The purpose of education [is] the intellectual, moral, and emotional growth of the individual and, consequently, the evolution of a democratic society.

Carol Rodgers

Essential to effective learning, the complex cognitive act of reflection can assume different forms. On one hand, reflection may occur in the moment, as it might for a nurse or mathematician intent on resolving an immediate situation or problem. In this case, he or she engages in a simultaneous process of selecting among alternative approaches, connecting to prior experiences, and imagining future applications. Or reflection can be less immediate, a kind of stepping away to look at our experience from a distance. In both cases, writes John Chaffee, we “figure out the way our thinking operates and thus learn to do it more effectively” (2). In Chaffee’s view, reflective thinking is critical thinking, an intrinsic part of our “natural human ability” (2).

Donald Schön, influential theorist of reflection in practice, distinguishes between these two forms as “reflection-in-action” and “reflection-on-action.” In the former, we are “thinking what we’re doing as we do it,” as suggested by the nursing and math examples above (Schön, “Donald” 5). In the latter, we think about an action after it has been completed, “thinking back on what we have done in order to discover how our … action may have contributed to an unexpected outcome” (Schön, Educating 26). But whether in-action or on-action, reflection is “a meaning-making process that moves a learner from one experience to the next with a deeper understanding of its relationships with and connections to other experiences and ideas” (Rodgers 845).

As teachers of Introduction to Algebra (MAT095) and Critical Thinking (HUP102) at LaGuardia Community College, we are well aware of our students’ need to improve critical thinking and quantitative reasoning skills. With the goal of improving these skills, in Fall 2007, we integrated our courses into a single learning community. Two projects on environmentalism structured the community’s disciplinary content, and reflective practices shaped classroom activities. Our objec-
tive was to intensify the learning experience of our students in math and critical thinking, to shake open, in the words of Jeremy Kilpatrick and his colleagues, their “capacity to think logically about the relationships among concepts and situations” (National 129). The semester ended, but questions about achievement remained, the result of unsatisfying evaluations of student work. How could we have better developed “number sense” in students who have had, for the most part, irregular exposure to fundamental math principles? What could we have done better to improve student abilities to integrate logical and quantitative reasoning, to recognize inaccurate calculations when they see them, and to understand the need to justify belief with evidence?

Resolved to find answers to some of our questions, we approached the following Spring 2008 semester with several modifications. This paper presents a study of that semester’s endeavors, describes and compares the codesigned first and second class projects which framed our math and critical thinking community, and offers a brief evaluation of several examples of student work from the first project. Our evaluations of the first project yielded insights that led to modifications in the second, midsemester, project. The discussion that follows is presented within the context of those modifications, and traces an evolving practice of student reflection.

Assigned to our community of twenty math and critical thinking students, both projects offer insights into our understanding of the ways reflection can support classroom teaching and learning. Indeed, the implicit question threading its way through our discussion of our classroom practice is the degree to which reflection in combination with compelling contexts, can intensify, deepen, and excite learning in both teacher and student. In our conclusion, we offer a comparison of Project One and Project Two in Spring 2008, and suggest plans for future inquiry.

Compelling Contexts and Learning Communities
It is an American commonplace that many arrive in the nation’s math classes with low interest and little confidence in “doing math.” Students often declare that they “hate” math (see the online I Hate Math Club, I Hate Math T-Shirts, etc.). Their antipathy is partially explained, perhaps, by the tendency, in a traditionally taught basic math class, to require rote learning of skills that may appear socially and culturally irrelevant to today’s learner (Fuson, Kalchman, and Bransford 29). Educators agree that this perceived disconnect between mathematics and
everyday life adversely affects student motivation (Grubb and Cox 93, 95–97) and disrupts achievement and retention (CUNY 4–5). Committed to confronting students’ negative perceptions of math, LaGuardia’s Division of Academic Affairs and the LaGuardia Center for Teaching and Learning launched, in January 2007, Project Quantum Leap (PQL), a faculty development seminar for the study of ways to improve math achievement. To narrow the “relevance” gap, PQL adopted two teaching and learning strategies: The first was the engagement of students in the exploration of “unresolved public issues,” or compelling contexts, a pedagogy inspired by the Science Education for New Civic Engagement and Responsibilities (SENCER) initiative. Among the public problems identified as having immediate social relevance for LaGuardia students were the environment (in Introduction to Algebra, MAT095), public health (in Elementary Algebra, MAT096), and economics and finance (in College Algebra and Trigonometry, MAT115). The second PQL educational strategy was the creation of learning communities, paired courses linked by themes and projects that generate connections within and across disciplines. In Spring 2007, along with eleven math and four nonmath colleagues, we participated in PQL’s first phase, the exploration of specific conditions believed to enhance math learning.

Drawn together by PQL, the transformative pedagogies of SENCER and learning communities are meant to improve student performance in each of the paired courses and deepen social awareness. In addition to the concepts of context and community, we view the practice of reflection as equally vital to effective learning. As understood by Carol Rodgers, reflection is “the thread that makes continuity of learning possible, and ensures the progress of the individual and, ultimately, society. It is a means to essentially moral ends” (845). At the heart of our Fall 2007 and Spring 2008 environmental projects, the practice of reflection in community furthered both of our educational goals: advancing math and critical thinking skills and clarifying connections between individual choice and the fate of the planet.

Fall 2007 Background and Analysis

Introduction to Algebra and Critical Thinking Learning Community

Our initial experience with contexts, communities, and reflection unfolded in Fall 2007. Forming our first learning community, we began to integrate compelling contexts and civic engagement into our disciplinary content. As an initial step, we designed our classroom projects with four goals in mind. First, and most broad, the projects
had to address themes of energy consumption on both the individual and global levels. Second, the projects had to involve students in regular practice of skills common to both math and critical thinking, such as problem-solving logic, decision making, and argument building. Third, we placed content distinct to each discipline front and center; for example, in math class, students worked at developing “number sense,” and in critical thinking class, they read and analyzed texts, wrote essays, and discussed controversies to develop decision-making and problem-solving skills. Finally, students would apply these skills to personal issues related to energy consumption in their everyday lives.

We assigned the first project on electricity consumption at the beginning of the semester, conceiving it as an individual effort that required no research. The students were their own source of information. The second, midsemester, project, designed as a group activity and focused on consumption of resources at LaGuardia, required some research and an oral presentation. Depending on the topic they chose, students interviewed LaGuardia staff and gathered information from online sources. Each three-week project incorporated two loosely structured aspects of the reflection process: informal class progress “check-ins,” or feedback, and a final reflection on the overall project.

Throughout the semester, observations of Introduction to Algebra students revealed that they most often fixed on finding the “right” answer rather than on understanding how they arrived at it. In other words, our students simply relied on the instructor, the Internet, or their peers to confirm conclusions. While checking with sources and recalculating the problem is arguably a form of Schön’s reflection-in-action, in fact, this kind of “thinking while doing” suggests a rather weak form of thinking, especially as this back-and-forth process between student and resources usually stopped once the correct answer was found. Without pausing to “step back” to reflect on the ways he or she had arrived at the correct answer, the student then moved on to the next problem. Similarly, in the critical thinking class, beginning students often expressed strong opinions about the environment and many other issues. But, again, their claims were frequently unsupported by credible evidence. Instead, in discussion and in writing, students often replaced justification with generalization.

In both classes, the lapse in second-order thinking, or careful thinking about the ways we think, was demonstrated by math and critical thinking students’ difficulty in justifying the accuracy of their conclusions. Our evaluations of their projects on energy consumption led us
to conclude that our goals of improving student reasoning called for a more intentional and deliberate approach to the practice of reflection. That is, informed by Schön’s distinction between reflecting *in* and reflecting *on* action, we believed that motivating our students to reflect on numeric operations while in the process of performing the operations could result in improved ability to determine accuracy of their calculations. In turn, accurate calculations could be transformed, after reflection, into data used to support reasoned positions on the environment. At the end of our first learning community in Fall 2007, we resolved to confront these lapses in reasoning head on, and made modifications to classroom practice for Spring 2008.

**Spring 2008, Project One**

*Household Electricity Consumption*

Once again, we framed the semester with two projects. More personal, the first project focused on household electricity consumption; the broader second topic was recycling at LaGuardia. Our teaching challenge was to provide our classes with opportunities to construct a clear understanding of environmentalism and of the differing perspectives surrounding it, and to develop a way to make meaning of their own experience of it. Among the learning goals, three were essential: Common to both projects was the primary requirement to justify the validity of conclusions. Second, a successful project depended upon the thoughtful collection, selection, analysis, and application of valid data. Last, the expectation, *sine qua non*, was that students could perform numeric operations in the service of a reasoned argument about the environment.

We structured both projects around three activities. In the first week of Project One, our math and critical thinking learning community students gathered one week of data on the electricity consumption of three home appliances. In the second week, they reduced their individual usage by approximately half, calculated their personal savings of money and consumption, and projected the global impact of their actions on the reduction of carbon dioxide emissions. At the end of the third week, students wrote an essay that described their collection of data, analyzed the consequences of reducing their energy consumption, and reflected on the changes, if any, in their personal behaviors as consumers and the possible effects of their behaviors upon the environment.

To help students produce more informed and analytic arguments, we assigned activities to increase skill sets and knowledge. In math class, students reviewed decimals, simple averages, and unit rates within
the context of activities about energy consumption. In the critical thinking sessions, students read excerpts from Al Gore’s *An Inconvenient Truth*, summarized its positions, and evaluated its presentation of numerical data. Later, students were to use this information to build their own arguments about the consumption of energy.

As students worked on their projects, we introduced practices of reflection *in* and *on* action. In math class, for example, students reviewed their homework calculations; while reviewing the operations, they also identified computation steps and justified the results. Pairs of students discussed their calculations of electricity use and checked them for accuracy. If the validity of the answer was questioned, we put the calculations on the board for the whole class to examine. To help make sense of the numbers under discussion, we provided concrete contextual situations, calculating, for example, the total electricity consumption of a whole household. Recognizing the impossibility of a single home computer consuming in a week an amount of energy equal to the total amount of electricity consumed by a household in three months, beginning students could then identify and correct the mistaken calculation. Thus, after stepping back to look at homework calculations (*reflection-on-action*), students began to *reflect as they calculated*. In other words, by “thinking on their feet” out loud, mindfully, and in the moment, students were *reflecting-in-action*, a process of evaluating and modifying that is essential to the practice of quantitative reasoning (Smith).

The commitment in Spring 2008 to a more intentional pedagogy had implications in critical thinking class, too. In Fall 2007, like many teachers who wish for student feedback, we had always devoted a few minutes at the beginning or the end of class to ask a general “How’s it going?” question regarding progress of large projects. In those exchanges, students who felt comfortable volunteering their ideas reported out to the instructor; after they had spoken, we would move on to the “central” topic of the day.

Modified in Spring 2008, the practice of “checking in” became a guided and more deliberate exercise. Its aim was the creation of focused conversations held by a community of thinkers engaged in discussing an issue in ways that led to insights and new ways of understanding their approach to the project. For example, we turned our informal Fall 2007 “How’s it going?” feedback sessions into “good conversations.” Once a week, in small groups, students discussed the information they had gathered for their projects for fifteen minutes, and then each group reported out to the full class. This process ensured that students would
carefully and thoughtfully talk with one another about their data collection progress. Identifying impasses and possible solutions, they created “good conversations,” guided, but not controlled, by the instructors. In Schön’s words, these more directed exchanges were “neither wholly predictable nor wholly unpredictable” (“Donald”). For example, a student once hit a snag in his research of household energy consumption in that his father wanted around-the-clock TV, and did not like the suggestion to turn it off in order to consume less energy. Rallying around, students urged the student to convey to his father the importance of the learning project, suggested that he take his father out to dinner, and asked if the instructor could write a letter to the father! Another time, when a few students reported falling behind on collecting data, their peers worked out an adjustment to the deadline.

A clear difference between the Fall 2007 and Spring 2008 projects was the completion of data collection by everyone in the Spring class, a result, we think, of the community of encouragement provided by our “good conversations.” A combination of both reflection in and on action, these deliberate and thoughtful investments in each other’s progress helped students to find solutions to difficulties. Without data, they would have given up; without “good conversations,” they may not have shared their frustrations and suggestions. From teachers-giving-solutions in Fall 2007, we became coaches (Schön, “Donald”), encouraging our students to be active learners who rely on their knowledge and past experiences to analyze situations, make connections, and provide workable solutions not only for themselves, but also for others. These kinds of collective, reflective discussions created community, and also provided a stronger foundation for students as they wrote the final assignment for the first project. As presented below, this concluding segment required the application of concepts learned in math and critical thinking classes and asked students to evaluate their findings as well as their experiences of the project and the ways the project might have motivated changed behaviors.

Analysis of Student Work, Project One

Of the twenty students in our learning community, fourteen were also enrolled in Basic English (ENG099); the others were either in Composition I (ENG101) or not enrolled in English courses. At the end of the first three-week project, students were required to submit a formal paper in which they were to answer the following set of questions and include a separate worksheet that demonstrated their calculations:
Reflect on your experience in using both critical thinking and math concepts. How much energy and money have you saved by using your appliances differently? How did Math help you to understand and complete this project? What were your ideas about each individual’s impact on the environment before and after this experiment?

The paper did not require a specific number of pages; however, most were between one and two pages long. As math and critical thinking instructors, we looked forward to essays that would reveal the degree to which our students managed to integrate their critical thinking skills with numerical data in support of their arguments about energy consumption. As well, we wanted student demonstrations of the ways math applications helped in understanding and completing the energy project, and the ways the experiment changed their understanding of an individual’s impact on the environment.

Although eighteen of twenty essays submitted at the conclusion of Spring 2008 Project One demonstrated students’ ability to present an argument and discuss what they had learned about energy consumption, their skills in using data in support of their arguments varied significantly. For our evaluations, we devised a rudimentary rubric to categorize student responses to the assignment:

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Level 1</th>
<th>Level 2</th>
<th>Level 3</th>
<th>Level 4</th>
<th>Level 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presentation of argument</td>
<td>Presents no argument</td>
<td>Presents an argument</td>
<td>Presents an argument</td>
<td>Presents a detailed argument</td>
<td>Presents a fully developed and detailed argument</td>
</tr>
<tr>
<td>Use of numerical data in support of argument</td>
<td>Does not include numerical data</td>
<td>Does not include numerical data</td>
<td>Includes numerical data, but data does not support the argument</td>
<td>Supports the argument with numerical data, but the data is mis-calculated</td>
<td>Supports the argument with numerical data that is appropriate and accurate</td>
</tr>
<tr>
<td>Description of impact of experiment on student’s life</td>
<td>Does not describe impact of experiment</td>
<td>Does not describe impact of experiment</td>
<td>Describes impact of experiment</td>
<td>Describes impact of experiment</td>
<td>Describes impact of experiment in detail</td>
</tr>
</tbody>
</table>

Below are excerpts of student work, each categorized by level of competency. Our evaluations of the integration of math and critical thinking skills accompany the student excerpts:
Level One (2 papers): There is no developed argument, no conclusion describing the impact of the experiment on the student’s life, and no reference to data:

I learned how to reduce on our daily consumption, it open my eyes on how often I leave my computer on and leave my cell phone charge plug[ged]… in the littlest things count.

Level Two (9 papers): The three students quoted below present an argument, but do not provide numerical data or indicate the impact of the experiment on their lives (emphasis added):

Energy consumption is very important to people like me because now I know how much energy I use in my house.... After this experiment I saved lots of energy in my house.... I stopped watching television and started spending more time at school [rather than] coming home and spend[ing] lots of electricity.

Most families like me waste a lot of energy causing us to have high energy bills.... I no longer use lights during the day unless absolutely necessary.... [M]ore reading replaces the use of television.

What I have learned about energy consumption is that we consume a lot of it at an alarming rate.... Math has helped me understand the theme of energy consumption by enabling me to see the numbers in the CO₂ levels that the earth emits.... Critical Thinking has enabled me to think of new ways to conserve energy.

Here students provide information about their patterns of energy consumption and prove insightful about the necessity to think about these issues. But as shown in the examples above, they use quantifiers (a lot, at high level, more) without giving the numerical results of the calculations performed. Some submissions include generalizations based on personal experience. For example, one student wrote:

I am concerned of what is going on in my building, because if I had a lot of usage that isn’t needed, I’m sure that in many other apartments it is worse than inside my apartment. I am concerned with what’s going on in the world. I found interestingly enough that I was able to conserve energy and at the same time exercise more.
The latter response shows the student’s interest in and concern about the issue; the comments are personal, but they are too general. While the student included data with her project, the work reflects an inability to use the data as evidence in support of her argument.

**Level Three** (4 papers): This work includes an argument and data, but again the data used does not support the argument:

I did my experience with all three appliances which I used the most, like the TV, the computer, and the living room light bulb. Altogether per day that became in current electricity consumption of 2.145 and reduced rang up to 0.99 which made a difference of 1.155. After getting to this point of my experiment, I calculated how much electricity I could be able to save in 1 year, which gave me a total of 421.575. Having known that the average retail cost of electricity per kilowatt-hour in New York State is $0.1619, I calculated how many dollars I was able to save, which gave me $0.202.

It is difficult to interpret the data provided in the above example because we do not know what the numbers refer to. In addition, there is no analysis of the impact on the student’s life. Instead, the essay jumps to a general conclusion:

I find that if people were to reduce their energy consumption not only [would] that benefit our environment but also can benefit them as well. As it turns out, the more time we get away from our computers and TVs the more time we can spend on self improvements. Our environment is suffering due to our laziness.

This final excerpt does develop an argument, but the argument is not based on the data provided by the student. The paper shows an attempt to use data to support an argument, but the data is not appropriate to the argument.

**Level Four** (2 papers): Students include interesting conclusions, but these are based on miscalculated numerical data:

I think that money and energy are crucial points. In my data collection I realized that I reduced my time in half on each appliance. This also reduced the money in half.... To many people this may be beneficial because they are reducing your
costs and helping the environment. To others, however, they may rely on the use of things such as a computer so much that the price will not encourage them to use it less.

On her worksheet, not included here, the student calculated a saving of $0.6811 for a year. The student makes a good argument: If we reduce usage by half, we save half the money paid for electricity. However, the student’s calculations suggested that her annual electricity costs totaled only $1.36 ($0.6811 \times 2$). Clearly, there is an error in her calculations.

**Level Five** (3 papers): These papers include an argument and support it with appropriate and accurate numerical data. The following excerpt is a student’s concluding paragraph, which follows presentation of appropriate data, accurately calculated:

> I realize that, after all the electronic devices/appliances were stripped away from me, they were in a sense, not only polluting the earth, but also my mind. That’s something I wasn’t expecting to discover! On the money standpoint, Math held more weight, on displaying how much money was saved. I’m always back and forth with Math and how it relates to me. It’s kind of like a love/hate relationship and I’m sure my reflection on Math is coming across like that. Nevertheless, I was able to save money by reducing my usages. After I reduced everything, I was able to save $56.84! That’s a lot of money, maybe math does hold significance! Although I know everything we do in our lives has an impact on our environment, I didn’t know what appliances/electronics did more or less damage!

This student makes a good argument supported by correct data. In his conclusion, he reflects on the impact that his work on the project has had on his life. He discusses both his increased understanding of energy consumption and his developing appreciation for studying math.

**Conclusions, Project One**

Overall, our evaluations of Project One revealed two significant patterns. In general, as evidenced in student responses to the final segment of the project, students were able to use personal experience to draw conclusions about the consumption of energy at the individual and global level, illustrating improved ability to reflect on their actions. Their responses provided insight into our students’ ways of thinking...
about the effects of the project on their lives. However, a pervasive absence of data or the inclusion of inaccurate data demonstrated that students remained uncertain about how to use numerical evidence to support an argument despite our incorporation of deepened reflective practices, i.e., reflection-in-action (while they were doing calculations), and reflection-on-action (“good conversations”).

Again and again, our evaluations of the first project of the semester pointed to a gap between students’ demonstrated ability to reflect out loud while calculating, and their inability to use those calculations to support a reasoned written argument. Simply put, our first project did not successfully guide students to integrate numerical data as evidence for their views.

Based on these realizations, we resolved to reorient the second project in three ways. First, in addition to increasing our practice of reflection in both classes, we decided to model and stage additional activities more concretely, thus giving students more focused practice with the effective use of data. Second, we agreed that math learning should be more frequently reinforced in the critical thinking assignments. Third, our prompt for the reflection paper would more explicitly guide students to make connections between the class project and its impact on their personal, everyday lives.

Spring 2008, Project Two

*Institutional Consumption of Resources at LaGuardia*

With these discoveries about our learning community in mind, we targeted the improvement of student skill in using data to support logically reasoned critical analyses. We scheduled the modified second project to begin around midterm of the Spring semester. Once again designed as a three-week project, the focus shifted from personal, domestic use of energy to institutional consumption of resources at LaGuardia. Another difference was an emphasis on student collaboration to gather information from college personnel as well as to conduct research using online sources. Finally, each of the five groups was required to present their arguments to their peers in an oral presentation that included data-driven proposals for sustainable solutions for reducing LaGuardia’s consumption of resources. Included in the requirements for these presentations were individual reflections on the changes in their views and their lives as a consequence of the project.

As presented in critical thinking class, the application of problem-solving methods provided a research framework. Among the research
topics were the use of paper towels in the bathrooms, the recycling of water bottles and aluminum cans from campus vendors, and the disposal of a variety of paper products and cafeteria garbage. Guided by clearly delineated and systematic problem-solving steps, students brainstormed specific questions about these issues, offered and evaluated reasonable solutions, and recommended future actions to reduce consumption. Throughout the project, students collected information from online sources and/or interviews with Building Operations personnel, cafeteria staff, and librarians. Outside of class, groups met separately with the math instructor to present and evaluate the data; in critical thinking class, students discussed its relevance. If the data collection appeared incomplete, students scheduled follow-up interviews and looked for additional information online. This additional time for reflective thinking about their research provided the students with more feedback and ensured steady project progress.

One skill isolated for improvement was the use of data to support arguments. To encourage students to see the relation between institutional consumption and their individual responsibility, we incorporated two separate activities in math and critical thinking in the early stage of the project. In math, with data provided by the instructor, students evaluated the reduction in air pollution and use of natural resources such as oil, water, and trees if an imaginary computer lab were to recycle paper. This activity showed students how to use data to make useful comparisons, and helped students to make similar comparisons in their own projects. The potential effectiveness of this additional activity was demonstrated by one group’s conclusion that if four departments around the college did not use paper at all for five years, the savings would pay one semester of tuition for almost 300 students. Another group found that the amount of paper consumed as paper towels in the E Building in one year requires the destruction of approximately 1,800 trees.

A critical thinking assignment required students to tally their personal use of the same resource for one week. For example, students calculated the amount of garbage they produced or the amount of paper they had used. This data gave students a more personal frame of reference for examining and measuring the consumption of resources. As indicated below, when compared to the papers they had submitted in Project One, the Project Two presentations revealed an increase in student ability to use data to support an argument.
Evaluation, Project Two

We used the rubric developed for the Project One papers (see page 8 above) to evaluate student ability to integrate appropriate and accurate data into their research. In comparison with the first project, the presentations of the second project demonstrated an increased ability to use quantitative data in support of an argument:

*Levels One and Two:* No work fell in these categories since all five groups built an argument and included some data.

*Level Three:* One group supported their argument with data on the national consumption of aluminum cans, but did not calculate the consumption for LaGuardia and therefore could not support their conclusion with the appropriate data; that is, the data was calculated correctly, but it was inappropriate to the argument the group made.

*Level Four:* No work fell into this category since the remaining four groups provided arguments, used appropriate and accurately calculated data in support of their argument, and described the impact of the experiment on their lives.

*Level Five:* Four groups supported their arguments with appropriate and accurate data and showed the impact of the project on their attitudes and behavior.

We attribute improved integration of quantitative data in support of beliefs about the environment to the modifications we made to Project Two. These modifications included a more systematic and intentional approach to reflection throughout the project. Second, we modeled ways to use data in support of an argument. In addition, during the research, data collection, and analysis phases, we scheduled more time for students to meet with the math instructor and devoted more critical thinking class time to discussion, thereby increasing opportunities in both cases for students to “think aloud” about their data collection and its relevance to their argument.

However, we realize that the additional assignment of an individual essay that would require reflection on the project as a whole would have allowed students to deepen the meaning of what they had learned, draw individual conclusions about the issues they had
investigated, and discuss how their own behavior would change as a result.

Project Two did not include the higher level of reflection upon personal responsibility and behavior promoted, perhaps, by the cognitive demands of individual reflections. We can nevertheless point to an increase in critical thinking and math skills attributable to increased intentionality in thinking made possible by the practice of reflection in our classes. The average score for the COMPASS exam (the test used to determine student placement into and exit from the developmental math course sequence) in this class was 56.8, which is significantly higher than the required passing score of 30, and slightly higher than the 53.5 average score for Fall 2007. In order to assess student learning gains distinct from the COMPASS, we conducted pre- and post-tests in the math class. In Fall I 2007, the average for the pre-test was 25, for the post-test, 44. In Spring I 2008, the average pre-test score was 32, the post-test, 61. The bigger difference indicates a significant increase in student knowledge. In critical thinking class, 24 out of 28 students completed the course in Fall 2007; in Spring 2008, 22 out of 25 students completed the course, a 2.3% increase. Although the pass rate did not improve, Spring results showed a slight increase in class completion.

Final Thoughts on Fall 2007 and Spring 2008
As we explore ways to improve our students’ critical thinking and quantitative reasoning skills, we recognize that systematic inclusion of two types of reflection – in- and on-action – in addition to careful staging and modeling of activities, and more classroom time for projects are all essential to achievement. Scores in our pre- and post-tests suggest that learners benefit from deliberate thinking aloud as well as from a more considered “stepping back” to regard completed actions. We also believe that math teaching benefits students when made more explicit and visible, challenging them to reflect on the ways they arrive at the identification of algorithms needed for data analysis. As indicated by their final projects, reflecting on the connection of numbers to their everyday experience enhanced skills required for the completion of their projects on energy consumption. Similarly, careful staging of activities and scaffolded projects can help students to see the relations among parts of assigned projects, resulting in improved critical thinking skills. Increased attention to modeling how to incorporate data in arguments offers students greater insight and examples that they can include in their everyday lives. Finally, devoting more class time to the practice of
reflection on a common project within a compelling context encourages students to be more active and collaborative in their learning, and more visible and accountable to each other.

The process of reflection has also led us to improve our teaching practice. Although this article has focused on our work in Fall 2007 and Spring 2008, we have continued to refine our projects, incorporating topics such as cell phone recycling and clothing consumption to increase our students’ awareness of their responsibilities as consumers and inhabitants of our planet. In Fall 2009, we added a reflective writing assignment, “This Week in Math,” to the critical thinking syllabus. In the first week of the semester, students create a list of the learning goals and strategies needed to pass MAT095. Each week, they evaluate their graded assignments and reflect on their progress, devising new strategies to improve success. These activities reinforce our exploration of issues related to the environmental theme of our learning community and the concept of compelling contexts stressed by Project Quantum Leap.

WORKS CONSULTED


