awaken student awareness of, enthusiasm for STEM
2. Many projects targeted specific populations (eg disadvantaged populations; females; students with+ learning disabilities)
3. Many projects included an assessment, but in most cases these were based on surveys of students regarding reactions to participation in project; almost none examined impact on educational outcomes (eg grades, school completion rates) or career outcomes (eg employment in STEM field); almost none used rigorous analytical methods (eg comparison of treatment and control groups)
4. Only one project used assessments of student progress to guide instruction over the course of the project—was in Indonesia! (Parno, Mufti, Widuri and Ali 2021)
5. Most common fields of study were engineering and computer sciences
6. Partners—some industry consortia; some government institutions, eg NASA's Space and Rocket Center (Huntsville, Alabama) engages with consortium of aerospace manufacturers, eg Lockheed-Martin
7. Popular model involves partnering a 2- or 4-year higher educational institution and one or more secondary schools
8. Relatively few projects cited the use of intermediary organizations to coordinate partnerships

Conclusions:

1. “Liberal model” of capitalism in US creates strong path dependencies, eg decentralization of educational initiative, variety of approaches to enhancing STEM education for workforce development
2. Despite much scholarly literature demonstrating importance of intermediary organizations in coordinating partnerships among schools and other organizations to provide real-world, employment-related experience, almost no projects explicitly include intermediary organizations as partners
3. Despite high spending on projects, little effort to measure effectiveness in reaching larger goals
4. Most projects appear to enhance existing instructional curricula rather than introduce significant changes in structure and content
5. ***What is the overall impact of these projects?***

