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# THE IMPACT OF PROJECT-BASED LEARNING ON STEM EDUCATION IN HIGH-NEED SCHOOLS

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Abstract

This study examines the relationship of two important components of the Woodrow Wilson Teaching Fellowship (WWTF) program: project-based learning (PBL) and effective instruction in science, technology, engineering and math (STEM) at high-need schools. WWTF Fellows administered a survey to their students, all of whom attended high-need schools and were eligible for free- or reduced-priced meals. Analysis of the survey data revealed three positive statistically significant relationships between (1) PBL use and student engagement, (2) PBL use and classroom culture, and (3) PBL use and STEM interest. This means that increased use of PBL could predict more agreement in questions related to students' engagement, classroom culture and STEM interest. The addition of student open-response questions provided further detail about how Fellows are engaging students, cultivating a positive classroom culture and generating interest in STEM.

This paper presents the findings from an evaluation of the Woodrow Wilson Teaching Fellowship (WWTF) mentoring program at a private university located in a Midwestern state. The Fellowship focuses on recruiting high-quality science, technology, engineering and math (STEM) teachers to high-need schools. This study utilized survey analysis to examine the relationship between project-based learning (PBL) and students' perceptions of their education as it relates to the Fellows. The study was guided by the following two research questions: 1.) How do students perceive Fellows as STEM teachers and 2.) how does PBL influence students' engagement, learning environments and interest in STEM?

## Background

In 2007, the Woodrow Wilson National Fellowship Foundation selected the site of this study as one of four host institutions for its STEM Teaching Fellowships. WWTF has two purposes: (1) to create the Rhodes Scholarship equivalent for teachers so as to recruit high-quality candidates into STEM teaching in urban and rural high-need schools; and (2) to improve teacher education through restructuring the curriculum, expanding the clinical experience, and developing high-quality mentoring programs for new teachers. Fellows make a commitment to teach at an Indiana high-need school for three years. Some highlights of the study site's program are: (1) completion of the program in cohorts; (2) immersion in urban schools from day one; (3) appointment of district teacher leaders to serve as clinical faculty; and (4) creation of a PBL curriculum that prepares Fellows to teach in 21st-century schools.

## Literature Review

### *Project- and Problem-based Learning*

In outlining the key differences between project- and problem-based learning, British researchers Hanney and Savin-Baden (2013) note that project-based learning is one of the "more technical rationalist approach…most commonly utilised [*sic*], yet little theorised [*sic*], paradigms for structuring the learning experience" (p.7). In contrast, problem-based learning is more "Socratic and dialogic," (p.7) with a more robust theoretical framework and established pedagogy, which "places the process of knowledge acquisition at its core" (p.8), emphasizing both the problem-solving process and the solution. However, problem-based learning does not support training in applied skills and is not always useful for "creative, practice-based programmes [*sic*] of study" (p.8). While there is some overlap between project- and problem-based learning, the difference, according to the authors, is in the applied nature of project-based learning, whereas problem-based learning is more focused on the learning process.

The authors also note that project-based learning is a general term, and "means different things in different countries and different disciplinary areas" (p.7). Thus, project-based learning in the United States for STEM disciplines might be quite different from project-based learning in medical programs in the United Kingdom. For the particular context of this study, Buck Institute for Education (BIE)'s definition of project-based learning is used, as several of their materials were used to train Fellows in PBL. Additionally, the measure utilized to gauge students' PBL use in the survey instrument was adapted from BIE's survey of teachers' PBL use (Ravitz, 2008). So, PBL is defined as an instructional method that uses standards-based instruction and student-directed learning to foster an environment of investigation. The entire PBL process is organized around an open-ended driving question, which connects content to relevant problems and issues. Through PBL, students develop their own questions, conduct research independently and apply their knowledge to products they produce (BIE, 2011); critical features that set apart project-based learning from problem-based learning.

*PBL and Student Learning*

A specific component of this site's program was creation of a PBL curriculum that prepared Fellows to teach in 21st-century schools. Research suggests that mentoring programs similar to WWTF help teachers employ PBL. In one study, Pegg, Schmoock, and Gummer (2010) found that when science teachers participated in a professional development project that involved mentoring with scientists or science educators, the teachers found the mentoring aspect valuable in helping them to better implement innovative teaching methodologies like PBL.

The rationale for training Fellows to implement PBL comes from emerging research on the benefits of this educational approach. PBL encourages more rigorous learning because it requires students to take an active role in understanding concepts and content, and it enables them to develop 21st-century skills. Since students are empowered to connect classroom content to real-life phenomena, PBL also facilitates career exploration, technology use, community connections, and content relevancy (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991). Researchers have also found high levels of student engagement in PBL classrooms (Belland, Ertmer, & Simons, 2006; Brush & Saye, 2008) because it places students in an applied, problem-solving context (Blumenfeld, et al., 1991). For example, a study of one economics class revealed that a PBL unit was successful in engaging both the lowest- and highest-performing students, as well as students who were least interested in economics at the start of the unit (Ravitz & Mergendoller, 2005). Another study reported that PBL had a positive effect on student motivation to learn. Further, when secondary students from high-need schools participated in an applied shipbuilding project, they proved more enthusiastic about marine engineering and physical science (Verma, Dickerson, & McKinney, 2011). In the postsecondary context, Ocak and Uluyol (2010) found that features of PBL were related to students' intrinsic motivation to learn, as they uncovered positive, statistically significant relationships between PBL and interest and between PBL and cognitive engagement.

Additionally, students reported more enjoyment of their PBL work because it gave them opportunities to interact with their friends and to make new acquaintances through cooperative projects (Lightner, Bober & Willi, 2007), all of which helped promote positive classroom culture. Krishnan, Gabb and Vale (2011) found that collaboration skills learned through PBL were essential to positive learning outcomes in their study of first-year engineering students. Groups who adopted a collaborative learning culture emphasized gaining as much knowledge as possible in the team setting. Researchers observed that this group exhibited excellent communication, high levels of participation and mutual respect, and that most students in these teams "used deep learning approaches…[and] focused on finding more than one solution to each program" (Krishnan et al., 2011, 74). These groups were the most successful in encouraging education for all members, compared to other types of group cultures that were focused on finishing the project or maximizing students' grades.

Possibly due to students' increased levels of engagement and positive classroom culture, research has shown several positive effects on student content knowledge from students in PBL classrooms. Strobel and van Barneveld (2009) conducted a qualitative meta-synthesis of meta-analyses to identify generalizeable findings regarding the effectiveness of PBL in teaching content knowledge. They concluded that traditional instruction produces better outcomes when assessing basic knowledge, but PBL produces better results when assessing clinical knowledge and skills: "PBL is significantly more effective than traditional instruction to train competent and skilled practitioners and to promote long-term retention of knowledge and skills" (Strobel & van Barneveld, p. 55).

Within the area of STEM and PBL, research has examined marine engineering and physical science (Verma, et al., 2011), as well as content knowledge and interest in STEM subjects (Lou, Shih, Diez, & Tseng, 2011) in high school settings. Overall, these studies have found that students traditionally underrepresented in STEM, such as females and those of minority race and ethnicity status, reported higher levels of engagement and interest in STEM subjects after participating in PBL-instructed classes (Lou et al.; Verma et al.). Other studies have focused on PBL in middle school science classrooms (see Eskrootchi & Oskrochi, 2010; Krajcik, Blumenfeld, Marx, Bass, Fredricks, & Soloway, 1998). Eskrootchi and Oskrochi, (2010) found females and those who might not learn effectively in a traditional format benefit from new technological innovations combined with PBL in STEM areas, like computer technology. A study of a fifth-grade science class found that PBL was "appropriately efficient and effective" in science learning achievement, science process skills, and analytical thinking for all students (Panasan & Nuangchalerm, 2010, p. 252). Further, when a project-based science (PBS) unit was implemented in an urban public school district, researchers found increased student performance in standards-based science tests, especially for African-American males (Geier, Blumenfeld, Marx, Krajcik, Fishman, Soloway & Clay-Chambers, 2008). From a longitudinal study of this program, the authors found statistically significant increases in the science scores for every year of PBS participation (Marx et al., 2004).

*STEM Education in High-need Schools*

STEM jobs typically have higher salaries and more opportunities for growth than other occupations (Terrell, 2007). According to the U.S. Department of Labor, more than 1.2 million job openings will be available in STEM-related fields by 2018, but there will be a vast shortage of qualified professionals to fill them (Lacey and Wright, 2009). Additionally, STEM workers earned about 70 percent more than the national average income (Terrell, 2007). Though the benefits of such jobs are many, individuals are not obtaining them at equal rates, with women and minorities still underrepresented (National Science Board, 2010).

Teachers play a critical role in student learning and interest in STEM. According to a national survey of STEM college students, more than half reported that before pursuing college, a teacher or class got them interested in STEM (Harris Interactive, 2011). Thus, it is critical to examine the impact of the Wilson Fellows, who came from STEM fields, on interest in STEM for students in high-need settings.

Scholars point to inquiry and culturally relevant teaching for engaging high-need students in science. From his ethnography of urban youth in science classrooms, Emdin (2010) argued that traditional forms of science participation, such as observing reactions in typical laboratory assignments, were superficial modes of engagement and stressed the importance of inquiry and debate. Based on her ethnographic research in an urban classroom, Olitsky (2006) provided a more sociological argument, observing that students were less engaged in science when it was presented as elitist, but more engaged when the teacher and asked students to investigate and struggle with the content. Waks (1991) argued that urban youth do not have the resources to be successful in science and technology, and that researchers should focus on how to make science and technology appealing to these students: "The problem is not *how to teach* urban school children, but rather *how to win their hearts and minds"* (p.197).

In high-need math classrooms, relevance and inquiry were also important. In their review of mathematics education literature, Jackson and Wilson (2012) argued that success should not be determined by state assessments, but by critical thinking. Ensign (2003) attributed the success of culturally connected math teaching at high-need schools to students' personal experiences being applied to math content, so that students solved their own math problems rather than those from a textbook. Positive classroom culture is also important to engaging students and improving teacher retention. In her study of retention for African-American urban science teachers, Fraser-Abder (2010) found that educators who successfully persisted in urban schools were those that cared for their students' well being and understood of their backgrounds. Because they created a supportive and academically-focused classroom culture, these teachers also witnessed substantial improvement in their students' intellectual and emotional growth.

While there is emerging research on what can be gained through PBL implementation, there are still many gaps in the literature, especially in the context of how PBL impacts student engagement and classroom culture, the impact of PBL in a variety of high-need settings, and PBL's relationship with students' interest in STEM. The literature does reveal the importance of relevant content and classroom interaction as major influences in students' progress in STEM, especially those in high-need schools. PBL addresses this need since it highlights real-world applicability, student inquiry and teachers as learning facilitators. This study addressed the gaps in the literature by examining how PBL impacted student engagement, classroom culture and interest in STEM in high-need schools through analysis of a student survey that gauged the effectiveness of Fellows' teaching. Outside of standardized assessments, student surveys can be important indicators in how students perceive learning, especially when reliable measures are used.

## Methodology

*Sample*

As part of a mixed-methods study of the WWTF at this university, the students of a sample of WWTF Fellows during the 2011-2012 academic year were asked to take a survey about their classroom experiences and postsecondary plans. The survey was administered in both paper and online form during the fall and spring semesters. A response rate could not be calculated, as the number of classes in which Fellows administered the survey is unknown.

Table A.1 in Appendix A shows the demographic profile for the 256 respondents of each administration and both semesters. Overall, more students completed the survey in Fall 2011 (69.5%). Slightly more of the respondents were female (52.7%). The majority of survey takers were white (67.2%), and almost half of the respondents were eligible for free or reduced-price meals or milk (41.1%), though a sizeable percent were unsure of their meal status (15.6%). A large proportion of those responding were not Special Education participants (87.1%) or English language learners (83.6%), and most of the respondents were born in the United States (88.3%).

Table A.2 in Appendix A shows these students' plans for postsecondary education. Most of the respondents planned to work toward a bachelor's degree (69.9%), and almost three-quarters of students also reported that their family expects them to continue their education after they graduate high school (72.3%).

*Instrument*

The survey instrument was comprised of questions that probed students' engagement, classroom culture and interest in STEM. Respondents scored their answers on a scale from 1 to 5, with 1 signifying strong disagreement and 5 signifying strong agreement. The survey also included items from the PBL Index (Ravitz, 2008), which was developed by BIE to measure PBL use. The PBL Index was originally created for teachers, so questions were adapted for a student audience. The questions asked students to identify the frequency with which teachers performed various components related to PBL. Respondents scored their answers on a scale from 1 to 5, with 1 signifying teachers never perform those components and 5 signifying that they did so almost every day

Finally, the instrument asked three open-response questions: (1) "What are some activities you have completed for this class that apply to the real world?" (2) "How is this teacher different from other teachers you have had?" and (3) "How does this teacher make the subject area you are learning more interesting?" See Appendix B for the survey instrument.

*Analysis*

Using items from BIE's PBL Index and previously implemented surveys, the following four scales were developed to measure students' perceptions of their teachers' PBL usage and their own learning: PBL Index, Student Engagement Scale, Classroom Culture Scale, and Interest in STEM. Items were combined and averaged to form all of the scales, and the mean score for each question was used to replace missing responses. All four of the scales were found to be reliable, as shown in Table 1.1.

| **Table 1.1.**<br>**Descriptive Results for Survey Scales (N=256)** | **Mean** | **Standard Deviation** | **Min. Score** | **Max. Score** | **Cronbach's alpha** |
|---|---|---|---|---|---|
| PBL Index Scale* | 2.45 | 0.58 | 1.00 | 5.00 | 0.85 |
| Student Engagement Scale | 3.31 | 0.56 | 1.00 | 5.00 | 0.79 |
| Classroom Culture Scale | 3.52 | 0.65 | 1.00 | 5.00 | 0.71 |
| Interest in STEM Scale | 2.66 | 0.87 | 1.00 | 5.00 | 0.80 |

*Note: Cronbach's alphas are standardized.*

Demographic variables were mostly kept in their original codes. Exceptions include race/ethnicity, where students who reported any other race or ethnicity besides white, non-Hispanic were grouped together in order to examine any differences in minority groups as an aggregate to white, non-Hispanic students. U.S. residency was categorized into a new variable so that those were not born in the United States were measured compared to all others. Similarly, students who reported eligibility for free- or reduced-price meals or milk were grouped and compared to those who reported not being eligible. Students who did not know their meal status were coded as missing responses.

SPSS Statistics, version 19 was utilized for statistical analysis. Multiple linear regression analysis was used to find significant associations among gender, race/ethnicity, special education participation, English Language Learning status, U.S. residency, meal status, survey administration timeframe, teacher, and the survey scales. The PBL Index was also included as an independent variable in the analysis to examine if increased PBL use was associated was better scores in the other three areas of student engagement, classroom culture and interest in STEM.

The National Center for Education Statistics' guidelines on statistical significance were utilized (see Seastrom 2002). Only statistically significant results that are practically relevant are reported, since statistical significance can be found among variables, but provide no important and applicable evidence toward the research questions. These findings have shown evidence for how students' use of PBL influences their perceptions of learning. The results presented here are organized around the statistically significant positive relationships found between the PBL Index and the Student Engagement Scale, Classroom Culture Scale, and Interest in STEM Scale, so that students who used PBL more often ranked higher levels of agreement in these three areas.[1]

## Findings

*PBL Use*

Table 1.2 details the questions that were included in the PBL Index, as well as the means and standard deviations of students' responses. Students reported participating in group projects most often (mean=3.04), as well as frequently collecting, organizing and analyzing information and data (mean=3.00), and taking multiple choice, short answer or essay tests (mean=2.79). Students reported spending less time on completing community-based projects (mean=1.86), peer reviews (mean=2.00) and portfolios of their work (mean=2.14).

| **Table 1.2. Summary of Items within the PBL Index Scale (N=256)** | **Mean** | **Standard Deviation** |
|---|---|---|
| Overall, how often did you use the following in this class? | | |
| Multiple choice, short answer or essay tests* | 2.79 | 0.88 |
| Open-ended problems | 2.66 | 1.07 |
| Portfolios of student work | 2.14 | 1.23 |
| Student peer reviews | 2.00 | 0.98 |
| Group projects | 3.04 | 1.05 |
| Individual projects | 2.74 | 1.00 |
| Hands-on exhibitions, demonstrations or oral presentations | 2.73 | 1.06 |
| Over the last academic year, how often did you perform the following in this class? | | |
| Solved real-world problems | 2.36 | 1.06 |
| Collected, organized and analyzed information and data | 3.00 | 1.10 |
| Presented what I learned | 2.34 | 0.94 |
| Defended my views, ideas or perspectives | 2.26 | 1.11 |
| Orally presented my work to peers, parents, teachers or others | 2.17 | 0.96 |
| Researched topics in detail to be able to clearly explain them to others | 2.25 | 0.97 |
| Participated in community-based projects | 1.86 | 0.98 |

*Note: The mean score of each question was used to replace missing responses.*
**Baseline survey responses were averaged for this question, as respondents had separate choices of multiple choice or short answer tests and essay tests.*

*Student Engagement*

Table 1.3 details the questions that were included in the Student Engagement Scale, as well as the means and standard deviations of each item. Students most readily agreed with the statements, "I rarely get in trouble during this class" (mean=4.17), "I am getting a good grade in

[1] No statistically significant differences were found in any of the dependent variables between the fall and spring survey administrations.

this class" (mean=3.85) and "I complete my homework for this class" (mean=3.84). Respondents were less likely to agree with statements such as "I check my homework for this class multiple times before turning it in" (mean=2.68), "I apply what I learn in this class to everyday life" (mean=2.77) and "I share what I learn in this class with my friends and/or family" (mean=2.83).

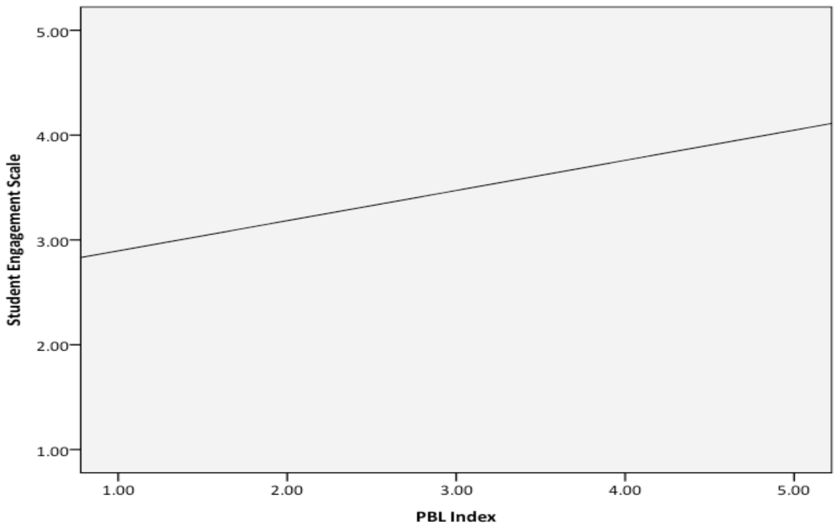
| **Table 1.3. Summary of Items within the Student Engagement Scale (N=256)** | **Mean** | **Standard Deviation** |
|---|---|---|
| This class is interesting | 3.36 | 1.02 |
| This class is challenging | 3.10 | 1.02 |
| I rarely get in trouble during this class | 4.17 | 1.04 |
| I work hard in this class | 3.73 | 0.91 |
| I complete my homework for this class | 3.84 | 0.91 |
| I check my homework for this class multiple times before turning it in | 2.68 | 0.96 |
| I am getting a good grade in this class | 3.85 | 1.02 |
| In this class, I try to see things from other students' perspectives | 3.10 | 0.96 |
| This class makes me question my views on different topics/ideas | 3.04 | 0.99 |
| I share what I learn in this class with my friends and/or family | 2.83 | 0.99 |
| I apply what I learn in this class to everyday life | 2.77 | 0.86 |

*Note: The mean score of each question was used to replace missing responses.*

Multiple linear regression results revealed a positive linear relationship between the PBL Index and the Student Engagement Scale, which was found to be statistically significant ($t=3.66$, $p=0.00$). The PBL Index exerted the strongest influence on this scale when controlling for the other demographic and academic variables ($\beta=0.25$), which demonstrates that PBL use was strongly associated with students' level of academic engagement (see Table C.1 in Appendix C for detailed statistical results).

Figure 1.1 gives a visual representation of this positive linear relationship, showing that as the PBL Index increased, respondents reported higher levels of agreement in the Student Engagement Scale. This shows that students who used PBL more often (as represented by the PBL Index Scale) were more likely to agree with statements related to academic engagement (as represented by the Student Engagement Scale).

**Figure 1.1. PBL Index vs. Student Engagement Scale (N=256)**




When asked about how WWTF Fellows made subjects more interesting, almost a quarter of students (23.8%) noted that the teacher had them participate in hands-on experiments, activities, projects and group work: “She has tons and tons of examples and group projects. We have looked through microscopes and done pH symbols. Very fun. Very educational.” When asked about specific class activities that applied to the real world, students cited tasks associated with 21$^{st}$-century skills, such as learning research strategies, presentation skills and collaboration: “We learn it better when we're interacting with other students.”

*Classroom Culture*

Table 1.4 lists the questions that were included in the Classroom Culture Scale, as well as the means and standard deviations of each item. Students most readily agreed with the statements, “I work with my classmates during class to complete projects/assignments” (mean=3.85) and “My teacher is supportive of my work in this class” (mean=3.84). Respondents were agreed less often with statements such as “I work with my classmates outside of class to complete projects/assignments” (mean=2.79) and “I have been recognized by my teacher for doing well in this class” (mean=3.36).

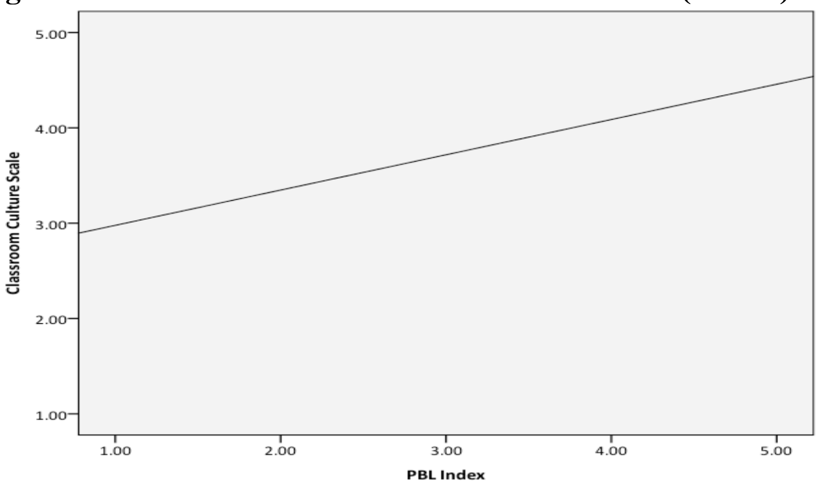
| **Table 1.4.<br>Summary of Items within the Classroom Culture Scale (N=256)** | **Mean** | **Standard Deviation** |
|---|---|---|
| My teacher for this class has high expectations | 3.73 | 0.88 |
| My teacher is supportive of my work in this class | 3.84 | 0.96 |
| I work with my classmates during class to complete projects/assignments | 3.85 | 0.92 |
| I work with my classmates outside of class to complete projects/assignments | 2.79 | 1.06 |
| I have been recognized by my teacher for doing well in this class | 3.36 | 1.03 |

*Note: The mean score of each question was used to replace missing responses.*

Multiple linear regression results revealed a positive linear relationship between the PBL Index and the Classroom Culture Scale, which was found to be statistically significant (t=4.15, p=0.00). The PBL Index exerted the strongest influence on this scale when controlling for the other demographic and academic variables (*β*=0.29*)*, showing that PBL use was strongly associated with students' perceptions of positive classroom culture (see Table C.2 in Appendix C for detailed statistical results).

Figure 1.2 gives a visual representation of this positive linear relationship, showing that as the PBL Index increased, students reported higher levels of agreement in the Classroom Culture Scale. This demonstrates that students who used PBL more often (as represented by the PBL Index Scale) were more likely to agree that their classroom had a positive learning environment (as represented by the Classroom Culture Scale).

**Figure 1.2. PBL Index vs. Classroom Culture Scale (N=256)**




When asked how WWTF Fellows are different from other teachers, students frequently referenced Fellows' instructional abilities, such as being able to explain content better and being sure to review material to ensure students comprehended it: "[My teacher] explains things in ways we will learn it." One student appreciated how one Fellow would "get down to my level" to explain material. Students also felt Fellows made learning enjoyable and relatable, explaining how they would check in with students before letting them work independently on assignments: "She's much more firm on our actually learning the topic of study as opposed to simply going over it." Almost a quarter of students (19.5%) felt that Fellows' disposition distinguished them from others, often referring to Fellows as caring, "super friendly," and fun. One student also appreciated her teacher's tenacity: "[S]he seems kinder, more caring, and she doesn't give up on us learning about stuff that is hard…because she can believe in us!"

However, some students mentioned that the Fellows stood out as novice teachers because they struggled with classroom management: "I can tell he is a first year teacher." Another student felt one Fellow was "a very nice teacher, almost too nice…some kids don't take her seriously."

*Interest in STEM*

Table 1.5 lists the questions that were included in the Interest in STEM Scale, as well as the means and standard deviations of each item. Students most readily agreed with the statement, "This class makes me interested in science, technology, engineering, or math (STEM)" (mean=2.86). Respondents agree less often with the statement, "I am involved in a science, technology, engineering, or math (STEM)-related extracurricular activity" (mean=2.22).

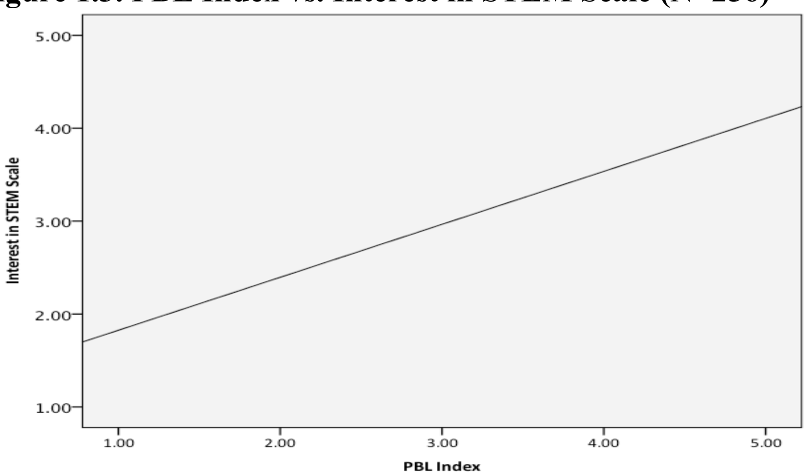
| **Table 1.5.<br>Summary of Items within the Interest in STEM Scale (N=256)** | **Mean** | **Standard Deviation** |
|---|---|---|
| I am involved in a science, technology, engineering, or math (STEM)-related extracurricular activity | 2.22 | 0.99 |
| This class makes me interested in science, technology, engineering, or math (STEM) | 2.86 | 1.04 |
| I will take more classes in science, technology, engineering, or math (STEM) even if they are not required | 2.84 | 1.12 |
| I will pursue a career in a science, technology, engineering, or math (STEM)-related field | 2.71 | 1.24 |

*Note: The mean score of each question was used to replace missing responses.*

Multiple linear regression results revealed a positive linear relationship between the PBL Index and the Interest in STEM Scale, which was found to be statistically significant (t=5.29, p=0.00). The PBL Index exerted the strongest influence on this scale when controlling for the other demographic and academic variables ($\beta$=0.35), demonstrating that PBL use was strongly associated with students' interest in STEM. Though statistically significant positive relationships were found between gender and the Interest in STEM Scale, the impact was not as strong as the PBL Index (see Table C.3 in Appendix C for detailed statistical results).

Figure 1.3 shows this positive linear relationship, illustrating that as the PBL Index increased, students reported higher levels of agreement in the Interest in STEM Scale. This shows that students who used PBL more often (as represented by the PBL Index Scale) were more likely to agree that they were interested and participated in STEM-related activities (as represented by the Interest in STEM Scale).

**Figure 1.3. PBL Index vs. Interest in STEM Scale (N=256)**



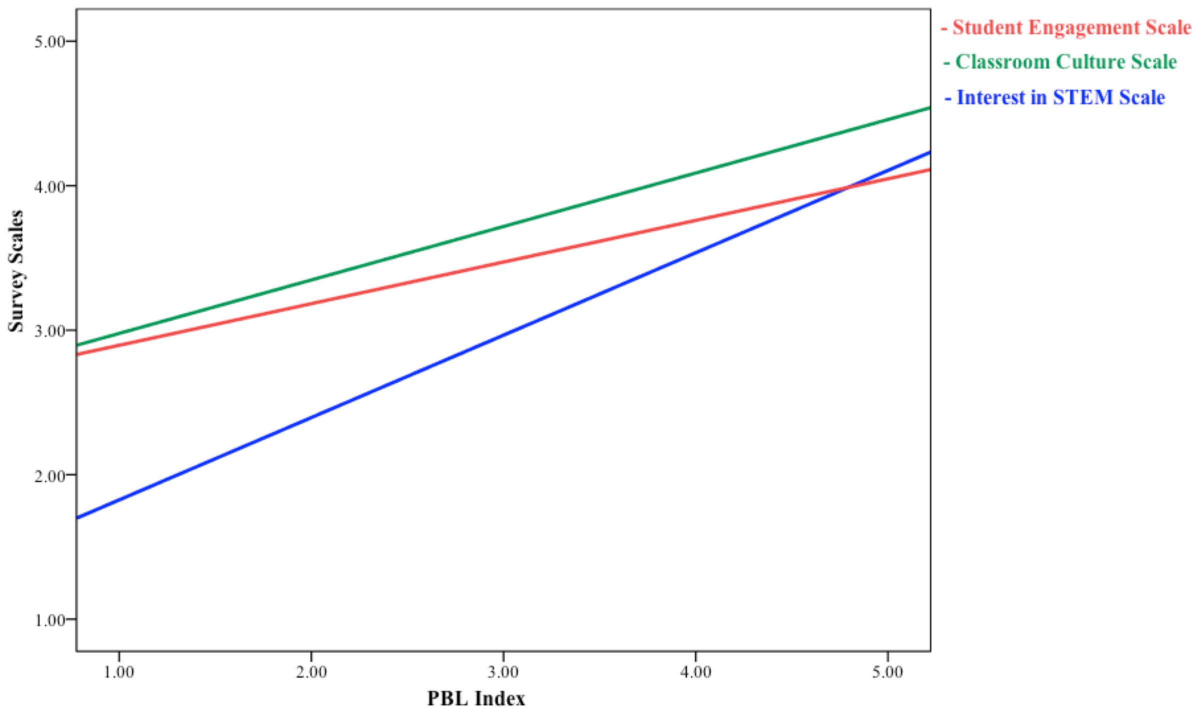

When asked how Fellows made subjects more interesting, students mentioned activities related to college and career readiness: "We have done things that real-world scientists most likely do as a career." When asked about specific class activities that apply to the real world, over a quarter of students (27.7%) reported participating in science and math activities related to atoms, pH, and unit conversion. Students also engaged in lab experiments quite often, which they enjoyed: “She has us do a lot of labs, and I think that makes it a lot more fun…we learn it better when we're interacting with other students.”

Some students also stated that Fellows’ enthusiasm for the content sparked their interest: “By being interested in the topic itself, she does a good job of [teaching] it.” One student noted that a Fellow enjoyed the content more than other teachers, which distinguished him from others.

## Discussion

Results from the statistical analysis revealed that increased PBL use was strongly associated with better outcomes in the three areas of student engagement, positive classroom culture and interest in STEM, even when controlling for demographic characteristics, survey administration timeframe and teacher. This means that if students used PBL more often in Fellows’ classrooms, they felt more engaged in the content; perceived a positive, academically-focused culture; and were more interested in STEM. This type of relationship is visualized in Figure 1.4, which shows the positive relationships of these three learning areas and PBL.

**Figure 1.4. Relationship of the PBL Index and Student Engagement, Classroom Culture and Interest in STEM Scales (N=256)**




These outcomes are similar to findings from a New Tech Student Survey (Romano, Bradley-Levine & Perkins, 2012; Bradley-Levine, Romano & Perkins, 2011) where higher levels of PBL were associated with better outcomes in curriculum and instruction, learning, community relationships, and school culture. The results from both of these surveys provide evidence that PBL improves many components of student learning, regardless of the school environment.

## Significance

This study provides support that increased STEM learning can be accomplished through PBL. In the unique setting of high-need schools, PBL increased engagement, classroom culture and interest in STEM. Students were better engaged through PBL because they were personally interested in the content, as it was applied to real-world phenomena. Further, students' responses to the open-response portion of the survey aligned with current research findings, as students reported feeling more engaged in STEM because of the compassion, excitement and tenacity of Fellows. Future work can look at development of more specific instruments to measure STEM interest for students so that researchers can understand more thoroughly how students become interested in STEM and how they stay engaged.

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**Appendix A.1: Descriptive Profile of Respondents & Postsecondary Plans**

Table A.1. Student Profile (N=256)

| | **Number and Percent** | | |
|---|---|---|---|
| | **Fall 2011 (N=178)** | **Spring 2012 (N=78)** | **Both Semesters (N=256)** |
| **Gender** | | | |
| Male | 83 (46.6%) | 37 (46.8%) | **119 (46.5%)** |
| Female | 94 (52.8%) | 41 (51.9%) | **135 (52.7%)** |
| Missing | 1 (0.6%) | 1 (1.3%) | **2 (0.8%)** |
| **Race/Ethnicity** | | | |
| American Indian | 4 (2.2%) | 1 (1.3%) | **5 (2.0%)** |
| Black (Not of Hispanic Origin) | 25 (14.0%) | 4 (5.1%) | **29 (11.3%)** |
| Asian or Pacific Islander | 3 (1.7%) | 1 (1.3%) | **4 (1.6%)** |
| Hispanic | 13 (7.3%) | 3 (3.8%) | **16 (6.3%)** |
| White (Not of Hispanic Origin) | 110 (61.8%) | 63 (79.7%) | **172 (67.2%)** |
| Multiracial (Two or more races) | 21 (11.8%) | 7 (8.9%) | **28 (10.9%)** |
| Missing | 2 (1.1%) | 0 (0.0%) | **2 (0.8%)** |
| **Special Education Participation** | | | |
| Special Education | 22 (12.4%) | 6 (7.6%) | **28 (10.9%)** |
| Not Special Education | 154 (86.5%) | 70 (88.6%) | **223 (87.1%)** |
| Missing | 2 (1.1%) | 3 (3.8%) | **5 (2.0%)** |
| **Limited English Proficiency** | | | |
| English Language Learner | 27 (15.2%) | 10 (12.7%) | **37 (14.5%)** |
| Not English Language Learner | 147 (82.6%) | 68 (86.1%) | **214 (83.6%)** |
| Missing | 4 (2.2%) | 1 (1.3%) | **5 (2.0%)** |
| **Residency in the United States** | | | |
| Born in the U.S. | 156 (87.6%) | 71 (89.9%) | **226 (88.3%)** |
| Lived 1-5 Years in the U.S. | 5 (2.8%) | 1 (1.3%) | **6 (2.3%)** |
| Lived 6-10 Years in the U.S. | 4 (2.2%) | 1 (1.3%) | **5 (2.0%)** |
| Lived 11-16 Years in the U.S. | 13 (7.3%) | 5 (6.3%) | **18 (7.0%)** |
| Missing | 0 (0.0%) | 1 (1.3%) | **1 (0.4%)** |
| **Free or Reduced-Price Meal Status** | | | |
| Free Lunch/Milk | 63 (35.4%) | 16 (20.3%) | **79 (30.9%)** |
| Reduced-Price Lunch/Milk | 17 (9.6%) | 10 (12.7%) | **26 (10.2%)** |
| Not Free or Reduced-Price Lunch/Milk | 63 (35.4%) | 47 (59.5%) | **110 (43.0%)** |
| Unsure | 34 (19.1%) | 6 (7.6%) | **40 (15.6%)** |
| Missing | 1 (0.6%) | 0 (0.0%) | **1 (0.4%)** |

Table A.2 Students Plans for Postsecondary Education (N=256)

| | **Number and Percent** | | |
|---|---|---|---|
| | **Fall 2011 (N=178)** | **Spring 2012 (N=78)** | **Both Semesters (N=256)** |
| I plan to start a full-time job after I graduate from high school | 44 (24.7%) | 38 (48.1%) | **82 (32.0%)** |
| I plan to start a technical training program after I graduate. | 13 (7.3%) | 16 (20.3%) | **29 (11.3%)** |
| I plan to work toward an associate's degree | 57 (32.0%) | 30 (38.0%) | **87 (34.0%)** |
| I plan to work toward a bachelor's degree | 113 (63.5%) | 66 (83.5%) | **179 (69.9%)** |
| My family expects me to continue my education after I graduate | 115 (64.6%) | 70 (88.6%) | **185 (72.3%)** |

*Note: Respondents could choose more than one response for this question.*

## Appendix B: Data Collection Instrument

**Woodrow Wilson Fellowship: Student Survey**

**Welcome!**
You have entered the Woodrow Wilson Indiana Teaching Fellowship student survey. This survey should take about 15 minutes to complete. All answers are anonymous. If you know now or decide later that you do not wish to take the survey, click on "exit this survey" at the top right corner of this page or simply close your web browser. There will be no record of your having visited the site and your answers will not be included. For your answers to be included in our data, you must select the "done" button at the end of the survey.
Completing this survey indicates your willingness to participate in the study. Thanks for your time!

**Student Profile**
**Please select the options that best describe you.**

**1. Who is your teacher for this course?**

**2. My gender:**
Male
Female

**3. My race/ethnicity:**
American Indian
Black (Not of Hispanic Origin)
Asian or Pacific Islander
Hispanic
White (Not of Hispanic Origin)
Multiracial (Two or more races)

**4. I receive special services from a resource teacher or other special needs professional:**
No
Yes

**5. I am an English language learner (English is NOT my first language):**
No
Yes

**6. I have lived in the United States:**
I was born in the U.S.
1-5 years
6-10 years
11-16 years

**7. I qualify for the following:**
Free lunch/milk
Reduced-price lunch/milk
None of the above
I don't know

**8. Check all that apply to you.**
I plan to start a full-time job after I graduate from high school
I plan to start a technical training program after I graduate.
I plan to work toward an associate's degree (2-year degree)
I plan to work toward a bachelor's degree (4-year degree)
My family expects me to continue my education after I graduate

**About this class.**
**9. Please select the option that best describes your view for each of the following questions. Leave blank if the question does not apply to you.**

| *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|
| *Strongly disagree* | *Disagree* | *Neutral* | *Agree* | *Strongly agree* |

This class is interesting.
This class is challenging.
I rarely get in trouble during this class.
I work hard in this class.
I complete my homework for this class.
I check my homework for this class multiple times before turning it in.
I am getting a good grade in this class.
My teacher for this class has high expectations.
My teacher is supportive of my work in this class.
I work with my classmates during class to complete projects/assignments.
I work with my classmates outside of class to complete projects/assignments.
I have been recognized by my teacher for doing well in this class.
In this class, I try to see things from other students' perspectives.
This class makes me question my views on different topics/ideas.

**About this class.**
**10. Please select the option that best describes your view for each of the following questions. Leave blank if the question does not apply to you.**

| *1* | *2* | *3* | *4* | *5* |
|---|---|---|---|---|
| *Strongly disagree* | *Disagree* | *Neutral* | *Agree* | *Strongly agree* |

I am involved in a science, technology, engineering, or math (STEM)-related extracurricular activity.
I share what I learn in this class with my friends and/or family.
This class makes me interested in science, technology, engineering, or math (STEM).
I will take more classes in science, technology, engineering, or math (STEM) even if they are not required.
I will pursue a career in a science, technology, engineering, or math (STEM)-related field.
I apply what I learn in this class to everyday life.

**More about this class**

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| *Never* | *A few times* | *Once or twice a month* | *Once or twice a week* | *Almost every day* |

**11. Overall, how often did you use the following in this class?**
Multiple choice, short answer or essay tests
Open-ended problems
Portfolios of student work
Student peer reviews
Group projects
Individual projects
Hands-on exhibitions, demonstrations or oral presentations

**12. Overall, how often did you perform the following in this class?**
Solved real-world problems
Collected, organized and analyzed information and data
Presented what I learned
Defended my views, ideas or perspectives
Orally presented my work to peers, parents, teachers or others
Researched topics in detail to be able to clearly explain them to others
Participated in community-based projects

**Free Response**
13. What are some activities you have completed for this class that apply to the real world?
14. How is this teacher different from other teachers you have had?
15. How does this teacher make the subject area you are learning more interesting?

## Appendix C: Data Analysis and Statistical Tables

**Table C.1.**
**Summary of Multiple Regression Analysis for Variables Predicting the Student Engagement Scale (N=256)**

| | B | SE | β |
|---|---|---|---|
| Female | -0.03 | 0.08 | -0.03 |
| Minority | -0.13 | 0.09 | -0.11 |
| Special Education Participation | 0.13 | 0.13 | 0.07 |
| English Language Learner | -0.02 | 0.12 | -0.01 |
| Not Born in U.S. | 0.04 | 0.13 | 0.02 |
| Eligible for Free or Reduced-Price Meals | -0.09 | 0.08 | -0.08 |
| Survey Administration Semester | -0.16 | 0.08 | -0.14 |
| Teacher | -0.00 | 0.01 | -0.03 |
| PBL Index | 0.25 | 0.07 | 0.25* |

*Note: $R=0.33$ $R^2$ (adj)= 0.07; B=slope, β is the standardized beta*
** $p<.05$*

**Table C.2.**
**Summary of Multiple Regression Analysis for Variables Predicting the Classroom Culture Scale (N=256)**

| | B | SE | β |
|---|---|---|---|
| Female | -0.07 | 0.09 | -0.05 |
| Minority | 0.03 | 0.11 | 0.02 |
| Special Education Participation | 0.10 | 0.16 | 0.04 |
| English Language Learner | -0.14 | 0.14 | -0.07 |
| Not Born in U.S. | 0.03 | 0.15 | 0.02 |
| Eligible for Free or Reduced-Price Meals | -0.03 | 0.10 | -0.02 |
| Survey Administration Semester | 0.01 | 0.10 | 0.01 |
| Teacher | -0.01 | 0.01 | -0.09 |
| PBL Index | 0.33 | 0.08 | 0.29* |

*Note: $R=0.32$ $R^2$ (adj)= 0.06; B=slope, β is the standardized beta*
** $p<.05$*

**Table C.3.**
**Summary of Multiple Regression Analysis for Variables Predicting the Interest in STEM Scale (N=256)**

| | B | SE | β |
|---|---|---|---|
| Female | -0.34 | 0.12 | -0.20* |
| Minority | 0.17 | 0.14 | 0.09 |
| Special Education Participation | 0.14 | 0.20 | 0.04 |
| English Language Learner | 0.07 | 0.18 | 0.03 |
| Not Born in U.S. | 0.05 | 0.19 | 0.02 |
| Eligible for Free or Reduced-Price Meals | -0.21 | 0.13 | -0.12 |
| Survey Administration Semester | 0.09 | 0.12 | 0.05 |
| Teacher | 0.01 | 0.01 | 0.06 |
| PBL Index | 0.54 | 0.10 | 0.35* |

*Note: $R=0.44$ $R^2$ (adj)= 0.16; B=slope, β is the standardized beta*
** $p<.05$*