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Oregon State University redesigned the college algebra class to make group learning at least 50% of class time. Specifically, in two out of four class hours each week students were organized into small groups where they completed exploratory activities involving new material. Although instructors were present during those group activity days, the focus was on student interactions to promote learning. The purpose of this thesis is to understand what aspects of the redesigned course are useful and challenging to students by conducting five focus group interviews with students over the course of a term. I share my findings from my investigation of the student experiences in the redesigned course: what students want from teaching and learning, and the varied student experiences in the course, particularly in terms of group work. Within these larger themes I explore the tensions that occur between student and instructor expectations from the course and use the lens of boundary crossing to provide possible explanations for unexpected student push-back to this new model. Finally, I offer suggestions for improving the structure of the course based on student feedback.

Student Experiences in Redesigned College Algebra

by
Krista Foltz Hocker

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Chair of the Department of Mathematics

Dean of the Graduate School

I understand that my thesis will become part of the permanent collection of Oregon State University libraries. My signature below authorizes release of my thesis to any reader upon request.

Krista Foltz Hocker, Author

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Chapter 1: Introduction

In recent years there have been numerous campaigns to increase the enrollment and success in STEM fields. Some of these efforts include: the Educate to Innovate campaign which aims to improve the participation and performance of America's students in STEM with the goal of enabling all learners to excel in STEM (U.S. Department of Education, 2010); a new set of public-private partnerships committing $250 million in private resources to attract, develop, reward, and retain STEM educators (U.S. Department of Education, 2010); the Workforce Investment Act with a focus on preparing youths for the STEM workforce (Sturko-Grossman, 2008); and Change the Equation, a new coalition that has been described as "more than a hundred CEOs […] who are committed to bring innovative math and science programs to at least a hundred high-need communities over the next year" (Robelen, 2010, para. 8). STEM fields are important to the national economy (Sturko-Grossman, 2008) and specifically, a more mathematically literate society provides benefits to the economy including "greater earning potential, more job mobility, and citizens who are more prepared for the demands of today's workforce" (Hodges & Kim, 2013, p. 59).

In addition to increasing the recruitment and retention of STEM students in post-secondary education, universities are also trying to address why half of all students that begin college with a STEM major switch to a non-STEM major before graduation (Lowery, 2010), which is the highest rate of switching out of any major, and is coupled with the fact that the sciences have had "the lowest rates of recruitment from any other major" (Green, 1989, p. 478). One such study to understand why undergraduate students switch from fields in mathematics and science to other majors found that inadequate teaching and concerns about the faculty's pedagogical methods topped the list of reasons (Seymour & Hewitt, 1997). Studies also confirm that these pedagogical issues are most prevalent and problematic in mathematics (Daempfle, 2002; Pemberton et al., 2004).

One initiative to improve teaching in undergraduate mathematics was led by the Mathematical Association of America's *Committee on the Undergraduate Program of Mathematics* (CUPM) to redesign and improve the nation's college algebra and pre-calculus courses through the work of a subcommittee: *Curriculum Renewal across the First Two Years* (CRAFTY) (Ganter & Haver, 2011). This initiative was driven by the fact that every year in the United States of America, between 650,000 and 750,000 students enroll in college algebra courses with the goal of meeting his or her academic program's mathematics requirement (Katz & Mathematical Association of America, 2007) and most college algebra courses have a 40-60% withdrawal and fail rate (Gordon, 2008; Hagerty, Smith, & Goodwin, 2010; Katz & Mathematical Association of America, 2007; Mayes, 2004). This amounts to 57-80% of all college mathematics enrollments per university (Mayes, 2004). For those students pursuing a career in science, technology, engineering, or mathematics (STEM) fields, college algebra and pre-calculus courses are merely prerequisites to the calculus series, however these failure and withdrawal statistics result in a matriculation rate of only 9% to calculus and the affective result of negative student attitudes toward college algebra (Gordon, 2008; Hagerty et al., 2010; Katz & Mathematical Association of America, 2007; Mayes, 2004). According to the National

Center for Academic Transformation (NCAT), there are at least 45 community colleges and universities who are redesigning their college algebra courses ("NCAT - Projects Sorted by Discipline," n.d.) and the National Science Foundation (NSF) is supporting teams from eleven institutions in their redesign of college algebra ("NSF Award Search: Award#0511562 - Renewal of College Algebra," n.d.). In addition to redesigning college algebra courses, the Mathematical Association of America (MAA) and the American Mathematical Association of Two Year Colleges (AMATYC) recommend conducting research that studies numerous aspects of the redesigned course and "the impact of well-designed and well-supported refocused College Algebra courses on student achievement and understanding" (Katz & Mathematical Association of America, 2007, p. 35).

Understanding the impact of the college algebra course on students' achievement of STEM degrees, Oregon State University (OSU) redesigned and piloted its college algebra course during the 2012-2013 academic year and implemented the course at scale in 2013-2014 to improve student success in the course as well as student understanding and appreciation of mathematics. Following the recommendations of the MAA and AMATYC mentioned above, the Department of Mathematics at OSU designed several research projects surrounding this change. My thesis is one such project and in Chapter 2 I will provide rationale for my qualitative research regarding student experiences in the redesigned course based on a review of the literature on the subject. In Chapter 3, I will describe the methods used to recruit student participants, collect data, and analyze the student data through the method of thematic analysis (Braun & Clarke, 2006). These methods were determined by my research question, which is presented at the conclusion of Chapter 2. The over-arching themes that I identified in the data will be presented in Chapter 4 and a discussion of such themes will be presented in Chapter 5. Within Chapter 5 I will suggest improvements that can be made to the redesigned course based on the findings in Chapter 4, as well as new questions for future research.

Chapter 2: Literature Review

2.1 College Algebra Redesign

The traditional structure of many undergraduate mathematics courses, including college algebra, at most universities involves large lecture sections of 100-200 students that are predominantly direct instruction of college algebra with limited student participation (Gordon, 2008). The critics of traditional university mathematics instruction put forth the claim that students who learn within a lecture-based classroom will gain little understanding of what constitutes mathematical activity and will see few, if any, connections between the various pieces of mathematics they have studied through the course of their schooling (Davis & Hersh, 1981; Kline, 1977; Postareff, Lindblom-Ylänne, & Negvi, 2007). This lecture-dominated structure of college algebra has been riddled with low student passing rates and negative student attitudes toward the course (Gordon, 2008; Hagerty et al., 2010; Mayes, 2004). Although this structure is not unique to college algebra, the lack of inquiry and student interaction affects a population of students who have serious doubts about their mathematical abilities and will often choose a career requiring less mathematics to avoid struggles in their coursework (Hagerty et al., 2010).

The CRAFTY guidelines for college algebra include an emphasis on problem-solving, a foundation in quantitative literacy, and developing algebra skills necessary for future careers (Ganter & Haver, 2011). To incorporate many of these new foci, universities have started to transition from the lecture-only structure to a mixed model approach that includes cooperative activities, computer-based learning, whole class discussions, and active student learning (Gordon, 2008; Hagerty et al., 2010; Mayes, 2004). Another format of redesign is commonly referred to as the emporium model, where students work at their own pace through a computer-based algebra curriculum that emphasizes problem-solving and real world applications with little to no instructor contact (Hodges & Kim, 2013).

The mixed model approach of redesigning college algebra includes student engagement and active learning, which recent research has shown to be effective at improving student performance and decreasing failure and withdrawal rates (Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014). This study by Freeman et al. (2014) is a meta-analysis of over 225 studies comparing the class sessions of courses using traditional lecturing and those with aspects of active learning, which included "occasional problem-solving, worksheets or tutorials completed during class, use of personal response systems with or without peer instruction, and studio or workshop course designs" (p. 1). Their findings indicated that active learning increased "student mastery of higher- versus lower-level cognitive skills" and that active learning had "the highest impact on courses with 50 or fewer students" (Freeman et al., 2014, p. 3).

2.2 Student Voice in Learning

Several education researchers argue that often, student voice is absent from educational policy and classroom practice decisions, which creates a deficit in holistic feedback in our education system that needs to be addressed (Cook-Sather, 2002; Dahl, 1995; Fisher & Fraser, 1983; Heshusius, 1995; Johnston & Nicholls, 1995;

Lincoln, 1995; Rodgers, 2006). In our society, adults often dictate what educational policy changes should be made for the best interest of the students (Cook-Sather, 2002; Dahl, 1995; Fisher & Fraser, 1983; Heshusius, 1995; Johnston & Nicholls, 1995; Lincoln, 1995; Rodgers, 2006). This is a pattern that can be seen in classroom practice decisions as well and is often rooted in the belief that adults' ideas are more important and informed than those held by youth (Cook-Sather, 2002; Lincoln, 1995). It is not necessarily the case that students do not participate in classroom activities or that teachers do not solicit responses from students throughout class, but rather that the student voice is missing in the construction of their learning experience (Cook-Sather, 2002). Cook-Sather (2002) argued that because the student voice has been overlooked for so long and because they have a distinct role in the classroom, students can provide "singular and invaluable views on education" that can be beneficial for the entire community (p. 3).

Researchers suggest that teacher resistance or reluctance to soliciting student feedback might stem from the teacher-as-authority identity that many educators started to develop in teacher education programs (Cook-Sather, 2002; Heshusius, 1995). Similarly, the experience of providing feedback can be difficult for students who may view this new attention as extra work. This pattern of overlooking student voice has caused many students to develop the viewpoint that knowledge is something provided by the teacher and comes with specific instructions of what to learn and how to learn it (Johnston & Nicholls, 1995). The difficulties described above should not deter teachers from seeking the student perspective, as research shows that teachers who encourage descriptive feedback from their students can create trusting relationships with their students that lead to a more effective learning environment (Rodgers, 2006).

The overwhelming conclusion by researchers is that student voice should inform teaching (Cook-Sather, 2002; Dahl, 1995; Lincoln, 1995; Rodgers, 2006). With an increase in student opinions and thoughts, teachers have a clearer understanding of what interests or confuses their students and in turn can make the material more accessible (Cook-Sather, 2002). One way for instructors to hear such feedback is to ask for students to comment on their experiences, learning, and thought processes without a prescribed framework for response. This can provide an opportunity for student metacognition which produces better learners and better teachers (Heshusius, 1995; Rodgers, 2006). Rodgers (2006) asserted that descriptive feedback was often more valuable to teachers than evaluative feedback. When students were asked to self-evaluate performance on a task, the teacher had usually arrived at a conclusion about that student's work prior to reading the self-evaluation. However, descriptive feedback provided the opportunity for students to describe learning as an experience which led to new connections or questions that the teacher had not considered previously (Rodgers, 2006).

Another implication of including student voice is that it promotes student engagement. When teachers listen to students, they feel empowered and more likely to devote time and energy to the class. If students know someone is listening, they feel accountable for information and will put time in to learning outside of class (Cook-Sather, 2002; Lincoln, 1995; Rodgers, 2006). Additionally, such effort and reflection creates self-awareness about a student's learning process. This kind of student behavior should surely be encouraged by teachers. However, when students feel empowered, they may present opinions and ideas that run counter to those of the teacher. Such ideas may be considered "digressions" and for the unaccustomed teacher, may serve to derail the conversation rather than enrich it (Heshusius, 1995; Johnston & Nicholls, 1995). As Rodgers concluded, student feedback should not be considered an evaluation of teaching practices, but "an exploration of what helps and hinder learning, and why" (Rodgers, 2006, p. 219).

The third benefit of incorporating student voice is that it creates a holistic view of learning. Because of their unique roles in the classroom, teacher and student perspectives often differ when it comes to opinions about quality instruction, classroom environment, and learning (Cook-Sather, 2002; Fisher & Fraser, 1983; Johnston & Nicholls, 1995). One particular study provided a comparison of actual and preferred classroom environments, as perceived by students and teachers in junior high school science classrooms. This study showed that teachers ranked their classroom environments more favorably than their students and, significantly, that students in the study indicated a preference for an even more positive classroom environment than what they currently experienced (Fisher & Fraser, 1983). Although this is only one example of how student and teacher perspectives can differ, it also illuminated how the student perspective could help to complete our view of the classroom and classroom practices. To actively seek the student voice, teachers should pursue open-ended and qualitative questioning that allows students to provide individual and descriptive perspectives on their learning and understanding (Heshusius, 1995; Rodgers, 2006).

2.3 Experiences of First-Year College Students

Students undergo many changes during their college years and these changes can affect their perception of learning, expectations for college classes, and their overall success (Clark, 2005; Erickson, Peters, & Strommer, 2006; Fazey & Fazey, 2001). Erickson et al. (2006) described a progression of student development during undergraduate education and how it related to their perception of learning. Although they described four different groups in the sequence, dualism and multiplicity pertain most adequately to my research as most first-year students exhibited behaviors characterized by these two stages (Erickson et al., 2006). Dualism was described as a stage where students “view knowledge as truth—factual information, correct theories, right answers” and students see “the professor as an authority who knows these truths and believe that teaching constitutes explaining them to students” (Erickson et al., 2006, p. 22). Students in this stage of development wanted to be taught directly from the instructor and found activities involving peer instruction frustrating (Erickson et al., 2006). Multiplicity was the next stage of development, when students “realize that in some areas or on some issues no one yet has a definitive answer” and thus believe that knowledge is “a matter of opinion” (Erickson et al., 2006, p. 24). Students in this stage believed that everyone had the right to an opinion, but they also recognized that they must support their opinion with evidence and justification (Erickson et al., 2006). The research provided by Erickson et al. (2006) described an academic environment where students were at different stages of development in their perceptions of learning and these stages must be understood by educators in order to better support their students. Some suggestions they offered based on the research included: providing thought-provoking problems and tasks, supporting students by being available to meet with students, and providing clear expectations for students (Erickson et al., 2006). Supporting first-year students can also take the form of faculty feedback, which is essential to developing a sense of competence in the academic setting (Fazey & Fazey, 2001). According to Fazey and Fazey (2001), most of their participants reported that one quarter of the way through their first term in college, they still had not received any feedback from their instructor about their progress in the course.

In addition to navigating changes in their perceptions about learning, students must also navigate some of the physical challenges present in the transition to college. Research by Clark (2005) described large lecture sections as prohibitive toward student participation and that first-year college students' experiences in these courses taught them that "the classroom was not the proper place or time for asking questions" (p. 303). College students must also develop strategies for studying in their new environment (Clark, 2005). Students in Clark's (2005) research reported changing study locations numerous times during the term to avoid noise and over-crowding, but also to accommodate their college schedules which differed from high school.

2.4 Student Experiences in the Context of Mathematics Reform

The final piece of this review is to examine the investigations addressing student experiences within the context of mathematics reform. Both internationally and nationally, the installment of mathematics reforms has been prevalent across grade levels and courses (Ellis, Malloy, Meece, & Sylvester, 2007; Kyriakides, Charalambous, Philippou, & Campbell, 2006; Ponte, Matos, Guimarães, Leal, & Canavarro, 1994; Star, Smith III, & Jansen, 2008). Most of the reform movements described here involved a departure from both direct instruction and the emphasis on procedural knowledge, to a curriculum that promoted cooperative learning and concept-driven problem-solving techniques. Student perspective is often missing from reform efforts, so these articles each included specific student reactions to reform because the authors believed it should be included in subsequent investigations into the effectiveness of the reform (Ellis et al., 2007; Kyriakides et al., 2006; Ponte et al., 1994; Star et al., 2008). Ellis et al. (2007) took the research one step further and not only provided the student reaction to new instructional practices, but gave proof for the validity of the student perspective when compared to observer ratings of classroom practices.

The student reactions to each reform differed because of the specific reform structure and methodology of the study, however they echoed themes that have been presented in other sections of this review. For example, Ponte et al. (1994) described resistance from students toward methodologies involving group work because of their deeply held beliefs about the instructor transmitting knowledge and the students receiving it. Students also struggle to work in groups because they believe that mathematical learning is less about the process and more about finding the right answer (Ponte et al., 1994). Work by Kyriakides et al. (2006) described a decrease in student self-efficacy when working with new problem-solving models that are unfamiliar. Although the reactions were context-specific, the researchers showed that students struggled and resisted new methods that shook their deeply held beliefs about mathematics. Because of this, Ponte et al. (1994) promoted continued research in this field because little is known about the effect of curriculum reform designed to improve student attitudes against well-developed student expectations and conceptions about mathematics learning.

In addition to the affective response to reform, other studies aimed to investigate what students noticed as different between traditional and reformed courses. Reformed curriculum involving group work and an emphasis on conceptual knowledge and problem-solving is often considered to be more challenging, varied, and requiring more work (Ponte et al., 1994; Star et al., 2008). Specific to calculus reform, students identified differences in content and typical problems as most different between traditional and reform courses. This includes global differences in the difficulty of course material, and typical problems describe the type of tasks that were assigned (Star et al., 2008). It seems to be that perceived difficulty level as it relates to material learned in class and required homework are what students tend to focus on during a reform movement (Ponte et al., 1994; Star et al., 2008). These common struggles among reforms provide useful information for universities who are looking to redesign college algebra.

2.5 Looking Forward

Student Experiences in Redesigned College Algebra

There is compelling research that indicates student voice should be an integral part of reform efforts in education (Cook-Sather, 2002; Dahl, 1995; Johnston & Nicholls, 1995; Rodgers, 2006). This includes the college algebra reform movement. As universities continue to improve their reform efforts, it will be essential for researchers to provide insight into instructor opinions, data evaluating student learning in the reform, *and* the student perspective on how they experience the reform. Such experiences might include likes and dislikes of the reformed structure, aspects of the course that students find atypical of a mathematics course, and their opinions about the methods used to teach the content. As Hodges and Kim (2013) suggested, this research must involve qualitative data to better clarify the quantitative data that already exists.

My study involved college algebra students at OSU who were enrolled in the redesigned college algebra course. In an effort to generate a holistic understanding of the student experience, I developed an intentionally broad and open-ended research question. My research question is: How do students experience the redesigned college algebra course at Oregon State University? Although the broad nature of my question precludes any hypothesis testing during data collection, I did generate possible sub-questions to support my research question and ensure a complete view of the student experience. Some of the sub-questions are listed below:

What do the students view as different in the redesigned course?
What do the students see as the role of the instructor in the course?
What do the students see as their role in the course?
How do their previous experiences in mathematics influence the way they experience the redesigned course?

Student Experiences in Redesigned College Algebra

In the following chapter I will present a detailed description of the methods used in the study, but here I will briefly indicate how the literature influenced the structure of my research. As mentioned above Hodges & Kim (2013) suggest a qualitative study to prove a detail rich data set that can provide insight into existing quantitative data. To collect such data, I facilitated focus group interviews with students. My questions within these focus groups related to CRAFTY's guidelines (Ganter & Haver, 2011) for college algebra to monitor how students perceive their progress in those areas and included opportunities for students to discuss what they viewed as different in the reformed course as suggested in the Star et al. (2009) study on calculus reform.

Chapter 3: Methods

In this chapter I will describe in detail the structure of the redesigned college algebra course, present the recruitment procedures used to enroll participants in the study, describe the population of student participants, and explain the methodology used to collect data and to analyze the data.

3.1 Structure of the Redesigned College Algebra Course

Using recommendations from the research cited in Chapter 2, the Department of Mathematics at OSU redesigned the college algebra course. Although both the traditional and redesigned courses meet four hours per week, the instructor is present all four hours in the redesigned course whereas in the traditional lecture the instructor is only present three days per week with a recitation led by a teaching assistant in the fourth hour. Class sizes were decreased from 200+ to less than 60 and two days per week the teaching assistant for the course is present to support group learning.

Table 3.1 Traditional vs. Redesigned Course at OSU

Class Type	Class Size	Class Time	Communication between educators
Traditional	180-240	3 hours lecture, 1 hour recitation	Instructor and teaching assistant (TA) each facilitate a separate aspect of the course, with limited communication
Redesign	<60	2 hours small group work 2 hours lecture	Instructor and TA co-teach during group activity days Instructors and TAs attend weekly team meetings to discuss content, improve course materials, and create common exams

Student Experiences in Redesigned College Algebra

The most dramatic change between the traditional college algebra course and the redesigned course is that now 50% of class time is dedicated to students working in groups of three to four and actively engaged in mathematical learning. Prior to these group activity sessions students are not taught the material by their instructor, but rather complete reading assignments in the textbook and a preparatory online homework assignment to familiarize themselves with the content. Students then work in groups to solidify the concepts through scaffolded problems and models.

Table 3.2 Schedule for Redesigned Course at OSU Based on Four Class Meetings Each Week

Prior to Day 1	Day 1	Day 2	Prior to Day 3	Day 3	Day 4
Online homework	Activity/ small group	Wrap up of Day 1	Online homework	Activity/ small group	Wrap up of Day 3

Each activity includes a section with key concepts, prerequisite skills, and learning outcomes. The first problem of most activities is a modeling or contextualized problem to help students see the real world value of the particular concept. The subsequent tasks guide students through procedural learning by building off of previous knowledge and then help them identify patterns between topics. These group activities were developed at OSU, piloted during the 2012-2013 year, and then modified as we learned more about how students engaged with them. An example of one such activity can be found in Appendix A. Groups that do not complete the activity in class have to finish the assignment on their own and turn it in one to two days later (depending on the instructor) for credit based on completion. The next day, the instructor wraps up the key concepts of the group activity and lectures on additional content from that particular section. Although a majority of the college algebra sections have been redesigned, due to limited classroom space, there are still a few sections of the traditional lecture course that also run each term.

3.2 Recruitment and Student Population

The data for this study was collected during the ten-week winter term at OSU. In order to understand the student experience in the course, it was important to recruit as many college algebra students as possible from the redesigned section during that term. In addition to collecting data during winter term, I was also working as a graduate teaching assistant for one of the redesigned sections. For this reason, my thesis advisor, Dr. Mary Beisiegel, assisted in the data collection by recruiting and interviewing students who were enrolled in my section of the course. Dr. Beisiegel and I visited the first class of each section of redesigned college algebra to speak with students about the research study and recruit volunteers to participate. After visiting the classes, we followed up with a recruitment email, which can be found in Appendix B.

Of the approximately 600 students enrolled in redesigned college algebra, 23 self-selected for the study and completed the pre-survey, which can be found in Appendix C. There were five students that never responded to our communications after initial interest and another four students completed part of the study before dropping out due to illness, schedule conflicts, or withdrawing from the course. Thus 14 students completed the entire study. Students were asked to participate in six to eight hours of data collection over the span of 10 weeks, so the time commitment may have deterred them from participating. At the onset of the research, we expected greater participation and thus the statistical power to make some conclusions about the course through the survey data. Given that only 14 students completed both surveys, we did not have the power to run the analyses. Students were paid for their participation and the stipends were funded by a grant from the Center for Teaching and Learning at OSU. When students signed up for the research we explained the potential risks and familiarized them with the protocols we had in place to protect their identity: randomly assigned research identification number and de-identified transcripts. During the preliminary meeting we asked students to complete a scheduling form that would allow us to organize them into groups.

The table below provides some personal and academic attributes of the 16 students highlighted in this thesis. Although two of the students listed in the table did not complete the entire study, their comments did provide useful insight into the student experience. Fourteen of the 16 students listed were second-term, first-year students which means that college algebra was either their first or second college mathematics course. The two students who were not in their first-year of college were Adriana, a transfer student from a university outside of Oregon, and Tim, who attempted to earn a degree at OSU several years ago and had returned to complete his degree. Seven participants listed a STEM field as their intended major (i.e., zoology, pre-medicine, pre-nursing, biology), whereas eight students listed intended majors in non-STEM fields (i.e., business, public health, or forestry). Students were asked to describe themselves as a mathematics learner and based on their responses I grouped them in to one of three categories: (1) confident and able to learn concepts quickly, (2) moderately confident, but learning concepts required effort, (3) not confident and learning concepts was a struggle. This classification can be seen in the final column of the table.

Table 3.3 Summary of Student Participants

Pseudonym	Number of Years at Oregon State	Intended Major	Enrolled in College Algebra Previously?	Student as Mathematics Learner
Adriana	Second-year	Business	No	3
Ashley	First-year	Business	No	1
Cassandra*	First-year	Exercise and Sports Science	No	3
Connor*	First-year	Business	No	1
Cynthia*	First-year	Merchandising Management	Yes	2
David*	First-year	Zoology	No	2
Ian	First-year	Business	No	2
Jesse*	First-year	Biology/Pre-Medicine	No	2
Katie	First-year	Public Health	No	2
Maria	First-year	Biology	No	1
McKenzie	First-year	Physical Therapy	No	2
Roland*	First-year	Business	No	1
Stacey*	First-year	Zoology	No	1
Theresa	First-year	Pre-Nursing	No	2
Tim*	Returning Student	Forestry	Yes	3
Veronica*	First-year	Not known	No	2

*These students participated in focus group interviews with Dr. Mary Beisiegel
_These students completed between 2-4 focus group interviews

3.3 Focus Group Interviews

Student Experiences in Redesigned College Algebra

Students were organized into four groups of two to six people, based on their schedules, and participated in five focus group interviews (Wilson, 1997), conducted every two weeks during the ten-week term. One focus group was comprised of only females, but the other three groups had both male and female participants. The choice to conduct focus group interviews was both a purposeful and logistical one. I wanted to observe and hear peer interactions regarding the redesigned course, especially those interactions between students of differing mathematical ability and students experiencing differing levels of success in the course. These interactions between diverse groups of students helped me identify consensus views from the students as well as important differences in their experience of the course (Wilson, 1997). Logistically I also chose focus group interviews because I did not have time to interview students individually. The goal of these focus group interviews was to understand the students' experiences in the course, but also their thoughts about (1) mathematics teaching and learning, (2) the role of students and instructors in the course, (3) previous experiences with mathematics, and (4) group work as a learning and teaching tool. The focus group protocols were developed using validated questions from previous research as well as suggestions from the literature (Ganter & Haver, 2011; Star et al., 2008) . The full list of focus group interview protocols can be found in Appendix D, but here are some sample questions:

> How do you describe quality math teaching and learning?
> What does it mean to be successful in learning math?
> What are challenges you encounter in the class?
> How would you describe the class to another student?
> How would you describe a well-taught math lesson?

During the focus group interviews each student was given the opportunity to answer every question, however, students were allowed to skip questions that they did not feel comfortable answering. In order to see how students' thoughts and opinions changed over the term, Dr. Beisiegel and I revisited certain questions at different points in the study. In particular, the focus group protocols for the first and last interview are the same except for a few summary questions in the final focus group. Although Dr. Beisiegel and I used the same focus group interview protocols, we asked follow-up and clarifying questions at our own discretion. Some of these follow-up questions pertained to what students had just experienced in the class, such as an exam or a particular concept they learned in lecture. The sessions were held on campus, lasted between 60 – 90 minutes, and were video recorded, though students were given the ability to opt out of having their image recorded. In order to protect the students' anonymity we addressed them by their randomly generated research identification number and asked the transcription service to use these numbers in the transcripts. Students were reminded at the beginning of the focus groups that any comments made during the focus groups needed to stay confidential within the group.

3.4 Thematic Analysis

I used the process of thematic analysis, as described by Braun and Clarke (2006), to analyze the transcriptions of the focus group interviews. As Braun and Clarke (2006) describe it, thematic analysis is a useful tool in qualitative analysis that provides a rich and complex data set. There are six phases to thematic analysis and I have included a table with a brief description of each phase.

Table 3.4 Phases of Thematic Analysis

Phase	Description of the process
1. Familiarizing yourself with your data	Transcribing data (if necessary), reading and re-reading the data, noting down initial ideas
2. Generating initial codes	Coding interesting features of the data in a systematic fashion across the entire data set, collating data relevant to each code
3. Searching for themes	Collating codes into potential themes, gathering all data relevant to each potential theme
4. Reviewing themes	Checking in the themes work in relation to the coded extracts and the entire data set, generating a thematic 'map' of the analysis
5. Defining and naming themes	Ongoing analysis to refine the specifics of each theme, and the overall story the analysis tells; generating clear definitions and names for each theme
6. Producing the report	The final opportunity for analysis. Selection of vivid, compelling extract examples, final analysis of selected extracts, relating back of the analysis to the research question and literature, producing a scholarly report of the analysis

During phase 1 and 2 of thematic analysis, I worked with an undergraduate mathematics major intending to be a high school teacher in her senior year of college. She was not involved with the college algebra redesign and thus was unfamiliar with many details of the study. The purpose of working with an outside reader was to add validity to the data by checking some of the bias I might bring to the reading of the transcripts. In my role as a graduate teaching assistant I have in-depth understanding of the aims of the redesigned course, the expectations that instructors have for students, and first-hand experience with the day-to-day logistics and interactions within redesigned college algebra classes. While this understanding helped me connect with students and understand their comments about the structure of the course, I was also concerned that my emotional and professional investment in the redesign effort might influence my reaction and interpretation to student critique and feedback. The undergraduate and I read each set of transcripts at least two times: once to familiarize ourselves with the data, and a second time to generate initial codes. We met every week to discuss the transcripts and her feedback during those meetings provided interesting insights. She often had a distinct interpretation of the attitude a student projected in their comments and could compare and contrast the participants' experiences in math classes with her experiences in the same department. Our interpretations of and takeaways from the transcripts were similar and provided a coherence to the themes we interpreted in the data. For an example of our notes from one particular session, see Appendix E.

After generating the initial codes of the data, I started to make several key decisions about the thematic analysis as encouraged by Braun and Clarke (2006). Thematic analysis provides the researcher some flexibility, but Braun and Clarke (2006) advocate for purposeful and transparent decision-making during the process. My research question was open-ended and I conducted the focus group interviews without specific hypotheses to test. These aspects of the study affected the choices I made during data analysis. In an effort to explore the entire student experience of the redesigned college algebra course, I decided that the best-suited method of analysis was to first create a detail-rich description of the entire data set and then focus on a few particular topics or themes that best communicated the student experience in the redesigned course. Similarly, I wanted to push beyond the surface-level understanding of student comments and try to understand the students' perspective within the frame work of boundary crossing (Jansen, Herbel-Eisenmann & Smith III, 2012) which I will explain further in Chapter 5. This decision to analyze the underlying ideas behind student comments is called the latent approach (Braun & Clarke, 2006). I have included a table that summarizes these decisions and how they informed data analysis.

Table 3.5 Decisions Within Thematic Analysis

Option 1	**Option 2**	**Decision and rationale**
Rich description of the entire data set	Detailed account of one particular aspect of the data	I began with a rich description of the entire data set and then narrowed my focus to a few aspects of the data that best communicated the complexity of the student experience.
Inductive (bottom up) approach	Deductive (top down) approach	Inductive: my research question is open-ended and therefore lends itself to a data-driven approach to analysis without the constraints of a particular hypothesis or theoretical framework.
Semantic themes: explicit/surface level; researcher does not look beyond what the participant has said or written	Latent themes: interpretive level; researcher looks to examine the underlying ideas and assumptions	Latent: I am to analyze and explore student comments in the context of boundary crossing (Jansen et al., 2012)

The following chapter will present the results from the thematic analysis of the focus group interviews. The findings will be presented in the form of themes that I identified during phases 4 and 5 of thematic analysis. Thematic analysis is a hypothesis-generating method and so student comments and quotes will be essential to the understanding of themes and subthemes.

Chapter 4: Data Analysis and Discussion

In this chapter I will present results from the thematic analysis (Braun & Clarke, 2006) of the student data. After initially coding the data by topic (i.e., “math learning”, “attitude about math”, “class structure”), I organized them into very specific themes (i.e., “how students want to instructors to present examples”, “students think that teaching peers during group work is inefficient”) and then explored ways to connect these themes with broader descriptions that provided a coherent story. Thus I reclassified my original, specific themes to be the subthemes of the broader descriptions (i.e., “what students want”). These encompass the themes I present here. I identified two overarching themes in the data that describe how students experience the redesigned college algebra course at OSU: (1) what students want and (2) the wide-ranging experiences of students in the course. For each theme and subtheme I will provide student statements from focus group interviews. These statements have different features in that they are either illustrative of common experiences among the focus group participants or provide interesting contrasts in the students’ thoughts or experiences.

4.1 What Students Want

Students responded to a variety of questions during the focus group interviews ranging from those that asked for their opinions about quality math teaching and learning to specifics about the college algebra course. Within the student comments that conveyed their expectations and desires from the course, I identified patterns in what students want from learning and what students want from teaching. Although these two subthemes address different aspects of the course, one cannot be analyzed without the other. The way that students want to learn mathematics is certainly influenced by how students want to be taught mathematics. Thus it is important to consider the interplay between the role of the teacher and the role of the learner in the opinion of the student. These comprise the subthemes of “what students want” and offer insight into the tensions that occur when students encounter teaching and learning behaviors that differ from their expectations.

4.1.1 What Students Want From Teaching

With the exception of two students, the majority of our participants were in their first year of undergraduate education with college algebra as either their first or second college level mathematics course. This provides a context for some of their responses to questions about quality teaching and what makes a good teacher, because several students referenced high school experiences in their responses. In most focus group interviews we asked students to comment on quality teaching and almost every participant described good teaching as teaching through step-by-step examples and then asking students to replicate the instructor’s work on similar examples. Students also emphasized their preference for procedural thinking. Even more prominent was their opinion that students should not have to complete tasks prior to learning the material from the instructor. The rationale behind this opinion varied slightly between students. Some said that completing tasks prior to learning the material from an instructor was difficult and time consuming, others lacked confidence in their own learning abilities and wanted assurance that they were learning the material "correctly". Regardless of the reason, the conclusion was the same amongst students: the best way to learn math is to hear it from an instructor and then apply it to a similar problem. This student's comment illustrates this conclusion:

> Adriana: I am like a visual, hands-on learner, but I -- I can't learn on my own. So for me a good teacher is one who will explain the problem, will do a couple examples to show you how it's done and why, and then, say you went to group work, so you can work on it with fellow peers so they can explain it in their terms to you and kind of use the – the transition of the teacher explaining it versus you doing it on your own for homework. (Focus Group Interview #1)

By comparing this student's example of good teaching to "doing it on your own for homework", she intimated that the task of completing homework before learning material from the instructor was not a good learning experience for her because she felt like she was unable to learn on her own. This student self-identified as a relatively low-achieving math learner. Other low-achieving students said they wanted the material modeled first to give them more confidence as they started to solve problems individually or with peers.

As mentioned in the description of the course in Chapter 2, students were required to complete assignments on-line and in-class before hearing a lecture/presentation from their instructor. In response to this feature of the course, another student talked about her struggle with completing homework when she was asked to submit the assignment prior to learning the material from her teacher:

> Maria: I feel like we're spending way too much time outside of class trying to figure it out and like you know we have to do the homework before we learn it, before the teacher tells us how to do it and so it's we're reading it out of a book and the book is not the best thing I don't think. It doesn't have like – all steps are

> explained, all the steps like a teacher can. If you don't get something you can't ask the book how do you do this and then you have to get the homework done before and you only have like two chances to do it. So, I mean yeah, it's like I feel like I'm spending way too much time on the homework because I don't know how to do it and then the next day we talk about it in class I'm just like "oh, that makes way more sense now" like every time the teacher explains it. (Focus Group Interview #2)

In addition to reinforcing the order of learning (teachers teach and *then* students learn) that students expect to experience in the classroom, Maria also introduced the notion that teachers explain material in the best way. When she said that the book "doesn't have like – all steps explained…like a teacher can" she suggested that it would be better or more efficient if the teacher explains the material to her, rather than learning the information independently from a textbook. In the redesigned college algebra course, students were expected to utilize their textbook as a resource during exploratory active learning where students engaged with material prior to an instructor-led lecture. To prepare students for these activity sessions, they were required to complete online homework assignments to expose them to the vocabulary and basic concepts. These two teaching strategies received push-back from nearly every student and students brought up these issues in every focus group interview. Not only did students prefer to learn mathematics from the teacher before applying that learning, it is what they expected from a typical math class:

> I: Okay. Just – what do you – you said like a normal math class, what would normal math class be like?
> Veronica: I think it's just like the teacher like giving us an example of a problem and like you would solve something and then giving us like problems to apply it to, and to solve them. (Focus Group Interview #4)

Thus, asking students to complete mathematical tasks or learning prior to teacher-led instruction was not appreciated and is a source of tension in the student learning process.

My interpretation of the data from the focus group interviews is that students have specific expectations regarding how teachers teach the material to students. Using a colloquialism, students wanted teachers to "just lay it all out" for them. This applies to the way teachers talk about material, how they respond to student questions, and their expectations for content knowledge. When talking about the material, students wanted teachers to use language that they could understand and with just enough detail about the subject to be able to complete tasks:

> Theresa: I think to like translate everything so that we can understand. And to get through all the material. Because I know my current instructor for this term, he gets like super descriptive and over-explains things, and we only get through like two concepts, and it's kind of frustrating. (Focus Group Interview #1)

In using the word "translate", Theresa gave the impression that the mathematical language known to the instructor was not something that students could understand. Therefore it was the instructor's job to take his or her mathematical understanding and adapt or simplify it for students. Theresa also thought her instructor "over-explains" things, which is surprising since many students expected step-by-step and thorough explanations of problems. Perhaps for this student, explanation was good so long as it did not delay the instructor in covering other material for which the students were also responsible. If the instructors over-explained one topic and did not have time to cover another, then the students had to self-teach the other concept which was not their preferred method of learning.

I saw a similar discrepancy in how content knowledge was actually communicated compared to how students wanted it to be communicated. Students discussed the fact that their teachers wanted them to have conceptual knowledge, but they viewed procedural knowledge as more useful for assessments:

> McKenzie: I mean, I'm not saying I don't care about the concepts, but obviously I need to know what the concept is, but I don't know, they just aren't as important, because how I see it is I'm going to lose points on my step-by-step procedure rather than knowing what a word really means. If I know the general idea of what something means, then I'm fine. I don't – I feel I don't have to necessarily understand it completely to know how to do the problem. (Focus Group Interview #3)

This passage provides reasoning behind why students may have preferred procedural knowledge over conceptual knowledge, and also identifies a flaw in the redesigned course. An aim of the redesigned course is to place greater emphasis on the conceptual knowledge of the content and to show the utility of modeling data using the functions learned in the course; however the data shows that students still interpreted exam questions as procedural in nature. By emphasizing conceptual understanding, instructors pushed students to understand the "why" behind the material, rather than memorizing steps. If students were not used to this kind of thinking and did not feel that they needed to engage in this kind of thinking to be successful, it could leave them confused and anxious for answers to their questions.

Here, a student described a situation where his instructor asked him a conceptual question about the meaning of a vertical asymptote as a method of guiding him to answer his original procedural question:

> Tim: Well, they come up. I'm a person that I ask a question, I like a straightforward answer. But if you want to explain to me later, you know, then I'm willing to listen. But it's like, you know, do the vertical asymptotes come from the numerator or the denominator? And I understand she was trying to make me think about it, but at this point we're so far into the day that I just want to know. (Focus Group Interview #4)

Tim's comment indicates a level of frustration with wanting the instructor to provide direct answers that attend to the procedural nature of the problem and not receiving those answers. The sentiment in this student's statement is representative of other examples where students felt exasperated that their instructors would not "spell out" the material in the way that the students wanted. In some cases, this led students to refuse to ask their instructors for clarification because they viewed it as pointless and requiring too much effort.

Compounding this issue of communication between students and instructors was the fact that students wanted timely feedback on assignments and were not receiving it in the redesigned course. The intent of the redesigned course was to allow students the opportunity to struggle with new material during group activity days and then connect the activity to the concepts from the book as a "wrap-up" of the big ideas during the very next class period. After talking with students, I realized that this was not actually happening. Instead, students turned in their group activities with little to no classroom discussion, received credit based on completion, and did not receive feedback about their level of understanding:

> McKenzie: I feel like with the worksheets we do, I think – I mean, I guess a problem for me right now is the whole kind of grading it on completion. Like sometimes I think they're too big to go through in one hour and like actually know what you're doing instead of just kind of rushing through it to get all the points you can get. And then I think that's another thing is don't know how I did on our very first worksheet. I don't know if I got all the questions right or if I got half of them wrong, because there's no answer sheet. (Focus Group Interview #1)

Not only does this reveal an area of the course that needs to be improved, it also gives one reason why students did not view the group activities as useful learning experiences. Without instructor feedback on the correctness of their work, students were left without any closure on the material which they identified as important to their learning. It is clear from the focus group interviews that students wanted their instructor to be a more attentive guide through the course by checking for understanding during class, providing regular feedback, and answering questions thoroughly when asked. Rather than focusing on individual learning and conceptual thinking which can be time-consuming, students wanted their instructor to provide an efficient and straightforward way to learn the material.

4.1.2 What Students Want From Learning

Students unanimously believed that the best way to learn mathematics was through repetition, practice, and memorization of procedures. In the context of the redesigned course, these are relatively superficial behaviors that are de-emphasized. However, students saw the repetition and memorization as essential to learning, mentioned here by this discussion among the students about why their instructor disabled the "show me how to do it" feature in the online homework which would provide step by step procedures to problems:

> Veronica: I know what my instructor said about the "show me how to do it" that she didn't like it because people were memorizing the steps and then applying it, but I mean –
> Stacey: That's how you learn.
> Maria: That's how you learn math!
> Tim: Math is memorization, a lot of it.
> Maria: Yeah. Math is doing the problems.
> (Focus Group Interview #5)

And while most students were confident in their view that repetition and practice were the best ways to learn mathematics, there were some comments that caused me to conclude that students might not have known of another way to study for mathematics:

> Cynthia: I don't really know how to study for math because like I feel like the best way to study is to keep doing new problems that are like the same but different and keep doing them over and over. And there's no probably the resources to have like a quiz like constantly like new stuff. So it's always hard for me. It's like you can't really just like read over your notes, at least for me. I feel like it's part of being active and like doing the problems. But I don't have the resources to keep doing that work over. (Focus Group #5)

The timing of Cynthia's comment is worth noting, because it was recorded during the final week of the term and shows frustration or lack of confidence in her current study method. It could be the case that in a course with instructors who de-emphasize the procedural aspect of the material, the repetition and memorization that has served well in the past is insufficient. This example also illustrates the level of sophistication of the learners that enroll in college algebra and their struggle to transition from high school classrooms to college classes. Cynthia admitted that she did not know how to study mathematics, which presumably means that the tasks in high school did not require her to study much, or that the study techniques she did learn are no longer valid in college.

I again saw the level of sophistication of college algebra students through the absence of mathematical behaviors when they described their role as learners. Students described superficial participatory behaviors such as regular attendance, active listening, seeking help, and a maintaining a good attitude as their responsibilities in the course. These ideas are described by David:

> David: I think being positive in the class and being a hundred percent there, not letting your mind go somewhere else and worrying about oh, I have two kids. I didn't bring their backpacks. Hopefully this class ends early. So just being well focused and like prepared for the class, like having your stuff ready like for recitation, having all the papers printed it out, having a pencil or pen, just ready for the class. (Focus Group Interview #1)

He clearly thought that paying attention was important for understanding, but in terms of being prepared for class he only mentioned non-mathematical behaviors like having writing utensils and printing the worksheet. This viewpoint, that having a good attitude and showing up to class is sufficient for learning, put the onus on the instructor to make sure that all necessary learning occurred in the classroom whether or not students were deeply interacting with the material. Here is another example of students relying solely on superficial participatory behaviors to learn:

> Cynthia: Just making sure that you're talking with your classmates, asking questions. I think that asking questions is really important like there's no way to learn if you don't ask and definitely paying attention, just not like zoning out or anything. (Focus Group Interview #1)

Other than the superficial mathematical practices like taking notes or memorizing procedures, students did not consider deep mathematical practices part of their role in the course. It might be the case that students were unfamiliar with what deep mathematical practices look like, or it could be the case that they did not want to engage with the mathematics on that level for lack of interest. Nonetheless, the emphasis on superficial participatory behaviors may have led to success in lower level math classes, but it left them unprepared for the mathematical effort required to be successful in this college level course.

A final subtheme about what students want from learning involves what they consider atypical work or activities in a mathematics class. Within this subtheme of what students want from learning, I have described that the level of sophistication of college algebra learners is such that they preferred to engage with mathematics on a superficial level either on purpose or by default based on previous experiences. This was evident in what they viewed as different in the redesigned course: reading the textbook was required, self-teaching concepts, and they were not provided practice test for exams. Most students expressed a dislike for reading the textbook, but this student most clearly described why:

> Maria: Yeah, I don’t think we should have to read the assignments in math. It’s just the textbook doesn’t make sense all the time like I always liked trying to figure out – it took me forever to figure out inequalities and I read the textbook like ten times on inequalities and it didn’t tell me how to get from point A to point B and it was so frustrating and I finally went to my instructor today and asked “how do you do this?” and then I finally talked to my instructor and told me and it made so much more sense than in the textbook. (Focus Group Interview #2)

Within her comment I saw her desire for the book to present step-by-step procedural knowledge, a dislike for the amount of time it took to "figure out" the material, and the relative ease of asking her teacher to explain the concept. If self-teaching and reading the textbook were going to be required in the course, then this student wanted the textbook to provide a quick and clear explanation of the material, similar to what she felt like she could receive from her instructor.

The notion of atypical tasks appeared again during Focus Group Interview #3, when Dr. Beisiegal and I asked students about the pedagogical methods they experienced in other courses to put their college algebra experience in perspective. In terms of textbook use, we found that either students were not expected to read a textbook in other 100-level courses, or chose not to and were still successful in those courses. Students were also accustomed to receiving practice exams or explicit test items prior to the exam. For reference, the college algebra review materials provided an overview of the exam topics but were not described to be a practice exam. Here I saw an example of how one student's study habits have changed in college algebra with the absence of a practice exam:

> Cassandra: Well for me I have to like, review the homeworks, like go through it once again, remember what I was doing and then look at the activities as well.
> I: Okay, and is that different from when you've taken a math class before, like you wouldn't have to go back and review things?
> Cassandra: No because they'd usually give me like a study guide like a week before the test.
> Cassandra: Yeah because we wouldn't know what would be on the test and so we had to study, like, everything.
> I: Yeah. Okay. So in previous math classes seems like really clear, like exactly what the –

> Cassandra: They're going to give us the specific things on what we were going to be tested on. (Focus Group Interview #4)

What Cassandra described as a change to her study habits is exactly what mathematics faculty would hope to hear from students (e.g., reviewing all the materials, studying everything), yet this was a new process for her.

In college algebra at OSU, students typically do not perform well on the first of two midterms in the course. During the focus group interviews we asked students for their reaction to the first midterm and many students agreed that the test looked nothing like the study guide, which surprised them. In fact several students commented that based on previous experiences in "typical" math and non-math classes, being able to complete the study guide meant receiving a high score on the exam. Therefore, students thought it atypical to have to review materials other than the study guide, such as group activities, lecture notes and reading assignments in the textbook.

We also heard examples of students simply memorizing and replicating problems on exams in other classes:

> McKenzie: I really like my – I mean, I don't really like it, but my chemistry, like how my chemistry is set up….So you have extra practice with problems on top of the practice test that is basically the same as the exam, just changed a little bit. And that's really helpful. That's probably why I do so well on the tests because there are so many ways – like other problems to look at and to study and to actually kind of learn, I don't know, learn chemistry I guess. And we can also have a note card on the tests, which is really helpful, like writing things down. (Focus Group Interview #3)

These examples of students' experiences in other 100-level courses, coupled with the fact that most students reported never reading a math textbook in high school, means that college algebra is seen as anomaly in terms of the effort required to pass the course. Most of the 100-level courses that the participants were enrolled in were part of the undergraduate core requirements and not necessarily classes in their major. For this reason, students seemed to like the structure of those courses because it made the course easy to pass, but they were also honest about the fact that exams requiring only replication or memorization were not the best for learning:

> I: Can I ask you a question about the tests again in geology?
> Ian: Yeah.
> I: And answer honestly, because I'm obviously not here to judge. Do you like the format of the tests because you really feel like it's a good way to learn the material? Or is it easy and so you know that you'll do well?
> Ian: It's easy. But I think – because I memorize the questions. And so if she were to reword the question, I don't know if I'd get it right.
> Maria: Is it like multiple choice?
> Ian: Yeah. But it's – so there's a quiz, and then she just pulls the questions word for word, puts them on the test. So you can just memorize – I finished the 80-question test in 25 minutes. (Focus Group Interview #3)

Even though the expectations in place in the redesigned college algebra course represent quality math learning and teaching at any level, the students perceived the expectations to be atypical of a 100-level course. More importantly, I concluded based on this data that some students were genuinely unprepared to engage deeply in the material. Even though these students are in college, they are in a transition period between being reliant on teachers for the bulk of their knowledge and being a self-sufficient and curious learner.

4.2 Varied Experiences of Students

Student Experiences in Redesigned College Algebra

As described in Chapters 1 and 2, the most significant difference between the traditional and redesigned college algebra course is that 50% of class time is spent working in groups on active learning tasks. Recent research, particularly Freeman et al. (2014) suggests that active learning increases student performance in mathematics classes. Results from such studies are presented in the aggregate and only emphasize positive outcomes and so such techniques are implemented under the assumption that it will be a consistent or uniform experience for all students. Through the data Dr. Mary Beisiegel and I collected in the focus groups, I interpreted that students experienced the course in varied ways, particularly in the group setting. These diverse experiences can be broken into subthemes involving what works for students in group work and what needs to improve, as well as examples of why it is important for students to find the right group dynamic. While student comments presented here are specific to the group work setting, they are still related to the first themes of what students want from teaching and learning.

4.2.1 What Works in Group Work (And What Doesn't)

Students enjoyed working in groups for two main reasons, one of which takes us back to what students want from teaching: regular feedback on their work. Students described working in groups as a place where they could discuss answers and give each other feedback:

> Jesse: I agree with the group thing, because sometimes someone thinks it's this answer and someone thinks this answer, and then kind of like, go back and forth and see why someone is right, and why someone is not right, I guess. So just having feedback from each other is helpful. (Focus Group Interview #2)

While students did not receive enough feedback from their instructors, it appears that students relied on their peers to fill some of those voids. The next example not only reiterates the theme of peers as resources, but introduces the affective advantages of peer interaction versus instructor-student interaction for students with lower mathematical confidence:

> Veronica: Yeah, definitely because I mean sometimes people just don't like ask questions to a teacher they are up on the board and they're writing something down, but when you're in a group, you're not afraid to like, since you're in a smaller like environment like in front of all the classroom you don't have to ask the stupid question. You can just ask it to your peers, and it's not that bad. And you're actually understand it rather than just like staying quiet and not asking it to the professor in the lecture setting. So I think that's beneficial too because then they can give you an answer to like a question that you have like one in the class before. (Focus Group Interview #4)

In explaining the benefit of a small environment and peer interaction, Veronica also provided insight into the behaviors students used when they were confused during lecture. In comparison to group work, the student mentioned that students were quiet during lecture and did not ask the instructor for clarification.

The second reason students enjoyed group work is the peer interaction and ability to discuss problem solving ideas. All but two students said that they considered group work part of a typical math course, so most students had experience working with their peers. Students described both a social and collaborative aspect of working in groups:

> Cynthia: I like the activity day and how it's been broken up. I'm sure everyone does this, too. But activity one day and lecture the next day. But I like activity day because you just have basically the whole time to work on basically your homework with other

> people. And it's like more, what's the word, engaging with like your peers instead of just the teacher teaching and talking at you and stuff. So I've always liked that. (Focus Group Interview #3)

This student's testimony about group work shows that not only did she enjoy the peer interaction, but she found it more engaging than a traditional lecture setting where the teacher talks and the students listen. The engagement piece, particularly engaging with peers, maintained its appeal even when students had a negative outlook on the course:

> Theresa: I like interacting with other students, but I don't like doing math.
> I: Okay. So you like interacting with other students but you don't like doing the worksheets. Anybody else feel that way?
> Katie: Yes.
> I: You like interacting with students but not doing the activities?
> Katie: Right. (Focus Group Interview #3)

These two students received poor scores on the first midterm and had a difficult time adjusting to the independent learning and mathematical rigor of the course. However, as we can see above, they still enjoyed working in groups. The focus group data indicates that for students who considered group work typical in mathematics classes, they found interacting with their peers engaging and helpful for receiving feedback on work.

Although students indicated that group work could be helpful, they also shared aspects of group work that were frustrating and unproductive. While students enjoyed interacting with peers, they recognized how unproductive the group sessions could be if only a few students understood the material and the rest of the group was unprepared:

> Ashley: I don't like the group activity before lecture, because the group – always the lecture will explain the group activity the next

> day, but in the group – in the group no one – no one knew the answer or no one knows the solution for the question sheet, and how come just a third of the people sit there and smile and –
> (Laughter from everyone)
> Ashley: – and it is no help for those who don't understand the question. But if there's just one person know the whole solution, then the person has a responsibility to teach them. And how come this, it happen? Because it's supposed to be the teachers or TA's job to teach, because sometimes student teach student is not as good as teacher or TA can explain clearly. (Focus Group Interview #1)

In another focus group, Ashley described her role as the prepared student as a burden because she had to wait for her group mates to understand and spent most of the class explaining content to them. The structure of the group activities may have compounded this sense of burden because of the length of the activities. Most of the group work was written to take longer than one class period to complete, yet it was presented as in-class work. Thus if students were unable to complete the entire group activity in class, they were required to complete it on their own and turn it in the next day. An unexpected side effect of writing such involved and lengthy activities was that students were more concerned with completing it in class than having meaningful interaction. Thus, a dysfunctional group dynamic emerged where the students who understand the material told the students who did not understand to just copy their work and try to understand it later:

> Katie: A lot of times in my group, like maybe one or two people might know, like have an idea of what they're doing. But then the rest of us don't. And so there's a lot of like sharing answers going on. So we do not really understand what we're doing; we're just getting like an answer. (Focus Group Interview #3)

Not only did this dynamic negatively affect the high-achieving students who missed out on the opportunity to teach others and therefore better their understanding of the material, but it also harmed the low-achieving students who continued to not understand. For some of these students, it led to exasperation with the material or a feeling that they would never catch up in the class. And for others this group dynamic produced a sense of reliance on others and had a leveling effect where students either felt “smart” or not:

> Adriana: I find them useful. Yeah, I would – like again I would enjoy it if I just knew kind of beforehand what was going on. So I wouldn’t have to be relying on everyone else, that I can – sometimes I feel like I’m relying for them to give me the answer, and I’d rather have a lecture and be able to sound smart –like everyone else. (Focus Group Interview #2)

The fascinating subtlety to Adriana’s comment here is that she tied “sounding smart” to knowing the material prior to group work, however none of her group mates had had lecture either. It would have been interesting to ask her why she thought her group mates understood the material and why she did not. It could be the case that her group mates completed the suggested reading, terms and concepts logs, and online homework assignments and therefore engaged with the material ahead of time; whereas Adriana admitted to not using those resources. Some of the comments by other students indicated a belief that students who were “smart” in group work were naturally smart, rather than assuming that they completed the necessary preparatory exercises. So once again there was disconnect between what students thought was necessary for success in the course and what their instructors expected from them. If a majority of students disregarded the suggested reading and preparatory work, then it gave the impression that the group work was too hard and the students who did the reading were just “naturally smart.”

4.2.2 Finding the Right Group

With the exception of one instructor, all of the instructors asked students to change group members at least once during the 10-week term. Their method for changing groups varied: counting off by fours, grouping by birth month, asking students to reorganize themselves. The common theme here though is that students were organized into groups nearly at random without any thought about personality, ability, or attendance. In this section I will highlight the varied group experiences between students, how student experiences changed as they transitioned from one group to the next, and the importance of finding the right group for students to ensure productive learning.

The first example is from a student who had a positive attitude about group work from week one. He repeatedly described the group work session as productive and here we have an insight into the group dynamic:

> Ian: I don't know. Mine's pretty good. The group we worked – the group I'm in – we work pretty well together. It's, like, two – me and this other guy then two girls next to me and we go off on our own, but we ask each other questions, usually – figure out. (Focus Group Interview #3)

Several of his comments were about working in pairs within the group of four students and then talking as a whole group about different solutions to problems. When I prompted him in an earlier session about what his role was in the group, he said that each person took turns leading at some point based on their understanding of the material. Based on the comments from this student, he benefitted from the positive aspects of group work during the entire term. In contrast, the next example shows a student who did not explicitly dislike her group, but preferred to interact with several groups in order to get all of her questions answered:

> Adriana: I think some of the challenges were working in – in group settings, and I've probably tried to make that towards my advantage –working in group settings, kind of just like not just worming in my own group, but I'll go around to other groups and be like, "Hey, like what did you get for your answer?" And like, "How did you get it?" Because, you know, I noticed you can't rely on every single group, because not every group is strong as another group. (Focus Group Interview #2)

She talked about group settings being somewhat of a challenge and making it work for her by interacting with several groups in the class. The emphasis on trying to get the correct answer prevented her from having deep interactions with her own group mates. An interesting follow up question would have been to ask what her group mates did while she checked in with other students. While most instructors would not classify this as ideal group work, the positive takeaway is that Adriana still learned mathematics from peer interaction. Finally I saw an example of group work that was not productive for students:

> Stacey: Where it's like now in my group, it's me and two other guys who don't really know what they're doing. And so if it's like, if, if like I'm confused or stuck or something, we kinda just sit there staring at the paper. Or like we'll like go to the next question and hope that we got it right. Like I wasn't sure, like, to get the X intercepts of a rational function or something like that, and like so I kinda like just guessed, and then we would just move on, you know? We didn't really get much done, or at least nothing like productive. (Focus Group Interview #3)

There are several perceived components to their lack of productivity. First, it appears that this student had been paired with others who were either unprepared or not understanding the material. If Stacey was also unprepared or shaky in her confidence, it left the group without a member who could motivate and lead the team. Based on her language, it sounds like the group also struggled from a lack of feedback during the group session. This means that they either did not ask the teaching assistant and instructor for help or it means that they did not understand the help that they receive. In either case, the result is that students spent 50 minutes of unproductive guessing and did not view the time as quality mathematics learning.

The above examples illustrate the varied experiences of different students in the context of group work, some of whom were working in productive groups and some of whom were not. Of equal interest are the varied experiences of the same student in different groups. With the course, student, and instructor staying constant in each of these cases, we were able to see the impact of varying group work on student attitudes and opinions. This first example follows the transition of Roland from an unfavorable group experience to a favorable one over the course of two weeks:

> Roland: My group is horrible.
> I: Oh, no!
> Roland: I hate it.
> I: How so?
> Roland: Because everybody's so egocentric. Nobody cares. Everyone's doing his own work.
> I: Oh, that's terrible.
> Roland: Yeah, nobody helps you, and just you're always like, "What do you guys get here?" They're like – they just tell you the answer, but nobody's out to [inaudible]. No one helps you. (Focus Group Interview #2)

The student clearly did not enjoy his "horrible" group experiences because his group mates will not interact with him during the activities. In fact in another excerpt from this session he went so far to say that other students were "selfish with their knowledge" which prevented others from learning. Roland's group mates are not the right fit for him, because he is looking for partners to interact with and bounce ideas off of. Now we see his description from the focus group two weeks later:

> Roland: I think I really prefer Tuesday/Thursday
> I: Okay
> Roland: Yeah, because like since I changed groups–
> I: Oh, I was gonna ask.
> Roland: Yeah.
> I: Because last time you were like–
> Roland: Yeah.
> I: "My group's not really working as well."
> Roland: So like the new group I met, like so, like so really nice and it's like teamwork. (Focus Group Interview #3)

In this excerpt, the interviewer asked Roland whether or not he preferred the lecture days or the group activity days (which occur on Tuesday and Thursday). One could surmise that in the first excerpt, the student would not have answered that he really preferred group activity. Yet two weeks later he described enjoying the new group and the teamwork component of the new dynamic. This student self-identified as a confident mathematics learner at the start of the term and we see that he still wanted the peer help and interaction during group work. Although the first group experience was negative, it is encouraging to see that by switching groups the student changed his opinion about group work. The final example of varied group work involved a student who had struggled in the past with mathematics and readily admitted that he did not enjoy group work:

> Tim: My, when we just changed groups, and my group now, we don't, we just kinda sit there and stare at one another.
> I: Oh.
> Tim: Because it's – last group was okay, you know? We tried to work. There was like one person that could get something, the other

> person gets something, so we get halfway through. But yeah, it's just – and I drive an hour and a half to get here, and especially on Tuesdays, it's my only class.
> I: Oh, jeez.
> Tim: And so all's I'm doing is sitting there looking at somebody else, you know? And it's a three-hour round trip for me just to sit there and look at somebody else for an hour. Say, "Do you get it? Okay." (Focus Group Interview #3)

Even though this student may have had prior bias against group work, it is still possible to glean some important information from his comments. First, he was initially able to find a group that he enjoyed. This is an accomplishment that should have been recognized and maintained during the term. Even though changing groups was necessary for students who are in unproductive settings like Roland from an earlier example, instructors needed to be careful not to then disrupt productive groups in the process. The second interesting aspect of his comments is how he measured the success of his group work in terms of completion rather than the discussion and debate of the material. His group may have been lacking some of that discussion because he described them sitting and looking at each other, but nonetheless it ties into disconnect between what students think they need to accomplish during group work and what instructors want them to accomplish. For this struggling student, an unproductive group where no one was talking was a waste of time and added to the amount of work that he had to complete on his own.

Throughout the themes and subthemes of the data we saw how students' expectations of the teaching and learning in the course often did not match with those of the instructors. I am able to speak to this mismatch because in addition to interviewing students about their expectations of the course, I also participated in weekly meeting with the college algebra team where we discussed such expectations of students. This miscommunication led to tension and frustration for students who felt like they could not be successful in the course. Similarly I saw how instructor expectations of implementing group work did not match the reality of the experience for students. These tensions and miscommunications should be the focus of future redesigns of the course, and in the following chapter I will present implications of the data collected in the study as well as recommendations for subsequent iterations of the course.

Chapter 5: Conclusion

As I identified in Chapter 4, the data collected in the focus group interviews not only provides insight into the student experience of the course, but it also motivates the need to revise the redesigned college algebra course at OSU. I highlighted some of the tensions that occurred when student expectations of teaching and learning in the course conflicted with the aims of the course. In this chapter I will use the lens of boundary crossing (Jansen et al., 2012) to explain the findings of the previous chapter and present implications of the data on future redesign efforts of the course.

5.1 Boundary Crossing

In an attempt to further discuss and explain the themes I identified in Chapter 4, I will use the framework of boundary crossing to analyze student comments about the redesigned college algebra course (Jansen et al., 2012). Their article is a case study following students transitioning from middle school to high school mathematics classes and the discontinuities students face when crossing boundaries in the sense of physical settings (middle school to high school) and also in terms of learning environment (problem-based instruction to procedure-based instruction and vice versa) (Jansen et al., 2012). These discontinuities, or "differences that are meaningful to students and that co-occur with a change in students' attitudes", can be a source of frustration for students and their method of coping with them can affect their learning (Jansen et al., 2012, p.285). For the purpose of understanding the boundary crossings that students face, Jansen et al. (2012) interviewed students individually with the belief that data from the student perspective is helpful in “capturing which differences matter to students” and also explaining the “learning that students can experience as they make sense of these differences when they move from one setting to another” (p. 285-286). Although the focus of their research is two student case studies, they interviewed 27 students over the course of two and a half years. Within the larger population, Jansen et al. (2012) concluded that students vary in their ability to utilize resources in order to be successful in their new mathematics setting.

For these reasons, I see that boundary crossing applies to first-year students in college algebra and the discontinuities they face when transitioning from high school mathematics to college level mathematics. In the crossing to college, many students move away from home and begin to learn social independence away from their usual support system. Academically, students are expected to take more initiative and responsibility for their learning than they typically did in high school. At a university like OSU, it would not be unreasonable to assume that students will encounter larger class sizes than in high school with less personal attention. All of these changes could lead to discontinuities for students. Similar to Jansen et al. (2012), I think that understanding what these discontinuities are and how students try to reconcile them is critical for better supporting students during this transition. Based on the research, I expect students to experience struggle with the transition to a new learning environment and to ascribe to the new pedagogical aspects (i.e. instruction methods, assessments, expectations) of their math course to a varying degree.

5.2 Discussion of Findings

Student Experiences in Redesigned College Algebra

Established by my interpretation of themes using boundary crossing, I conclude that students are in a transition period in their role as a learner of mathematics. Within the themes presented in Chapter 4 I can see how students navigate the boundary crossing from high school and community college mathematics to college algebra. In “what students want” I discussed student expectations and preferences for methods of teaching and learning. A summary of some of the subthemes follow here: (1) students wanted to be taught the material before they engage with it on their own, (2) they wanted instructors to emphasize procedural thinking, (3) students felt uncomfortable learning from a textbook or on their own, and (4) they relied on superficial participatory behaviors for success in the class rather than mathematical behaviors. These subthemes reveal that most students were resisting the new pedagogical formats they encountered, and acclimating to those formats was necessary to cross the boundary from high school mathematics to college algebra. The resistance stemmed from the fact that mathematics teaching and learning in the four subthemes above was what students considered “typical” for a math course and those students had experienced previous success in such a math course. This resistance arose from several discontinuities that students described during the focus group interviews: completing online homework and group activities *prior to* lecture, focusing on conceptual knowledge instead of procedural, not receiving timely feedback on tasks, reading the textbook outside of class in order to learn on their own, and realizing that previous study habits are insufficient in the new model. Just as Jansen et al. (2012) suggested in their article, students varied in the way that they navigated the boundary crossing. Roland, for example, wanted to positively cross the boundary into college mathematics and adapted his study habits and learning method to do so. He regularly sought help in the Math Learning Center and completed extra problems from the textbook in order to familiarize himself with the material. These actions set him apart from the rest of the participants and his attitude about the class was markedly more positive than those of his peers. Other students made smaller changes to their learning behaviors and showed an interest in boundary crossing without fully engaging in the process. In particular Veronica, McKenzie, and Maria began to use the textbook as a source of content knowledge rather than just a set of problems. These students commented that it was difficult and uncomfortable at first to read from a mathematics textbook, but then admitted that as the term progressed they learned some useful material from the book. And then finally there were students who did not seem to want to cross the boundary into college mathematics. Adriana and Tim frequently discussed their frustration with the structure of the redesigned course and their inability to learn within the model. Both students preferred the transmission model of mathematics where the teacher is the sole source of knowledge and the student listens and takes notes during lecture. These two students had negative attitudes toward the course and talked about “despair” and “giving up” during the focus group interviews. By refusing to cross the various boundaries in how they learned and what the course asked for in terms of mathematical practice, these students clung to their previous methods of learning mathematics and were ultimately not successful.

There are also instances of students negotiating the boundary crossing within the theme of “varied experiences of students,” particularly in the area of group work. Although most students said that group work was a part of a “typical” mathematics course, the way that the instructors and teaching assistants implemented the group work required a higher level of mathematical thinking than what students expected. In Chapter 4 I identified tension in the group dynamic surrounding the role of the prepared and unprepared students. Students like Ashley who came to class prepared for group work (i.e., completed the required reading, filled out the terms and concepts log) described the burden of teaching other students in the group who did not understand as time-consuming and frustrating. On the other hand, students who came to class unprepared for group work felt frustrated that they spent the time copying answers without actually understanding the material. Using the lens of boundary crossing, combined with the discussion from “what students want” I can infer that those students who were unprepared for group work were the same students who half-heartedly attempted to cross the boundary to college level mathematics. Students who continued to believe that the teacher should provide instruction before group work most likely did not invest enough time preparing for the activities on their own. Those students who did attempt to cross the boundary to higher-level thinking and academic autonomy, by reading outside of class and preparing for the group activities, were the ones who felt prepared. Thus one cause for the varied experiences of students in the context of group work is the variation in how students negotiate the discontinuities present in boundary crossing.

Student Experiences in Redesigned College Algebra

Some of the findings discussed above were expected based on what I presented in the literature review. For example I anticipated that students would have negative attitudes about the structure of the course because they were encouraged to learn cooperatively without direct instruction from instructor. This contradicted their accepted notion that the instructor was the "dispenser" of knowledge and someone that told students the correct way to learn the information (Erickson et al., 2006; Johnston & Nicholls, 1995; Ponte et al., 1994). Similarly, the emphasis on group learning and conceptual understanding in the redesigned course challenged some of their existing understanding about how math should be taught and learned, which could have been a cause of their resistance (Kyriakides et al., 2006). These existing notions of math teaching and learning include memorizing facts and procedures which are consistent with the stages of multiplicity and dualism as presented by (Erickson et al., 2006). Based on the research by Star et al. (2008), I expected that students would comment most frequently on changes they noticed to the difficulty level of in-class material and homework problems, and their perception of an increase in work, rather than conceptual differences between past courses and the redesigned course. Therefore the frequency of comments about the conceptual differences between the redesigned course and a "typical" math course was somewhat unexpected. After reviewing the literature, the most unexpected finding of this research was the variation present in the way students experienced group work. Prior to the study I had assumed that because of the consistent structure of and tasks provided on group activity days across sections, students in the redesigned course would generally have similar experiences. Although the literature predicted some of the overall responses and trends, the critical piece of this study was the detail-rich explanation of each viewpoint that the students had to offer.

5.3 Implications for Future Redesigns

After analyzing the student data from the focus groups using thematic analysis and interpreting my findings using the framework of boundary crossing, I present recommendations to the designers of the college algebra course as to how to incorporate this data to aid students in their transition to college mathematics.

As I mentioned in Chapter 4, I concluded that some students were genuinely unprepared to engage deeply in the college algebra material. Through boundary crossing I observed that even though these students are in college, they are in a transition period between being reliant on teachers for the bulk of their knowledge and being a self-sufficient and curious learner. In addition to their existing preferences for how mathematics should be taught and learned, student comments in focus groups also indicated that there were varying expectations of students, in terms of the sophistication of their learning, across disciplines at the university level. Thus, instructors and course designers of college algebra should be aware that what students want from teaching and learning is influenced not only by their past mathematics experiences, but by other courses they take at the college level.

If students are indeed unfamiliar with deeper mathematical practices and behaviors, it will be essential for instructors to explain and model these behaviors for students as part of the redesigned course. This might include taking time to teach students how to read the textbook for content knowledge by taking notes, completing examples, and making note of questions or confusions. Students also indicated that they do not know how to prepare for a mathematics exam, so instructors could provide general study skills suggestions for how to prepare for the test without revealing specific content. Some of these general study habits might include pattern seeking, relating new material to previous learning, and strategies for checking the correctness of their work.

Students also crave more instructor feedback on tasks. While this could include written feedback, it could also be in the form of whole class “wrap-ups” at the end of a group activity or formative assessments like clicker questions, hand signals, or exit slips to assess their understanding. Instructors can also provide feedback and guidance by making meaningful connections between the tasks that students complete (i.e., online homework, group activities) and the content of the lecture. One unexpected conclusion I made based on the focus group data is that with the absence of instructor feedback, students looked to their peers to fill that void. If students actually feel comfortable enough to share work with each other and provide feedback out of necessity, the instructors should consider including peer feedback in an intentional way in the course. Asking students to regularly review and critique each other’s work on activities or modeling problems would engage students in analytic and evaluative thinking, while providing useful feedback on their work. This could increase the student voice in the course and provide an opportunity for students to experience mathematical authority.

As courses are redesigned and active learning is implemented, educators need to consider the diversity of our learners' personalities, mathematical abilities, and comfort with group work. Assuming that on average more students are successful with group work, regardless of group structure, is not true based on the findings in this study and requires more purposeful and thoughtful implementation. The feedback from students on this point has been enlightening as I realize that simply putting students into groups and "turning them loose" does not guarantee a successful environment. If the department continues to have group work as a main component of the course, groups need to be intentionally formed based on group dynamic. For instructors who are inexperienced with implementing group work, this process can be challenging. This is why I think that instructors should be given guidance on this aspect during the professional development sessions for the course. It could also be a topic of discussion during the weekly college algebra team meetings. While some group mismatch may be inevitable in a class of 50-60 students, the instructor should recognize this mismatch and pay attention to their productivity level during the activities to provide support.

5.4 Limitations

Although this study was designed to provide insight into the student experience in a redesigned college algebra course, the reality is that there are aspects of the redesigned course that are specific to OSU. The designers of the redesigned course made changes based on our student population, classroom space, academic calendar, and so on, and thus they may not apply to other institutions. Similarly, at the time of the redesign it was important to the university and to the leadership of the department of mathematics to implement a student engagement model of reform rather than an emporium model. Universities that have chosen the emporium model for the redesign would likely have different results if such a study were conducted on that campus. Another limitation of this research is the small population of participants that completed the entire study. With a limited number of participants and the inherently personal and subjective nature of their experiences in the course, I recognize that my data and conclusions may not generalize to other college algebra courses.

5.5 Future Directions

It is my hope that the implications I suggest in this chapter can be incorporated to some degree in future iterations of the redesigned college algebra course. Once these changes are in place, it would be interesting to replicate this study with a new group of college algebra students to see if their experiences with the course differ from the first group of participants. I also think that there could be value in conducting a study that includes both student and instructor participants as a way of facilitating communication about the expectations each party has for the course and ways to minimize the discontinuities that students face in their transition to college mathematics.

Based on this research I understand how influential students' previous experiences in mathematics can be in their transition to college. My focus group protocols focused primarily on the day-to-day experiences of students in the redesigned course, but a more in depth study regarding student beliefs about mathematics could provide interesting insight. One such research question might be how do students' beliefs about mathematics affect their transition to college mathematics? Similarly my intuition says that the level of sophistication of learning of a college algebra student is different than that of a beginning calculus student. Thus it might be worthwhile to investigate answer the question how does the mathematical sophistication of students affect their experience in a redesigned mathematics course?

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APPENDICES

Appendix A: Group Activity

Math 111 Group Activity Problems Week 7B Name:______________________________

Composition of Functions

Section 5.1

Prerequisite Skills	Key Terms	Learning Objectives
• Evaluating functions • Determining Domain/Range • Graphing a function point-wise	• Composition of functions • Inside function • Outside function	• Use composition of functions to model multistep processes. • Compose functions defined numerically, graphically and symbolically. • Interpret the meaning of the output of composed functions • Determine the domain of a composition of functions

1. In the United States, temperature is commonly measured in degrees Fahrenheit. However in most sciences temperature is measured in Celsius or Kelvin. The function $C(F)=\frac{5}{9}(F-32)$ accepts an input of temperature in degrees Fahrenheit and outputs the corresponding temperature in degrees Celsius. The function $K(C)=C+273$ accepts a temperature measured in Celsius and outputs the corresponding temperature measured in Kelvin.

   a. Use the formulas above to complete the following temperature conversion tables.

Fahrenheit	Celsius
– 13	– 25
5	
32	
59	
77	
95	
122	

Celsius	Kelvin
– 25	248
0	
15	
35	
40	
50	
55	

   b. Fill out the table below converting temperatures directly from Fahrenheit to Kelvin.

Fahrenheit	Kelvin
-13	248
32	
59	
77	
104	
122	
149	

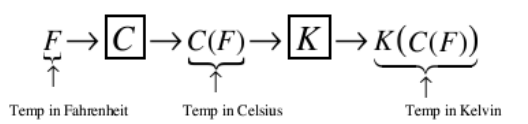
c. Give a formula for a function that will accept an input of temperature in degrees Fahrenheit and will output the corresponding temperature in Kelvin.

The function you created in part (c) is the ***composition*** of the functions *C* and *K*, and is written as $(K \circ C)(F) = K(C(F))$.

This is read "K composed with *C* of *F*" or "*K* of *C* of *F*." In a composition, the output of a function becomes the input into another function. (See the diagram in the box below).

A Composition of Functions

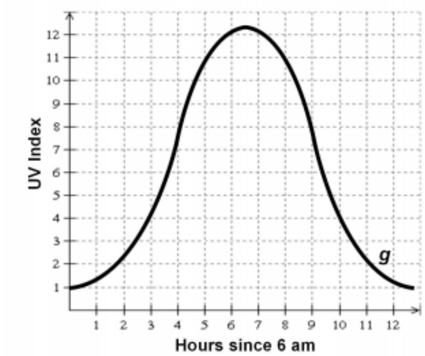
The diagram below illustrates the composition $(K \circ C)(F) = K(C(F))$

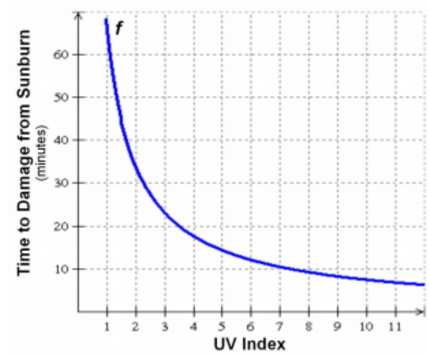


d. Use the formula you found in part **c** to determine $(K \circ C)(50)$, and explain what this represents. Include units.

[Check Your Work]. You should get $(K \circ C)(50) = 283$.
Make sure to fully explain what this represents.

2. The functions *f* and *g* are graphed below. The function *f* accepts as input a UV index, and outputs the time it takes for the skin of an average person to begin showing damage from sunburn. The function *g* accepts as input the time of day (measured as hours after 6 am) and outputs the UV index for a typical spring day in Waikiki, HI.





a. Find and interpret $f(7)$. Include units.

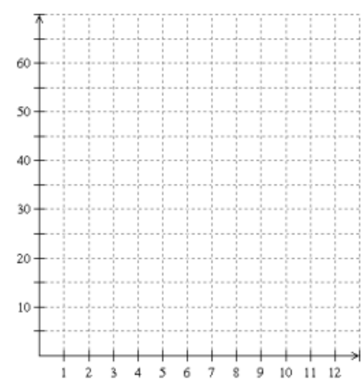
b. Find and interpret $g(10)$.

c. If a person starts sunbathing at 2 pm in Waikiki how long will it take to begin showing sunburn damage?

d. Sketch a diagram, like the one in the box above problem #1(d), illustrating the composition of functions $(f \circ g)(x)$.

e. Find and interpret $(f \circ g)(10)$. Include units.

f. On the axes at right, sketch a graph of $(f \circ g)(x)$. Place appropriate labels (including units) on each axis. Use the table below!



x							
$(f \circ g)(x)$							

g. Explain why the shape of the graph makes sense in terms of the context.

3. The tables below define two functions *f* and *g*.

x	−3	−1	5	3
f(x)	2	0	4	−1

x	−4	2	0	−3
g(x)	3	5	−6	−1

Thinking about the domain of a composition of functions

This diagram illustrates a composition of functions $(g \circ f)(x)$.

x
↓
[f]
↓
$f(x)$
↓
[g]
↓
$g(f(x))$

If *x* is not in the domain of *f*, then *f*(*x*) does not exist, and *g*(*f*(*x*)) does not exist. So if *x* is not in the domain of *f* it is also not in the domain of $g \circ f$.

Similarly, if *f*(*x*) is not in the domain of *g* then *g*(*f*(*x*)) does not exist and *x* is not in the domain of $g \circ f$.

a. Compute each of the following, or **<u>explain why</u>** it is undefined.

$g(f(-3))$ $f(g(-3))$

$(g \circ f)(2)$ $g(f(5))$

$g(f(-1))$ $(f \circ g)(-4)$

(NOTE for parts (b) and (c): The functions *f* and *g* are defined by their tables!)

b. What is the domain and range of *f*?

c. What is the domain and range of *g*?

d. What is the domain of $(g \circ f)(x)$? Need help? Sketch a diagram to illustrate this composition.

4. Let $f(x) = \frac{1}{x^2}$ and $g(x) = 2\sqrt{x-9}$.

When computing a formula for a composition, it is often easier to see what the domain of that composition will be if we don't simplify. For instance, on part (e) of #5 determine the domain (part f) BEFORE you simplify the formula for the composition in part (e). This should make it easier to answer part (f).

a. What is the domain of *f*?

b. What is the range of *f*?

c. What is the domain of *g*?

d. What is the range of *g*?

e. Give a formula for $f(g(x))$.

f. What is the domain of $f \circ g$?

g. Explain how you found the domain of $f \circ g$ in part (f).

Appendix B: Recruitment Letter

Dear Math 111 Students,

My name is Mary Beisiegel and I am an assistant professor in the Mathematics Department at Oregon State University. I am conducting a research study about students' experiences in Math 111: College Algebra. The title of the study is *Students' Experiences of College Algebra Redesign*. The goal of this study is to understand students' experiences in redesigned College Algebra courses that focus on student engagement in mathematics. We will use the results from this study to continue to improve the course and learning experiences for students.

We are inviting all students registered in Winter 2014 redesigned Math 111: College Algebra courses at Oregon State University to participate in five focus group interviews during the term about their experiences and to complete two surveys, one at the beginning of the term and one at the end of the term. The focus group interviews will take place in a classroom on the Oregon State University campus, and will take approximately an hour and half each. The focus groups will occur during Weeks 2, 4, 6, 8, and 10 of the Winter 2014 term. The surveys will be administered in the Mathematics Learning Center (MLC) in Kidder Hall 108. Answering the questions on the surveys will take an hour total. You will be compensated in the following ways: $10 for each focus group interview and $5 for completing each survey for a total of $60.

If you are interested in participating in this study, please go to the Mathematics Learning Center (MLC) in Kidder 108 during the following hours:

Mary Beisiegel	Wednesday, Jan 8	12:30 pm – 4:30 pm
	Thursday, Jan 9	8:30 am – 12:00 pm
	Friday, Jan 10	12:30 pm – 4:00 pm
Krista Foltz	Wednesday, Jan 8	8:30 am – 12:30 pm
	Thursday, Jan 9	12:00 pm – 1 pm, 3:00 – 5:00 pm
	Friday, Jan 10	8:30 am – 12:30 pm

During this visit to the MLC, we will ask you to sign a consent form, acknowledging that you are participating in the study. You will also complete the first survey. We will also have you respond to a questionnaire that asks about your availability to participate in the bi-weekly focus groups. *If you are a student in one of Krista Foltz's sections, please go to Mary Beisiegel's hours to sign up for the study.*

If you have any questions or concerns about this study, please feel free to contact Mary Beisiegel at mary.beisiegel@oregonstate.edu or by phone at 541.737.8397.

Best regards,

Mary Beisiegel
Assistant Professor
Department of Mathematics

Appendix C: Pre- and Post-Surveys

Math 111: College Algebra Student Survey I
Winter 2014

1. First and Last Name:

2. Section of Math 111:

3. Age:

4. Gender:

5. Have you taken Math 111 in the past?

☐ Yes ☐ No

If you answered 'yes' to question 5, please answer questions 6 and 7. If you answered 'no' to question 5, please continue on to question 9.

6. If you took College Algebra in the past, in what type of institution did you take the course? Please check all that apply:

☐ High School
☐ Community College
☐ Oregon State University
☐ College other than Oregon State University

7. If you took College Algebra in the past, were you successful (earned an A, B, or C)?

☐ Yes ☐ No

8. If your answer to question 7 was 'no', please provide a short explanation of why you were not successful. If your answer to question 7 was 'yes', please provide a short explanation why you are taking College Algebra again.

Instructions: Suppose that you were asked the following math questions. Please indicate how confident you are that you can give the correct answer to each question. You do not need to solve these problems.

1	2	3	4	5	6
Not at all Confident					Completely Confident

HOW CONFIDENT ARE YOU THAT YOU CAN SOLVE THE FOLLOWING PROBLEMS:

9.	$\sqrt{5x+5}+5=0$	1	2	3	4	5	6
10.	$2x^2+7x-4=2x+8$	1	2	3	4	5	6
11.	$x^2+16x+41=0$	1	2	3	4	5	6
12.	Find the domain of the function $f(x)=\sqrt{4-x}$	1	2	3	4	5	6
13.	Factor the polynomial completely: $9-49x^2$	1	2	3	4	5	6
14.	Write in terms of i: $\sqrt{-169}$	1	2	3	4	5	6
15.	Find the distance between the points (6, −1) and (4, −5)	1	2	3	4	5	6

HOW CONFIDENT ARE YOU THAT YOU CAN EARN AN "A" OR "B" IN THE FOLLOWING COLLEGE COURSES:

16.	College Algebra	1	2	3	4	5	6
17.	Statistics	1	2	3	4	5	6
18.	Calculus	1	2	3	4	5	6
19.	Chemistry	1	2	3	4	5	6
20.	Physics	1	2	3	4	5	6
21.	Biology	1	2	3	4	5	6

Please answer the following questions by circling the letter that best describes your response. The scale is given by:

F	F	F	T	T	T
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

22.	No matter who you are, you can change your math abilities a lot.	F F F T T T
23.	No matter how much math ability you have, you can always change it quite a bit.	F F F T T T
24.	You can always change how much math ability you have.	F F F T T T
25.	You have a certain amount of math ability, and you really can't do much to change it.	F F F T T T
26.	Your math ability is something about you that you can't change very much.	F F F T T T
27.	You can learn new things in math, but you can't really change your basic math ability.	F F F T T T
28.	Being involved in math is a key part of what I am.	F F F T T T
29.	I can see math-related activities as being a part of my future.	F F F T T T
30.	I consider myself a math person.	F F F T T T
31.	I can imagine myself being involved in a math-related career.	F F F T T T
32.	I have never been a math person.	F F F T T T
33.	I don't think math will be an important part of my future.	F F F T T T
34.	In math, the truth means different things to different people.	F F F T T T
35.	In math, everyone's knowledge can be different because there is no absolutely right answer.	F F F T T T
36.	Things written in math textbooks are true.	F F F T T T
37.	I believe everything I learn in math class	F F F T T T

Student Experiences in Redesigned College Algebra

F	F	F	T	T	T
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

38.	If a math teacher says something is a fact, I believe it.	F F F T T T
39.	Mathematical knowledge is all factual and there are no opinions.	F F F T T T
40.	In math, there is usually one correct way to solve problems.	F F F T T T
41.	To be successful in math, you need to memorize procedures and facts.	F F F T T T
42.	In math, something is either right or it's wrong.	F F F T T T
43.	Good math teachers show students lots of different ways to look at the same question.	F F F T T T
44.	Good math teachers show you the exact way to answer the math questions you'll be tested on.	F F F T T T
45.	In math, you can be creative and discover things by yourself.	F F F T T T
46.	Real math problems can be solved by common sense instead of the math rules you learn in school.	F F F T T T
47.	The best way to do well in math is to memorize all the formulas.	F F F T T T
48.	I can't invest the time that is needed to do well in this class.	F F F T T T
49.	Being in this class won't be worth all the things that I will have to give up.	F F F T T T
50.	This class will require too much time.	F F F T T T
51.	Because of other things that I do, I won't have time to put into this class.	F F F T T T
52.	I will put in the time I need to in order to be successful.	F F F T T T

If you have questions or concerns about the survey, please contact Mary Beisiegel by email at mary.beisiegel@oregonstate.edu or by phone at 541.737.8397.

Math 111: College Algebra Student Survey II
Winter 2014

1. First and Last Name:

2. Section of Math 111:

3. Age:

4. Gender:

5. Have you taken Math 111 in the past?

☐ Yes ☐ No

If you answered 'yes' to question 5, please answer questions 6 and 7. If you answered 'no' to question 5, please continue on to question 9.

6. If you took College Algebra in the past, in what type of institution did you take the course? Please check all that apply:
☐ High School
☐ Community College
☐ Oregon State University
☐ College other than Oregon State University

7. If you took College Algebra in the past, were you successful (earned an A, B, or C)?
☐ Yes ☐ No

8. If your answer to question 7 was 'no', please provide a short explanation of why you were not successful. If your answer to question 7 was 'yes', please provide a short explanation why you are taking College Algebra again.

Instructions: Suppose that you were asked the following math questions. Please indicate how confident you are that you can give the correct answer to each question. You do not need to solve these problems.

1	2	3	4	5	6
Not at all Confident					Completely Confident

HOW CONFIDENT ARE YOU THAT YOU CAN SOLVE THE FOLLOWING PROBLEMS:

9.	$\sqrt{5x+5}+5=0$	1	2	3	4	5	6
10.	$2x^2+7x-4=2x+8$	1	2	3	4	5	6
11.	$x^2+16x+41=0$	1	2	3	4	5	6
12.	Find the domain of the function $f(x)=\sqrt{4-x}$	1	2	3	4	5	6
13.	Factor the polynomial completely: $9-49x^2$	1	2	3	4	5	6
14.	Write in terms of i: $\sqrt{-169}$	1	2	3	4	5	6
15.	Find the distance between the points $(6,-1)$ and $(4,-5)$	1	2	3	4	5	6

HOW CONFIDENT ARE YOU THAT YOU CAN EARN AN "A" OR "B" IN THE FOLLOWING COLLEGE COURSES:

16.	College Algebra	1	2	3	4	5	6
17.	Statistics	1	2	3	4	5	6
18.	Calculus	1	2	3	4	5	6
19.	Chemistry	1	2	3	4	5	6
20.	Physics	1	2	3	4	5	6
21.	Biology	1	2	3	4	5	6

Please answer the following questions by circling the letter that best describes your response.
The scale is given by:

F	F	F	T	T	T
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

22.	No matter who you are, you can change your math abilities a lot.	F F F T T T
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24.	You can always change how much math ability you have.	F F F T T T
25.	You have a certain amount of math ability, and you really can't do much to change it.	F F F T T T
26.	Your math ability is something about you that you can't change very much.	F F F T T T
27.	You can learn new things in math, but you can't really change your basic math ability.	F F F T T T
28.	Being involved in math is a key part of what I am.	F F F T T T
29.	I can see math-related activities as being a part of my future.	F F F T T T
30.	I consider myself a math person.	F F F T T T
31.	I can imagine myself being involved in a math-related career.	F F F T T T
32.	I have never been a math person.	F F F T T T
33.	I don't think math will be an important part of my future.	F F F T T T
34.	In math, the truth means different things to different people.	F F F T T T
35.	In math, everyone's knowledge can be different because there is no absolutely right answer.	F F F T T T
36.	Things written in math textbooks are true.	F F F T T T
37.	I believe everything I learn in math class	F F F T T T

Student Experiences in Redesigned College Algebra

F	F	F	T	T	T
Strongly Disagree	Disagree	Slightly Disagree	Slightly Agree	Agree	Strongly Agree

38.	If a math teacher says something is a fact, I believe it.	F F F T T T
39.	Mathematical knowledge is all factual and there are no opinions.	F F F T T T
40.	In math, there is usually one correct way to solve problems.	F F F T T T
41.	To be successful in math, you need to memorize procedures and facts.	F F F T T T
42.	In math, something is either right or it's wrong.	F F F T T T
43.	Good math teachers show students lots of different ways to look at the same question.	F F F T T T
44.	Good math teachers show you the exact way to answer the math questions you'll be tested on.	F F F T T T
45.	In math, you can be creative and discover things by yourself.	F F F T T T
46.	Real math problems can be solved by common sense instead of the math rules you learn in school.	F F F T T T
47.	The best way to do well in math is to memorize all the formulas.	F F F T T T
48.	I can't invest the time that is needed to do well in this class.	F F F T T T
49.	Being in this class won't be worth all the things that I will have to give up.	F F F T T T
50.	This class will require too much time.	F F F T T T
51.	Because of other things that I do, I won't have time to put into this class.	F F F T T T
52.	I will put in the time I need to in order to be successful.	F F F T T T
53.	I enjoy taking this class.	F F F T T T
54.	I value taking this class.	F F F T T T
55.	I think this is a useful class to take.	F F F T T T

If you have questions or concerns about the survey, please contact Mary Beisiegel by email at mary.beisiegel@oregonstate.edu or by phone at 541.737.8397.

Appendix D: Focus Group Interview Protocols

Focus Group #1 (Week 2: Baseline Data)

1. Name
2. How long have you been a student at Oregon State University?
3. Why are you enrolled in College Algebra?
4. What are your previous experiences as a learner in mathematics?
5. How would you describe quality math teaching?
    a. If you had a great math class in the past, what was great about it? What did the teacher do to make the class great?
6. How would you describe quality math learning?
    a. What are the most important things to do when learning math?
    b. Think of a time where you did well on an exam, what are some of the things that you did to do well?
    c. Was there ever a time that you felt good about the math learning you were doing, not just because you had a good grade, but also because you felt like you were really getting it… What was that like and how did that happen?
7. What do you think the instructor's responsibilities are in teaching a math class?
8. What do you think the students' responsibilities are in a math class?
9. How would you describe a well-taught mathematics lesson?
    a. What is the teacher doing?
    b. What are the students doing?
    c. What does the lesson involve?
10. How would you describe a great **(college?)** mathematics teacher?
11. What do you think it means to be successful in learning mathematics?
    a. Do you believe that students who struggle with mathematics can ultimately be successful?
    b. Do you believe that there are either good students or bad students in mathematics?

12. How would you describe yourself as a mathematics learner?
    a. What resources (online, textbook, tutors, instructors, TAs, etc) do you use?
    b. Do you study regularly or only when absolutely necessary?
    c. How do you feel about your abilities in math?
13. What are your perceptions or expectations of College Algebra at Oregon State University?
14. Who or what will be important resources for you during this class?
15. Do you plan to take another mathematics course at OSU after College Algebra?
16. Additional questions based on the previous focus groups to clarify understanding of participants' contributions.

Focus Group #2 (Week 4: Midterm 1)

1. How have the first few weeks of College Algebra been?
2. What are some of the challenges you have encountered during the first few weeks?
3. What do you like about the class so far? What do you dislike about the class?
4. Are there any aspects of this course that do not match with your vision of a typical mathematics course?
5. How would you describe a typical group activity day (T-TH) in College Algebra? What about a typical Wednesday or Friday?
6. When you are confused about a concept, what do you do to try to understand it?
    a. What resources do you have?
    b. Who do you talk to?
7. What affects your level of understanding in a math class?
8. How would you describe the kind of work or tasks that you are asked to do in this class?

9. What is the role of your instructor in the course?
10. What is your role as a student?
11. Do you feel like you are going to be successful in this course? Why or why not?
12. How are you going about learning the material in College Algebra? Is this similar to have you have learned mathematics before?
13. Do you have any concerns as you move forward in the term?
14. Additional questions based on the previous focus groups to clarify understanding of participants' contributions.

Focus Group #3 (Week 6: Halfway)

1. What other classes are you taking this term? Are you enjoying those classes?
2. Can you describe the format of the other classes you are taking this term? [Are they lecture-only, lab based, group activities, etc.]
3. Are your other classes challenging? If so, what is challenging about them? If they are easy, can you describe why they are easy?
4. What do you like best about your other classes?
5. What do you like about College Algebra so far?
6. Which days do you prefer, group activity days or Wednesday-Friday? Why?
7. Would you describe the learning that occurs during the group activity as meaningful or helpful? Why or why not?
8. Do you think you are engaging in quality mathematics learning in this class? Why or why not?
9. How would you describe the interactions between you and your instructor or TA?
10. How would you describe your interactions with other students in the class?
11. How do you describe yourself as a mathematics learner?
12. Additional questions based on the previous focus groups to clarify understanding of participants' contributions.

Student Experiences in Redesigned College Algebra

Focus Group #4 (Week 8: After Midterm 2)

1. How have the past few weeks of College Algebra been?

2. How does this class compare with your vision of a traditional mathematics course?

3. a. What is your opinion of working on mathematics in groups?
   b. Do you think that students can discover mathematics on their own, or does all mathematics have to be shown to them?
4. a. What are your TA and instructor doing in class that's really working for you? What are they doing that's not working for you?

   b. Have you had to modify your study habits or patterns for this class? If so, how? If not, why not?
   c. What study habits have you developed that are really working for you? What is something that you're still struggling with?
5. How would you describe the work or tasks that you are asked to complete in class?

   a. Is the online HW helpful? What about the group activities? We often ask you to summarize procedures on the activities or to explain your thinking; does that help you learn the material?

   b. Do you find the reading guide and terms/concepts logs helpful?

6. Who or what is your most useful resource in the class?

7. How would you describe this course to another student? If you knew someone who was registered for this course next term, what would you say to them?

8. a. If you could restart the term, would you do anything differently? If so, what would that/those things be?

   b. If you were to take this class over again, would you register in the redesigned course or the traditional lecture course? Why?
9. a. If you were the instructor of this course, what would you do differently?

   b. If you could tell the designers of the course two good experiences and two bad experiences, what would those experiences be?

10. Do you feel like your instructor cares about your success? If so, what makes you feel that way? If not, what makes you feel that way?

11. When do you feel most supported by an instructor? What do instructors do to make you feel supported and encouraged?

12. We know that the midterm 1 scores were low for most students. How did your instructor address this with your class? What did they do to support or help you prepare for midterm 2? Did you do anything differently to prepare for midterm 2? Did it help?

13. Additional questions based on the previous focus groups to clarify understanding of participants' contributions.

Focus Group #5 (Week 10: Post-course data)

1. How would you describe quality math teaching?
    a. If you had a great math class in the past, what was great about it? What did the teacher do to make the class great?
2. How would you describe quality math learning?
    a. What are the most important things to do when learning math?
    b. Think of a time where you did well on an exam, what are some of the things that you did to do well?
    c. Was there ever a time that you felt good about the math learning you were doing, not just because you had a good grade, but also because you felt like you were really getting it… What was that like and how did that happen?
3. What do you think the instructor's responsibilities are in teaching a math class?
4. What do you think the students' responsibilities are in a math class?
5. How would you describe a well-taught mathematics lesson?
    a. What is the teacher doing?
    b. What are the students doing?
    c. What does the lesson involve?
6. How would you describe a great **(college?)** mathematics teacher?
7. What do you think it takes to be successful in learning mathematics?
    a. Do you believe that students who struggle with mathematics can ultimately be successful?

   b. Do you believe that there are either good students or bad students in mathematics?

8. How would you describe yourself as a mathematics learner?
   a. What resources (online, textbook, tutors, instructors, TAs, etc) do you use?
   b. Do you study regularly or only when absolutely necessary?
   c. How do you feel about your abilities in math?
9. How would you describe College Algebra at Oregon State University to another student?
10. Would you recommend this course to another student? Why or why not?
11. Was talking about this class helpful? Did you find it useful to be a part of the focus groups?
12. Do you plan to take another mathematics course at OSU after College Algebra?
13. Additional questions based on the previous focus groups to clarify understanding of participants' contributions.

Appendix E: Meeting Notes From Transcript Review Sessions

Meeting Notes from Review of Session 4 Transcriptions
May 22, 2014

HALEY'S NOTES

Wednesday, Session 4 (Interviewer #2)
Notes:
- Students feel more confident now than before after midterm 2 (1, 1353)
- Some improved but still didn't "pass" the midterm (2, 1539)
- Should have S/U'd or did SU (3)
- Don't feel confident to teach someone else (5, 1173) there are "exact" ways of doing things and they don't know if they are right or not

- *"I agree. I think its being taught and then kind of using that and applying it to your problems and kind of learning from those problems because you're going to be* ***using what you know*** *and still learning a little bit."* (6, 1413) Do students not have enough background knowledge to be doing activities? ZPD?
"I think we should be taught the basic concepts before we do math or solving some math because the basic – we can just – if we can have the basic concept we can go through the difficult part. Yeah. (6, 1173)" Does not think they have enough information to do the material. What basic information do they want to know? Should they already have this information?

- "Like a vocab word and its definition" (8, 1353) Want the instructor to give a clear definition but doesn't do the vocab sheet himself….. (2*, 1353,*1539, 1413)
- Reading textbook more (10, 1353, 1898, 1539)
- Use friends as resources but don't realize that their group mates can be considered resources as well? (4*)
- Those who read mention the textbook is a good resource (4* 1539)
- Use resources more (7*, 1539)
- Would like a solid review for the midterms (11*) extra practice from the book (11*)
-MLC is not inviting for those who don't know where anything is. Instructors should give more information about the MLC
- Instructor doesn't know their names yet passes out their tests to them… contradictory? (16*)

Possible Themes:
- Still hesitant to accept structure of the class (4, 1413, 1353, 5, 1173, 5*, 1173, 1898, 1353)
- TA needs to look approachable in order for students to want to get help (7) all of them say this

- Like study guides that are relevant to the test (11, 1898, 1353)
- If the activities are meant to be done in a group, they shouldn't be so long that you can't finish them during recitation. Shouldn't have to take them home and work on them.
- Hate online homework, like clicker points
- Learning people's names is important

Thursday, Session 4, (Interviewer #2)

Notes:

- Study guide related to test and midterm 2 was easier (1309 and 1891)
- Likes groups because two is better than one (2) like the group work but don't understand why they lecture after you have to use the information. Like the smaller class sizes to ask questions and have groups (17, 1309, 1891) Enjoys group work (2* ,1891)
- Having a solid foundation on the basics is important.
- " *I look at the questions and the answer keys because then I just memorize them with the answer kets. But – and it helps me do better. So that's why I like having the example – like it would help me memorize them because I'm like writing it down, and like being the steps, and I'm applying that to the questions."* (8, 1309) want to memorize answers…?
- Don't know the terms very well but are not using the log sheet because there are too many of them every week…. (11, 1891, 1309)
- To get an A you need to use all of your resources. (15, 1309) (16, 1891)
- Tests should be created by profess for their class, not a group of them. (3* 1309)

Possible Themes:

- The structure encourages them to use their resources more. Changing learning habits (5)
- Review packet is important and helpful to feel confident (7)
- Activities are long and use a lot of paper
- Hates PowerPoint
- Learning people's name is important

Monday, Session 4, (Interviewer #1)

Notes:

- "Math is not a team sport." (11, 1494) Does not like to do math as a community (13, 1494) (14, 1494) looks at math as a complete individual subject
- Communicating math is doing it on your own and telling someone how you did it. Not teaching each other and explaining how you see a process and learning from other people. (12, 1860)
- Working with people is messy (13, 1494)

- 1073 mentions how they like being shown how to do a problem step by step but then mentions how they try to find patterns on how to get the right answer. While their way of finding the patterns may not be exactly how we want them to, they still are learning how to find patterns and justify why something is right or wrong. Interesting! (14, 1073)
- Students are not used to learning before lecture. Lectures should be the source of all learning, not reading prior to class. (19, 1073)
-Work backwards and then forwards. (1494) Hard to keep up with all of the work/worksheets, to keep things straight (2*, 1073)
- Don't use the reading guide. Sometimes use the term log but took too long
- Best resource is YouTube, textbook, concept log to refer back to (7*, all)

Possible Themes:
- 103 does not prepare you for 111
- Issues with activities before lecture
- Want to switch groups based on abilities (7)
- You learn first and discover later (16, 1860)
- Be ready to teach yourself (8*, 1073)
- Take lecture over the redesign
- Positive correlation between doing alright in class and liking parts of the redesign (11*, 1860)
- Like group work and quizzes on Friday (13*, 1860)

Thursday, Session 4 (Interviewer #1)
Notes:
- Would rather have the teacher check in on them than have to raise their hands for questions
- Enjoy when teacher walks around the classroom and listens in on conversation (13, 1986)
- The information builds off of itself. Pay attention to everything the instructor says (2*)
- The redesign helps you focus better (5*)
- Students like to know what is expected of them

Possible Themes:
- Lectures before activities, want some instructions and then discover
- Structure of the class still needs to be modified on when homework is due/ study guides
- Textbook is becoming more of a resource
- Don't go into the class thinking that it's easy
- Math 103 is not a prep course for math 111. (9*)

- Like groups and longer class periods
- Discuss homework and activities more during lecture. Link the three

KRISTA'S NOTES

Wednesday, Session 4 (Interviewer #2)
Notes:
-1353 and 1173 did better on the exam and are more confident that they'll pass the class
-1539 S/U'd the class
-1898, 1413 wished that had S/U'd the class, but didn't do their paperwork in time

-They like the group work because they like interacting with peers, but they don't think the time is productive
-Want to see lecture before HW and group activity
-Find the lectures to be more useful because they're getting "correct" information
-During the lecture they want handwritten notes, NOT power points (in fact this is a deciding factor over redesign vs. lecture even)
-Instructors need to be intentional about how they form and re-order groups
-Students need to be shown math first and then they can apply it
-Negative comments about TA/instructor, look bored/in pain, don't put effort in to helping during class, don't offer help during group work…you have to ask
    -1173 hasn't changed study habits
    -1539: didn't change how she was studying, but increased the time
    -1353: started reading the textbook
    -1898: increased the amount of time she was studying a little bit and start reading the book
-Students aren't using the activities to study because there aren't full solutions posted so they see the activities as useless because they don't know if their answers are right or wrong
-Don't use reading guide or terms and concepts logs
-Talking to future students: "Good luck", "don't take it at Oregon State", "if it's not necessary, don't take it", "it it was taught differently, I would be doing better than I am",
    -1353 doesn't know what else she could do differently
    -1413: wants the option for a smaller class
    -1353: get a tutor
    -1898: get a tutor and SU the class
    -1539: utilize outside resources more
-Don't think that the TA/instructor care or know their names, they want the instructor to be more approachable

Thursday, Session 4, (Interviewer #2)

Notes:
-Both students say it's going better and that midterm 2 helped
-Working in groups is good if you have a good group, so the instructor should assign the groups
-1309: most of the material should be shown, 1891: some of it needs to be shown
-1309: keeps reiterating that they're not teaching everything
-Both students have read the text more in this class than in other classes, but 1309 says she doesn't like it and she also guesses on the activities a lot of the time. 1891 seems to invest more time in completing the activities correctly
-Neither one really uses the terms and concepts guide
-Both view teacher as a main resources, and 1891 also uses his friends
-When talking to future students: "don't' take it", "it's a lot of work", "make sure you understand it", "study a lot", "ask a bunch of questions"
-Restarting the term, they would use their resources more and study more for the first midterm
-Positives: Like the smaller class sizes, like the group work
-Negatives: want activity and hw before lecture, don't like the power points (1309)
-Think that their instructors care a little bit

Monday, Session 4, (Interviewer #1)
Notes:
1073: Reading before activities is helpful, not reading before activity days means you're totally lost
1860: doing extra problems out of the book, things are starting to come together, "downhill"
1494: Has already given up
1494 is done and no longer trying
1860 is excelling and doing extra problems from the book to prepare
1073 is behind on the reading and has zoned out the past week and is a little behind

General comments:
-1494 says it's a totally different class than he's seen, doesn't like the change (8)
"Math isn't a team sport" and if we don't allow them to use groups on the midterm, then they shouldn't work in groups (11)
-Students want the HW due after lecture
-The components of the class are typical (lecture, group work, online HW) but the ordering isn't
-Instructors should be more purposeful about how they re-order and assign groups
-Most students agree math should be shown and then students can apply it to new problems
-1073 thinks her TA and instructor are happy to be there and engaged

-1494 feels like there isn't time built in to the class to go back and correct mistakes on previous activities
-group activities start with a hard/intimidating problem and then get easier
-No students use the reading guide
-1860 uses the textbook, 1073 uses textbook and T&C log, 1494 uses Youtube and tutor
-Students would tell other students, "be read to be self-taught", "take the lecture course", "be ready to put in a lot of effort"
-what they would do differently would be to study harder for midterm 1 and read the textbook
-All 3 students said if they could restart the term, they would probably take the lecture class
-1073: teacher is doing a good job, 1860: teacher is doing a really good job,
Positive things: group work (2 people), Friday quizzes, likes having the TA and Instructor during group activity day, likes having notes on Blackboard
Negative things: hw and activities before lecture (2 people), the reading guide, doesn't like the Friday quizzes because it makes the day rushed
-1073: yes, the instructor cares (test corrections)
-1860: yes, instructor cares a lot
-1494: not sure if she cares about the students or just about her numbers (upset about how she handled the first midterm and that she didn't email him to figure out what went wrong in midterm 2). Also doesn't think it's fair that the lowest midterm can be replaced by the final

Thursday, Session 4 (Interviewer #1)
Notes:
-Ordering of group work and hw before lecture is still problematic, different than a typical math class
-Most students need to be shown the basics of math and then they can apply it
-Negative comments about TA/instructor on group activity days…just stand there, don't walk around, aren't proactive about helping, "doesn't seem like they do much"
-After class or one-on-one instructor is more helpful
-1693 had to learn how to study, never really had to in high school
-Students are using lecture notes, examples from the book, terms and concepts,
-When telling students what to expect: "don't go into it thinking it's easy", "be prepared to do a lot of studying on your own….and that you'll need to buy a book", "read the book",
-If students could restart the term they would: read the book, do practice problems from the text, focus more in class, make sure you understand the material as you're going through it
Positives: group work, small class sizes,
Negatives:

Lecture vs. redesign: 1693 (lecture), 1358 (redesigned), 1831 (redesign), 1346 (redesign), 1986 (redesign)
-1986 and 1963 don't seem to care to much if their instructor does or doesn't want them to be successful

Possible themes from all session 4 transcriptions:
-Students think that the redesigned structure of hw before lecture is atypical
-Students wish they would have used their resources better in the class
-Instructors and TAs need to care about their students and know students' names
-Students like interacting with peers and working in groups (even if they don't like the math)
-Students think that the majority of concepts need to be shown rather than the students' learning material on their own