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# The Effect of Peer Leader Instruction on Introductory University Science and Mathematics Course Performance: Preliminary Results

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**Abstract**

The Peer Instruction Leader (PIL) program at Columbus State University pairs courses having historically low success rates with dedicated peer helpers in an attempt to boost student learning and success. PILs are selected from undergraduate students who have demonstrated success in the targeted subject. They attend classes, meet with the assigned instructor periodically, participate in PIL training, and manage course focused discussion groups. The authors analyze data collected in the early stages of the program, which shows that students who attended the discussion groups fared better than those who did not.

Across the country, higher education institutions are struggling to improve success rates in introductory STEM courses. "At University System of Georgia (USG) institutions, the lack of appropriate student preparation is manifested in DWF (drop, withdrawal, and fail) rates for introductory level science, technology, engineering and mathematics (STEM) courses ranging from 30% to 50%" (USG STEM Initiative report, 12/18/08). In 2010, at Columbus State University (CSU), the DWF grade rates in introductory STEM classes ranged from a high of 39% in mathematics to as low as 29% in chemistry. To address this issue, the institution piloted a peer instruction leader project for introductory math and science courses in Fall 2011 with the support of USG STEM II Initiative grants and the Dean of the College of Letters and Sciences. This paper discusses the development of the project, as well as the preliminary results of its implementation.

## Background

The USG Math + Science = Success STEM Initiative (STEM I) was a significant springboard for postsecondary institutions in Georgia to demonstrate sustainability of research-based effective strategies to improve STEM education. STEM I funding in 2008 allowed CSU to establish the Math and Science Learning Center (MSLC), hire additional faculty to address course bottlenecks, and award small grants to faculty for projects that supported the scholarship of teaching and learning. In 2011, CSU was awarded additional funds to support the second phase of the USG STEM Initiative (STEM II).

With STEM II, CSU built on the success of one of the STEM I mini grants: Cross Year Peer Assisted Learning in Introductory Biology Courses. Dr. Kathleen Hughes, a biology faculty member, initiated the project because of large percentages of students that failed a lower division biology course offered in 2007 and 2008. As a result, 41% of the enrolled students were repeating the course. Background research noted that these percentages aligned with national attrition rates in introductory science courses (Tenny & Houck, 2003). In an attempt to raise students' scores, Hughes (2011) implemented a Peer Instruction Leader (PIL) program, which Tenney & Houck (2003) demonstrated as efficacious for introductory science courses, and Hughes (2011) found effective for anatomy and physiology courses. PIL programs are based upon student leaders that are enrolled in or have passed a particular course. The PILs manage specific course-focused discussion groups or laboratory sections for students (Tariq, 2005). Hughes recruited PILs and provided regularly scheduled training specific to her course section. Hughes' results from implementation were encouraging. Students who attended at least five PIL help sessions had higher grades, and higher posttest versus pretest scores, than students who attended fewer than five sessions.

The goal of the PIL project was to replicate Dr Hughes's program across a variety of introductory math and science courses to determine if an institution-wide program utilizing PILs could significantly improve student success rates.

## Literature Review

The use of peer tutoring has been shown to positively impact student academic performance when associated with specific courses. For example, optional peer-led supplemental instruction sessions have been shown to have positive effects on end of courses grades in introductory chemistry courses (Rath, Peterfreund, Bayliss, Runquist, Simonis, 2012), in anatomy and physiology courses, (Hughes, 2011), and in calculus courses (Fayowski & MacMillan, 2008). Similarly, Comfort (2011) found that undergraduates in sports science who attended optional peer tutoring sessions in their final year of the same program had significantly higher grades that those that did not attend. Contrastingly, Walker and Dancy (2007) studied the academic performance of students who utilized a Physics Resource Center for tutorial services for algebra-based and calculus-based physics courses and found significantly lower grades among those who visited the center, but attributed the result to "those who need the help the most being more likely to attend, rather than any adverse effects of tutorial attendance" (p. 138). These findings (Comfort, 2011; Fayowski & Macmillan, 2008; Rath, et al., 2012; and Walker & Dancy, 2007) suggest that the use of undergraduates for peer tutoring may be effective when course-based, but results may be impacted by self-selection bias.

## Implementation of the Project

A long-term goal of a project such as this is to determine the viability of an institutionalized program across all introductory Math and Science courses. Since literature suggests that course-based peer instructional leaders are successful, the next step would be to establish an institutionalized program that employs PILs in a sample of introductory courses that represent a majority of STEM disciplines. A successful pilot implementation will also have a secondary benefit in that it may improve faculty buy-in for future implementation on a larger scale.

The initial goals established were to 1) develop well-defined roles for PILs and for mentors, 2) recruit mentors teaching a broad range of introductory STEM courses, 3) recruit qualified PILs, 4) determine the impact of attending PIL sessions on course performance, and 5) determine if attitudinal differences of instructors or PILs impacted course performance. This paper discusses the progress on the first three goals and preliminary results on the fourth goal. The fifth goal will be the subject of future analysis.

The peer instruction leader project began by the careful development of roles and responsibilities of the PILs and their mentor teachers, in consultation with Dr. Hughes and the current and former Directors of the Math and Science Learning Center (MSLC) (who oversee both faculty development and tutorial services in STEM). It was essential to define the role of a PIL as providing coordinated supplemental instruction rather than providing teaching and grading assistance to the instructor. This distinguishes traditional Teaching Assistant roles that support instructors from PILs, which primarily provide student learning support.

## PIL Roles and Responsibilities

A peer leader is an undergraduate student hired to organize and lead optional discussion sessions outside of class meeting times. The peer leader is knowledgeable of course content and attends all class meetings. The peer leader attends periodic training sessions. Discussion sessions may include, but are not limited to, clarifying course information, cooperative learning exercises to foster student learning, and advice on studying and assimilating the course material. The peer leader should be able to contact the instructor with course-related questions. See Table 1 for more explanation of the PIL roles and responsibilities.

Table 1
*Defined Responsibilities of Peer Instruction Leaders and Course Instructors*

| | **Responsibilities include** | **Responsibilities do not include** |
|---|---|---|
| **Peer Instruction Leaders** | *Attending a peer leader orientation meeting at the beginning of the semester<br>*Attending all course meetings<br>*Leading 2-4 optional sessions for students in this section outside of class time per week<br>*Taking student attendance at all session meetings<br>*Recording and submitting contact times with the professor<br>*Contacting the instructor if questions or problems arise<br>*Completing a Peer Instruction Study survey at the end of the term | *Grading assignments or exams<br>*Preparing course materials for lecture or lab<br>*Informing the instructor who is/is not attending sessions<br>*Leading exercises during lecture or lab times<br>*Setting up laboratory exercises or class demonstrations |
| **Course Instructor** | *Introducing the peer leader to the class at the beginning of the semester<br>*Submitting final grades in the form of percentage points earned by all students in the course<br>*Completing a Peer Instruction Study survey at the end of the term<br>*Allowing time at the end of the semester for students to complete a Peer Instruction Study survey. | *Tracking which students attend/do not attend peer leader sessions.<br>*Giving any grade incentive to those students who attend peer leader sessions<br>*Creating or distributing materials for the peer-led discussion sessions |

## Recruitment

Faculty mentors and PILs were recruited by email contact, informational sessions, and one-on-one contact with the project directors. Faculty members were selected based on 1) their willingness to participate and 2) the variety of disciplines represented in the pilot group. While some PILs were specifically identified by faculty mentors, all PILs were vetted through an application process to ensure their levels of academic competence, willingness to execute the roles and responsibilities as defined by the project directors, and potential to have successful interactions with peers in this context. Mentors and PILs attended professional development sessions periodically throughout the semesters in which they participated in this project. The content and frequency of the professional development sessions varied by semester and that variation will be included in future analysis of the project with respect to attitudinal differences of mentors and PILs. In total, a total of 11 faculty and 20 PILs were recruited during three semesters of implementation from Fall 2011 to Fall 2012, serving a possible 1653 students.

## Impact of PIL Session Attendance on Course Performance

The following data were utilized to determine the impact of sessions held by Peer Instructional Leaders (PILs) for introductory math and science courses during three semesters at Columbus State University:

- Attendance records maintained by the PIL.
- End of course letter grades submitted to the university by professors and converted to a numeric scale (A=4, B=3, etc.)
- Percentages of courses points submitted by professors to the researchers

Data were requested from all professors who were assigned a PIL to their particular courses (e.g. Principles of Biology) and included end of course performance for all students who were enrolled in any of section of the course that the professor taught. For the analysis, only courses that had complete PIL session attendance records were included and all cases of academic withdrawal or course auditing were excluded. The latter exclusion allows us to compare grade performance of all those completing the course, since those who withdraw typically did not attend PIL sessions. As a result, a total of 1000 cases were included, but were not disaggregated by course since the sample sizes in some disciplines were not large enough to reach conclusions. Of those cases, 653 students never attended a PIL session and 347 attended at least one session. One of the initial concerns of the PIL project was an observed lack of attendance at PIL sessions, but it has steadily improved as seen in Table 2.

By Fall 2012, 62% of Principles of Biology students attended at least one PIL session, with an overall average of 41% of students enrolled in targeted courses attending at least one PIL session. There was also an improvement in the number of sessions students attended comparing Fall 2011 to Fall 2012, with 24% of student attending more than one session (See Table 3).

When comparing performance of those students who attended any PIL session to those who did not attend, the percentage of end of course points earned (course points), which were available for only 762 cases, and end of course grades for all 1000 cases were examined. The course points earned had a dramatic range from 6 to 104 points, so end of course grades tempered extreme ranges of those who earned F's (6-59 points). A two-tailed t-test for independent samples found that those who attended at least one PIL session earned significantly greater course points *t*(722)=2.84, p<0.005. Overall, those who attended more than one PIL session performed an average of 5.7 percentage points higher on their end of course grades than those who never attend sessions, as shown in Table 4.

Table 2
***PIL Session Attendance***

| **Course** | **Attended** | **Enrolled** | **Percent** |
|---|---|---|---|
| Principles of Biology | 71 | 166 | 43% |
| Principles of Physics | 11 | 45 | 24% |
| Introductory Statistics | 11 | 65 | 17% |
| **Total Fall 2011** | **93** | **276** | **34%** |
| College Algebra | 14 | 116 | 12% |
| Principles of Chemistry II | 13 | 38 | 34% |
| Principles of Biology | 40 | 125 | 32% |
| Principles of Biology | 34 | 75 | 45% |
| **Spring 2012** | **101** | **354** | **29%** |
| Principles of Biology | 58 | 93 | 62% |
| Geology of Natural Disasters | 37 | 162 | 23% |
| Principles of Chemistry I | 58 | 115 | 50% |
| **Fall 2012** | **153** | **370** | **41%** |
| **Overall** | **347** | **1000** | **35%** |

Table 3
*Percentage of Enrolled Students Attending PIL Sessions*

| | Fall 11 | Spring 12 | Fall 12 |
|---|---|---|---|
| Never attended | 66% | 71% | 59% |
| Attended only once | 14% | 11% | 18% |
| Attended more than once | 20% | 18% | 24% |

Table 4
*Average Percentage of End of Course Points*

| Attended | Fall 11 | Spring 12 | Fall 12 | Overall |
|---|---|---|---|---|
| Never | 70.1% | 70.3% | 70.2% | 70.2% |
| Once | 70.4% | 68.3% | 75.5% | 72.0% |
| More than once | 73.1% | 77.9% | 76.9% | 75.9% |

With respect to end of course grades, a one-tailed t-test also found significantly greater performances (*t*(998)= 5.68, p<0.001) for those who attended at least one PIL session earning a 2.21 course grade point average in their course compared to a 1.75 earned by those who did not attend. The grade distributions also indicated that 75% of students who attended at least one PIL session earned grades of A, B or C compared to only 56% of students who never attended a session as shown in Table 5.

Table 5
*Grade Distributions*

| Grade | Attended | Never Attended |
|---|---|---|
| As | 14% | 10% |
| Bs | 25% | 21% |
| Cs | 37% | 25% |
| Ds | 17% | 23% |
| Fs | 8% | 21% |

**Controlling for Student Ability Using Grade Point Averages as Predictors**

To determine if there was a significant difference in student ability between students who attended and never attended PIL sessions, two separate t-tests for independent samples were conducted using (1) high school grade point averages (HS-GPA) and (2) mean institutional grade point averages earned by the students the semester prior to enrolling in the introductory course, (I-GPA). There was not a statistically significant difference (*p* =0.05) in ability between those who attended and those who never attended when using either HS-GPA or I-GPA to predict ability (see Table 6).

In addition, multiple regressions controlling for the same variables (HS-GPA and I-GPA) were performed to determine if the number of times a student attended PIL sessions was a predictor of course points earned. In both regressions, the numbers of times a student attended PIL sessions was a significant contributor to the statistical models, though both models demonstrated weak correlations for predicting course points. The HS-GPA & Attendance model explained 11% of the variance ($R^2 = 0.11$, $F(2,638) = 39.6$, $p<.001$), and the standardized attendance coefficient was a significant predictor ($\beta =.154$, $t(640)=4.11$, $p<.001$). Similarly, I-GPA & Attendance explained 6.7% of the variance ($R^2 =.067$, $F(2,759) = 27.114$, $p<.001$) and the standardized attendance coefficient was a significant predictor ($\beta = 0.148$, $t(761)=4.21$, $p<.001$).

Table 6
*Mean High School and Institutional Grade Point Averages (GPA)*

| | Attended PIL | N | Mean GPA | St Dev |
|---|---|---|---|---|
| High school GPA | Yes | 227 | 3.06 | 0.49 |
| | No | 414 | 3.07 | 0.52 |
| Institutional GPA | Yes | 275 | 2.54 | 1.21 |
| | No | 487 | 2.43 | 1.19 |

Since course points were again being used, and varied dramatically, we repeated our analysis excluding all cases with course points below fifty to make sure those grades were not skewing the interpretation. The results were again statistically significant. The HS-GPA & Attendance model explained 10% of the variance ($R^2 = 0.10$, $F(2,599) = 33.8$, $p<.001$), and the standardized attendance coefficient was a significant predictor ($\beta =.131$, $t(600)=3.37$, $p<.001$). Similarly, I-GPA & Attendance explained 5.2% of the variance ($R^2 =.052$, $F(2,712) = 19.462$, $p<.001$), and the standardized attendance coefficient was a significant predictor ($\beta = 0.118$, $t(712)=3.22$, $p<.001$). Therefore, when statistically controlling for either high school or CSU grade point averages, the number of times a student attended PIL sessions, as reported by peer leaders, appeared to positively impact the course points earned.

**Discussion**

Preliminary results indicate a higher rate for productive student grades, as defined by percentage of students receiving a grade of A, B, or C for the course. In particular, the percentage of A grades increased for those students attending PIL sessions (perhaps indicating the impact on students of higher ability). The percentage of C grades also increased, while rates of D and F grades decreased among students attending PIL sessions.

The preliminary results of this study are consistent with the findings of Hughes (2011) and others who have utilized course-based peer assisted learning. Students who attended PIL sessions increased their end-of-course grades on average 0.5 on a 4.0 point scale and by 5 points on a 100 point scale. There were not significant differences in student HS or college grade point averages between those that attended sessions and those that did not, indicating that the PIL sessions could be having a positive impact on course performance. This allows accounting for the ability of the students, but not necessarily other factors such as motivation or other self-selection biases.

The results may also be confounded by limiting the analysis to cases with complete records of course points earned and attendance at PIL sessions. The former may limit the data to only those faculty who were committed enough to the project to provide all of the requested information, and the latter limited data to those peer leaders who maintained accurate and reliable data. It is unclear how the attitudes and behaviors of the faculty mentors and PIL's impacted course performance. For example, the following factors may influence student attendance and course performance: positive faculty endorsements of PIL sessions during lectures, faculty use of incentives for attending PIL sessions, level of coordination between faculty mentors and PIL's, and the level of involvement of the PIL during faculty lectures. Therefore, such analysis is critical to the final interpretation of these results. The researchers are cautiously optimistic that the positive results in student course performance will extend to a larger sample that is currently being collected.

Overall, preliminary results suggest continuing the project since the program is positively impacting student performance in introductory math and science courses. Institutional and departmental strategic planning may be influenced by the final analysis, which may include disaggregation of results by discipline. Since PIL models have already shown to be effective in course-based programs, future research will be needed to determine whether the implementation of a large-scale program is as effective.

The study of PIL programs has many intriguing questions for future research. First, how did the attitudes and behaviors of the faculty mentors impact student performance? Second, how did the PIL program impact the content knowledge of peer leaders? Third, did participation in the PIL program influence the peer leaders' interest in teaching careers? And finally, did participation in PIL sessions impact conceptual understandings in courses? Positive responses to any of these questions would further encourage resource allocations that support peer-tutoring programs. The PIL model presents many facets to explore such as documentation of its impact on student performance and determination of the mechanisms that foster positive outcomes on student retention and progression.

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