Abstract
This paper discusses the design and integration of a scoring rubric to assess quantitative reasoning projects embedded in the basic math courses at LaGuardia Community College. In order to contextualize the basic math skills course material and make it more engaging and relevant to students’ interests, LaGuardia’s faculty have developed and incorporated PQL (a SENCER-based model) projects into courses such as Pre Algebra, Elementary Algebra, and College Algebra and Trigonometry. Here, we provide an essential tool, the PQL generic rubric, to measure students’ success in these projects. The rubric can be used to grade students’ work consistently, as well as to provide them with meaningful feedback for improving their learning.

Introduction
Overview of PQL: The Project Quantum Leap (PQL) program at LaGuardia was established in 2007-2009. The primary goal of the PQL program was to adapt the SENCER (Science Education for New Civic Engagements and Responsibilities) approach in basic mathematics courses, allowing students to gain mathematical reasoning skills that they can apply to learn math topics in a relevant context and to solve real-life problems. SENCER, a National Science Foundation initiative for improving STEM education, supports contextualized course material and explores it through “compelling context and civic engagement. It focuses on real-world problems and extends the impact of this learning across the curriculum to the broader community and society” (SENCER. 2009a, 2009c). The aim

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1 The PQL program was funded by grants from the U.S. Department of Education (Betne 2010). The project, supported by LaGuardia’s Center for Teaching and Learning, was expanded in the years 2009–2012, after additional grants from the U.S. Department of Education were received.
of the PQL program is to use the SENCER approach in order to increase students' interest in math and thereby improve student retention and pass rates in developmental math and college gateway level courses.

At LaGuardia, more than 35 percent of the students in basic skills math courses retake the course at least once (Betne 2010). This could perhaps be due to students' perception that the subject is irrelevant and not connected to their lives. Recent studies by Wagstrom suggest that integrating civic/environmental issues into the Pre-Algebra course and teaching mathematics through context of real-world applications improves students' confidence and interest in learning mathematics (Wagstrom 2010). The PQL program at LaGuardia was designed to integrate thematic projects into basic skill math courses and college gateway level courses. Integrating quantitative reasoning skills, such as reading and comprehending of numerical data, into basic math courses seems indispensable, since they have become essential skills in our daily lives. In fact, at LaGuardia, it is one of the core competencies in the General Education curriculum. The PQL projects aimed for enhancement of students' quantitative reasoning skills.

PQL Faculty development seminar: A key component of the PQL program was faculty development and course design. In 2007–2009, the math and non-math faculty participants of the PQL professional development seminar designed and piloted the use of class projects for four courses: Introduction to Algebra (MAT 095), Elementary Algebra (MAT 096), College Algebra and Trigonometry (MAT 115), and Elementary Statistics-I (MAT 120). These projects were class activities focused on themes such as Energy and the Environment (MAT 095 and MAT 120), Problems and Issues in Public Health (MAT 096), and Business and Finance (MAT 115). In 2009, the Center for Teaching and Learning published these projects in the form of a Project Quantum Leap Sampler (LaGuardia Center for Teaching and Learning, 2009). Several additional PQL projects were created by the seminar participants in 2012 and were added to the sampler.

Assessment of the PQL program demonstrated an improvement in students' quantitative reasoning skills, confidence, and level of engagement in mathematics, as well as higher passing rates for students who took courses with PQL (Betne 2010). In Fall 2012, the mathematics department revised the curricula for the MAT 095 and MAT 096 courses, and PQL project activities were integrated as a part of the course material. For Pre-Algebra (MAT 095), the “Instructor's Assessment” grade book category now includes PQL projects, along with tests contributing a total of 15 percent to the course grade. Similarly, for Elementary Algebra (MAT 096) PQL projects are defined as a separate grade book category worth 5 percent of the overall course grade.

Overview of the PQL assignment rubric: When the PQL projects were integrated into the courses as graded activities, it became clear that some discussion and standardized approaches for grading the projects needed to be developed.

Each PQL assignment consists of the following three parts:
1. Concept or Theme: The first part of the assignment includes reading material related to the theme, such as a discussion of environmental issues or problems in public health. Students are required to comprehend the material and understand the problem.
2. Mathematical Analysis: In this part of the assignment, students are expected to interpret and analyze the given quantitative information (data) and perform mathematical analysis to produce numerical results.
3. Conclusion and Reflection: The final part of the assignment requires students to convert the numerical results obtained in Part 2 into qualitative information and draw meaningful conclusions related to the theme. Students are also asked to reflect on the overall activity to exhibit their understanding of the lesson and to include a summary of their perspective about how mathematical concepts can be applied to solve real-life issues.

Grading PQL projects is complex and challenging. Since the three components of the assignment are interrelated, an examiner needs to carefully evaluate each one of them and ensure that students have exhibited their ability to comprehend the social issues, to apply mathematical reasoning, and to interpret the results in context in order to solve a given problem. When PQL projects were first included in the course curriculum, instructors used either a holistic approach or created their own scale...
to assess students’ work. Therefore, the assessment of
dents’ work varied based on the instructor’s expectations.
For example, an instructor might have assigned a fairly
good grade for an assignment that exhibited a strong re-
sponse to the questions related to the overall theme, but
contained some inaccuracy in mathematical calculations,
while another instructor might have assigned the most
credit to accuracy in mathematical calculations, thereby
creating a different scale. This could have led to inconsis-
tencies in grading students’ work. Moreover, among our-
selves, we noticed that there was a discrepancy in overall
grades when we graded the same assignments at different
times with different performance expectations.

This experience led us to create an analytical scoring
rubric for PQL projects. We realized that it is critical to
have clear learning goals and an efficient evaluation tool
in order to be consistent in grading. Assessments that are
tailored both to course goals and to institutional goals for
students’ learning could play a crucial role in producing
the desired results (Burns 2012). Assessment and grading
of students’ PQL project work was important in order
provide meaningful feedback to students and to clarify
performance expectations. We chose to create an analyti-
cal rubric (Mertler 2001) for scoring the individual parts
of the project, since scoring each individual part of the
assignment was crucial in finding the overall grade. We

<table>
<thead>
<tr>
<th>Scale</th>
<th>1 - Beginning</th>
<th>2 - Developing</th>
<th>3 - Competent</th>
<th>4 - Good</th>
<th>5 - Excellent</th>
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<tbody>
<tr>
<td><strong>Understanding information and data; ability to interpret quantitative information</strong></td>
<td>Minimal understanding of information and/or incorrect use of the data; not capable of interpreting quantitative information</td>
<td>Some understanding of information and occasionally uses data correctly; some confusion with interpretation of quantitative information</td>
<td>Understands most of the information and use of data is mostly correct; reasonable interpretation of quantitative information</td>
<td>Understands information and use of data is correct; interprets quantitative information correctly</td>
<td>Understands information, uses data confidently, accurately, and efficiently; flawless interpretation of data</td>
</tr>
<tr>
<td><strong>Ability to apply math concepts; using formulas; performing mathematical analyses</strong></td>
<td>Applies math concepts incorrectly; uses formulas incorrectly; incorrect math analyses</td>
<td>Some grasp of math concepts but not always applied correctly; errors with formulas; many numerical errors</td>
<td>Use of math concepts is mostly correct; use of formulas is correct; several errors in mathematical computation</td>
<td>Math concepts used correctly; formulas are correct; mathematical computations exhibit minor or insignificant errors</td>
<td>Math concepts used correctly; use of formulas is correct, proficient, and even elegant; math analyses are perfect</td>
</tr>
<tr>
<td><strong>Conclusions and/or reflection on the activity</strong></td>
<td>Inappropriate conclusions or blank responses</td>
<td>Weak or vague conclusions or blank responses</td>
<td>Reasonable conclusions and/or reflection; demonstrates relevance of math in approaching social issues</td>
<td>Insightful conclusions and/or thoughtful and focused reflections</td>
<td>Precise and well-established conclusions and/or great insight into use of math when approaching social issues</td>
</tr>
<tr>
<td><strong>Presentation (language use, look and feel, citations)</strong></td>
<td>No effort to write carefully or to create thoughtful presentation; no citations</td>
<td>Some effort to write carefully but many errors; no attempt to follow a logical sequence; few or no use of references and citations</td>
<td>Some errors but follows a logical sequence; little attempt to enhance the project with graphics, etc.; occasional use of references and citations</td>
<td>Good, careful, and logical writing; attempts to enhance presentation with graphics or additional comments; provides citations to references but may not format citations correctly</td>
<td>Well-written and logical; enhances presentation with graphics and comments; citations of references are present and correctly formatted</td>
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The rubric was originally developed by the author and then revised and edited with support from Ros Orgel of the Center for Teaching and Learning at LaGuardia. This preliminary version of the rubric was presented by the author during the SENCER MidAtlantic Regional Meeting held on November 11, 2011 at Metropolitan College of New York with Dr. Sreedevi Ande from LaGuardia Community College.
used the three components of the PQL project (mentioned above) as criteria for grading. We used a fourth criterion, Presentation Skills, for assigning bonus points to encourage students to perform better.

Since grading requires precision (Allen 2010), our objective was to provide scoring guidelines to faculty for grading PQL projects. In order to evaluate student’s assignments consistently, we designed the following assessment rubric. We were careful to keep in mind the need to give and receive more meaningful feedback on students’ learning, in order to help them understand the concepts more deeply. Our discussion of the usefulness of the PQL Rubric to assess students’ learning is based on our experiences.

Application of PQL Rubric to PQL activities: In the following examples, specific parts of the projects are discussed to show how each criterion of the rubric can be applied to assess the PQL assignment. We have also provided general guidelines for using the rubric to assess any PQL project.

1. Understanding information and data; ability to interpret quantitative information: For assessing students’ work under this criterion, we give the following example of a PQL project:

“Carbon Emission” – a PQL project for MAT 095 (Betne 2009)

In this activity students need to understand the concept of simple average and weighted average. Based on a chart given in the assignment, they are required to obtain the average carbon emissions per person for the seven regions. In order to do this, they will have to find the weighted average. A conceptual error can occur if a student ignores the population of each region and calculates only a simple average. In this case, we can refer to the first row of the rubric to evaluate a student’s work on the scale of 1-5.

2. Ability to apply math concepts; using formulas; performing mathematical analyses: The following example of the activity demonstrates the use of this criterion for examining students’ work:

“Projected Deaths for Selected Causes to 2030” – PQL project for MAT 096 (Gbedemah 2009).

In this activity a graph of projected global deaths due to HIV/AIDS starting from year 2000 is given. It is assumed that the graph starting from 2010 can be described as a square root function of the type \( H(t) = a\sqrt{t} + b \), where \( a, b \) are constants and, \( H(t) \) represents the number of projected global deaths (in millions) in year \( (t) \) after 2000. Students are required to use the given data points to find values of unknowns \( a \) and \( b \) in the equation. The second row of the rubric could be helpful to evaluate a student’s work when mathematical errors are exhibited. For example, students may compute values of the constants \( a \) and \( b \) inaccurately or make numerical errors in evaluating the function \( H(t) \) for a given \( t \).

3. Conclusions and/or reflection on the activity: The following example illustrates how this criterion can be applied for assessing the PQL project:


In this activity, students are asked to reflect on the increase in the gasoline prices and its impact on daily life. The activity includes questions such as, “In what way did you connect the math to a real situation?” “What factors do you feel may be responsible for this crisis?” A well-established conclusion should address these questions based on the math the student has learned. In this particular problem, a summary should show how the knowledge of the average rate of change helped the student to understand the severity of the gasoline crisis. It could also include an extract or a supporting argument based on the mathematical equations that the student learned in the activity. One can refer to the guidelines listed in the third row of the rubric to judge the student’s insight into the topic and for understanding the relevance of math.

4. Presentation: We found that awarding students a few bonus points for a detailed and outstanding explanation of work, with appropriate citations, greatly motivated and inspired them to engage with the content and to learn more.
Results and Discussion

During the Spring 2012 semester, in order to train faculty on the use of the rubric, we asked participants of the PQL professional development seminar to pilot test the rubric by assessing two anonymous samples, PQL projects that were exemplars of different levels of performance. We asked participants to use the scale 1-5 of the rubric to score independently each component of the project and then average the scores of all components to report the overall score for the entire assignment. Out of eleven faculty participants who responded, nine of them assigned identical scores for sample A while for sample B, eight participants gave identical ratings, thereby indicating the high inter-rater reliability of the rubric (see Table 1 below). We then discussed the differences in the ratings and asked raters to explain their judgments. This helped us to establish the standards and to gauge usefulness of the rubric. We agreed that the majority of our remedial math students needed be at the level of 3 or higher.

<table>
<thead>
<tr>
<th>Score (on Scale 1-5)</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample A</td>
<td>2</td>
<td>9</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sample B</td>
<td>8</td>
<td>3</td>
<td></td>
<td></td>
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</table>

We presented the PQL Rubric during the departmental basic skills workshop at the beginning of Fall 2012 semester and shared it with all faculty teaching basic skills math courses. The instructors were also provided with a handbook giving them guidelines for implementing the PQL approach in basic skill math classrooms. We observed that during Fall 2012 more of the faculty piloted the use of the rubric in their classes to assess the PQL projects. To test further the usefulness and applicability of the PQL Rubric and its three components, we ran an anonymous survey to receive feedback from the instructors on the use of PQL handbook and rubric. About 61 percent of the faculty who responded to the survey reported that they used the PQL handbook and about 44 percent of them said that they used the PQL Rubric to assess the PQL projects. About 11 percent of the survey respondents used the PQL Rubric along with their own judgments or some other method of grading. One faculty member responded that the PQL Rubric was used for estimation of overall grade, while another reported no knowledge of this resource.

It is evident that the PQL Rubric was useful in examining students’ PQL project work in a consistent manner. Since each assignment had quantitative reasoning components, it was easy to use the PQL Rubric to grade that part of the project. It also gave the instructor a fairly good estimation of the score and judgment about the overall proficiency that students exhibited through their work. Although several faculty members piloted the use of PQL Rubric in their classes and reported its usefulness in gauging students’ learning, we realize that much more research still needs to be done to fully validate the PQL Rubric we have developed.

In the future, we would like to determine whether providing the rubric to the students along with the project assignments would have any effect on their performance on the project. We plan to compare the performances of the math students who are given the PQL Rubric as a guideline for their PQL project with those who do not get the rubric. We also plan to administer the SALG assessment tool (SENCER 2009b) to gauge the effectiveness of the use of rubric. Further, we need to make this PQL Rubric assessment tool available to the greater community of faculty and students, get their feedback, revise the tool to suit their needs, and measure its impact on students’ learning.

Conclusions

We noticed several potential advantages of having faculty use a standardized rubric format for evaluating students’ PQL projects. First of all, a standard rubric can provide uniform measures of quality to assess students’ work, as opposed to using a holistic approach or using different grading scales devised by individual faculty members for each of their assignments. The use of rubrics provides consistency in grading, thereby ensuring greater accuracy in the measurement of learning gains and enhancing the reliability and validity of the assessment. Secondly, the use of rubrics allows the instructor to grade the assignment in parts, making grading easier and more efficient. Furthermore, using a rubric helps clarify to students the expectations of their performance on projects. Since the
instructor can provide detailed feedback on their progress for each part of the assignment, students can better understand how well they are learning and how they can improve.

Moreover, examining students’ work and scoring assignments using the rubrics could allow the faculty to create or revise assignments, so that students are able to demonstrate their proficiency as expected. Instructors could even tailor their pedagogy according to the levels of learning that they want to measure. Finally, the standardized PQL Rubric could be helpful for measuring students’ learning, not only in the mathematical aspect of Quantitative Reasoning, but also in interdisciplinary core competencies such as Research and Information Literacy, Critical Thinking across the Curriculum, or Communications Skills. Recently, Grawe et al. (2010) viewed Quantitative Reasoning in the context of writing skills, and they have developed a rubric to assess quantitative reasoning in students’ written arguments.

We believe that the PQL Rubric presented here is not limited to only PQL projects but could be applied to any mathematical assignments that are designed using the SENCER approach. We hope that this work will provide valuable insight into students’ learning and may even lead to development of more powerful assessment tools in the future.

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References


