Evaluating Implementation and Impacts of Problem Based Economics in U.S. High Schools*

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Abstract

This paper presents a year long study involving Economics teachers in public U.S. high schools. These teachers implemented units from a Problem Based Economics curriculum after being trained and provided with detailed materials and guidelines for instruction. The study included 15 teachers, and 1162 students who provided data consisting of a) student and teacher background surveys; b) student and teacher checklists of practices used and their helpfulness; and c) pre-, post- and final (delayed post) content tests. The study relates the background characteristics of the teachers and students to learning outcomes. The students who appeared to perform less well than expected based on prior achievement were students for whom English is a second-language and students with mid-to-average prior achievement. Overall, the largest gains in learning were seen among students who reported low prior achievement, while high prior-achieving students also outperformed expectations. This suggests an overall curvilinear relationship between prior achievement and learning in problem based instruction. Specific problem based practices were associated with long-term learning gains, while other more traditional or non-problem-based practices were associated only with short-term learning. Implications for high school reform efforts and connections to observation and interview findings are discussed.
Objectives and Purposes

This research seeks to understand factors that shape implementation of problem based curriculum by teachers and how these influence student learning. By extension, it contributes to an understanding of how curriculum and professional development efforts can be designed and delivered more effectively in support of school reform and meaningful learning outcomes. The research questions were as follows:

Research Questions

1. How is student prior achievement level, gender, and language status related to learning in problem based economics units?

2. How does unit implementation vary according to student and teacher characteristics?

3. What instructional practices (as part of implementation) are related to short- and long-term learning?

Educational Importance

Economics is often called the “dismal” science and it can be a dull and abstract subject for teachers and learners. In high school, it is often taught by reluctant and under-prepared teachers to uninterested high school students in their senior year. The curriculum units being studied was developed by the Buck Institute of Education (BIE) in concert with subject experts and experienced teachers. The focus of this study is the well-defined Problem Based Economics (PBE) curriculum that has been specially tailored for use in high school settings over the last five years. These curriculum units are available from BIE and increasingly at Centers for Economic Education across the country.¹

Educational reformers seeking to make schools and classrooms more effective learning environments have frequently proposed restructuring traditional curriculum and instruction to engage students in meaningful problem solving (Cognition and Technology Group at Vanderbilt [CTGV], 1997; Hiebert, Carpenter, Fennema, Fuson, Human, Murray, Alwyn, & Wearne, 1996, May). Problem-Based Learning (PBL) is an instructional approach where students are confronted with simulated, real-world problems, and is frequently advanced as a powerful and engaging learning strategy that leads to sustained and transferable learning (e.g., Bransford, Sherwood, Hasselbring, Kinzer, & Williams, 1990; Jones Rasmussen, & Moffitt, 1996; Stepien & Gallagher, 1993; Stepien, Gallagher, & Workman, 1993). By engaging students in a realistic problem that reflects the context and constraints of the “real world,” and by requiring students to clarify the problem and to conduct research necessary to solve the problem, it is argued that PBL encourages students to retain newly gained knowledge and solution strategies, fosters the development of self-directed learning strategies, and enables them to apply what they have learned to new and unfamiliar situations (Blumberg, 2000; CTGV, 1997; Maxwell, Bellisimo, & Mergendoller, 2001).

PBL deviates from more conventional instructional strategies by restructuring traditional teacher/student interaction toward active, self-directed learning by the student, rather than

didactic, teacher-directed instruction (e.g., Barrows, 1988; Birch, 1986; Savery & Duffy, 1994; Smith & Ragan, 1999; Stepien & Gallagher, 1993; Torp & Sage, 1998). In PBL, teachers coach students with suggestions for further study or inquiry while students pursue their own problem solutions by clarifying a problem, posing necessary questions, researching these questions, and producing a product that displays their thinking. These activities are generally conducted in collaborative learning groups, and these groups often solve the same problem in different ways and arrive at different answers.

An inquiry-based approach to curriculum continues to be an essential component of current school reform models (Expeditionary Learning Outward Bound, 2001; Honey & Henriquez, 1996; Newmann & Wehlage, 1995). The literature on “small schools” emphasizes an inquiry approach to help prepare students for the future, but research has found “these instructional practices were more the exception than the rule. . . . (Many teachers) lacked models and ready-to-use curricula” (Hendrie, 2003). While progress is being made, the American Institute for Research and SRI International (2004) also highlighted the need for teachers in start-up schools more effectively implement reform-like approaches without sacrificing rigorous coverage of basic skills and content learning. In addition, because most teachers do not have the time or expertise to design their own PBL units, our pre-designed, all-materials-included units may help meet these demands.

It is important to determine if content learning outcomes from PBL are equivalent to traditional instructional outcomes. If content learning achievement is equally good, problem based learning had additional benefits that recommend its use. These benefits include PBL’s potential to “engage students, cut absenteeism, boost cooperative learning skills, and improve test scores” (George Lucas Educational Foundation, 2005). PBL also offers students more of a chance to practice “21st century” skills like problem-solving, working in groups, and presenting to an audience than traditional instruction does. A number of national reports have indicated that high schools do not offer students enough opportunities to learn these and other essential skills for life and the workplace – e.g., reports from the Secretary’s Commission on Achieving Necessary Skills (SCANS, 1991), the American Youth Policy Forum (AYPF, 2000) and the National Commission on the High School Senior Year (NCHSSY, 2001).

Jonassen (2004) and Jonassen & Hernandez-Serrano (2002) has defined a typology of problem-based educational strategies that can range from well-structured to ill-structured, depending on the level of the learner, the type of content, and how it is presented. According to this typology, the problems presented here (and possibly within economics in general) are a combination of decision-making problems and dilemmas, with the latter representing the most ill-structured kind of problem (Jonassen, 2004). This study is partly of interest because it addresses how teachers might give high school students the chance to solve problems that are typically among the most ill-structured for adults.

**Theoretical Perspective**

Theoretical arguments linking the learning activities in problem-based curriculum are supported by several decades of research in cognitive psychology as advanced in *How People Learn* (Bransford, Brown & Cocking, eds., 1999), a work commissioned by the National Research Council. The authors argue for approaches to education that:
... expose students to the major features of a subject domain as they arise naturally in problem situations. Activities can be structured so that students are able to explore, explain, extend, and evaluate their progress. Ideas are best introduced when students see a need or a reason for their use – this helps them see relevant uses of knowledge to make sense of what they are learning. Problem situations [can be used to introduce] ideas and concepts in ways that promote deep understanding (p. 127).

Advocates of problem-based learning often argue that they are encouraging students to develop their planning, metacognitive and self-monitoring skills. They argue complex tasks give students the opportunity to practice and apply these skills required for “authentic intellectual work” including disciplined inquiry, construction of knowledge, and application of knowledge beyond the classroom (Smith, Lee & Newmann, 2001; van’t Hooft, 2005). However, research suggests that students do not inevitably respond to high-level cognitive tasks with high level learning strategies (Blumenfeld et. al., 1991; Anderson & Roth, 1989; Blumenfeld & Meece, 1988; Paris, Lipson, & Wixson, 1983; Winne & Marx, 1982). This suggests problems must be carefully constructed and artfully managed if they are to facilitate student learning and deep understanding. Leading researchers and theoreticians whose work incorporates standards-focused, well-structured PBL in K-12 teaching include Linn & Hsi, (2000), Schwartz, Lin, Brophy, & Bransford (1999) Resnick, (1987), and Resnick, & Nolan (1995).

Despite findings which illustrate the potential of a well-structured approach for improving the learning of lower-achieving students (Smith, Lee & Newmann, 2001) and the body of scientifically based research that indicates PBL can be as effective as traditional instruction (Culver, 2000), there are concerns about the quality of PBL in many classrooms. A 1998 nationwide survey of teachers in grades 4-12 found that teachers rarely assign activities that research has shown lead to deep and meaningful thinking, such as keeping a journal, or sharing work with others outside the classroom (Ravitz, Becker & Wong, 2000, p.35).

A key question for researchers is not so much whether problem based instructional strategies work in the abstract, but for whom and under what conditions? It has been shown that “direct assessment of implementation at the classroom level is necessary to evaluate the effects of educational innovations on student outcomes” (Archie, Hall & Uchiyama, 2000). Newmann (2004) raises equity concerns about use of teaching methods such as problem based learning. He calls for an examination of differences in the distribution of “authentic pedagogy” to different students and for a better understanding of when different practices lead to favorable learning outcomes. One such study focused on how such practice can help engage low-achieving students in the deep thinking and problem solving: “Our findings call into serious question the assumption that low-achieving, economically disadvantaged students are best served by teaching that emphasizes didactic methods and review (Smith, Lee & Newmann, 2001).

The research presented below takes several steps toward assessing effective implementation of problem based learning. It helps us understand the challenges facing teachers and curriculum developers as they try to engage learners more meaningfully in complex problem solving tasks.
METHODS

Data concerning implementation of PBL and learning outcomes are reported for two economics units that have been in use for over five years, one addressing micro-economics and one addressing macro-economics. Maxwell, Bellisimo & Mergendoller (2001) provide a discussion of the common structure of the units and the instructional strategies they offer to teachers. The first unit, called *The High School Food Court* is designed to engage students in micro-economic concepts -- like demand, profit, trade-offs and opportunity costs. Students must select five (5) from a list of twelve (12) restaurant bidders to serve lunch at their high school. The students want to maximize profits to fund student activities but also must try to meet the needs of all students. Detailed cost and demand data are provided for each restaurant. There is a “twist” where special interest groups weigh in, e.g., vegetarians, environmentalists, school-to-work, and low income students. The students work as a group and present a solution to a panel of school board members sympathetic to various interest groups who are role-played by the teacher and other students, teachers, staff or community members.

The second unit, called *The President’s Dilemma* is designed to engage students in macro-economic concepts – like fiscal and monetary policies, inflation, and national economic health. The unit simulates conditions of cost-push inflation, much like the oil crisis of the 1970s. The students are presented with data and told they must prepare and explain a policy speech for use by the President. They defend their solution in front of a panel that includes the President, who is also an economist, and representatives of business, unemployed labor, and the elderly.

This study addresses both the content knowledge and pedagogical background of teachers as well as student characteristics that might shape teacher use of these units of problem based instruction and influence student learning outcomes. It takes into account the nature of teachers, schools and students before correlating teaching practices to learning outcomes.

<table>
<thead>
<tr>
<th>This Research Question</th>
<th>Is Addressed By</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. How is student prior achievement level, gender, and language status related to learning in problem based economics units?</td>
<td>correlating student background measures to test scores and test score gains on the two units</td>
</tr>
<tr>
<td>2. How does unit implementation vary according to student and teacher characteristics?</td>
<td>analyzing student and teacher unit checklists of practices used and their reported helpfulness for each of the two units, and correlating these checklists of practices to background measures</td>
</tr>
<tr>
<td>3. What instructional practices (as part of implementation) are related to short- and long-term learning?</td>
<td>correlating test scores and test score gains to the practices that were used in both units, after controlling for background measures</td>
</tr>
</tbody>
</table>

Teacher background surveys were collected at the outset of workshops introducing the units. These surveys provided information about teachers’ economics content knowledge including about the number of college classes taken and confidence teaching economics. Items contributed to a reliable 6 item index (alpha = .84). Teachers also provided information about their pedagogical background using items from Teaching, Learning and Computing, 1998 (Ravitz, Becker & Wong, 2000) to assess prior use of PBL-related methods such as the extent of
their use of group work or having students work on open-ended problems. These contributed to a reliable seven-item index (alpha=.90). Both indices are provided in Appendix A, followed by the full teacher entry survey in Appendix B.

Student background surveys were administered by the teacher at the beginning of the semester. These included questions about student gender, ethnicity, first language, languages spoken at home, and interest in economics. This brief survey is provided in Appendix C. Anonymous identification numbers were used to match student and teacher responses. A measure of student prior achievement was based on the self-reported expected grade point average for the semester, and what students’ plans were for after high school (ordered from no plans to attending a 4-year, very competitive college). The overall correlation for these two measures was r=.39 (.32 for males and .43 for females, p < .001). Willison & Kelly (2004) have demonstrated that self-reports from students are effective stand-ins for pre-tests of content knowledge in economics in terms of predicting outcomes. This is probably because students know very little about economics and their high school class is typically their first formal exposure to the discipline. What they know and how well they do in economics closely mirrors their overall patterns of academic achievement.

Teacher and student checklists addressed PBL implementation. For 31 different practices students and teachers indicated the extent of use of the practice in terms of proportion of days (0 = “None”; 1 = “Only one day”; 2 = “A few days”; 3 = “About half the days”; 4 = “Most of the days”; 5 = “Nearly every day”). They also indicated on a scale of 0 to 3 how much each practice helped their learning or learners (0 = “None”, 1 = “A little”; 2 = “Some”, 3 = “A Lot”). The checklists had slightly different wordings to express point of view, e.g., students answered for what they did, while teachers provided their own frequency ratings of student activities. The student version of the checklist is provided in Appendix D with the teacher version available from the author.

The assessment model for this study is shown graphically in Appendix E. Assessments of learning outcomes are made based on pre- and post-tests for each unit and a final exam. Measures of learning outcomes include the raw final exam score, the pre-post (short term) gain score, the pre-final (long term) gain score, and the gain scores controlling for prior achievement. These measures of learning are then correlated to background measures and to the practices used.

We also look at final exam scores controlling for prior achievement. This produces a residual score based on what would be predicted, but is not technically a gain score. Multiple regression in SPSS™ offers creation of standardized residual measures as an output variable. These indicate whether a result is above or below what would be expected based on control variable(s) alone. This is shown graphically for 3 variables in Ravitz (2003). Standardized residual, or “gain” scores are used in this study to assess test scores after removing the effect of the pre-test score and students’ self-reported prior achievement.

Data are presented using standardized measures. This allows one to judge differences as effect sizes, the mean is close to zero and the standard deviation is close to one. (Slight discrepancies are due to missing cases and because standard residuals are not exactly normally distributed; they have an approximate mean of zero and standard deviation of one.)

The pre-tests for The High School Food Court and The President’s Dilemma had 10 and 11 items, respectively. This was a brief test because students were expected to have limited prior knowledge of economics. On the final exam, there were questions containing content from each unit; some questions were identical to those asked on the pre-test and several were different. There were 7 items on the final for The High School Food Court and 9 items on the final for The President’s Dilemma. It is worth noting that the Test of Economic Literacy measures individual
concepts with as few as 3 items per concept (Walstad & Rebeck, 2001). The correlation between pre-test scores and the final exam scores for unit items was .39 (p < .001), accounting for almost 16% of the variance (r-squared) in the final exam score on those items.

Each multiple choice test was extensively reviewed by teachers and experts, piloted with several hundred students, analyzed using traditional and item-response theory analyses by researchers at University of California, Berkeley (cite), and revised. Items that were too difficult or confusing were removed along with any items that did not contribute to the overall measure. The final exam has an overall reliability rating of alpha= .89. The High School Food Court post test had alpha = .81, and The President’s Dilemma post test had alpha= .84. The following Table A shows the number of items used for each measure of content learning. Lack of reliability suggests it will be more difficult to show relationships and relationships that are found would be greater with better measures.

Table A. Reliability of Assessment Data

<table>
<thead>
<tr>
<th></th>
<th>The High School Food Court, # items</th>
<th>The High School Food Court, alpha reliability</th>
<th>The President’s Dilemma, # items</th>
<th>The President’s Dilemma, alpha reliability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre test</td>
<td>11</td>
<td>.49</td>
<td>10</td>
<td>.52</td>
</tr>
<tr>
<td>Post test</td>
<td>26</td>
<td>.81</td>
<td>31</td>
<td>.84</td>
</tr>
<tr>
<td>Items on Final</td>
<td>7</td>
<td>.58</td>
<td>11</td>
<td>.67</td>
</tr>
</tbody>
</table>

As noted in van’t Hooft (2005), Wolf (1997) indicates that measures with reliability as low as .5 are acceptable for use when aggregating scores to the class level (p. 227).

Study Details

Both units are designed to have students follow a problem solving process built around several “core” practices (Maxwell, Bellisimo & Mergendoller, 2001). Roughly speaking, use of these practices represents a measure of “implementation fidelity” (Mowbray, et al., 2003). These practices are designed to promote greater reflection, deeper thinking, and critical analysis of the problem; they are used later in this paper to predict learning outcomes:

- Creating, and coming back to revise a problem statement (e.g., “How can we, as the Student Council, allocate the food concessions in the new Food Court so that the Student Council gains revenue and serves the needs of the competing constituencies?”)

- Keeping and updating a “knowledge inventory” (What do we know and need to know?)

- Writing and keeping a problem log (e.g., “What are the positive and negative features of each restaurant?”)

For comparison purposes we also analyzed another set of practices that are included with the units and that are probably more commonly used by students and teachers: watching
instructional videos, listening to lectures, asking and answering questions, and reading in textbooks. Good teachers seek ways to blend these “traditional” practices with the more “problem based” practices to produce the best opportunities for students to learn. Background lessons on economic content are provided in the unit materials, to be used once students have firmly established a “need to know” in the problem.

Limitations

Our focus is on a well-developed problem based curriculum and its implementation. While we are interested in teacher background as an independent variable, we do not focus on the process of teacher professional development. Teachers in our study attended workshops in which they were given an overview of the curriculum and a chance to experience a few units from the student perspective. They worked out the problems together, in the role of students, and discussed the experience with other teachers. This kind of interaction among teachers and the impact on student learning is valued by professional development researchers (Ingvarson, Meiers, & Beavis, 2004; Guskey, 1995; Guskey, 1998). A different study would be required to focus on strategies for teacher professional development and change.

This study relies on relatively blunt measures of unit implementation and learning outcomes. The checklists of practices used in our study provide only a rudimentary indication of PBL implementation; they do not go into depth into the quality of teaching practices or classroom interactions such as those under development by researchers like Blumenfeld and colleagues (from AERA 05). Similarly, the outcome measures rely on a traditional multiple-choice test that does not address related skills and attitudes students might develop in PBL. A different study might focus on characterizing learning outcomes in a more comprehensive fashion, with post-surveys of students and rigorous transfer tasks to assess deeper content learning, problem solving skills, and attitudes.

In summary, this study uses a number of fairly blunt instruments. When findings appear with these admittedly weak measures, it is worth considering if the same findings would be even stronger when better measures are used. (A truly awful measure has no predictive validity, and will not correlate to anything; a better measure will have stronger predictive validity). A similar argument pertains to our heavy reliance on self-report data. We know little about unit implementation of units from our student and teacher checklists, or about student and teacher background from our self report data. However, findings suggest these instruments are a step in the right direction because of the relationships that were found.

Another limitation concerns the low number of cases (N) providing complete data for teacher and class-level analyses. Few teachers provided complete sets of teacher and student surveys, checklists for students and teachers that could be matched to pre-, post-, and final exams. In particularly, absences during the spring semester (among seniors) were particularly problematic in providing complete data. As a result, several findings with large effect sizes are were not statistically significant. It is also possible these results are caused by chance and are not “real”. However, these large differences in mean test scores or practices are reported because they suggest there may be a phenomenon to be studied. When several non-statistically significant findings (say, at the p < .20 level) indicate the same pattern, this decreases the likelihood that the larger pattern is caused by chance. It is more likely for one result to be caused by chance than several. If one out of five results may be caused by chance, then we believe three or four results pointing in the same direction is worth noting for future investigation.
Additionally, convenience sampling prevents us from drawing conclusions beyond the current sample of teachers, and we do not know how well students of these or other economics teachers would have learned without the problem based curriculum. Finally, as always, it is important to keep in mind when reporting findings based on student background characteristics that mean scores for groups cannot be ascribed to individuals within the group who, on an individual basis may have a full range of scores. It is important not to stereotype based on group mean scores (Popham, 2002).

FINDINGS

Student background and achievement in PBL

These findings highlight the relationship of student background characteristics to their learning in problem based economics, using pre-tests, post-tests and final exams. Table B provides a summary of these findings. This table shows that gender, on average, is not related to final exam scores. In addition, black/African-American students scored just about average on the final. It was Hispanic students, and students who spoke another language at home, who did least well on the final exam. Despite the potential importance of various background characteristics, the single best indicator of performance on the final exam score was the self-reported prior achievement measure n-tile. This is consistent with Willison & Kelly (2004) who found self-reports of prior achievement could effectively stand in for an extensive pre-test of economics knowledge.

Table B. Summary of Mean Effect Sizes on Final Exam, by Student Background Dichotomies

<table>
<thead>
<tr>
<th>Student Responses to Background Survey</th>
<th>White (N)</th>
<th>Asian (N)</th>
<th>Black (N)</th>
<th>Hispanic (N)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>(305)</td>
<td>(479)</td>
<td>(493)</td>
<td>(467)</td>
</tr>
<tr>
<td>Male</td>
<td>0.60</td>
<td>0.62</td>
<td>0.63</td>
<td>-0.10</td>
</tr>
<tr>
<td>Female</td>
<td>0.66</td>
<td>0.71</td>
<td>0.61</td>
<td>0.64</td>
</tr>
</tbody>
</table>

| English is Your First Language         | (101)    | (281)    | (312)    | (209)       |
| Male                                  | 0.58     | 0.62     | 0.64     | 0.55        |
| Female                                | 0.58     | 0.62     | 0.64     | 0.55        |

| Do you speak another Language Spoken at Home | (101) | (281) | (312) | (209) |
| Lower N-tile                            | 0.58   | 0.62   | 0.64   | 0.55 |
| Higher N-tile                           | 0.58   | 0.62   | 0.64   | 0.55 |

| Prior Achievement                       | (267)   | (281)   | (112)   | (249)       |
| Lower N-tile                            | 0.64    | 0.64    | 0.57    | 0.70        |
| Higher N-tile                           | 0.64    | 0.64    | 0.57    | 0.70        |

*** p < .001, ** p < .002, * p < .05

Note: The standard deviation for the final exam was .18. Similar results were seen for both unit tests.

The measure of prior achievement was strongly correlated (p < .001) with final exam scores at the student (r=.47), teacher (r=.67) and class levels (r=.66). Expected grade point average was a stronger predictor of final exam scores than the graduation plans question. However, the index combining both these items showed stronger correlations than either item alone. These strong correlations suggest that between a quarter and a half of the final exam score is predicted by prior achievement (using r-squared for the above correlations).
When one looks at the amount of learning that occurs beyond what would be expected, the findings are quite clear: It is really the students with the lowest prior achievement who surpassed expectations. Table C shows that students who expected to get Cs or lower in school actually did better on the Final Exam than those who expected to get mostly Bs. They scored 10% points better than students who expected to get Bs and Cs and 5% points better than students who expected to get Bs. Using the z-scores that are also provided in Table C, this represents an effect size differences of .5 and .25, respectively. Further analysis revealed that this finding was present in seven out of nine teachers that were compared; it is not the result of one or two teachers obtaining remarkable results.

The residual scores in Table C indicate how students in each category scored on the final, after removing the influence of prior achievement (see Ravitz, 2003 for a discussion of residual test scores). The first row residual reflects the higher than expected scores among those who initially expected to get Cs or lower (.73). Students who expected to get All As also had a positive residual (.14), as did students who expected to attend the most competitive 4-year colleges (.10), but the lowest prior achievers had much larger positive residual scores on the final exam. In summary, students with the highest residual test scores (after controlling for prior achievement) were those at the bottom of the prior achievement index, and to a lesser extent those at the top. Based on this analysis it is those in the middle-range of prior achievement who, on average, gain the least from problem based instruction.

Students who did not have college plans scored lower on the final compared to students with college plans, but their residual score was higher (.48) and their mean z-score on the final (z = -.54) was substantially better than those students who expected mostly Bs and Cs (z = -.73). In addition, students with technical school, job, or military plans obtained similar scores to those with plans to attend a 2-year community college category and scored better on average on the final than students who expected to get mostly Bs.

Table C. Student Prior Achievement Items Related to Final Exam and Residual Scores

<table>
<thead>
<tr>
<th>Prior Achievement Items</th>
<th>Average Final Exam Scores</th>
<th>Average Final Exam Z-Scores</th>
<th>Average Residual Final Exam scores, controlling for Prior Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cs or lower</td>
<td>15</td>
<td>60</td>
<td>.12</td>
</tr>
<tr>
<td>Bs and Cs</td>
<td>78</td>
<td>50</td>
<td>.17</td>
</tr>
<tr>
<td>Mostly Bs</td>
<td>70</td>
<td>55</td>
<td>.17</td>
</tr>
<tr>
<td>As and Bs</td>
<td>170</td>
<td>66</td>
<td>.17</td>
</tr>
<tr>
<td>Mostly As</td>
<td>91</td>
<td>71</td>
<td>.16</td>
</tr>
<tr>
<td>All As</td>
<td>33</td>
<td>79</td>
<td>.14</td>
</tr>
<tr>
<td>Total</td>
<td>457</td>
<td>63</td>
<td>.18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>College Plans</th>
<th>Average Final Exam Scores</th>
<th>Average Final Exam Z-Scores</th>
<th>Average Residual Final Exam scores, controlling for Prior Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Other/None/Don't know</td>
<td>30</td>
<td>53</td>
<td>.20</td>
</tr>
<tr>
<td>Technical school, job, military</td>
<td>31</td>
<td>57</td>
<td>.16</td>
</tr>
<tr>
<td>2-year, community college</td>
<td>166</td>
<td>57</td>
<td>.17</td>
</tr>
<tr>
<td>4-year, less competitive</td>
<td>124</td>
<td>67</td>
<td>.18</td>
</tr>
<tr>
<td>4-year, most competitive</td>
<td>106</td>
<td>74</td>
<td>.15</td>
</tr>
<tr>
<td>Total</td>
<td>457</td>
<td>63</td>
<td>.18</td>
</tr>
</tbody>
</table>

Table D, below, lends further support to the above findings by showing a similar pattern for differences based on student prior interest in economics. Interest in economics was not part of the prior achievement measure because it did not add to the reliability of the index. Interest was correlated with expected grades ($r = .15$, $p < .001$) but not to college plans ($r = .03$, NS).

Students who initially said economics was not interesting and not worth taking had a prior achievement measure of -.39 and -.15 respectively, more than a third a standard deviation below the mean in the first case. These same students ended up scoring just about average on the final (within .10 standard deviations of the mean). This pattern can be seen in the average residual score of .30 for the first group.

Table D. Average Student Achievement with Residuals, by Interest in Economics

<table>
<thead>
<tr>
<th>INTEREST IN ECONOMICS</th>
<th>N</th>
<th>Mean Prior Achievement</th>
<th>Mean Final Exam and Residual</th>
<th>Mean Final Exam controlling for Prior Achievement</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Prior Achievement</td>
<td>Final Exam and Residual</td>
<td>Final Exam</td>
</tr>
<tr>
<td>Not interesting, not worth taking</td>
<td>35</td>
<td>-.39</td>
<td>1.06</td>
<td>.09</td>
</tr>
<tr>
<td>Not as interesting, but worth taking</td>
<td>208</td>
<td>-.15</td>
<td>1.01</td>
<td>-.10</td>
</tr>
<tr>
<td>As interesting as other classes</td>
<td>323</td>
<td>.08</td>
<td>.99</td>
<td>.08</td>
</tr>
<tr>
<td>One of the more interesting classes</td>
<td>236</td>
<td>.08</td>
<td>.99</td>
<td>.11</td>
</tr>
<tr>
<td>Total</td>
<td>802</td>
<td>.00</td>
<td>1.00</td>
<td>.04</td>
</tr>
</tbody>
</table>

P < .003     NS     NS

Student Gender, Ethnicity and Language

Table E provides more details about the relationship of student achievement on the final exam to student background variables including gender, ethnicity, and language. These data are consistent with Table B but use standardized measures and also show residual scores -- the mean is close to zero and the standard deviation is close to one. (Slight discrepancies are due to missing cases and the fact that standard residuals are not expected to be exactly normally distributed).

Starting at the top of the Table E, female students reported stronger prior achievement than males, but their scores on the Final Exam were essentially the same. The result is that males had a residual score, on average, slightly higher than females. The differences were small and not statistically significant. Concerning student ethnicity, these data show that white students, on average, reported only slightly higher than average prior achievement, while Asian students reported substantially higher prior achievement (.26 represents one-quarter a standard deviation, generally considered a moderate difference). Asian students ended up scoring even better than would have been predicted based on their prior achievement alone. They scored almost a half standard deviation above the mean on the final; the result is a residual score of .33. A similar but less dramatic pattern is seen for white students who started barely ahead on prior achievement (mean $z$-score = .08), and ended up about one-fifth a standard deviation above average on the final exam; the result is an average residual score on the final of .11.

In summary, both white and Asian students started with higher than average prior achievement and made learning gains beyond what would be expected based on this prior achievement alone. It is worth noting that these groups probably tend to do well in school in general, in part as indicated by their higher than average prior achievement measures. These
residual gains therefore are not necessarily an effect of problem based learning. It might be more generally the case that these students, on average, learn more effectively, even with non-problem based lessons.

Table E. Average Student Achievement, by Gender, Ethnicity and Language

<table>
<thead>
<tr>
<th>BACKGROUND MEASURES</th>
<th>Prior achievement z-scores N S.d.</th>
<th>Final Exam Z-scores N S.d.</th>
<th>Final Exam controlling for Prior Achievement (&quot;residual&quot;) N S.d.</th>
</tr>
</thead>
<tbody>
<tr>
<td>GENDER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>-.13 341 1.01 .03 182 1.05 .07 182 1.05</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>.11 452 .98 .06 267 .93 -.01 267 .94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>.00 793 1.00 .05 449 1.00 .02 449 .98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P &lt; .001</td>
<td>NS</td>
<td>NS</td>
<td></td>
</tr>
<tr>
<td>Ethnicity</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White (non-Hispanic)</td>
<td>.08 426 .99 .19 232 .94 .11 232 .95</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Asian American</td>
<td>.26 92 1.03 .47 58 .88 .33 58 .92</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Black/African American</td>
<td>-.32 66 1.04 -.10 44 1.01 .07 44 .97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hispanic/Latino/Latina</td>
<td>-.34 118 .98 -.55 70 .99 -.40 70 1.04</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>.03 41 .90 -.61 23 .85 -.63 23 .84</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mixed</td>
<td>.07 50 .89 .15 20 .80 .13 20 .93</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>.00 793 1.00 .04 447 .99 .02 447 .99</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P &lt; .001</td>
<td>P &lt; .001</td>
<td>P &lt; .001</td>
<td></td>
</tr>
<tr>
<td>Is English your First Language?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>.01 571 .97 -.02 281 .94 -.05 281 .94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>-.16 151 1.07 -.25 101 1.11 -.26 101 1.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>-.03 722 .99 -.08 382 .99 -.11 382 .98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P &lt; .06</td>
<td>P &lt; .05</td>
<td>P &lt; .06</td>
<td></td>
</tr>
<tr>
<td>Do you speak another language in your home?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>.07 572 .98 .09 312 .97 .05 312 .97</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>-.23 190 1.01 -.33 112 .99 -.33 112 .96</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>-.01 762 .99 -.02 424 .99 -.05 424 .98</td>
<td></td>
<td></td>
</tr>
<tr>
<td>P &lt; .001</td>
<td>P &lt; .001</td>
<td>P &lt; .001</td>
<td></td>
</tr>
</tbody>
</table>

Note: Statistical significance for this table is based on ANOVA comparison of means. Some students did not answer the language questions resulting in fewer cases. Missing cases resulted in z-scores averaging to not exactly 1.00 for these groups.

In contrast to white and Asian students, Black and Hispanic students reported substantially lower prior achievement on average. This means fewer of them on average expected to go to 4-year colleges or to get As and Bs. This finding is consistent with extensive literature on the “achievement gap” in schools (e.g., Kober, 2001; National Study Group, 2004). Both Black and Hispanic students had similar prior achievement scores -- on average about one-third a standard deviation below the mean. Unlike Hispanic students, however, black students scored only slightly below the mean on the final exam (mean z-score = -.10). In contrast, students who identified themselves as Hispanic or Latino/Latina averaged lower scores than would have been predicted based on prior achievement alone. The result of having similar prior achievement to Black students but different final exam scores is reflected in the residual scores of .07 and -.40 for these two groups, respectively. Similarly, students whose first language was
not English or who said they spoke another language at home scored only slightly lower on prior achievement, but scored significantly lower than average on the final exam, with a residual of -.33. This suggests these are students who may be struggling with PBL, as compared to others.

Further analysis of language categories suggests that a small group of students whose first language is not English may do very well with traditional teaching methods, as indicated by their strong prior achievement scores, and very poorly with PBL. They scored substantially above average on prior achievement but had extremely low final exam scores. This is similar to the pattern seen among students who gave “other” as their ethnicity – they scored about average on prior achievement but had a z-score on the final exam of -.61. The ability of some students to do well with traditional instruction but poorly in PBL is addressed in the discussion section.

**Summary of Student Background Findings**

Overall, based on analysis of prior achievement and final exam scores, it seems that problem based learning benefits the lowest performing students the most. Although they do not suddenly score at the top of the class (prior achievement is still the strongest predictor of learning outcomes) students who might be expected to do most poorly and who express the least interest in economics performed surprisingly well on the final exam. This is consistent with a definition of “resilience” in Borman and Overman (2004) as discussed at the end of this article. Problem based learning also appears to serve the groups of relatively high performing students. Asian students on average had both high prior achievement, and high residual gain scores. The result is an overall curvilinear relationship between prior achievement and learning in problem based learning – it may benefit the lowest and highest performing students, leaving out some of those in the middle.

In addition to the above overall pattern, it seems clear that Hispanic students and English learners may struggle more with the PBL curriculum than others. On average they scored lower on the final exam than would have been predicted based on their prior achievement. One explanation is that lower performance on the final exam may be an indicator of their language skills, because the test was given in English. However, prior achievement should take this into account, with language issues equally likely to influence past performance on similar tests. It is possible that cultural issues could influence students’ understanding of the problem. However, the most likely explanation is that this result is due to problems with the more language-intensive aspects of the PBL curriculum, including reading documents, negotiating group tasks, and making oral presentations. This is a topic to be taken up in future research.

**Teacher Background and Student Achievement in PBL**

The curriculum being studied relies heavily on the quality of teacher use of materials and lessons. The teacher plays a critical role directing and facilitating student use of problem based learning. It is important to know how teacher background characteristics may impact student learning, particularly teacher content knowledge which has been shown to be a key factor in student learning outcomes (Allgood & Walstad, 1999; Willison & Kelly, 2004).

Teacher background measures include an index of teacher economic expertise that is based on the number of years teaching economics, college courses taken, and several other items. A different index addressed teachers’ experience using practices such as those found in the problem based approach – having students work on open-ended problems, in small groups, and others. These are the types of activities used in PBL and prior experience of the teacher was expected to contribute to the quality of implementation. These two indices had six and seven
items, respectively, and standardized reliability alpha values of greater than .80. Additional details are provided in Appendix A.

As in previous research, it seems economics teaching experience is the strongest teacher background predictor of how well students scored on the final, even controlling for student prior achievement. The number of years teaching any subject was related to student learning, but years teaching economics was much more strongly related. This is consistent with other research on economics education in general (Allgood & Walstad, 1999; Willison & Kelly, 2004). In contrast, teachers’ PBL background was associated with lower test scores, on average. This implies that success with the curriculum units may ultimately depend more on teachers’ content expertise than their expertise with PBL methods. To some extent the extensive support and scaffolding for use of PBL that are provided with the curriculum units may make prior PBL experience less essential. At the same time, veteran teachers may have greater facility managing projects even if PBL is less of a central part of their teaching. This is taken up further in the discussion.

The first row in Table F shows weak correlations between economics background and PBL background (r = -.12, NS), and weak but positive correlations with the achievement measures including the residual Final Exam (r=.17, NS) and the Residual Final score (r=.22, NS). The second row of Table F shows that students of teachers with more PBL experience demonstrated lower scores on the final exam (r = -.32, NS). This was the case despite these teachers having students with higher average levels of prior achievement (r=.40). The result is a negative relationship between teachers’ PBL experience and the residual final exam score (r=- .37). The last two columns show that PBL experience is negatively related to both years teaching economics and teaching overall. This means newer teachers tended to report more PBL experience, perhaps having been explicitly exposed to PBL methods in recent years. These same teachers also tended to have students with higher levels of prior achievement, but lower than average final exam scores. Because this is teacher level data we do not have enough cases to control for multiple variables like PBL background and years teaching. A case-by-case review revealed no clear patterns. While these results are not statistically significant, the correlations are strong enough to warrant consideration – with a few more cases these correlations could easily be statistically significant

The third row shows expected relationships between the Final Exam score and both prior achievement and the residual final exam score. The residual score uses the final exam in its computation, so this is not a finding. What is worth noting is the strong correlations between the final exam score and the teachers’ years teaching economics (r=.56) and years teaching overall (r=.41). The fourth row shows that student prior achievement is positively related to residual gains on the Final exam. Classes with high prior-achieving students did better than expected on the final exam. This is consistent with findings reported earlier that, on average, both white and Asian students who had high prior achievement demonstrated residual gains. In addition, this row shows that classes with lower prior achievement tended to have less experienced teachers overall (r = -.27), but teachers with similar years teaching economics (r=- .01).
### Table F. Correlations of teacher background with student achievement on BIE tests

<table>
<thead>
<tr>
<th></th>
<th>PBL Background</th>
<th>Final Exam</th>
<th>Prior Achievement</th>
<th>Residual Final Exam Score</th>
<th>Years Teaching Economics</th>
<th>Years Teaching Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economics Background</td>
<td>15</td>
<td>-.12</td>
<td>.17</td>
<td>-.06</td>
<td>.22</td>
<td>(.70)**</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(.003)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PBL Background</td>
<td>15</td>
<td>-.32</td>
<td>.40</td>
<td>-.37</td>
<td>-.27</td>
<td>-.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Final Exam</td>
<td>9</td>
<td>.67*</td>
<td>(.95***</td>
<td></td>
<td>.56</td>
<td>.41</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prior Achievement</td>
<td>13</td>
<td>.39</td>
<td>-.01</td>
<td>-.27</td>
<td>.34</td>
<td>.33</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Residual Final Score</td>
<td>8</td>
<td>.67</td>
<td>.53</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Years Teaching Economics</td>
<td>15</td>
<td></td>
<td></td>
<td></td>
<td>.73***</td>
<td></td>
</tr>
</tbody>
</table>

***p < .001; ** p < .01; * p < .05

Note: Boxes are drawn around correlations that hold the most interest. (Italicized) correlations represent expected relationships based on construction of the measure, not findings. The number of cases, N, is based on the fewest number of cases per row. Smaller text shows statistically significant p-values or those that approached statistical significance.

The fifth row, concerning the residual final score, is most important. Years teaching economics and years teaching overall are strongly correlated to residual “gain” scores on the Final Exam, controlling for student prior achievement. Teachers with stronger economics backgrounds had students who did better on the final, even after controlling for their prior achievement. Finally, the last row is no surprise. Teachers with more years teaching economics tend to have more years teaching as well.

To summarize, years teaching economics was more strongly related than years teaching overall to student learning, but both were positively correlated, even after controlling for prior student achievement. By comparison, teachers’ PBL experience was either weakly or negatively correlated with the Final Exam scores, perhaps because they tended to be newer to the profession.

### Implementation of PBL

For teachers who use problem based learning, the task of classroom instruction and management is quite different from that faced by teachers employing the traditional instructional methods of lecture, discussion, and seatwork. Although PBL can (and often does) encompass these traditional instructional approaches, it gives equal or more emphasis to independent...
problem-solving work in small groups or by oneself and to “authentic assessment” strategies such as oral presentations.

It is important to understand how much the use of a problem based approach varies, as well as the reasons for these differences, and impacts on learning outcomes. After describing the patterns of agreement and disagreement between teachers and students, selected practices are correlated to student and teacher background measures. The final set of findings correlates these practices to learning outcomes.

This section compares the responses of students and teachers to the single most reported unit in our study, *The High School Food Court* (N=11 teachers). Teachers and students both provided an indication of how often each practice was used (with a possible range from 0 to 5) and how helpful it was (with a possible range from 0 to 3). Our analyses of agreement between student and teacher responses are based on the correlation of teacher and student responses at the classroom level, and a comparison of their mean responses. Although responses by teachers and students were often strongly correlated in a positive direction, this was not always the case. There were also some large differences in mean ratings given by teacher and students.

There was general agreement among teachers and students on use of core practices. Correlations between student and teacher responses ranged from .32 to .71. We also examined some more “traditional” practices for purpose of comparison— for example days watching a video, reading the textbook, and using computers. While there were strong correlations between student and teacher responses, mean responses by teachers and students differed substantially, for example with teachers reporting more use of textbooks (ES=-.64) and students reporting more days watching a movie or video (ES=.62). Another item on which there was substantial disagreement concerned the teacher answering student questions (r=.02, ES=-.58) and lecturing to students (r=-.69, ES=1.01). Teachers seem to under-report how much time students spend listening to lectures and think they talk less than they do in class. In short, it seems answering student questions is a practice that results in discrepant points of view, perhaps because this activity can takes up a large amount of teacher time while impacting relatively few students. (A teacher could spend an entire period answering only a few student questions, for example). Further analysis of the quality or amount of teacher-student and student-student interactions is beyond the scope of this paper.

Concerning the helpfulness of the practices being reported, teachers and students generally agreed on the helpfulness of items. The least well correlated item concerned the helpfulness of problem logs (r=.30). Analysis of mean differences suggest teachers considered the problem statement and the know-need to know lists to be somewhat more helpful (ES=-.24) than students did. Because of the discrepancies between student and teacher responses we separate student and teacher-reported practices when correlating these to learning outcomes.

A potential source of concern is that the “core practices” that we identified as being central to PBL were generally reported as among the least helpful by teachers and students. These practices we identified as core to the problem-based methodology may be perceived as more useful in setting up the conditions for learning (e.g., making a list of what you “need to know”) while other practices may be perceived as more directly helpful in actual delivery of content. Delivering content through direct instruction may be perceived as more directly helpful, however it is still possible that setting up of conditions for learning indirectly has a larger or longer term impact on learning, as addressed in the section that correlates these practices to learning outcomes.
PRACTICES RELATED TO STUDENT and TEACHER BACKGROUND
Factors that may influence teaching practices

This section examines to what extent practices and their reported helpfulness can be predicted by teacher and student background data. Analyses (not shown) uncovered both teacher-level and class-by-class differences in how the units are taught and which practices are reported as most helpful. For example, student-reported use of the problem statement ranged between an average 2.85 for the teacher with the least use to 4.30 for the teacher with the most use, (ES=1.03; S.d.= 1.41). There were also differences when the same teacher taught several classes, i.e., class-by-class differences for the same teacher. One teacher, who taught several classes of *The High School Food Court*, had students report a mean of 3.56 for returning to the problem statement in one class, while another class taught by the same teacher reported a mean of 2.41. These differences are generally consistent with qualitative observations and based on interviews with teachers and they appear to be related to teacher perceptions of student prior achievement.

Surprisingly, teacher background measures were very poor predictors of practice. Teacher prior experience using PBL-related strategies as indicated on their entry survey were negatively correlated with reported use of the practices that we considered as “core” for the curriculum. This means the pre-workshop pedagogy measure was not useful in predicting actual PBL unit implementation as reported by teachers or their students.

Student prior achievement was negatively correlated to use of core practices. This means PBL practices we identified as being “core” were used more by teachers who taught lower achieving classes than by teachers of higher achieving classes. This finding is seen at both the class and teacher level. Table G highlights the large negative correlations between student prior achievement and reported use of problem based practices. In *The High School Food Court* unit, use of the problem log was negatively correlated -.50 with student prior achievement measures. For *The President’s Dilemma* there are negative correlates with student prior achievement for all of the core practices that are listed, e.g., -.57 correlation between student-reported use of the problem statement and their prior achievement measures. These patterns are seen more in data aggregated at the teacher-level data than the class-level. However, student prior achievement was not related to teaching practices reported at the individual student level. This means the difference in use of practices occurs at the teacher level and to a lesser extent is accounted for by class-level differences. One cannot predict the practices reported by individual students based on their prior achievement, but these decisions are made at the teacher level based on characteristics of the students; teachers of lower performing students tended to use PBL practices more, especially in *The President’s Dilemma*.

As mentioned previously, this finding is consistent with classroom observation and interview data. Several teachers, including one in a continuation high school for at-risk students, indicated they use the problem log primarily as a classroom management tool -- to make sure students keep on task. In this case, the Problem Log may not always be used as intended - to promote reflective thinking and increased ownership of the problem. However, there does appear to be greater reliance on this practice among teachers of lower performing students. Theses students may need more guidance and structure while working through the problem, which is provided by the “core” practices.
Table G. Student prior achievement is negatively correlated to use of “core” practices

<table>
<thead>
<tr>
<th>Practices by Unit</th>
<th>Student Level Data</th>
<th>Student Data Aggregated at the Teacher Level</th>
<th>Student Data Aggregated at the Class Level</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation</td>
<td>Sig. (2-tailed) N</td>
<td>Correlation</td>
</tr>
<tr>
<td>The High School Food Court</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>create and come back to the</td>
<td>0.05 NS 512</td>
<td>0.14 NS 9</td>
<td>0.08 NS 30</td>
</tr>
<tr>
<td>problem statement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>make and update lists of what</td>
<td>0.01 NS 513</td>
<td>-0.04 NS 9</td>
<td>0.01 NS 30</td>
</tr>
<tr>
<td>you know and need to know?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>write answers to questions in</td>
<td>-0.09 NS 513</td>
<td>-0.58 .10 9</td>
<td>-0.52 .005 30</td>
</tr>
<tr>
<td>your journal, problem log or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>workbook?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The President’s Dilemma</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>create and come back to the</td>
<td>0.02 NS 341</td>
<td>-0.57 .24 6</td>
<td>-0.41 .08* 19</td>
</tr>
<tr>
<td>problem statement?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>make and update lists of what</td>
<td>0.01 NS 346</td>
<td>-0.66 .15 6</td>
<td>-0.27 .27* 19</td>
</tr>
<tr>
<td>you know and need to know?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>write answers to questions in</td>
<td>-0.02 NS 341</td>
<td>-0.48 .33 6</td>
<td>0.00 NS 19</td>
</tr>
<tr>
<td>your journal, problem log or</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>workbook?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* Note. p< values are shown if it appears a few more cases would make the finding statistically significant.

These findings lead to questions about why the problem log is not used more frequently, particularly in high achieving classes, and how to encourage more substantive use. It also raises questions about differences in practices for each unit and differences in supports required for teaching different topics represented by these two macro- or micro-economic units.

PBL Practices Correlated with Learning Outcomes

This section analyzes the relationship of different “core” PBE and “traditional” practices to student learning outcomes. Learning outcomes are represented four different ways – 1) raw final exam scores; 2) short term gains based on unit pre-post test scores, 3) long term gain, based on unit pre-test to final exam test scores on similar items, and 4) long-term “residual” gains from pre-test to final exam, controlling for prior achievement, an independent variable that was previously shown to be a substantial predictor of final exam scores.

Although the previous section on implementation suggested “core” problem based practices were somewhat under-utilized and under-valued compared to other practices, our findings suggest they are more strongly and positively related to both the final exam scores, and long term gains in learning, than the other practices we examined. Table H clearly indicates that it is the “core” PBL practices that are associated more strongly with long-term learning outcomes, while the other practices tended to be associated with short-term gains only, with mostly negative correlations to long-term learning. When prior achievement is controlled these “core” practices were even more associated with long-term learning gains (data available from author) In contrast, the “other” or “non-core” practices we examined tended to be more closely associated with short-term learning only and were negatively correlated with long term gains. There were a couple of exceptions to this pattern. A few non-core practices also had larger long term learning gains (listening to lectures and asking questions) while classes that reported more
use of the problem log (a core practice) did not. These findings were not statistically significant and pertained only to student reports of practices used.

Table H shows correlations between practices (days or helpfulness) and the learning outcomes (short- and long-term). More teachers provided complete data for analysis of short-term learning gains (N=9) than for long-term learning gains (N=6). The short-term gain represents the gain from pre- to post test. The long-term gain represents the gain from pre-test to the final exam (using only items from the final pertaining to that unit). Correlation with each practice item is shown for both sets of gains.

To help summarize these data we created an overall measure of implementation fidelity, based on mean scores for each of the “core” PBL practice items (and dividing each item by its standard deviation to control for differences in central tendency and standard deviations). When the core practices are combined into an index for The High School Food Court the above pattern is even clearer. The “core practice index” was correlated with the overall final exam score (50 items) (r=.59 p < .20) and with the items on the final exam that correspond to this unit (r = .82, p < .02). In contrast the core practice index was not correlated (r=.09, NS) with the short term learning measure.

DISCUSSION

This section discusses the results of this study. First, it discusses the findings about student background and outcomes in PBL; these represent one of the most important sets of findings for this study. Second, it discusses how teacher and student background variables seem to relate to both implementation of problem based instruction, and third, it speaks to the evidence that long term learning outcomes are correlated to use of “core” PBL practices in our curriculum.

Student Backgrounds Related to Outcomes in Problem Based Learning

The first part of this article sought to clarify the backgrounds of students who benefit from a problem based curriculum. Results suggest problem based instruction may be particularly effective at engaging students who have done less well with traditional instruction – i.e., those
who report lower prior achievement -- and who initially had the least interest in economics compared to others. This finding is relevant to the growing interest in studying the “resiliency” of students who outperform expectations based on background characteristics alone. It is important to identify what allows students from groups that have traditionally done poorly to do well in school. It is possible that problem-based approach helps motivate students who otherwise have fared poorly, creating conditions for learning and resiliency (Borman & Overman, 2004).

The important exception in our study appears to be English language learners. On average, Hispanic and second-language English speakers scores suggest many of these students may have struggled with problem based learning, compared to what they reported in terms of prior achievement. Language barriers may play an important role influencing problem based learning outcomes because the problems can be fairly language-intensive. Economics may a conceptually difficult and abstract subject that is difficult for high school students to learn without good English skills. PBL methods may have to be refined to overcome difficulties using a problem-based approach with students who have limited English skills. At the same time, we speculate that this same issue may be present in traditional classrooms as well. (A limitation of this study is that there is no control group to see if this is the case). The assessments in this study were similar to those that are commonly used, so it seems doubtful that language issues on the assessments influenced the results; it is more likely something about students’ interaction with the curriculum and instruction. The language measures did not ask about level of fluency with English, only if the student’s first language was English. Besides English skills alone, we speculate that lower scores among Hispanic students could also reflect a cultural effect or adherence to a different set of economic beliefs, resistance to certain competitive economic principles in favor of a more communitarian view, or more traditional beliefs about the role of learners and teachers in the classroom. Future research will address whether this is the case or if it simply the language requirements of PBL that must be addressed to help these students.

The overall pattern we see is one that suggests PBL might help reduce the achievement gap between high and low performing students. However, it was not just the lowest achievers who appeared to do well with the curriculum. Instead, our findings suggest there may be a curvilinear effect between prior achievement and test score gains in problem based learning. We speculate it may be students with average prior achievement who do reasonably well with traditional lessons but who are not particularly adept at or willing to respond to the challenges of problem based instruction.

Teacher and Student Backgrounds Related to PBL Implementation

We had a limited number of cases, so we have to place less confidence and emphasis on teacher-level findings. Nonetheless, it is important note how teacher background seems to relate to PBL implementation and outcomes. Data suggest the content background could be one of the most important variables in predicting student outcomes, even after controlling for student entry characteristics. Teachers with strong PBL experience who lacked economic content knowledge were less likely to generate strong learning outcomes than teachers who has strong economics background but little experience with this kind of teaching.

These findings have added importance because a vast majority of economics teachers in our study, and nationally (cite) had little or no college coursework in economics. We conclude it is very important for researchers to take into account the content knowledge of teachers when assessing curriculum effectiveness. Even in a problem based curriculum, the content knowledge
of the teacher may be critical, as reported by economic educators like Allgood & Walstad (1999) and Willison & Kelly (2004). At the same time, our findings about implementation of “core” practices being related to long term learning suggests professional development may appropriately focus not only on teacher content knowledge but also on how one can use PBL pedagogy to generate better learning outcomes for students.

Variations in Implementation of Problem Based Learning

Teaching practices appear to vary by teacher, and to a lesser extent by class taught. Teachers’ prior PBL experience on their entry survey was a weak or even negative predictor of use of core practices when implementing the problem-based curriculum units. When there were class-level (within teacher) differences, they seemed to relate to the prior academic achievement of their students. We found that core practices are not being used as much in the most academically advanced classes as in others. We found teachers of students with higher prior achievement levels tended to use core practices less often than other teachers. Perhaps in high achieving classes there is substantial pressure to cover large amounts of content and the “core practices” are perceived as less good a fit for students who are generally succeeding well with traditional instruction.

Less experienced PBL teachers may rely more on the scaffolds that are provided with the curriculum, as indicated by their greater use of the “core” practices we identified. Teachers with stronger background implementing problem based learning may be more likely modify the script to their liking, while novices may follow a more routine approach. Research shows that once someone is familiar with an innovation many take the next step of modifying it to suit their purposes (Hall, Loucks, Rutherford & Vewlove, 1975). In the end, effective teachers follow routines and adapt them when they are helpful. Variations in implementation is a topic to be explored further and future research must ask what it takes to get faithful use of the materials and how these are related to effectively engaging diverse learners.

Even though the materials offer a fairly prescribed and structured approach, there is no “rote” curriculum that is used by all teachers with all students. Instead, there is substantial variation in the delivery of problem based learning. The curriculum in this study was designed so that “core” PBL practices are used in concert with more “traditional” instruction (it’s not either/or). The distinction in approach is in many ways more a question of timing -- not lecturing first and then doing a project, but starting the project and lecturing when students feel a true “need to know”. The problem log and other core practices were among the least helpful practices and used practices. Although the problem log was not intended for daily use, this finding supports the argument that the status quo of teaching includes frequent use of projects and problems but infrequent or ineffective use of journals or reflective writing (Ravitz, Wong & Becker, 1999). In addition, we saw evidence that what teachers and students perceive to be useful may not be what is really useful for long term learning.

Teaching practices also differed substantially based on the content of the unit being taught. Despite having similar overall structures, individual economics problem based units may have their own “best practices” for teaching. For example, content lectures are provided with each unit but may be more critical for units with relatively abstract macro-economics topics like The President’s Dilemma unit. Research has found perceptions about the nature of the subject influences the use of pedagogy (Ravitz, Wong & Becker, 1998; Grossman & Stodolsky, 1995).
Outcomes Related to Implementation

The last set of findings concern long and short-term learning outcomes related to implementation of problem-based learning. Checklists of practices provided data about differences in implementation and are correlated to learning outcomes. It appears that several of the “core” PBL practices are closely correlated with long-term learning. We tentatively conclude that traditional practices may sometimes correlate with short-term learning, even better than our “core” problem-based practices, but very rarely do they correlate as strongly with long-term learning. The core practices are the ones that had the strongest relationship to long-term learning. This is consistent with what theory would predict about the strengths of PBL in helping students retain their knowledge.

There are a number of reasons the core practices could lead to more meaningful long-term learning. First, these practices such as writing in the problem log and keeping a knowledge inventory may promote greater amounts of critical analysis, reflection and deeper processing of information about the problem. These practices may direct students’ attention to the deeper structure of the problem, causing them to think more carefully about the complex issues involved. It is also possible that these core practices provide a point of return for students to revisit these issues over the course of the problem, in a way that might accommodate their own learning needs while use of lectures and textbooks may be more single-dose treatments that do not promote ongoing reflection about the problem. Finally, it seems likely that there are motivational attributes of the core practices, a sense of ownership fostered among students that is lacking in a traditional lecture/discussion. Even though we observed core practices being used in fairly rote ways, with lower performing students, this may still be an improvement on traditional instructional methods. Further research is required to determine the extent to which the PBL approach stimulated student interest and motivation in economics.

Future Directions

In the future, greater rigor will be required to address the impact of PBE on high and low-achieving students. Specific steps include comparing learning outcomes for different types of students to those in traditional economic lessons, using a control group. Future studies will also increase the sample size to permit more rigorous multivariate and multi-level analyses of the numerous variables in the study to see which can account for the greatest amount of variation in teacher implementation and student learning. This includes further analyses of effects at the student, class, and teacher levels, and partial correlations, and regression analyses employing teacher and student background data.

Another important step is to develop better measures of implementation of problem-based learning, including not just which practices were used, but with what intention, quality, and resulting interactions. This includes creating unit-specific checklists of practices, further triangulating our results with observations and interviews in diverse settings. We might look more closely at use of the curriculum by teachers with stronger PBL backgrounds. We had assumed these teachers would pursue more faithful implementation of our core practices, but this is not what we found. In addition, we might reconsider or broaden our interpretation of “core practices” e.g., to include group work, and formative assessment, and aspects of the timing of content lectures and discussions.

It would also help to know more about what is taking place in economics classes when units are not being used, to have more information about student English fluency, and learn how
teachers adapt the materials for different types of classes. Adding a semester pre-test to address variable timing of the use of units within the semester would also be useful.

Finally, future research could employ a more complex set of assessments of learners that go beyond the multiple choice tests. We will work to create content-rich transfer tasks and “non-content” assessment of skills: problem-solving, collaboration, argumentation, presentation.

Conclusion
In conclusion, this study provided an opportunity to understand the use of PBL and its impact on diverse learners. Our findings suggest this is a complex area of investigation but that PBL can contribute to a reduction in the achievement gap and increase student retention of learning.

REFERENCES


Appendix A. Teacher Background Indices

Teacher Economics Content Background Index
Standardized reliability alpha = .83, .34 < Corrected item-total correlation < .70

1. Rate your content knowledge in economics (1=poor; 4=excellent)
2. How much College training did you have (1=none; 4=graduate major)
3. Years teaching Economics?
4. I have training that helps me understand economics (1-4, disagree/agree)
5. I have training about how to teach economics (1-4, disagree/agree)
6. Teaching economics is difficult (reversed) (1-4, disagree/agree)

Teacher PBL Background Index
Standardized Reliability Alpha = .89, .47 < Corrected item-total correlation < .82

1. Teaching with PBL is similar to how I teach all the time (1-4, disagree/agree)
2. How would you rate your own knowledge of PBL methods (1=poor; 4=excellent)
3. How would you describe your use of PBL (1-never really tried; 4-frequently)
4. How often do you assign projects for week or more (1-6, never/daily)
5. How often do you assign small groups (1-6, never/daily)
6. How often do you assign open-ended problems, no obvious solution (1-6, never/daily)
7. How often do you assign work that requires computers (1-6, never/daily)
APPENDIX B. TEACHER BACKGROUND SURVEY
STEP 2: TEACHER SURVEY: Problem-based Economics (PBE, Fall 2002)

Instructions: For each question, select one best response, unless indicated otherwise. Please fill in the blanks when they are provided. Thank you.

1. Your Name: (first) ___________ (last) ___________

2. How many years experience do you have teaching any subject or level? _______

3. How many years have you taught high school economics? _______

4. What semester(s) during the year do you teach economics now? Check ALL that apply.
   - [ ] Fall semester
   - [ ] Spring semester
   - [ ] Summer semester

5. Approximately how many economics classes are you teaching this year? (If not sure, what is your guess about how many economics classes you will teach in the next 12 months):
   (e.g., 2 semesters with 3 periods each = 6 classes) _______

6. How many other teachers, besides you,
   a. teach social science or social studies in your school? ___________
   b. teach economics in your school? ___________

7. Have you ever taken a college-level economics class? [ ] No [ ] Yes
   7b. If yes, please indicate the extent of your classes:
   - [ ] one course
   - [ ] a few college-level courses
   - [ ] undergraduate minor in economics
   - [ ] undergraduate major in economics
   - [ ] graduate level courses

8. How would you rate your own...
<table>
<thead>
<tr>
<th>Poor</th>
<th>Fair</th>
<th>Good</th>
<th>Excellent</th>
</tr>
</thead>
</table>
   a. content knowledge in the area of economics? [ ] [ ] [ ] [ ]
   b. knowledge of problem-based learning methods? [ ] [ ] [ ] [ ]

9. How would you describe your use of problem-based or project-based teaching?
   Answer for all subjects you have taught.
   - [ ] a. I have not really tried PBL very much
   - [ ] b. I have tried PBL, but have had only limited success
   - [ ] c. I have used PBL successfully in my teaching occasionally
   - [ ] d. I have frequently used PBL in my teaching with success
10. Indicate your agreement about your experience teaching economics. If you have not yet taught economics, check this box (□) and skip to number 11.

<table>
<thead>
<tr>
<th>Strongly Disagree</th>
<th>Tend to Disagree</th>
<th>Tend to Agree</th>
<th>Strongly Agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. I have training that helps me understand economics.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. I have training about how to teach economics.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. Teaching economics is difficult.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>d. My students find economics to be interesting.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>e. Students have difficulty learning economics.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>f. I am satisfied with what my students learn.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>g. I have used project- and problem-based methods to teach economics.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>h. I am concerned that using Problem Based methods takes too much time and prevents coverage of sufficient content.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>i. I have sufficient time in the curriculum for trying new ideas for teaching economics.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>j. How I teach PBE units is similar to how I teach all the time.</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>k. I have conversations with other teachers in my school about teaching on a regular basis?</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>l. I have conversations with other teachers outside of school about teaching, (e.g., in workshops, at conferences and meetings)?</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>

11. How much has BIE contributed to your knowledge and skills in these areas...

<table>
<thead>
<tr>
<th>BIE contributed very little, or none</th>
<th>BIE contributed a little</th>
<th>BIE contributed some</th>
<th>BIE contributed a lot</th>
<th>BIE is the primary source of my knowledge and skills</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. economics content.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>b. teaching economic concepts.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
<tr>
<td>c. using problem or project based methods.</td>
<td>□</td>
<td>□</td>
<td>□</td>
<td>□</td>
</tr>
</tbody>
</table>
12. When students in your economics classes are NOT working on PBE units, how often do you assign them to….

<table>
<thead>
<tr>
<th>Activity</th>
<th>Almost never</th>
<th>Occasionally</th>
<th>At least weekly</th>
<th>Several times per week</th>
<th>Almost daily</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Work individually answering questions in the textbook or worksheets</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>b. Work on projects that take a week or more.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>c. Write in a journal or write essays</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>d. Work in small groups</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>e. Work on “open-ended” problems with no obvious procedure or solution</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>f. Work on assignments that require use of computers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

13. Which of these characterizes the school where you teach?
Check ALL that apply.

- a. Public school
- b. Private or parochial (church) school
- c. Block scheduling
- d. Career academy
- e. Small learning community
- f. Alternative or continuation
- g. Team teaching/Interdisciplinary teams
- h. Other (explain): __________________________

14. Which of these characterizes at least one economics class you taught or will teach this year?
Check ALL that apply. You teach (or will teach) an economics class that is predominantly…

- a. heterogeneous students
- b. homogeneous students
- c. minority students (black, Hispanic, Asian, native American, or mixed)
- d. limited English proficient students
- e. honors/academic prep
- f. AP/college credit
- g. low-performing or remedial
- h. none of the above / other: ________________

15. Is there any other information that you feel would be helpful or that you want to share?
___________________________________________________________________________________________________________
___________________________________________________________________________________________________________

Next Steps
Please mail this TEACHER SURVEY with your ENTRY FORM using the enclosed envelope to:
Marie Kanarr    Buck Institute for Education    18 Commercial Blvd.    Novato, CA    94949

Note. If you are starting in the next two weeks, please contact us by email, fax, or phone!
Fax: 415-883-0260    Voice: 415-883-0122 x 310    Jason@bie.org
APPENDIX C. STUDENT BACKGROUND SURVEY
Instructions: We are interested in learning more about your background and interests in economics. Please fill in your answer like this:

1. Please fill in: Student ID #: _______   Teacher ________________________________Period #_______________

2. What is your gender (optional)?
   Male    Female
   A       B

3. What are you planning to do next year after you graduate from high school? (check one)
   A  Attend a community college, or 2-year college
   B  Attend a technical school, getting a license or certificate
   C  Join the armed forces or military service
   D  Get a job (including an internship, voluntary or for pay)
   E  Attend a very competitive 4-year college – like UC, Berkeley or Stanford
   F  Attend a less competitive 4-year college, like SFSU or a Cal State school
   G  Travel
   H  Do not know yet
   I  None of the above, or other (please specify): _______________________

4. Is English your first language?
   Yes    No
   A       B

5. Do you speak another language in your home?
   Yes    No
   A       B

6. How would you characterize your ethnicity(optional)?
   White (Caucasian, non-Hispanic)  Asian American  Black/African American  Hispanic/Latino/Latina  Mixed  Other
   A       B       C       D       E       F

7. How do you think you will do in school this coming semester, in all your classes? (Fill in one).
   All A's  Mostly A's  A's & B's  Mostly B's  B's & C's  Mostly C's or lower
   A       B       C       D       E       F

8. Compared with other classes you have taken, do you expect economics to be --
   A  One of the more interesting classes
   B  As interesting as other classes
   C  Not as interesting as other classes, but worth taking
   D  Not as interesting as other classes, and not worth taking
APPENDIX D. CHECKLIST OF PRACTICES (student version)
**STUDENT END-OF-UNIT CHECKLIST**

**Name of Unit (circle one):**  
- Food Court  
- Matildaville  
- Great Awakening  
- Running in Place  
- President’s Dilemma  
- Other

**Student ID#: ________**  
**Teacher : __________________**  
**Period: ___**

**Instructions**: Here is a list of things you may have done during this unit.

1) On the left choose “how many of the days” you can remember doing these things during the unit.

2) On the right choose how much each “helped you learn” when you did it.

There are no right answers! If you do not remember doing these things, fill in “None” on both sides. Fill in your choices completely – like this:

<table>
<thead>
<tr>
<th>How many of the days during this unit did you do these things?</th>
<th>Instructions:</th>
<th>How much did it help you learn when you did this?</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>One day</td>
<td>A few days</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>4</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- Reading or looking up information in the textbook
- Listening teacher lectures about economics and class discussions
- Taking or reviewing notes during a teacher-led discussion
- Participating in class discussions and answering questions from the teacher
- Studying a graphic or visual aid about economic ideas
- Watching a movie or video about economics
- Doing worksheets – with short answers or fill-in-the-blank questions
- Creating and coming back to the problem statement
- Making and updating lists of what you know and need to know
- Writing answers to questions in your journal, problem log, or workbook
- Spending time by yourself reviewing the information you had
- Talking about the problem in your group, without the teacher
- Talking about the problem when the teacher visits your group
- Studying numbers, tables or graphs you were given about the problem
- Understanding concerns of different groups (elderly, unemployed, business)
- Using math to help solve the problem or understand economics concepts
- Filling in charts with other information about the problem, not just numbers
- Asking the teacher questions when you do not understand
- Reviewing the economic concepts needed to solve the problem
- Creating your solution to the problem
- Preparing your presentation to the class
- Making pictures, charts or drawings to summarize your solution
- Using a computer for any purpose to help complete the unit
APPENDIX E. ASSESSMENT MODEL

Assessing Short- and Long-term Learning

Semester Begins

"Short-term" learning (pre-post)

Unit Pre Test → Unit Post Test

"Long-term" learning (pre-final)

Final Exam with items from each unit

Semester Ends