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Board 401: The Fidelity of Implementation of a Lesson-Study Framework in Engineering Courses at a Hispanic-Serving Institution

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The Fidelity of Implementation of a Lesson Study Framework in Engineering Courses at a Hispanic-Serving Institution

This paper reports on one aspect of a four-year NSF-funded transforming STEM undergraduate education initiative carried out at a public, research-intensive Hispanic Serving Institution (HSI) in the U.S. Southwest. The aim of the initiative focused on improving the academic achievement of Latinx undergraduate education in STEM courses through 1) the restructuring of undergraduate STEM courses, 2) providing research opportunities, and 3) developing a near-peer mentoring program. This paper examines university faculty engagement in a language-rich[1] STEM Lesson Study (LR-LS) framework developed by the research team and applied to the restructuring of critical undergraduate courses [4], [5]. The LR-LS framework was introduced and used during collaborative interdisciplinary meetings (Education, Engineering, and Physics) following the lesson study model [10]; lesson study meetings involved two LS teams—an engineering and a physics team. Lesson study (LS) meetings were intended to offer engineering and physics faculty professional development through a collaborative network of support that focused on student-centered instruction and student learning. In this paper, we examine the extent to which engineering faculty engaged in the LR-LS framework through a fidelity of implementation (FOI) analysis across four years. FOI refers to adherence and quality of implementing an instructional model or framework deemed important to understand if an instructional model is implemented as intended [3], [1], [8]. Additionally, a report on student outcome data connected to the FOI of the LR-LS framework is provided as it relates to seeing improved student learning outcomes.

The LR-LS framework incorporates sociocultural pedagogical principles within lesson study designed to improve instruction and learning through focused attention to learning challenges [6],[10]. According to Smith [7], the use of implementation fidelity data collected for explaining educational interventions can "provide detailed representations of the curricula, pedagogies, and activities that students experience." Such data can contextualize the design and the delivery of the intervention. To examine FOI, an LR-LS fidelity rubric was developed by the research team to score faculty on five "critical components" [1] of the LR-LS framework: 1) STEM/academic literacy, 2) affordances for student interaction, 3) orientations to student learning, 4) reflective practice, and 5) faculty leadership. Our FOI rubric was intended to capture the extent to which LR-LS components were enacted during lesson study (quality measure). The five LR-LS components were measured using a four-point scale. A score of "0" means the component was not present, "1" reflects minimal implementation, "2" reflects moderate implementation, and "3" reflects strong implementation.

Methods

Data for this analysis was drawn from four semesters of lesson study activities consisting of forty-six lesson study meeting transcripts and six classroom observation video logs of lesson implementations for two focal engineering instructors. Faculty 1 participated in one semester of lesson study meetings and implemented lessons over four semesters. Faculty 2 participated in three semesters of lesson study meetings and implemented lessons across four semesters. The research team conducted a qualitative analysis of lesson study meeting transcripts and video

[1] By language-rich, we refer to the explicit attention to the role of academic language and literacy in developing university-level STEM teaching and learning.

recorded lessons. Transcripts were coded for LR-LS components (e.g., Codes: STEM academic literacy, orientations to student learning, affordances for student interaction, reflective practices, and leadership). Transcripts were coded in 10-minute segments and then scored from 0-3 using the fidelity rubric developed by the research team. Composite (mean) scores and total sum scores were calculated to measure the quality of faculty engagement with the LR-LS framework. These overall scores helped determine the level of implementation during lesson study meetings and instruction: no implementation (score of 0), moderate implementation (score less than 2), and high implementation (score greater than or equal to 2).

Findings

Our analysis of the FOI data focused on the extent to which engineering faculty engaged with the LR-LS framework. Our findings indicated moderate to high implementation of the LR-LS framework in lesson study meetings and classroom observations. Figure 1 illustrates the mean composite scores per LR-LS component by engineering faculty engaged in lesson study meetings across time. Average scores ranged from 1.28 to 2.90, showing moderate to high implementation among engineering faculty. Faculty 1 demonstrated moderate levels of implementation with a mean score clustered at 1.60. Faculty 2 demonstrated higher levels of implementation across time, with a mean score of 2.38. Of note here is that each component score had at least a 2.5 average by the final implementation of the project, suggesting that sustained engagement in the project supported a stronger implementation of the framework.

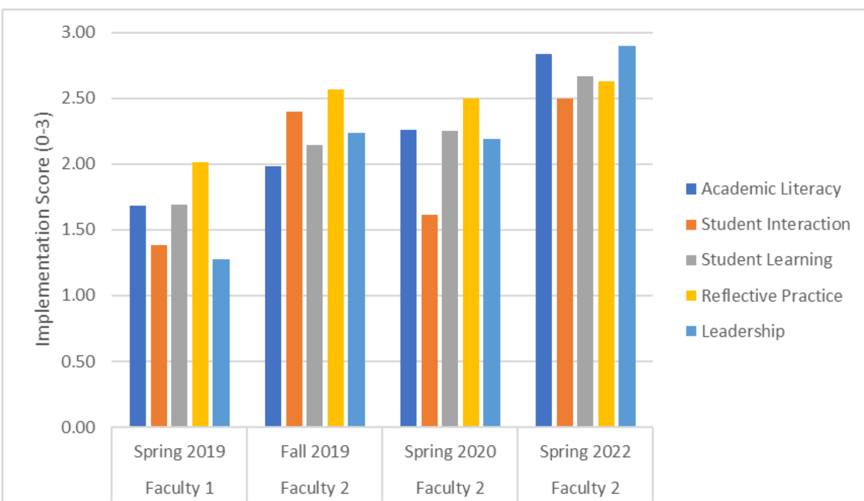

Figure 1. Mean scores per LR-LS component by engineering faculty engaged in lesson study meetings across four semesters.

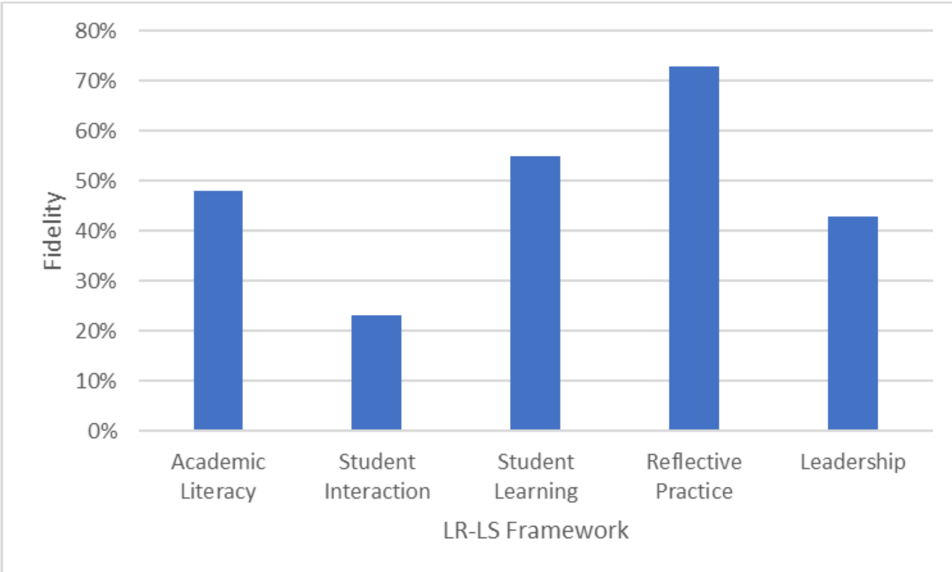

Figure 2. Engineering faculty fidelity by LR-LS framework components

Figure 2 shows engineering faculty fidelity as measured by the quality of the engagement with LR-LS components during lesson study meetings from spring 2019 to spring 2022. This graph illustrates how, on average, engineering faculty engaged the LR-LS components during lesson study meetings. Engineering faculty averaged a fidelity of 48% for STEM/academic literacy, 23% for affordances of student interaction, 55% for orientations to student learning, 73% for reflective practices, and 43% for leadership. This finding suggests adherence to the LR-LS framework components were moderately sustained over the time of participation for at least four of the components. A closer examination of engineering faculty variations in fidelity across components is central to understanding how the framework can be improved and consider contextual factors (e.g., shift to online lesson study during COVID-19) that can impact the implementation process. Classroom observation data also showed moderate to high levels of implementation. Across the six lessons implemented by the engineering faculty, five of the lessons scored in the high range of implementation (overall fidelity score greater than or equal to seven), and one scored in the moderate range of implementation (overall fidelity score six or below).

Additionally, FOI data was analyzed to determine the relationship between instructor's fidelity of implementation and student outcomes [9]. The fidelity of implementation (FOI) data from lesson study meetings and lesson observations for two engineering instructors, and student outcome data gathered from four years of student-level administrative and student survey data were utilized in this analysis. Student data was limited to Latinx students as the grant aimed to support Latinx students' experiences and outcomes. The analysis further focused on students who participated in a lower-division engineering course section in the spring of 2019, fall of 2019, and spring of 2020. This resulted in a sample of 579 Latinx students. This analysis examined the following questions: 1) What is the relationship between instructors' fidelity of implementation (FOI) of the reform practices in redesigned courses and the academic achievement of Latinx undergraduates in STEM fields? And a) How do observed changes in outcomes vary by level of implementation fidelity? [9]. Findings suggest that Latinx students in high FOI course sections had a higher change in STEM self-efficacy. Students in a course redesign with high fidelity were more likely to still be enrolled in a STEM major (72%), be in good standing (88%), and apply to graduate school (44%). Overall, students who participated in a course section with high and moderate implementation experienced positive changes in STEM self-efficacy, sense of belonging, GPA, persistence in STEM major, good standing, and graduate school application. A regression model was utilized to examine the relationship between participating in an engineering course section by level of implementation and student outcome data. Findings from the regression analysis indicated no statistically significant differences between students participating in a moderate or high implementation redesigned section compared to a section with no redesigned lessons. Student self-efficacy was marginally significant (p=.10) after accounting for student characteristics and instructor effects. While no significant impact was determined across the various outcome measures due to limited sample size and fidelity of implementation data for observed lessons, the descriptive and regression analysis results shared a similarly positive direction.

Conclusion

Our analysis of fidelity of implementation suggests that engineering faculty engaged in the LR-LS framework with moderate to high fidelity through the focal four semester period. Observational data and lesson study meeting transcripts highlighted the quality or the extent to which faculty engaged with the LR-LS framework. The categorization of LR-LS framework components allowed the research team to understand how engineering faculty engaged with specific components with fidelity across time. Findings concerning engineering faculty illustrated variations in their level of implementation. Variations in the level of implementation across lesson study meeting participation and classroom lesson observations could result from the level of participation in the lesson study model and contextual factors. To further understand how fidelity to the LR-LS framework is tied to student outcomes, an analysis of Latinx student data and FOI data revealed positive trends in student academic achievement outcomes but no significant relationship between redesigned lessons and student outcomes. Some reasons why no significant impact was observed were attributed to a limited student sample and FOI data. Our team recognized the need for robust data collection, particularly classroom observation data closely connected to the redesign of lessons and student outcomes. Additionally, an extensive FOI analysis of multiple data sources (both qualitative and quantitative) can help provide a deeper understanding of the intervention.

Recommendations

Recommendations for higher education practitioners and researchers engaged in fidelity of implementation activities are provided below:

- Develop clear guidelines, such as a rubric outlining key components of the professional development framework or intervention. These guidelines can support practitioners and researchers to ensure a shared understanding of the intended implementation structure and process [1],[8].
- Examine how professional development activities (planning, teaching, and reflection) advance particular components of instructional innovations.

- Allocate time and resources to support the fidelity of implementation; this includes training, ongoing evaluation of efforts/instruments, and robust longitudinal data collection.
- Employ quantitative and qualitative data collection methods and data sources to gain a holistic understanding of fidelity [2].
- Consider more proximal measures in assessing student outcomes, including measures of student learning within semester units such as course grades, DWF (drop-withdraw-fail) rate, midterm grades, and upper division grades.
- Gather instructor feedback regarding the fidelity of implementation to address any limitations and successes with the framework and instruments.

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