Convergent and Divergent Student Experiences in a Problem-Based Developmental Mathematics Class

Martha B. Makowski
The University of Alabama

In recent years low success rates in traditionally taught pre-college mathematics classes has led to new courses that use group work and problem solving to teach the required content. Early results examining student outcomes are promising, but say little about students' classroom experiences. This study uses interviews from six students and one instructor in a single class to explore differences between student experiences and the intentions of the instructor. Although several students expressed positive perceptions of the class, tensions arose between students who wanted to learn efficiently versus the classroom expectation that students stay together in their groups. Practices such as copying and dictation arose, at least partially, as coping mechanisms for students caught between these conflicting values. Future work should examine alternative grouping methods and ways of using early indicators of need to provide additional support.

Keywords: Community college, developmental mathematics, group work, problem solving

Community colleges, although initially conceptualized as a place to prepare students for advanced study, now serve an incredible range of missions and students (Dougherty & Townsend, 2006). Students enter these schools at dramatically different stages of life, ranging from recent high school graduates with plans to earn a PhD, to adults returning to school after many years in the workforce or at home raising families (Cohen, Brawer, & Kisker, 2013). As a result, the mathematics background of these students is wide: spanning from seeing the material the first time, to having taken advanced coursework. Nowhere within community colleges is this truer than in pre-college, or *developmental*, mathematics classes, where instructors must meet the challenge of addressing the needs of this unique and complex population in a single classroom.

For many community college students, achieving their educational plans requires completing a developmental mathematics class, which are intended to provide the knowledge and skills necessary for success in credit-bearing college-level classes. However, low success rates (Attewell, Lavin, Domina, & Levey, 2006; Bailey, 2009) mean that developmental courses often play a gate-keeping function, a fact that is particularly concerning given that African Americans (Attewell et al., 2006) and individuals from lower-socio economic backgrounds (Hagedorn, Siadat, Fogel, Nora, & Pascarella, 1999) disproportionately enroll in developmental classes.

In recent years, developmental mathematics educators have moved to address the high failure rates by implementing mathematics curricula that use real-world problems and group work to help make the curriculum more accessible, echoing the reform efforts from the 1980s and 1990s in K-12 mathematics (National Council of Teachers of Mathematics [NCTM], 1989, 2000). In addition, these classes, often called *Mathematical Literacy*, are intended to support students in learning how to see mathematics in their daily lives. Studies of K-12 classrooms have shown that in problem solving and group work contexts, some students may resist the instructional norms (Lubienski, 2000). In addition, group work, although promoting opportunities for learning, can also lead to power struggles within groups (Esmonde & Langer-Osuna, 2013) and lack of opportunity to learn for some students (Baxter, Woodward, & Olson, 2001).

The most famous of the *Mathematical Literacy* classes are the Carnegie Pathways (Carnegie, n.d.a, n.d.b), with research from early implementations of these Pathways yielding tentatively

positive results (e.g., Sowers & Yamada, 2015; Yamada, Bohannon, & Grunow, 2016; Yamada & Bryk, 2016; Norman, 2017). However, this work focuses on student success rather than on students' experiences with the curriculum. Given the large instructional shift, the uniqueness of the developmental population, and the diverse mathematics backgrounds of the students, it is important to understand how students experience these classes and what the individual instructor intended for students, paying particular attention to how these perceptions differed between students with different reactions to the class. This study sets out to do exactly this, asking:

1. How do perspectives on specific aspects of the course differ among students who have a positive, neutral, or negative reaction to the course?
2. How do students' experiences with the course compare with the intentions of the course instructor/developer?

Methods

All data were collected from students in a single *Mathematical Literacy* classroom at Fields Community College (FCC; all names are pseudonyms), taught by an instructor who had participated in the development of the course. The course was not a Carnegie Pathway. Data draw from interviews with the instructor and students conducted outside of class and classroom audio recordings of the interviewed students' groups during the Spring 2015 semester.

Sample

This study focuses on six of 22 students from a single *Mathematical Literacy* classroom who consented to participate in a single interview outside of class and contained more than 8 (of 24 possible) hours of audio of them in their groups. All students in the observed classroom were invited to take part in data collection. Everyone who indicated interest was interviewed. Table 1 provides basic demographics and the mathematics backgrounds of the interviewed students.

Table 1. Interviewee demographics, mathematics backgrounds, and class outcomes

Name	Demographics	Mathematics background	Expected grade
Carley	White female 19 years old	Started developmental at lowest level; Trigonometry in high school	
Carrie	Asian female 20 years old	First developmental class AP statistics in high school	
Craig	White male 25 years old	First developmental class Trigonometry in high school	
Dave	White male 20 years old	First developmental class Statistics in high school	
Emilia	Black female 19 years old	First developmental class Trigonometry in high school	
Tyrone	Black male 48 years old	Started developmental at lowest level; GED	

Data Collection

Most student interviews occurred during the eighth or ninth week of the semester. Audio data were collected throughout the semester, but I focus on the data collected in week seven.

Focusing on this subset of classroom data provides alignment between the observation data and the experiences students shared during their interviews. In addition, during week seven all 22 students were still actively attending class, meaning the class contained its full range of diversity, both mathematically and demographically. The instructor interview occurred the last week of instruction.

Analysis: Student Interviews

To examine the similarities and differences in students' perceptions of *Mathematical Literacy*, depending on the type of experience a student had in the class, three main stages of analysis took place. I discuss each stage in more detail in the following sections. The majority of the coding was done by two researchers trained in mathematics education.

Stage 1: Classifying student experiences. Students' experiences were classified as positive, neutral, or negative using their response to the interview question "would you recommend *Mathematical Literacy* to others who were considering taking the class?"

Stage 2: Coding for emerging themes. Interviews were coded for emerging themes related to their perceptions of the class and classroom phenomena using multiple rounds of open coding (Creswell, 2014; Emerson, Fretz, & Shaw, 2011). This study focuses on data related to three main, mutually exclusive codes: *Group Work*, *Problem Solving*, and the *Instructor*. *Group Work* referred to students' discussions of working in groups, relationships with group members, or reflections on working in groups. *Problem Solving* related to students' discussions about the problem-rich curriculum and experiences engaging in mathematics. The *Instructor* code related to students' reflections on the instructor, their relationship with her, and their experiences working with her individually or with their group. Within each of these three main codes, mutually exclusive sub-codes were developed.

Elements of the classroom are inherently closely related, which occasionally made mutually exclusive coding difficult. For example, sometimes students spoke about their group interactions with the instructor. Broadly, this discussion fell into both the *Group Work* and *Instructor* codes. In instances like this, the default code was always *Instructor*.

Stage 3: Contrasting student experiences. For each student, the final list of codes from Stage 2 were tabulated for each individual. Using these tabulations, I identified patterns using the mixed-methods-analysis technique of matrices (Miles & Huberman, 2013), which organizes data along two or more dimensions, one of which is ordinal, to identify patterns between cases. Each matrix cell contains project data and the entire matrix can be used to draw inferences and detect patterns. For this project, I apply matrices with a convergent-divergent purpose in mind, using students' experience type (i.e., positive, neutral, or negative) as the ordinal dimension and final codes along the other, looking for patterns in how students spoke within codes.

As part of this analysis, I draw on interview segments, combined with examples from the classroom audio, to explore similarities and differences in how students with positive, neutral, or negative perspectives spoke about the classroom. I include these classroom examples not to causally link the perceptions students shared to a particular classroom event, but rather to illustrate examples of the classroom phenomena students identified.

Analysis: Instructor Interview

The initial round of coding of the instructor interview relied on the same three main codes as students (i.e., *Mathematics Curriculum*, *Group Work*, and *Instructor*), with appropriate adjustments made for the fact that the subject of discussion had switched from perceptions of the

classroom to intentions for the classroom. Only the components of the interview that related to the instructor's experiences of these three things were considered.

I wrote these results to represent the intended curriculum with respect to each of the three codes. After analyses of the student interviews were complete, I returned to the instructor's interview, rereading it with a lens toward the student interview sub-codes. The analysis of the instructor's intentions was then refined to reflect the student sub-codes, noting places where the instructor's responses did not have comparable student codes.

Results

The research questions of this study examine how students with different experiences in *Mathematical Literacy* vary in their perspectives of the class and the classroom phenomena, contrasting these with instructor intentions. I start with the classifications of student experiences and then present the results from the instructor, followed by the students. In this brief report, I focus on the results from the main code of *Group Work* (this code had the most material). Results for *Problem Solving* and *Instructor* will be included in the full report and presentation.

Student Recommendations

Student recommendations fell into one of three categories: positive, neutral, or negative. Students who recommended the class tended to provide an overwhelming positive response. For example, Craig started answering the question with "I would now….especially if they were like me." Those coded as negative tended to qualify their answers, saying that the class might be appropriate for some students, but not for them personally. For example, Tyrone recommended the class for students "if they're up for a challenge," but would not recommend it for "people like me." Dave did not indicate his personal feelings, thus, his response was coded as neutral. Table 2 presents the recommendations of the students crossed with their anticipated grades.

Table 2. *Students' recommendations for the class and their expected grades.*

	Recommendation		
Expected grade	Yes	Neutral	No
A	Craig, Carrie	Dave	
B			
C	Carley		
Did not complete class			Emilia, Tyrone

Convergent and Divergent Perspectives on Mathematical Literacy

To explore the instructor's intentions and how students with different experiences in *Mathematical Literacy* vary in their perspectives of the class and the classroom phenomena, I organize the remaining results with (a) the instructor's perspective and (b) results related to the patterns within the student codes.

Group work: Instructor's perspective. Group work was an important part of the course design, for Ms. Ann, the instructor, who, together with her colleagues at FCC, decided that in order to get students to do the mathematics the way they desired, "lecture classes aren't just going to be able to work. They need to be having these conversations [about math] in class." Thus, the choice to implement group work was driven by the curriculum objectives.

During her interview, Ms. Ann explicitly discussed how she created groups, explaining that she liked to spread her top- and low-performing students evenly between groups, but within this

also considered "personalities and attendance" to create groups that provided a productive environment for all her students. She tried to include at least one "strong" member in each group. Thus, the instructor explicitly considered the range of abilities within the groups so as to provide as many students as possible with access to others who were fairly comfortable with the material.

An underlying assumption of much of Ms. Ann's discussions related to group work was creating conditions where students worked together and discussed many instances of reaching out to students to help manage group relationships and keep students working together.

Ms. Ann acknowledged that group work allowed some students to minimize the amount of work they contributed, but explained that the class grading structure meant that most of these students would not pass the class without some degree of personal understanding of the content. She also noted that the group project rubrics allowed students to grade each other, but she observed that "the students are not always willing to throw each other under the bus," which she found frustrating because it limited her ability to hold students individually accountable.

***Group Work*: Students' perspectives.** *Group Work* sub-codes fell into six categories: (a) *Group Dynamics*, (b) *Togetherness*, (c) *Checking In*, (d) *Copying*, and (e) *Accountability*. I discuss the main findings for each of these sub-codes below.

a. Group Dynamics. Many of the students with more positive experiences explicitly noted that groups usually contained students with diverse mathematics levels. Dave commented that sometimes groups have "someone who knows a lot about something with someone who doesn't know anything about it" and Carrie observed, "everyone is at a different levels [*sic*] and they all kind of contribute their own things." These remarks suggest that students, although perhaps not explicitly aware of the mathematical backgrounds of their group mates, recognized that a range of background knowledge existed within their groups.

b. Togetherness. Although a few students talked about the benefits of togetherness, the majority of the students' talk related to *Togetherness* related to divisions within groups.

Emilia and Tyrone, students who would not recommend *Mathematical Literacy*, both noted they usually found themselves behind. Tyrone commented, "sometimes I might be behind. I'm always behind. And then I look, 'hey where you at?' I'm just like man, 'you all just go ahead—I'll catch up.'" For both, a lack of togetherness resulted in being left behind. For example, a diagrams of Emilia's group for a day near the time of her interview (Figure 1) shows she lagged behind that day and rarely spoke. When she did speak, she was usually talking to the instructor about problems her group mates had already discussed. Although not shown here, similar lag patterns were observed for many of the students who did not complete the class. This suggests that an early lack of togetherness in groups might signal the need for additional intervention.

The four other interviewed students did not mention feeling left behind. However, Carley and Craig gave examples of the ways they strove to bring groups together, while Carrie and Dave distanced themselves from this responsibility. For example, Dave noted that "it's really difficult to get things done when you're in a bad or…not a good group…I mean once you've got a good motion going then there's no reason really you should have to stop." It should be noted that Carrie and Dave were in groups with Emilia and Tyrone respectively around the times of their interviews. As noted earlier, Emilia rarely spoke with her group, despite Carrie saying in her interview that usually everyone had someone to work with. Audio recording of Dave and Tyrone's group demonstrates that Tyrone was helped in his group, but not usually by Dave.

The lack of togetherness the students note and that is illustrated in Figure 1 show that togetherness was an issue. Dave and Carrie touched on reasons why this might be the case, noting that slowing down could be disruptive or distract from completing assignments quickly.

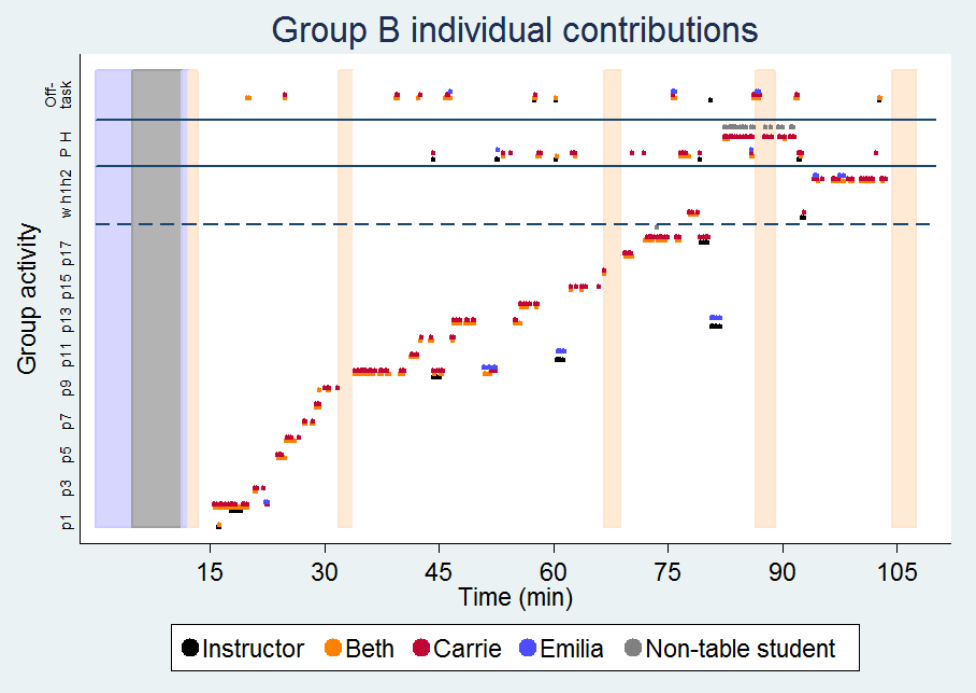

Figure 1. Individual contributions in group B. Each dot indicates when an individual started a new speaking turn. Recording of individuals started when the instructor opened the classroom up for group work (here, around minute 15). The light blue regions indicate when the instructor was returning assignments and checking in with students. The grey regions are when the students were engaged in a quiz or an activity related to the study. The light orange regions are when the instructor was lecturing. White regions are when the class working in groups. The Group activity labels mean, in ascending order: problems 1 through 17 (skipping even numbers on the labels), written reflection task (w), group homework assignments 1 and 2 (h1, h2), group planning discussions (P), helping other groups (H), and off-task talk.

c. Checking In. All six students talked about asking others for help or being asked by group members if they needed assistance and described the help they received from their group mates as useful. However, Emilia and Tyrone both mentioned times when they had needed help but encountered barriers to receiving aid. Emilia expressed feelings of stress when others checked on her, noting that in one group "they would like stop occasionally to see if I need help but it just, it makes me feel like 'Oh my god! I need to step it up.'" Tyrone discussed a group member who "really knows her shit, but I don't even speak to her." When pressed about the relationship, he indicated that he thought "she just don't like me." In both cases, the students who would not recommend the class did not trust that their group would provide the help they needed or wanted.

d. Copying. All the students acknowledged copying occurred within the groups, but clear divisions existed. Both Tyrone and Emilia, who negatively recommended the class, said they copied. Emilia said her group at the time "just tell me to copy down the answer," suggesting group-sanctioned copying to quickly address Emilia's questions or catch her up to the rest of the group occurred. Tyrone admitted to initiating the copying "so I can go back and look at it and do it like that….I always, like, go back and look at it so I can understand it." For Tyrone, copying was a strategy for learning, allowing him access to the content he could not cover in class. For Tyrone and Emilia copying was a coping strategy for the lack of togetherness in their groups.

The four other students admitted copying occurred but did not admit to themselves doing so. Three of these students said that they had let others copy, but none mentioned encouraging the practice. Instead, they distanced themselves. For example, Carley, in talking about a woman who

often copied, said "I'll let her copy, but it's…just going to hurt you in the long run." Thus, while the students universally acknowledged copying, the roles they played in the practice varied.

e. Accountability. Distribution of the workload and a lack of control were themes common among the students with more positive recommendations, identifying that the workload on group assignments was not always even and they lacked control over group assignments. Most of these students described conflicting feelings about trying to regulate or report their peers. In contrast, Tyrone and Emilia, the students who negatively recommended the class, said little about their experiences with group-graded assignments. Emilia did not mention group-graded assignments at all. Tyrone, rather than talking about the fact that the quality of the work was sometimes out of his hands, noted that group grades could hide the fact that not everyone in the group understood.

The contrast in experiences might be at least partially understood by a classroom instance during which Carrie and Emilia's group negotiated a graded group assignment. Emilia was responsible, by a class policy, for writing up the group answers. During the group conversation about the problem, Emilia functioned primarily as a scribe, with her group members effectively dictating answers. Thus, Emilia's group members managed the work to produce an acceptable product *efficiently*, meaning that Emilia lost the opportunity to reflect with and learn from her group, even when positioned by classroom rules to act as a critical person in the discussion.

Note that the scribe work Emilia did in this example differs from the copying discussed earlier. Here, Emilia was completing an assignment where each person in the group received the same grade, regardless of who did the assignment. In contrast, when copying, the students were doing so for work graded for completeness, so only the student who copied stood to lose.

Discussion and Conclusions

The results presented here demonstrate some of the consequences of forming groups with diverse mathematics backgrounds and demonstrates how these conditions mean classroom goals can come into conflict. During her interview, the instructor suggested that she *relied* on a diversity of mathematics knowledge within groups to provide the best opportunity for students to learn effectively from the curriculum. Although students recognized that groups often contained a large range of knowledge levels, not all students felt they received the support they needed, while those in a position to help did not always believe supporting others was a productive use of time. Through this lens, the decision to not always support their group mates can be viewed as a rational choice, even if this is not particularly kind or fair. Many of the classroom practices that students discussed were consequences of, or coping mechanisms for, addressing the range of needs within the groups. An uneven workload on assignments was a consequence of having high-knowledge students not trusting their slower moving group mates to do the work. Copying was, for at least some students, a coping mechanism to help them quickly acquire access to the course materials when they could not participate fully in the discussion during class.

The resulting lack of togetherness in some groups did not meet the instructor's intentions and could be an indicator, if it occurs early in the semester, that a student needs additional support. Although the instructor did notice and work to address the lack of togetherness within groups, these measures were not always enough. Future iterations of *Mathematical Literacy* should experiment with group structures that prioritize knowledge levels differently. In addition, an early lack of togetherness in mathematically diverse groups might be an early and actionable indicator a student requires additional support. While this study shows that not all students had positive experiences in *Mathematical Literacy*, some did. Refinements and reflections on ways to better meet the needs of students could do a lot for future *Mathematical Literacy* students.

References

Attewell, P., Lavin, D., Domina, T., & Levey, T. (2006). New evidence on college remediation. *The Journal of Higher Education, 77*(5), 886-924.

Bailey, T. (2009). Challenge and opportunity: Rethinking the role and function of developmental education in community college. *New Directions for Community Colleges, 145*, 11-30.

Baxter, J. A., Woodward, J., & Olson, D. (2001). Effects of reform-based mathematics instruction on low achievers in five third-grade classrooms. *The Elementary School Journal, 101*(5), 529-547.

Carnegie Foundation for the Advancement of Teaching (n.d.a) Quantway. Retrieved April 2017 from https://www.carnegiefoundation.org/wp-content/uploads/2014/07/QW_one_pager_2016.pdf

Carnegie Foundation for the Advancement of Teaching (n.d.b) Statway. Retrieved April 2017 from https://www.carnegiefoundation.org/wp-content/uploads/2014/07/SW_one_pager_2016.pdf

Cohen, A. M., Brawer, F. B., & Kisker, C. B. (2013). *The American community college* (6th ed.). San Francisco, CA: Jossey-Bass.

Creswell, J. W. (2014). *Qualitative, quantitative and mixed methods approaches* (4th ed.). Los Angeles, CA: SAGE.

Dougherty, K. J., & Townsend, B. K. (2006). Community college missions: A theoretical and historical perspective. *New Directions for Community Colleges, 136,* 5-13.

Emerson, R. M., Fretz, R. I., & Shaw, L. S. (2011). *Writing ethnographic fieldnotes* (2nd ed.). Chicago, IL: The University of Chicago Press.

Esmonde, I., & Langer-Osuna, J.M. (2013). Power in numbers: Student participation in mathematics discussion in heterogeneous spaces. *Journal for Research in Mathematics Education, 44*(1), 288-315.

Hagedorn, L. S., Siadat, M. V., Fogel, S. F., Nora, A., & Pascarella, E. T. (1999). Success in college mathematics: Comparisons between remedial and nonremedial first-year college students. *Research in Higher Education, 40,* 261–284.

Lubienski, S. T. (2000). A clash of class cultures? Students' experiences in a discussion-intensive seventh-grade mathematics classroom. *Elementary School Journal, 100,* 377–403.

Miles, M.B., Huberman, A.M., & Saldana, J. (2013). *Qualitative Data Analysis: A Methods Sourcebook.* Thousand Oaks, CA: SAGE Publications Ltd.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics*. Reston, VA: Author.

National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. Reston, VA: Author.

Norman, J. (2017). *Pathways post-parti* Reston, VA: Author.*cipation outcomes: Preliminary findings.* Stanford, CA: Carnegie Foundation for the Advancement of Teaching.

Sowers, N., & Yamada, H. (2015). *Pathways impact report*. Stanford, CA: Carnegie Foundation for the Advancement of Teaching.

Yamada, H., Bohannon, A., & Grunow, A. (2016). *Assessing the effectiveness of Quantway: A multilevel model with propensity score matching.* Stanford, CA: Carnegie Foundation for the Advancement of Teaching.

Yamada, H., & Bryk, A. S. (2016). Assessing the first two years' effectiveness of Statway: A multilevel model with propensity score matching. *Community College Review, 44*, 179-204.