

A Teacher Observation Instrument for PBL Classroom Instruction

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Background

In recent years, there has been growing concern that the United States is not preparing enough individuals for STEM careers. While other countries have seen an increase in the number of students pursuing degrees in STEM fields, students in the U. S. have been shown to lose interest in STEM fields at an early age and are less likely to pursue STEM majors in postsecondary education (National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, 2007). The growing gap between students in the U.S. who receive STEM degrees and those in other countries is considered a threat to economic stability and global competitiveness, as STEM fields drive innovation and technological change (Committee on Prospering in the Global Economy of the 21st Century: An Agenda for American Science and Technology; Marshall, 2010; Pfeiffer, Overstreet, & Park, 2010).

K-12 STEM education serves as the “pipeline” to post-secondary STEM education [NGA, 2008]. Students progress through the STEM pipeline through experiences that build their competence and interest in pursuing STEM areas. Efforts to promote the STEM pipeline and increase the number of post-secondary degrees attained in STEM has led to an increasing federal and state focus on promoting STEM education (Kuenzi, Matthews, & Mangan, 2006). In particular, the No Child Left Behind Act (2001) has addressed the growing concern over the STEM pipeline by advocating for greater attention to be paid to science and mathematics education. The focus on mathematics and science has resulted in the prolific growth of programs and professional developments (PDs) focused on STEM (Capraro, Capraro, & Oner, 2011). Despite the widespread nature of these STEM-oriented programs and PDs, there has been relatively little research examining the effectiveness of these programs (Capraro, Capraro, Stearns, & Morgan, 2011; Marshall, 2010).

Several factors have been shown to impact the number of students seeking post-secondary STEM degrees. In a recent study, Bhat-tacharjee (2009) found there were a lack of

social and economic incentives for pursuing STEM careers. The social and economic incentives contradict the previously held notion that the decline in STEM post-secondary majors was because of inadequate K-12 STEM preparation. Even though the average number of high school STEM credits students earned has increased from 1990 to 2005, it has not resulted in a solution to the STEM pipeline problem. In fact, there has been a decrease in the number of students graduating from college with STEM-related degrees (Laird, Alt, & Wu, 2009).

Increases in the number of STEM courses taken in high school have not improved post-secondary matriculation into STEM fields. Improvement in the quality and integration of STEM education should be the focus of national attention because increasing high school students’ STEM course load in high school has been shown to be insufficient. Generally, White and Asian males represent a greater proportion of STEM majors, while females, Hispanics and African Americans remain under-represented in STEM majors (Tsui, 2007). According to Marshall (2010), an advocate for STEM education, an effective STEM curriculum should nurture students’ problem solving and inventive thinking. Additionally, STEM courses should focus learning on creative exploration, projects, problem solving, and innovation rather than rote memorization of facts, which dominates the current practice in many schools (Marshall, 2010).

This manuscript presents a case for the importance of STEM PD, use of Professional Learning Communities (PLCs), and describes a method of providing feedback to teachers and other school professionals. Project based learning (PBL) provides a viable means for improving STEM education when accompanied by a well-designed and sustained PD and a feedback mechanism to improve teaching and learning.

Literature Review

Project-Based Learning

STEM PBL has been defined as a “well-defined outcome with an ill-defined task” (Capraro & Slough, 2006, p. 3) within an interdisciplinary framework. These ill-defined tasks can be com-

Abstract

Teaching is a complex activity that requires making ongoing multiple, decisions and engaging in sporadic, responsive actions while performing pre-planned prescribed tasks. The enactment of the essential aspects of teaching can be assessed by using a well-designed observation instrument. After a sustained professional development on Science, Technology, Engineering, and Mathematics (STEM) Project-Based Learning (PBL), an observation instrument was used to assess the enacted STEM PBL activities in secondary mathematics and science classrooms. This article provides the background precipitating the need for an instrument, using an observation instrument to provide feedback to teachers and other stakeholders, and follow-up suggestions for those engaging in STEM professional development, including districts, schools, academies, service centers and university partners.

plex and messy by nature (Bridges & Hallinger, 1996; Torp & Sage, 1998). With ill-defined projects, students investigate interdisciplinary, rigorous real-world topics (Chin & Chia, 2006), which usually originate from a driving question (Blumenfeld, 1991; Krajcik, Blumenfeld, Marx, & Soloway, 1994). STEM PBL integrates engineering design principles within the K-12 curriculum (Capraro & Slough, 2006). STEM PBLs are a model “for classroom activity that shifts away from the classroom practices of short, isolated, teacher-centered lessons and instead emphasizes learning activities that are long-term, interdisciplinary, student-centered, and integrated with real-world issues and practices” (Holbrook, 2007, Internet). Research has shown that students learn better when they are authentically engaged in meaningful activities (Fortus, Krajcik, Dershimerb, Marx, & Mamlok-Naamand, 2005; Hancock & Betts, 2002) that produce authentic artifacts (Hung, Tan, & Koh, 2006). Student engagement with real-world problems makes knowledge more relevant and increases their transfer of skills and information from the school setting to the world around them (Bransford, Brown, & Cockling, 2000; Colburn, 1998; Curtis, 2001; Satchwell & Loepp, 2002) thus promoting lifelong learning (Dunlap, 2005).

Well-enacted PBL activities enhance school learning. Pfeiffer et al. (2010) found that when a school’s curriculum was focused on STEM PBLs, the PBL projects fostered student understanding by encouraging students to make connections between the content taught in different classes. Therefore, a structured classroom observation is one way to examine the levels of integration of STEM PBLs across interdisciplinary areas and estimate the effects. The data gathered from the structured classroom observations can then be used to engage in a guided discussion with teachers that focuses on improving the implementation of STEM PBLs. In turn, an improved implementation of STEM PBL may increase students’ understanding of STEM, thus leading more students to pursue STEM careers (Feller, 2011).

Importance of STEM Professional Development

PD was considered essential for educators to keep up with current research-based practices and reforms. Research has shown that in order to fully implement a new practice or idea, teachers need to have opportunities to collaborate with peers and to engage in experimentation (Franke, Carpenter, Levi, & Fennema,

2001). VanTassel-Baska et al. (2008) found that PD over the course of a three-year period was effective when combined with classroom observations that tracked the targeted instructional behaviors. Therefore a prolonged and sustained PD model should include estimates of the assimilation of new ideas, introduced through PD into classroom teaching practices. One means for sustaining PD between activities is through Professional Learning Communities (PLCs).

Professional Learning Communities

PLCs provide organizations, such as schools, with a research-supported method for increasing organizational or collective learning (Argyris & Schön, 1978; Hedberg, 1981). Several descriptors can be used to characterize PLCs, such as, shared and supportive leadership, collective learning, supportive conditions, shared personal practice and a climate of shared beliefs, values, and vision (Hord & Sommers, 2008). During PLCs, administrators and teachers seek to continuously learn and share their learning with each other (Hord, 1997).

Sustained PD along with PLCs is one important method for encouraging teachers to continuously focus on the development of their PBL lessons. This process is similar to the lesson study model, in which teachers work collaboratively to develop and refine lessons (Stigler & Hiebert, 1999). Although the lesson study model has not been widely adopted by educators and schools within the U. S. because of policy and organizational constraints (Lewis, 2002), PLCs have been shown to achieve similar results and to be self-sustaining. The PLC model resembles lesson study in that collaborative groups of teachers work together to refine skills addressed in PD or to develop lessons (Buisse, Sparkman, & Wesley, 2003). The primary mission of the PLC model is to provide teachers with time to fully engage in a professional task, and to reflect and plan (Krause, Culbertson, Oehrtman, & Carlson, 2008).

PLCs can be used to support STEM education by enhancing the diversity of the STEM curriculum, and improving the level of PBL implementation school-wide (Liddicoat, 2008). Research has shown that PLCs create a positive community of collaboration with common goals advancing the STEM pipeline (Krause et al., 2008). PLCs combined with classroom observations by either fellow PLC teachers or PD providers can help to ensure full implementation of an innovation.

Observation of Teachers

In order to improve the quality of STEM courses (i.e. PBLs), teachers need feedback on their instruction and support from others. In this regard, “there is considerable evidence from different studies suggesting that how teachers behave in the classroom, the instructional approaches they employ, significantly affect the degree to which students learn” (Van Tassel-Baska, Quek, & Feng, 2007, p. 85). Classroom observations can either be peer or professional in nature, however, the observer needs to provide feedback to the educator so he or she can evaluate and adjust their teaching as necessary to benefit students (Patrick, 2009).

Without some form of classroom observation, teachers’ assimilation of PD ideas cannot be assessed and student learning may be compromised (VanTassel-Baska et al., 2008). Research has shown that ineffective mathematics teachers can depress student achievement by as much as 54% regardless of students’ abilities (Sanders & Rivers, 1996). To ensure that PD is implemented with fidelity in the classroom, there should be some form of assessment during actual teaching activities. When carefully aligned with the PD, a classroom observation instrument can be an effective tool for providing feedback about assimilation of PD teaching strategies.

An effective way of evaluating teaching behaviors is by using an observation instrument (Guskey, 2002; O’Malley et al., 2003; Simon & Boyer, 1969). An observation instrument can provide a descriptive account of targeted objectives. The observation instrument can be made up of a conceptual rubric in which observers rate predetermined objectives using a range of descriptors attached to a numeric value. Observational data can also be structured with a frequency-counting system or a coding system (Taylor-Powell & Steele, 1996). Observational tools can be used to monitor progress toward increasing a desirable behavior or diminishing an undesirable one. For example, our STEM PBL observation instrument (Capraro et al., 2011) includes the following item: “The teacher worked with members of all small groups (Item 11).” A score of four or five for this item would indicate that the teacher worked with all or most of the small groups. Providing structured feedback to a teacher who received a four or five on this item would serve to reinforce their continued engagement with all groups. In contrast, for a teacher who did not work with all members of the small groups and received a score of one or two, the discussion may lead to instructional

improvements by identifying the behavior and then discussing strategies for engaging with all groups. Further, a teacher who scores high on this item can mentor their peers who score lower through the PLC. As illustrated in this example, the information obtained by using the observation tool can also be used for teacher reflection and to customize subsequent PD.

Effective use of an observation instrument requires training and still contains a degree of subjectivity, although the information gathered through observations has been found to have a high degree of face validity (Volpe, DiPerna, Hintze, & Shapiro, 2005). This is not to say that no validity threats are present. For example, the following threats have been identified in behavioral observations: (a) poorly defined behavior categories, (b) low inter-observer reliability, (c) observer reactivity, (d) situational specificity of target behaviors, (e) inappropriate code selection, and (f) observer bias. These threats can be minimized with observer training and instrument validity testing (Merrell, 1999).

Using external observers to describe and evaluate teaching practices can provide teachers with a better sense of their classroom instruction (Hlebowitsh, 2005). Observers should be well trained to identify factors that are important to a student’s academic success. In addition, observers should understand how each school’s goals and initiatives, past and current PDs, and the content covered in courses are aligned. Many different observation tools may be used (Dinkelman, 2003; Felder & Silverman, 1988), however, it is important that goals are clearly defined and communicated to teachers prior to any observations.

Teacher observation instruments can provide the classroom educator with supportive feedback to guide future instruction. However, without ongoing PD aligned to the curriculum, effective change may not occur (Van Tassel-Baska et al., 2007). A study of teacher evaluation practices found that when PD did not follow teacher evaluations, there was limited change in teacher effectiveness (Kimball, 2002).

Follow-up Professional Development

After the observation process, an iterative planning and implementation phase should be undertaken for designing future PD. The observations should be aggregated (analysis) with attention to similarities in strengths and weaknesses across teachers. Feedback should then be provided to teachers during conferences (discussions) and the information should be used as a basis for planning subsequent PDs.

Analyses: While an individual observation can be the basis for individual feedback and estimating a single teacher's growth toward school or district identified target skills, it should not be the basis for determining school or district-wide PD. Personal PD needs can be addressed through PLCs. In PLC's, teachers can identify their own needs by reviewing the results from the observation instrument. They can then talk with other teachers and seek targeted assistance to meet their needs, either individually or communally. In some cases, one teacher may excel in an area where others need assistance. Assistance can then be provided by the teacher who excels in that area.

Aggregated observation analyses can be used to design and develop future PD. Information from aggregated analyses of observations provides opportunities to build on systemic strengths and address systemic weaknesses. This process also provides a structure for PLCs by sustaining the innovation and providing a gradual assimilation of new ideas. Finally, aggregated analyses allow all stakeholders to examine the information and build ownership for their own pedagogical behaviors and recognize where they may need change (Corcoran, 1995).

Discussion: It is important to engage in discussion of the aggregated analyses with different stakeholders. Discussion of the aggregated analyses provides teachers with insight into their assimilation of ideas and how lessons may appear to students (Capraro, & Capraro, 2009; Franke et al., 2008; Scheurich, Morgan, Huggins, Capraro, Avery, & Capraro, 2011;).

Two important aspects of the discussion phase are (1) differentiating between systemic and individual strengths and weaknesses and (2) teacher reflection on their classroom instruction (Franke et al., 2008). Without discussion, teachers would not know which areas their colleagues could help them with or what would be best addressed by large-scale sustained PD. Idiosyncratic weaknesses and strengths can be addressed in PLCs. Systemic weaknesses can form the basis for subsequent PDs.

Once teachers and administrators reach a shared understanding of the aggregated analyses, they can begin to prioritize which needs should be addressed first and how to plan for future PD. Follow-up PD for the identified needs should be addressed by the district or school in concert with the PD provider, allocating five or more PD days in which all teachers are encouraged to attend (Capraro, Capraro, Corlu, Younes, Han, & Morgan, 2010; Corcoran, 1995).

Study Etiology

Based on the need to inform the field and to support STEM teaching and learning, an observation instrument was designed to inform ongoing and sustained PD. Many researchers have previously identified issues with traditional PD (Garet, Porter, Desimone, Birman, & Yoon, 2001), and the missing link in both the literature and in practice appears to be the use of classroom observations and an instrument to guide those observations. The following section describes the instrument and its uses in STEM PBL classrooms and research.

STEM PBL Classroom Observation Instrument

The appendix contains a copy of a classroom observation instrument, which was created by a team of professors and graduate students at a STEM Center based at a large southwestern public university. Because this article is not intended as an instructional manual for the instrument, we provided a condensed instrument for publication purposes (contact the authors for the actual instrument). Each item is rated by observers and the observer must provide comments that justify their rating. A five-point scale was chosen because it was not possible to develop exemplars for points above five. Using three or fewer points left too much overlap among the exemplars used for training. Therefore, we decided that a five-point scale was most suitable. This instrument was specifically designed to evaluate observable teaching and learning objectives when teachers develop and implement PBLs activities in their classrooms. Teachers who were evaluated with this instrument participated in sustained PD (ten full days per year) for three years (for a total of 30 PD days and more than 240 contact hours) focusing on STEM PBL and the observation instrument. The PD focused on each of the measured objectives. Observers and teachers were trained on the components and purposes of the instrument.

The instrument contains 22 items organized by six objectives. The objectives include: (a) PBL Structure, (b) PBL Facilitation, (c) Student Participation, (d) Resources, (e) Assessment, and (f) Classroom Learning Environment. The number of indicators under each objective varies. Each indicator was evaluated on a scale ranging from 1 (no evidence) to 5 (to a great extent) with the observer justifying every score assigned to each item. Zero was used when the indicator was not addressed at all. Occasionally, an item will not apply to what is taught during

a particular observation. When this happens, or when the observer is only present for part of a PBL activity, a well-documented lesson plan can provide insights and further details. The observer may also indicate that a particular behavior was not applicable during the class period.

Observers are certified initially through three half-day sessions where they learn about the instrument and use sample videos to identify enactments of the criteria. The exit exam requires that observers meet a 95% minimum agreement between their scores and two expert reviewers of teaching videos at the completion of the training. The exit videos are only used for the exit portion of the initial training. Refresher training is done every six months. Observers attend a four-hour refresher where they watch and rate different video enactments and then compare their ratings with each other. The observers' exit video ratings are compared to the two experts and they must attain a 95% agreement or higher to pass.

Use of Instrument and Aggregating Observation Data

The observation instrument was intended to be used to measure progress toward an ideal level of implementation rather than as a teacher grading tool. Therefore, while it may be tempting to use the instrument as part of a teacher's formal evaluation process, caution should be used. A low score on the instrument serves as an indicator of a need for continued PD or support from peers in a PLC, but should never be used as part of a teacher's formal evaluation process. This observation instrument was based on our belief that teachers are caring individuals who want to do a good job and crave meaningful feedback on improving their instruction. The aggregation of data provides guidelines for how the data should be handled in the presence of trained observers or others who acquire the instrument.

For the observation instrument to function for its intended purpose, the observers should receive training and have a thorough understanding of what different levels of implementation would be like. In addition, observers should understand what it means to not see a particular item on the scale, and be able to provide dependable ratings of particular events similarly to peer observers. Inter-rater reliability is only achieved by multiple individuals observing and rating the same teaching event and then discussing their ratings and justifications.

For the identification of systemic issues, it

is important to aggregate data across observations and observers, campus boundaries, and subject areas within each of the six objectives. Data can be aggregated by using the mode when there is low inter-rater reliability or when observers were not provided with instrument training. However, in the presence of adequate training and therefore, inter-rater reliability, the instrument can be used to compute means and standard deviations. In either case, larger numbers indicate greater progress toward the ideal goal and lower numbers indicate greater opportunity for systemic PD.

Summary

This manuscript presented an observation instrument designed to assess the enactment of the essential elements for implementing STEM PBL in classrooms. To illustrate the use of the observation instrument, Figure 1 presents the data for mathematics teachers at one school where the instrument was used in accordance with our theoretical framework (i.e. PLCs and data-driven PD). During the initial assessment conducted in 2008, Structure and Facilitation were the lowest characteristics. After identifying these areas for improvement, and implementing PD and PLCs, the final assessment in 2010 shows that all teachers received ratings above 3 on the scale. Importantly, all six indicators were well above 3 by 2010. Only Resources saw a decline in 2009 (the middle year). The reason for this decline was that teacher planning and district allocation of resources were not well aligned. During a debriefing session following the 2009 assessment, the district examined allocation of resources and made the necessary changes, which was evident in the final year. The improvements in teacher performance across the indicators show a commitment to innovation and the effect of PD and PLCs on the classroom enactments of PBL. The graph clearly shows the systematic gains over time across all the indicators. This is indicative of progress toward their shared goals and mission for high-quality STEM PBL implementation. The longitudinal design allows a close look at how the indicators change in concert and are subject to administrative decisions. When administration saw a third party evaluation of the impact of their resource allocation choices on instruction, they were quick to change their procedures and priorities. This study was not designed to examine the impact on student achievement, however, the next step after the development and broader acceptance of the instrument is to

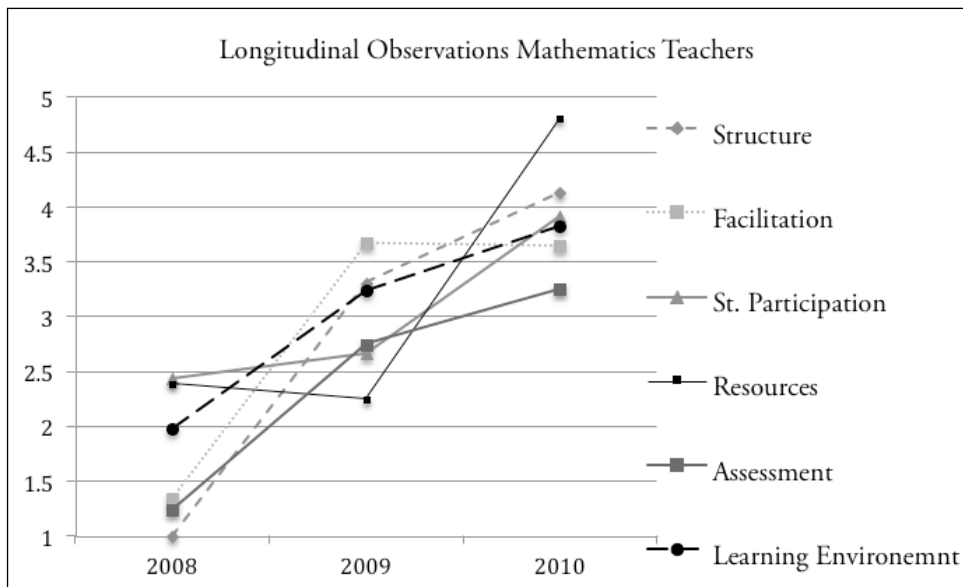


Figure 1.

examine how the sustained PD and systemic teacher observations contribute to student outcome measures.

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James R. Morgan, P.E., Ph.D. Associate Professor, Zachry Department of Civil Engineering, and Co-Director of the Aggie STEM Center at Texas A&M University. Jim was an active participant in the NSF Foundation Coalition, and also has received funding from the Department of Education FIPSE program and from the National Science Foundation CCLI program. He is active in the First-Year Programs, and the Educational Research Methods Divisions of the American Society for Engineering Education. He has conducted workshops (mostly on Teaming; Active Learning; and Project-Based Learning) in more than a dozen states and in Puerto Rico and Denmark. His research includes structural dynamics, earthquake engineering, engineering education, and PBL.



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Appendix

Project Based Learning Observation Record

Teacher _____

Date/Time _____

Subject area _____

School _____

PBL Title _____

PBL Description _____

To what extent was the following present? Please mark the box that best displays your response on a scale of 5 to 1. 5= to a great extent, 1 = no evidence.

(5)

(4)

(3)

(2)

(1)

Justification* _____

I. PBL Structure

1. The PBL has a well-defined outcome.
2. The PBL contains rigorous subject area content, which as a consequence leads to higher-order thinking.
3. The PBL lends itself to multiple, creative and unique tasks in which students can demonstrate a continuum of knowledge and understanding.
4. The PBL covers subject/grade level TEKS.
5. The PBL is not a stand-alone lesson.
6. The PBL is interdisciplinary.
7. The PBL contains high functioning activities requiring students to work in organized groups.

II. PBL Facilitation

8. The teacher clearly stated goals and tasks.
9. The teacher facilitated the students to remain on-task.
10. The teacher asked effective open-ended questions.
11. The teacher worked with members of all small groups.
12. The teacher achieved objectives he/she identified.

III. Student Participation

13. The students were actively engaged.
14. The students could explain tasks and solution strategies.
15. The students could explain the goal(s).

IV. Resources

16. The appropriate resources are ready and available for student use.
17. The students were proficient in using the resources (i.e. calculators, test books, computers).

V. Assessment

18. The assessment(s) was/were continuous and varied.
19. The evidence of holistic assessments existed (e.g. rubrics for participation/engagement, early stages of the PBL, or group work).
20. The students understood how the rubric would be used as an assessment.

VI. Classroom Learning Environment.

21. The teacher identified and engaged students around their prior knowledge.
22. The teacher identified and engaged the students around their cultural diverse contexts.

Other comments or observations _____

Observer _____

Date _____

*Space provided on the observation form to justify each of the 22 indicators is omitted in this appendix to respect journal space.