BOARD # 266: Leveraging Institutional and Community Capacities in Implementing Community-Engaged STEM PBL

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With higher and faster growing wages [1], STEM-related employment has been key to building thriving communities. In the deindustrialized Midwest, however, cities often have poverty rates double the national average, lower educational attainment, and the 'brain drain' problem [2]. These issues create barriers to developing and retaining a regional STEM workforce and competing in the knowledge economy. Thus, STEM engagement is not just a national imperative, but critical to revitalizing these Midwestern cities.

The University of Notre Dame developed and piloted a program to address the challenges of STEM engagement/retention in the disciplines and place retention. The program leveraged high impact practices such as immersive place-based education (internships), academic community engagement, and STEM-based experiential problem-based learning, while interns engaged in asset-based community development in the South Bend-Elkhart, Indiana region [3-14]. The pilot program was distilled into a model through evidence-based refinement – the Community-Engaged Educational Ecosystem Model (C-EEEM, pronounced 'seam'), and contributes to our understanding of building learning environments that meet those challenges [4-6, 15-18].

Project

Funded through an NSF Improving Undergraduate STEM Education (IUSE) collaborative research grant, the Community-Engaged Educational Ecosystem model (C-EEEM) targets those aforementioned challenges with which many deindustrialized cities struggle. As noted, through community and problem-based engagement and knowledge/skill building with student interns, the C-EEEM enhances the capacities of local communities to address issues - while using an asset-based lens. This has shown student outcomes across key areas of interest [6, 18]. Following the replication for the C-EEEM in two other Midwestern regions (Louisville, KY and Youngstown, OH), researchers have found that the approach demonstrated similar statistically significant outcomes in the new contexts across the areas measured (e.g., self-efficacy, STEM-identity, and place attachment) (*see Table 1*); this was true with all students, but our previous research showed stronger outcomes for many students in underrepresented (low socio-economic, women, underrepresented minority) groups [6, 18].

Table 1 Sample Questions

Question		TTEST	pvalue	Cohen's D	Effect Size
I have identified, accessed, cleaned and/or analyzed data in addressing a real-world issue	*ND*	1.74E-09	<0.001**	0. 865542	Large
	UL	2.25 E-04	<0.001**	0.915815	Large
	YSU	8.95 E-04	<0.001**	0.982895	Large
I know how to apply design thinking/empathic design to problem-solving in the real world.	*ND*	7.25E-12	<0.001**	.842	Large
	UL	2.96 E-04	<0.001**	0.482486	Small
	YSU	2.29 E-03	0.002*	0.897575	Large
I feel a connection to the (PLACE) region.	*ND*	3.20E-09	<0.001**	.772568	Medium
	UL	5.16 E-03	<0.001**	.560453	Medium
	YSU	1.09E-02	0.01*	.93901	Large
I understand how positive change happens in communities	*ND*	8.87E-11	<0.001**	0.948549	Large
	UL	1.14E-05	<0.001	0.450413	Small
	YSU	9.24E-05	<0.001	1.364816	Large

Broadly, C-EEEM engages students in community-identified problem-based learning (PBL) [11], showing broader impacts in neighborhoods, industry, and place attraction to the region [6, 17-19]. The design of training and projects to achieve these nested outcomes, with the community-issue as part of the curriculum and the community as the classroom, is difficult. Despite fidelity to the implementation of the core elements of the C-EEEM (i.e., collaborative infrastructure, community-identified problems, mentorship, training modules) [4-6], contextual differences at the institutional and community level meant differences in the learning environment and the student experience. This research provides an overview of contextual and programmatic implementation differences across replication sites of the Community-Engaged Educational Ecosystem model to understand implications for delivery and student outcomes.

Methods

Researchers collected and analyzed information regarding institutional capacities for community-engagement and C-EEEM implementation at each site through a structured survey instrument, Institutional Capacity and C-EEEM Delivery Survey (ICCDS), including both Likert-type and open-ended questions. C-EEEM institutions included the University of Notre Dame (ND), University of Louisville (UoL), and Youngstown State University (YSU). This information was examined against the student outcome data from the retrospective pre/post survey, using instruments refined from previous years [18]. In early studies, researchers identified the retrospective-pre/post is more sensitive than pre-post approaches for estimating dispositional shifts in unfamiliar settings, such as PBL [6].

Both the ICCDS and the post-internship survey instrument were digitally delivered (Qualtrics platform). Data for all three sites was cleaned and incomplete cases were removed. The University of Notre Dame's Institutional Review Board (IRB) provided review and approval of the research for all three universities. Researchers used Microsoft Excel for quantitative data analysis. For the ICCDS, this included descriptive statistics. For the student data, this included running Paired-Samples T Tests for statistical significance and Cohen's D to estimate the effect size of the internship on the internship participants [17].

Student outcome questions from the retrospective pre/post survey included over 15 items related to the aims of the grant aims and initial pilot outcomes, and were grouped into the areas of interest – **confidence and experience in STEM**, **problem-solving and teamwork skills**, and **contribution and attachment to the region** [17, 18]. A sampling of the questions across the groupings is provided in Table 1, with an emphasis on pulling out items that had different results across sites.

Results

Although the principal aspects of the model were followed by all sites, there were a variety of differences in the institutional capacities and delivery of the C-EEEM. At the institutional level, differences between sites included staff capacity for engagement at various levels (*see Table 2*).

Institution	Does your college/university have the Carnegie Classification for Community Engagement?	At the institutional level (e.g., office of the provost), is there a primary outreach and engagement office for community-engaged learning and research?	If yes, # of FTE	Are there dedicated staff at the institutional level for partnership development and facilitating community-engaged learning and/or research?	If yes, # of FTE	Does the primary entity (e.g., department, center) affiliated with C-EEEM delivery at your college/university have dedicated staff for partnership development and facilitating community-engaged learning and/or research?	If yes, # of FTE	Does the primary entity affiliated with C-EEEM delivery at your college/university have community-engaged learning (CEL) courses integrated during the academic year?
University of Notre Dame	Yes	No	0	Yes	1	Yes	1	Yes
University of Louisville	Yes	Yes	7	Yes	3	Yes	2	Yes
Youngstown State University	Application in process	Yes	1	Yes	1	No.	0	Courses planned, but not yet offered

Table 2 Institutional Capacity

Two of the universities had the Carnegie Classification for Community Engagement, yet only one institution (UoL) had substantial staff resources with substantially more full-time equivalent (FTE) staff for internal coordination and external partnership development. In addition, YSU provides an example of a community asset-based adaptation to the low YSU institutional capacity for network building and implementation, as they partner with a local nonprofit (Economic Action Group - EAG) for the delivery of the C-EEEM in Youngstown. All of the sites had not only the summer-based immersion for the PBL, but also have developed and integrated community-engaged learning courses during the academic year existing or planned.

For student preparation, all of the sites included training modules similar to the pilot (e.g., Project management; Time management; Design Thinking/Empathic design; Team building; Professional communications; Leadership; Diversity; Coding or ArcGIS) with a few additions (e.g., Arduino). However, support for teams (administrative and technical) and team community engagement had more variance. In delivering the program, EAG in Youngstown embeds substantially more community-based activities (*see Table 3*) into the delivery, which appears to correlate with stronger effect sizes with student attachment to the region (*see Table 1*). Further, while UoL and ND had greater frequency of connection with community engagement support, it did not appear to have a correlation with the program's impact on community change understanding.

	Number of required community exploration activies in the delivery of the C-EEEM	Number of optional community exploration activies directly coordinated in the delivery of the C-EEEM	Number of optional community exploration activies leveraged from other organizations in the delivery of the C-EEEM	What is the typical student team size?	How are high school students integrated into the program (e.g., teams of 1 HS and 3 university; some other configuration)	Administrative support	Technical support	Community engagement support
ND	4	0	7	4	1 HS and 3 university in South Bend; 3 HS and 1 university in Elkhart	Daily contact	A couple of times a week	A couple of times a week
UoL	3	0	3	3	1 or 2 HS working with 2 university make up a team.	Daily contact	Weekly contact	A couple of times a week
YSU	7	7	7	4	1 high school student per 4 person team, typically	Daily contact	Weekly contact	Weekly contact

Table 3 Student Experience

Final Thoughts

Given the small number of institutions, this information is insufficient to draw definitive conclusions. Nonetheless, initial findings from institutional support and delivery, coupled with student data does suggest that delivery of the model can occur across a wide range of institutional capacities with sufficient community-based supports and that embedding the exploration of the local community is correlated with greater place attachment. Further research that includes qualitative data on the learning environment will help to more fully explain these initial findings and quality differences in delivery. Finally, another area for future exploration includes examining demographic differences in student outcomes across the institutional and delivery factors.

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References

[1] "The State of American Jobs," Pew Research Center, Washington, D.C., 2016.

[2] K.-y. Wong and C. K. Yip, "Education, economic growth, and brain drain," *Journal of Economic Dynamics and Control,* vol. 23, no. 5-6, pp. 699-726, 1999.

[3] L. Cancado, J. Reisel, and C. Walker, "Impacts of a Summer Bridge Program in Engineering on Student Retention and Graduation," *Journal of STEM Education,* vol. 19, no. 2, 2018.

[4] D. Wood, A. Gura, J. Brockman, G. Gilot, S. Boukdad, and M. Krug, "The Community-Engaged Educational Ecosystem Model: Learning from the Bowman Creek Experience," presented at the Engaged Scholarship Consortium, Minneapolis, MN, 2018.

[5] D. Wood, A. Gura, J. Brockman, A. Rayna Carolan-Silva, S. Boukdad, and J. C. Alarcon, "Informing Replication of the Bowman Creek Educational Ecosystem Pilot," in *American Society for Engineering Education proceedings*, A. Genau Ed.: ASEE, 2019.

[6] D. Wood, A. Gura, and J. Brockman, "Critical Findings in the Development of the Community-Engaged Educational Ecosystem," in *American Society for Engineering Education proceedings*: ASEE, 2020.

[7] G. Arastoopour, N. C. Chesler, and D. W. Shaffer, "Epistemic persistence: A simulation-based approach to increasing participation of women in engineering," *Journal of Women and Minorities in Science and Engineering,* vol. 20, no. 3, 2014.
[8] J. Cullinane and L. Leegwater, "Diversifying the STEM Pipeline: The Model Replication Institutions Program," Institute for Higher Education Policy, Washington D.C., 2009.
[9] M. J. Graham, J. Frederick, A. Byars-Winston, A.-B. Hunter, and J. Handelsman, "Increasing Persistence of College Students in STEM," *Science,* vol. 341, no. 6153, pp. 1455-1456, 2013, doi: 10.1126/science.1240487.
[10] G. Lichtenstein, H. L. Chen, K. A. Smith, and T. A. Maldonado, "Retention and persistence of women and minorities along the engineering pathway in the United States," *Cambridge handbook of engineering education research,* pp. 311-334, 2014.
[11] J. Chen, A. Kolmos, and X. Du, "Forms of implementation and challenges of PBL in engineering education: A review of literature," *European Journal of Engineering Education,* pp. 1-26, 2020.
[12] M. LaForce, E. Noble, and C. Blackwell, "Problem-based learning (PBL) and student interest in STEM careers: The roles of motivation and ability beliefs," *Education Sciences,* vol. 7, no. 4, p. 92, 2017.
[13] M. Yemini, L. Engel, and A. Ben Simon, "Place-based education–a systematic review of literature," *Educational Review,* pp. 1-21, 2023.
[14] M. M. Elbaz, "Place-based education: Community as a multidisciplinary learning environment," *Port Said Journal of Educational Research,* vol. 2, no. 1, pp. 59-74, 2023.
[15] D. Wood, A. Gura, J. Brockman, and S. Alptekin, "Student Outcomes in Academic Community Engaged STEM projects with Multi-Dimensional Diversity.," in *American Society for Engineering Education proceedings*: ASEE, 2018.
[16] D. Wood, H. Marie, F. Aqlan, J. Brockman, D. Lapsley, and K. L. Meyers, "Building and Replicating a Community-Engaged Educational Ecosystem - a STEM Learning Commons," presented at the National Science Foundation Improving Stem Undergraduate Education Summit, Washington, D.C, June 1-3 2022, 2022.
[17] D. Wood, H. Marie, F. Aqlan, J. Brockman, K. L. Meyers, and D. Lapsley, "Replicating a Community-Engaged Educational Ecosystem: First Year Findings," in *American Society for Engineering Education proceedings*. Baltimore, MD, 2023.
[18] D. Wood, H. Marie, F. Aqlan, and J. Brockman, "Replicating the Community-Engaged Educational Ecosystem – Differences in Outcomes across Students," in *American Society for Engineering Education proceedings*. Portland, OR, 2024.
[19] M. M. Ehlenz, "The university and its neighborhood: A study of place-making and change," *Journal of Urban Affairs,* vol. 41, no. 6, pp. 776-794, 2019.