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Barriers to Curricular Change in General Education Mathematics at a Large Public Institution

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BARRIERS TO CURRICULAR CHANGE IN GENERAL EDUCATION
MATHEMATICS AT A LARGE PUBLIC INSTITUTION

by

Marcus Jorgensen

A dissertation submitted in partial fulfillment
of the requirements for the degree

of

DOCTOR OF PHILOSOPHY

in

Education
(Curriculum and Instruction)

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2014

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ABSTRACT

Barriers to Curricular Change in General Education Mathematics
at a Large Public Institution

by

Marcus Jorgensen, Doctor of Philosophy

Utah State University, 2014

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Department: School of Teacher Education and Leadership

This qualitative study looked for barriers to curricular change in general education mathematics at a large public university (LPU) in the Western United States. LPU still uses the traditional algebra-intensive curriculum and relies predominantly on College Algebra as its quantitative literacy (QL) course, which may be at the expense of more relevant and useful mathematics. The study uses Rogers' *Diffusion of Innovations* as a conceptual way to look at curricular change in higher education; and Bolman and Deal's *Reframing Organizations* as a framework that provides four different perspectives for examining issues within organizations. Interviews were conducted with 14 participants who included faculty, staff, and administrators. Analysis of the data showed 12 barriers that were grouped into four clusters: goals, control, quality, and communications. Finally, recommendations in each of the four clusters are offered for removing barriers,

considering alternative curricula, and designing an intentional curriculum around QL learning outcomes.

(183 pages)

PUBLIC ABSTRACT

Barriers to Curricular Change in General Education Mathematics
at a Large Public Institution

by

Marcus Jorgensen, Doctor of Philosophy

Utah State University, 2014

This qualitative study looked for barriers to curricular change in general education mathematics at a large public university (LPU) in the Western United States. The literature showed that a number of national organizations dealing in math education have recommended alternatives to the traditional algebra-intensive curriculum. LPU still relies predominantly on traditional College Algebra as its quantitative literacy (QL) course. With such an algebra-heavy emphasis, students may be missing more relevant and useful mathematics. In addition, the College Algebra course has a low success rate, which becomes a barrier to student retention and graduation. Interviews were conducted with 14 participants who included faculty, staff, and administrators. Analysis of the data showed 12 barriers that were grouped into four clusters: goals, control, quality, and communications. Finally, recommendations in each of the four clusters are offered for removing barriers, considering alternative curricula, and designing an intentional curriculum around QL learning outcomes.

DEDICATION

To my parents, Clarence (“Kelly”) and Arline. They grew up during the Great Depression and never had much of a chance to attend college. They wanted a better life for their children and consequently pushed the value of an education and sacrificed to ensure that I would have opportunities. For that, I will be eternally grateful. I am proud to say that they are both World War II veterans and certainly members of the “Greatest Generation.”

ACKNOWLEDGMENTS

I wish to thank a number of people who have made this study possible. I first recognize the participants of this study. Their willingness to be interviewed and to be frank in their comments and feedback is much appreciated. This study stirred up some unpleasant memories among the Mathematics Department faculty. That was not my intent but I recognize that some of the wounds of the past were deeper than I realized. The future looks optimistic though and I wish them all the best.

The faculty I worked with at Utah State University were extremely knowledgeable, interesting, fun, and helpful. I want to especially thank my original advisor, Dr. Barry Franklin, now retired. He provided guidance that opened up research possibilities for me. Special thanks to Dr. Spencer Clark who was a marvelous help in guiding me through this study.

Of course, I am extremely grateful to my wife, Gayle, and our children and grandchildren for their encouragement and support. I did my best to balance my life, work, and studies. I never missed the important opportunities to be with family. Still, there were many days when I was essentially locked in my office writing. My wife's patience is extraordinary and I could not have completed the program without her love and support.

Marcus Jorgensen

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CHAPTER I

THE PROBLEM

Nearly a decade ago, Steen (2004) made an “urgent challenge” to higher education to reform the undergraduate curriculum in order to improve the quantitative literacy (QL) of our college graduates. He and others have made the case that QL is needed more than ever to help our graduates be successful in what Niederman and Boyum (2003) referred to as the *quantitative information age*.

With the vast amount of quantitative data available for decision-making, it is helpful, and essential in some cases, for people to be able to reason with numbers in their professions, their day-to-day lives, or even as citizens in a democratic society. Critical thinking is something that we would hope students learn in college but it is not possible to think critically today if one cannot deal with quantitative data. However, despite the urgency of Steen’s challenge to reform the curriculum, the traditional algebra-intensive curriculum prevails and reform efforts have been slow or nonexistent at many colleges and universities. College algebra continues to dominate as a required general education QL course for far too many students, even though College Algebra does little to improve QL in students (Herriott & Dunbar, 2009).

The traditional College Algebra course, virtually unchanged for decades, was originally designed as a preparation for calculus. Many doubt the utility of College Algebra in terms of QL. In 1991, Peter Lindstrom wrote an editorial entitled “What’s Wrong with College Algebra?” He highlighted disagreements by educators over the focus of the course with some insisting that its purpose is to develop procedural algebra skills

while for others it is to develop conceptual understanding. These disagreements, which have been going on for years, “are cancers that will curse the course for many more years unless we tackle them immediately with seriousness” (Lindstrom, 1991, p. 94).

Seventeen years later, Sheldon Gordon (2008a) wrote an article with the same title: “What’s Wrong with College Algebra?” In his article he did not reference Lindstrom, but addresses a number of the same issues that have still not been addressed or resolved at many institutions. As a result, QL often takes a backseat to the traditional, skills-based algebra curriculum. As Lindstrom predicted, the course continues to be cursed. Steen (2004) stated that “with few exceptions, today’s college students study a curriculum that was developed for different students in a different time and for a different purpose” (p. 4). Bennett (2012) was even more critical, stating, “Let’s recognize ‘College Algebra’ for what it really is: high school algebra that is taught in college” (p. 194). Because College Algebra is essentially a remedial course, Bennett recommends that it not even count towards a college graduation requirement, let alone a QL requirement.

There are real consequences for many students who try to struggle through an algebra-intensive curriculum, unable to complete a college degree or their preferred major because of their inability to pass the mathematics requirement. While there is little published data on College Algebra completion rates, Herriott and Dunbar (2009) stated that it was not uncommon to hear of D-Withdrawal-Fail (DWF) rates of 30% to 40% and higher for traditional College Algebra courses. One large public university with 1,600 students per year enrolled in College Algebra reported a 50% DWF rate (Edwards, Ko, & Karakok, 2011). Conversely, S. Gordon (2008a) gave the typical success rate as only

50% or lower. The toll is even higher for students who enter college underprepared and need to follow a remedial path. A recent large study of 57 colleges in seven states found that only 20% of college students referred to math remediation are successful in starting and persisting through a developmental math sequence and then passing their freshman-level, gatekeeper mathematics course (Bailey, Jeong, & Cho, 2010).

Because large numbers of students are having difficulty with the traditional algebra curriculum is not reason enough to change the curriculum; however, it should give educators pause to examine what is happening. As a developmental mathematics instructor, my experience is that students are capable of learning the material but they see little relevance. The term *relevance* is often assumed to mean practical value.

However, Sealey and Noyes (2010) problematized the term by finding three different categories of relevance from students' perspectives: practical, process, and professional. *Practical* refers to the value or usefulness of the concepts; *process* is related to transferable skills (e.g., problem-solving); and *professional* relevance means the exchange value (e.g., being able to get a degree and go on to a career). From the perspective of many students, there is little practical or process value in the current QL math so it is seen as a hoop to jump through in order to get a degree. Other than that, they see little reason to engage in the learning process. Consequently, they do poorly and, even if they do well, develop negative perceptions of mathematics which decreases their level of quantitative literacy.

J. Michael Shaughnessy, as president of the National Council of Teachers of Mathematics (NCTM), wrote about the algebra-heavy curriculum in both high school and

college and the need for reform. He stated:

This endless sequence of algebra courses is not an uncommon experience for many students, and the attrition rate along this path is very high. Many students thus mired in algebra discover they don't need calculus, and they exit math at the level of College Algebra, never to return. This is an out-of-date, wasteful, and repetitive transition path for our students. Worse, it does nothing to improve our students' disposition toward mathematics. (Shaughnessy, 2011)

John Allen Paulos' best-selling book from 1989, *Innumeracy: Mathematical Illiteracy and its Consequences*, raised awareness of the issues related to an innumerate society. In the preface of the 2001 edition, he noted that the innumeracy condition is still virtually the same but that there does seem to be "greater awareness of the importance of numbers, probability, logic, and mathematics generally" (Paulos, 2001, Preface, ¶ 3). Bennett (2012), in a more recent effort, draws attention to the need for better quantitative reasoning on an individual and societal level. The title of his book speaks to the problem: *Math for Life: Crucial Ideas You Didn't Learn in School*.

What role can higher education play in improving QL? As noted above, the problem associated with QL in the undergraduate curriculum, regardless of major, is that it is not being addressed effectively through the decades-old, traditional algebra curriculum. As a result, students do not develop the necessary QL skills even if they manage to pass the antiquated mathematics course they are forced to take. Steen (2004) notes that "educational policy and practice have fallen behind the rapidly changing data-oriented needs of modern society, and undergraduate education is the appropriate locus of leadership for making the necessary changes" (p. xii). More research is needed on the types of policies that can improve implementation of general education QL reform in the undergraduate curriculum.

CHAPTER II

REVIEW OF THE LITERATURE

In the last decade, researchers and practitioners have been working to improve the quality of the undergraduate, general education mathematics curriculum. They have dealt with these questions: What is the math that all college students should know? For what purpose? What is the best way to teach it? This review of the literature provides background on the definition of QL, the call for reform, and recent efforts at implementing reform.

Quantitative Literacy Defined

A little needs to be said first about the term *quantitative literacy*. From a general education perspective, the Association of American Colleges and Universities (AAC&U), which describes itself as “a voice and a force for liberal education in the 21st century,” defines QL in this way:

Quantitative Literacy (QL) - also known as Numeracy or Quantitative Reasoning (QR) - is a “habit of mind,” competency, and comfort in working with numerical data. Individuals with strong QL skills possess the ability to reason and solve quantitative problems from a wide array of authentic contexts and everyday life situations. They understand and can create sophisticated arguments supported by quantitative evidence and they can clearly communicate those arguments in a variety of formats (using words, tables, graphs, mathematical equations, etc., as appropriate). (AAC&U, n.d.b)

For AAC&U, QL is deemed to be equivalent to numeracy and quantitative reasoning (QR). Such is the case also for Madison and Steen (2008). They provide an excellent history of numeracy and quantitative literacy in the National Numeracy

Network's (NNN) premier edition of their journal, *Numeracy*. However, they do not provide a definitive answer as to what the various terms mean. The NNN web site provided these essentially interchangeable definitions.

Some call it **Numeracy**, an expression first used in the UK's 1959 "Crowther Report" to include secondary school students' ability to reason and solve sophisticated quantitative problems, their basic understanding of the scientific method, and their ability to communicate at a substantial level about quantitative issues in everyday life. Others call it **Quantitative Literacy (QL)**, and describe this comfort, competency, and "habit of mind" in working with numerical data as being as important in today's highly quantitative society as reading and writing were in previous generations. Still others refer to it as **Quantitative Reasoning (QR)**, emphasizing the higher-order reasoning and critical thinking skills needed to understand and to create sophisticated arguments supported by quantitative data. (NNN, n.d.b, What is numeracy/QL/QR?)

Perhaps allowing for some blurring of the meaning of those three terms, their vision statement "envisions a society in which all citizens possess the power and habit of mind to search out quantitative information, critique it, reflect upon it, and apply it in their public, personal and professional lives" (NNN, n.d.a, About the NNN).

The Special Interest Group on Quantitative Literacy of the Mathematical Association of America (SIGMAA-QL) stated that QL "can be described as the ability to adequately use elementary mathematical tools to interpret and manipulate quantitative data and ideas that arise in individuals' private, civic, and work lives. Like reading and writing literacy, quantitative literacy is a habit of mind that is best formed by exposure in many contexts" (Mathematical Association of America, 2007, Article I, Section 2).

Some include more than just mathematical ability to the definition. Wilkins (2000) added "a recognition of the societal impact and utility of mathematics; an understanding of the nature and historical development of mathematics; a positive

disposition toward mathematics” to his QL framework (p. 406). Steen’s (2001b) elements of QL include confidence with mathematics and cultural appreciation.

My preferred view is to see QL as a broad term that encompasses everything beyond basic arithmetic skills to include math skills needed in a profession or in life. Perhaps the most concise definition would be that QL includes “attitudes, skills, and habits that they bring to bear whenever they need to make decisions based on numbers” (Niederman & Boyum, 2003, p. v3).

Call for Reform

Looking at the last two decades, a timeline (see Figure 1) can be developed of published calls for reform of the traditional College Algebra curriculum and an increased need for teaching QL. Lindstrom’s (1991) editorial, mentioned above, listed a number of disagreements between math educators including the degree to which College Algebra should stress procedural skills versus applications. His list also includes the use of calculators and whether or not College Algebra should be the course that satisfies the college mathematics requirement. He advocates the use of technology, no longer using rote memorization of formulas, and stressing the practical applications of algebra.

Also in 1991, the Mathematical Association of America’s (MAA) Committee on the Mathematical Education of Teachers published a report: *A Call for Change: Recommendations for the Mathematical Preparation of Teachers of Mathematics* (Leitzel, 1991). This report was written to help prepare K-12 teachers of mathematics given the reform movement in school mathematics. However, recognizing that the issues

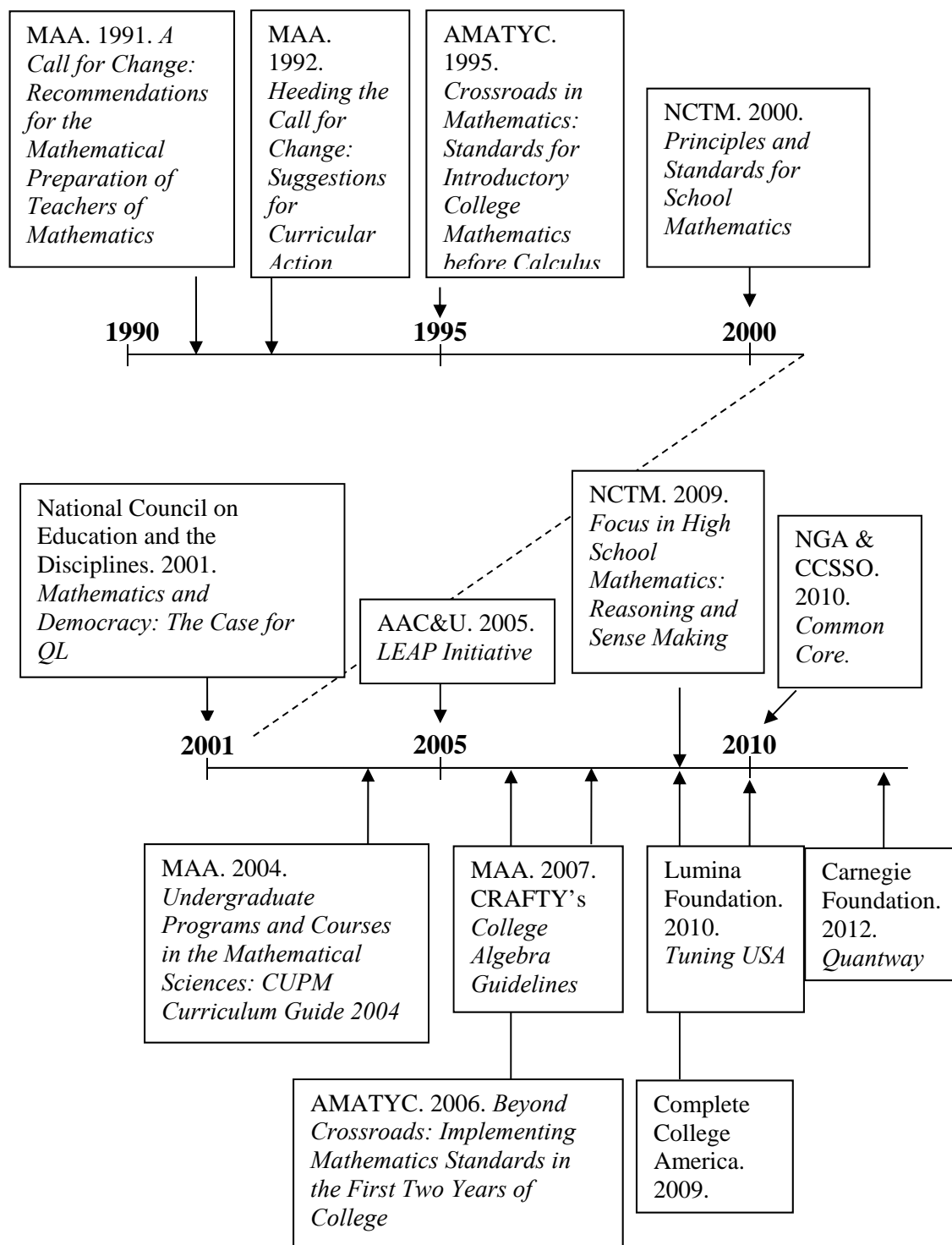


Figure 1. A timeline of key curricular initiatives in mathematics education.

are broader than just teacher preparation, the MAA's Committee on the Undergraduate Program in Mathematics (CUPM) published a report in 1992, *Heeding the Call for Change: Suggestions for Curricular Action* (Steen, 1992). In that report, the Focus Group on Quantitative Literacy looked at College Algebra and noted several issues, including a concern for whether or not College Algebra can assume the roles of both general education requirement (essentially quantitative literacy) and also preparation for follow-on mathematics courses (mathematical literacy). The report also addressed the need for college students to learn concepts in context with practical, real-world value. While these issues were identified, the report provided few specific recommendations.

A CUPM Curriculum Initiative began in 1999. One of the working assumptions was that a college mathematics program “must serve the quantitative literacy needs of a very large population often enrolled in, but not optimally served by, College Algebra courses” (Pollatsek et al., 2004; see also Appendix A). Over a series of years, they reviewed previous recommendations, sponsored sessions at conferences, conducted focus groups and surveys, and worked with other professional organizations. This work resulted in the publication of *Undergraduate Programs and Courses in the Mathematical Sciences: CUPM Curriculum Guide 2004* (Pollatsek et al., 2004). Recommendations for general education or introductory math courses included clarifying the rationale for student course requirements and examining how the courses were meeting student needs. This 2004 guide is still their most current.

Another CUPM effort was launched for curriculum renewal across the first two years of college: the Curriculum Foundations Project, which was designed to look at the

mathematical needs of students from a variety of disciplines. As a part of this effort, the CUPM Subcommittee on Curriculum Renewal Across the First Two Years (CRAFTY, 2006) developed *College Algebra Guidelines*, which were endorsed by CUPM on January 31, 2007. While not dictating specific course content, the guidelines give three areas of competencies for students: problem-solving, functions and equations, and data analysis. These competencies reflect more of a QL emphasis on real-world application and conceptual understanding than perhaps a traditional College Algebra course might have.

During the same time frame that the MAA was looking at college mathematics education, the American Mathematical Association of Two-Year Colleges (AMATYC) was examining some of the same issues. In 1995 they published *Crossroads in Mathematics: Standards for Introductory College Mathematics before Calculus* (Cohen, 1995), which recommends standards for general education, college mathematics. These standards are still considered by AMATYC to be valid and are designed to “provide a strong and flexible framework for the complete rebuilding of introductory college mathematics” (Cohen, 1995). Like the reports by CUPM, there is an emphasis on problem-solving, modeling, and appropriate use of technology. There are standards for intellectual development, content, and pedagogy.

Creating recommended standards is one thing but implementation by institutions of higher education is quite another. Thus, in 2006, AMATYC published *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years of College* (Blair, 2006), which reaffirmed the earlier standards and added new standards for

implementing reform. One of the guiding principles was that “quantitative literacy should be integrated throughout the mathematics program and the college curricula” (Blair, 2006). Also, an element of the AMATYC mission statement is to “ensure the preparation of mathematically and technologically literate citizens who are capable of making informed decisions, who have skills needed by business and industry, and who will continue to grow in their quantitative literacy” (AMATYC, n.d.).

In 2001, an important work was published by the National Council on Education and the Disciplines (Steen, 2001a) in which a QL design team looked at the QL requirements in contemporary society to make a case for QL in K-16 education. Steen (2001b) noted that “the public seems not to grasp either the escalating demands for quantitative literacy or the consequences of widespread innumeracy” (p. 18). He pointed out, ironically, that innumeracy in society may be a consequence of innumeracy: “People who have never experienced the power of quantitative thinking often underestimate its importance, especially in tomorrow’s society” (p. 18).

The AAC&U began its Liberal Education and America’s Promise (LEAP) initiative in 2005. One of the results is a list of essential learning outcomes for all college graduates (AAC&U, n.d.a) to include QL under one of four broad categories of outcomes, intellectual and practical skills. Recently, as noted above, AAC&U has helped define QL and provided a mechanism for assessing student learning in QL.

Another professional organization working to improve mathematics education by including more QL is the National Council for Teachers of Mathematics (NCTM). The organization, which emphasizes K-12 mathematics but is also concerned with college

math education, produced the *Principles and Standards for School Mathematics* in 2000. The process standards include problem-solving, reasoning and proof, communication, connections, and representations. In 2009 NCTM published *Focus in High School Mathematics: Reasoning and Sense Making*, which “describes ‘reasoning habits,’ which are productive ways of thinking that should become customary in the processes of mathematical inquiry and sense making” (NCTM, 2009). Additional changes are being made at the K-12 levels as states adopt the Common Core State Standards in Mathematics, an initiative begun in 2010 by the National Governors Association and the Council of Chief State School Officers (Common Core State Standards Initiative, 2010). As the K-12 system changes, new efforts are being made to improve how teachers are trained. The Science and Mathematics Teacher Imperative (SMTI) is sponsored by the Association of Public and Land-grant Universities (APLU) to help public universities “to increase the number and improve the quality and diversity of science and mathematics teachers they prepare” (APLU, n.d.).

Interestingly, the problem with QL in college may be exacerbated by changes in the K-12 system. Improvements in school mathematics education could potentially increase the quantitative literacy of high school graduates. However, when those students get to college they may have to face a traditional algebra curriculum taught in a way that is totally different than what they have experienced in school. How prepared will they be to succeed in their first-year college mathematics course?

The work of several other organizations shows recognition of the need for reform. The Carnegie Foundation for the Advancement of Teaching is an independent policy and

research center. One of their current initiatives is with developmental mathematics and helping community college students to successfully get the remediation they need for the QL course they need to take. Their “Quantway™ Networked Improvement Community provides an alternate and accelerated pathway that will motivate and engage students with an innovative quantitative literacy focus in which students use mathematics and numerical reasoning to make sense of the world around them” (Carnegie Foundation for the Advancement of Teaching, n.d.). The program started in 2012 and receives support from the Carnegie Corporation of New York, the Bill and Melinda Gates Foundation, the William and Flora Hewlett Foundation, Lumina Foundation, and the Kresge Foundation.

Complete College America, established in 2009, “is a national nonprofit with a single mission: to work with states to significantly increase the number of Americans with quality career certificates or college degrees and to close attainment gaps for traditionally underrepresented populations” (Complete College America, n.d.). The organization has a significant emphasis on mathematics in the undergraduate curriculum as well as remedial and developmental programs. One concern is that their focus on improving success rates in remedial math courses results in treating the symptoms and not addressing the underlying root cause found in the appropriateness of the curriculum.

Finally, with support from the Lumina Foundation, Tuning USA is a project just getting started that may eventually have an impact on the undergraduate mathematics curriculum. Tuning is a concept that has evolved from Europe’s Bologna Process to increase quality, transferability, and transparency in higher education (for more information see Kehm, 2010). “Tuning is a faculty-driven process that identifies what a

student should know and be able to do in a chosen discipline when a degree has been earned—an associate’s, bachelor’s or master’s” (Tuning USA, n.d.). Three state higher education systems (Indiana, Minnesota, and Utah) are experimenting with the process in which faculty committees, with members from the state institutions, develop learning outcomes in a particular discipline (Adelman, 2010). Utah was the first to look at mathematics and their work began on this discipline in 2012. The degree to which this project will include QL remains to be seen. One of the issues is that mathematics is not the same as QL and “in our discipline-dominated education system QL has neither an academic home nor an administrative promoter” (Steen, 2004).

In Utah, the tuning effort is being led by a committee of representatives mostly from mathematics departments. One of their goals is to establish common student learning outcomes. Utah Mathematics General Education (GE) Tuning Committee (2012) minutes indicated that as of September 7, 2012, the draft learning outcomes are that:

A student who has successfully completed any Math GE course will have demonstrated the following proficiencies:

1. Know when and how to apply mathematical knowledge to real world problems.
2. Interpret and critique quantitative information or arguments.
3. Construct quantitative, logical arguments.
4. Understand and use mathematics as a language to communicate.
5. Use technology to explore and analyze mathematical concepts.
6. Estimate, reason through, and make sense of both the mathematical processes and the results. (Utah Mathematics GE Tuning Committee, 2012)

It should be noted that not all agree with changing the algebra emphasis in college. Dudley (2010), a retired mathematics professor who taught for 30 years, recently made a strong point that the vast majority of Americans will never use higher math skills, such as algebra. So why did he spend a career teaching math? “It is to teach the race to

reason” (p. 613). This is the old mental discipline argument from the 19th century:

But a higher object is proposed [in studying mathematics], in the case of those who are acquiring a liberal education. The main design should be to call into exercise, to discipline, and to invigorate the powers of the mind. It is the *logic* of the mathematics which constitutes their principal value, as a part of a course of collegiate instruction. The time and attention devoted to them, is for the purpose of forming *sound reasoners*, rather than expert mathematicians. (Day, 1841, pp. iii-iv)

Does manipulation of symbols in algebra make one a better reasoner, in general? Much of the past research on this has been inconclusive (Atherton, 2007).

Recent Efforts to Improve Quantitative Literacy

Improving the teaching of QL in college can be described using three categories. The first category involves creating a specific QL course. In the optimal situation, that QL course is considered a foundation course and the concepts get reinforced in a comprehensive QL-across-the-curriculum program. A second category is the development of a mathematics course where QL is learned in the context of a specific discipline (mathematical literacy). The final category is reforming the College Algebra course so that it includes more relevant material and better addresses QL. Each of these categories is addressed below.

QL Courses

I conducted a search of the literature for reported examples of college courses designed to teach QL from 2000 to 2012. I found only four examples. I examined each article to see what factors may be attributed to the QL emphasis.

Hillyard (2007) described a junior-level, interdisciplinary QR course based on

pop culture. At the institution that taught junior, seniors and graduate students, they had recognized a gap between what their students had learned at a community college and what they needed for QR in their degree programs. While the level of math skills is admitted to be of a lower level, the rigor in this 3-year course is from the QR elements. The institution increasingly formalized integration of QR across the curriculum and even created a Quantitative Skills Center that could be used by students needing help in any course. This was modeled after the Writing Center and their writing-across-the-curriculum project.

Another interdisciplinary, pop culture-based effort was made by Belmont University (Pinter, 2007). The course was a first-year, general education requirement taught by faculty from all over the campus. The author reports being able to work in some QR since the emphasis for the seminar was “ways of knowing.” Individual faculty members have considerable freedom so it appears that consistency, in terms of a QL/QR emphasis, across sections of the course would be difficult.

The third example, like the first two, mention an awareness of the QL literature. Dewar, Larson, and Zachariah (2011) stated that “we believe this course represents one possible response to 21st century calls to institutions of higher education for greater emphasis on quantitative literacy” (p. 607). They taught QL in combination in the context of civic engagement.

The fourth article was about a developmental mathematics course, *Applying Mathematical Thinking*, at Alverno College (Banner, 2007). This institution is noted for its focus on student outcomes. The author noted that “for over twenty years, the college

has offered a dynamic, continuously evolving, ability-based curriculum” (p.34). Students demonstrate that they meet outcomes in eight “context-based ability areas,” which include communication, analysis, and problem-solving. Students enrolled in the mathematical thinking course “are being prepared for further work at the first level of the communication ability, with an emphasis on quantitative literacy” (p. 34). Again, as with the other examples, a context is chosen that will be of interest and importance to the students. In this case it concerned the poverty line. The author notes that the vast majority of students are first-generation college students and receive federal financial aid.

Initially, just from these four articles, factors necessary for making improvements to QL would include: a focus on general education outcomes, faculty working together, institutional commitment, course design and development based on student needs and interests, and knowledge of the QL literature and the recommendations of the national organizations.

The MAA published a book entitled *Current Practices in Quantitative Literacy* (Gillman, 2006). One section of the book described the QL courses at seven institutions. Background is provided on how the courses were developed. Most involve an interdisciplinary, institution-wide effort at reviewing what it is that they wanted their students to learn. In some cases, this was part of a review of general education requirements (e.g., Jabon, 2006). Two interesting examples involved different approaches. In the first, a new QL course was initiated after an English professor, and lead advisor for English majors, would continually ask the chair of the mathematics department why English majors needed to take College Algebra to graduate (Ellington &

Haver, 2006, p. 97). In the other case (Jabon, 2006), College Algebra became a prerequisite for a QL course. Both cases seem to speak to the inadequacy of College Algebra as a QL course.

Most of the chapters refer to the national discussions about QL and general education. In all cases, strong faculty involvement is indicated. The extent to which change was directed or encouraged by policy or administrators is unknown in these examples. More research is needed on reform policies and reform implementation.

QL in the Disciplines

QL is sometimes incorporated into courses in a discipline to either make up for inadequacies of the mathematics courses taken or to reinforce the concepts and skills from a QL foundational course. In the same QL/QR search noted above, there were several examples of disciplines incorporating QL or QR into their courses. These disciplines included biology, psychology, astronomy, oceanography, business, geology, and sociology. There were multiple examples of the latter in particular. This appears to be because of a special emphasis by the American Sociological Association; in 2002, the association launched the Integrating Data Analysis project in collaboration with the Social Science Data Analysis Network on a National Science Foundation-funded project to “close the quantitative reasoning gap in sociology” (American Sociological Association, 2004). The journal, *Teaching Sociology*, continues to regularly address QL in the curriculum although this may be considered more mathematical literacy than QL in that the goals seem to be the use of mathematical skills and thinking in follow-on courses in the major.

The MAA's *Current Practices in Quantitative Literacy* (Gillman, 2006) gave 11 examples of interdisciplinary or interdepartmental programs. In many of these, the program requires a QL course that can either be in the context of a discipline or a general contemporary math course. There are several common factors that were important in implementing these programs. All 11 were faculty-driven and required some level of cooperation and participation from faculty of various disciplines. Two examples noted the support of administrators. One set of authors noted that the program was set up under the leadership of the Vice President of Academic Affairs and the Academic Affairs Council (Diefenderfer, Doan, & Salowey, 2006). Another noted that “we have always been very fortunate at Farmingdale State that through several administrators—the president, the provost, and the deans—went well beyond being supportive of our projects, but strongly encouraged faculty to become deeply involved” (S. Gordon & Winn, 2006, p. 61). They also noted that “it helps if the project leaders have many professional connections on and off campus and have a good working relationship with the campus administration” (p. 61). Five institutions made their changes as part of an institutional review of their general education requirements. Most noted some resource support including federal grants, a state-sponsored initiative, and internal grants and resource support.

Wallace (2002) noted that “all disciplines must engage in a discussion aimed at repositioning quantitative reasoning in the curriculum” (p. 232) and that “the problem of structuring collaboration between faculty of various disciplines is the first of what I call the ‘design issues’ for institutional change” (p. 233). Wallace stated two paths to failure.

One is “relying too much on the enthusiasm and good will of faculty to continue pushing a project forward when there isn’t institutional support for it” (p. 234). The second pathway to failure is administration committing to a project too early and without consulting faculty or gaining their commitment.

The work with QL/QR in the disciplines continues. Ganter and Haver (2011a) edited an MAA publication, *Partner Discipline Recommendations for Introductory College Mathematics and the Implications for College Algebra*. It reports on five disciplinary curriculum workshops, sponsored by CRAFTY, for agriculture, arts, economics, meteorology, and social science. There is agreement on what a math course should include, but they focus on changing College Algebra because so many students are required to take it. CRAFTY’s goal is to have every college mathematics department review their College Algebra course, if they have one. “CRAFTY is convinced that if departments undertake such a review, utilizing resources made available by CRAFTY, many departments will realize that the course needs fundamental revisions and that the renewal process will result in a stronger and more effective course” (Ganter & Haver, 2011b, p. 40).

Reforming College Algebra

Rather than replace a College Algebra course, the path of least resistance may be to revise the course and make it more relevant and compatible with QL. I looked for any articles on College Algebra course improvement or reform. The only studies looked at were those that examined the whole course as opposed to articles about improved ways to teach specific concepts. Almost all of the recent literature on College Algebra

improvement focuses on pedagogical issues, as opposed to curricular changes. Many of the studies are primarily related to improving pass rates in reaction to increased concern about the number of students who are unable to pass College Algebra. The legitimacy of the College Algebra curriculum or requirements is not questioned.

There are some recent studies that address the appropriateness of College Algebra when it is used as a prerequisite for courses in disciplines other than mathematics. In each case, doubt is raised about traditional, skills-based College Algebra (S. Gordon, 2009; Matthews, Rech, & Grandgenett, 2010; Sibulkin & Butler, 2008).

S. Gordon (2008b) addressed College Algebra reform with respect to having a more conceptual-based approach. He described a reform course that he taught and how the performance results of his students was much better than they would have been in a traditional skills-based course. This qualitative report makes a point about being more concerned with concepts rather than algebraic manipulation.

Going back to 2000, there were only a few articles specifically pertaining to curricular changes. Three were opinion-based articles. One was a positive review of a reformed College Algebra textbook (Arney, 2003). Another (Haver, 2007) was simply an encouragement for implementing changes, stating that “College Algebra indeed provides an important place to begin the implementation proposed in *Beyond Crossroads*” (p. 33). The third article by F. Gordon and Gordon (2006) addressed what was meant by conceptual understanding as a way to better include it in the math curriculum.

There were just a few experimental studies and they showed alternative College Algebra comparing favorably to the traditional course (Chappell & Hardy, 1999;

Ellington, 2005; Fox & West, 2001; Mayes, 2004). Elliott, Oty, and McArthur (2001) studied the results of an interdisciplinary course, Algebra for the Sciences. Using traditional College Algebra classes as a control, they found that there was no significant difference in problem-solving ability between the two groups of students. However, they did find that students in the interdisciplinary course had slightly larger gains in critical thinking and significantly more positive attitudes.

Being interested in the process of implementation and the decision to implement, I broadened my search for any college mathematics curricular changes and found an article by A. Jacobs, Jacobs, Coe, and Carruthers (2007) in which they described an implementation of a standards-based math curriculum at their community college. The process took over 10 years. As they looked at their experience they identified four steps of successful implementation: (a) start with a manageable change, support the change to decrease the risk and make a plan to bring everyone along; (b) include the adjunct faculty in faculty development, aim to build mutual respect; (c) embark on a solution only after you have an agreement about what the problem is; and (d) build on past success. The authors urge other institutions to develop their own process.

Overall, there is a lack of research in reforming College Algebra, which is surprising given the mostly encouraging results of the research thus far and given the endorsement of reform by three professional organizations. However, the lack of research is partly due to the lack of implementation. With concerns about implementation, CRAFTY, with support from the National Science Foundation, provided opportunities for some institutions of higher learning to implement a modeling-based College Algebra

course that more closely matches CRAFTY's guidelines than traditional College Algebra courses. Over 200 institutions applied for a grant to participate of which 11 were selected. The process started in 2005 and the first report of the results has now been published (Gantner & Haver, 2011a). The intent was to create some sections of a modified College Algebra course at the institutions in order to compare the results to a control, the traditionally taught sections at the same institution. Interestingly, two institutions dropped out of the study before any grade data were collected and five institutions had only one semester of data (the remaining had two semesters). Five institutions had passing rates that were higher for the modeling sections while two had lower. One school had the same passing rates and one had mixed results. These are not overwhelmingly positive results, but some potential can be seen for revitalizing College Algebra.

It is clear that the curricular and pedagogical changes are slow and take time. The fact that over 200 institutions applied shows some recognition of a problem with undergraduate math education in higher education. However, actual change to address the problem is occurring slowly. The MAA report (Gantner & Haver, 2011a) did offer some lessons learned. One summarizing chapter in the report (Edwards, 2011) categorized the factors influencing the project as external and internal (personal). The external included lack of agreement nationally on the content of College Algebra, state and departmental mandates of content, physical facilities (for group work in class), budgets, and the lack of support from colleagues. Internal or personal factors included instructor attitudes and degree of commitment to change (including degree of commitment to this particular change to a modeling-based alternative), increased workload concerns for both faculty

and students, and students' discomfort with a new style of learning that required more participation and active learning.

Summary

From the studies above, the following factors were noted as important for curricular reform: faculty involvement and the ability to work together (sometimes across disciplines), commitment and cooperation by faculty and administrators, agreement on the problem, knowledge of the QL literature and the recommendations of the national organizations, a focus on general education learning outcomes, course design and development based on student needs and interests, and resource support. The A. Jacobs and colleagues (2007) article about their example of an implementation of reform noted that institutions need to develop their own processes. The focus of my study is on discovering any barriers to change at a specific institution. The lessons learned from the above studies informs this investigation.

CHAPTER III

SITE DESCRIPTION

Before proceeding it is important to describe Large Public University (LPU) in a way that sets the context necessary to give meaning to the findings and subsequent analysis and discussion. The description is taken from the LPU web site, an institution publication that details the history of the institution, and various documents including the curriculum files and the catalog.

An Introduction to Large Public University

LPU Mission and History

LPU was established in 1941 as a vocational school with a primary function of training workers for war production in World War II. Initially, the school was under the local public school district but in 1947 it became a permanent fixture in the state's higher education system. The school has grown dramatically in size and mission undergoing six name changes as the institution grew from a technical institute to a technical college, community college, state college, and finally becoming a university in 2008. Enrollments have gone from a headcount of 566 in 1945 to 4,481 in 1980 to over 31,000 in 2012.

In 1966, LPU was approved to grant associate of applied science degrees. From 1971 to 1973, and from 1981 to the present, it has awarded associate of science degrees. Associate of arts degrees were added in 1987 and, beginning in 1993, LPU added bachelor degrees. With university status it began offering masters programs but retained its community college mission because there are no other state community colleges in the

service region. Currently, LPU offers 3 master's degrees, 63 bachelor's degrees, 65 associate's degrees, and a number of certificates and diplomas. LPU is considered a regional teaching institution with a focus on teaching rather than research.

Student Characteristics

Having a comprehensive mission that includes the community college role, LPU is an open-enrollment institution. It is a commuter campus with several small branch campuses in the region. A 2010 survey showed that nearly half of all students (47%) worked at least 21 hours a week while going to school. The 2012 fact book shows that 43% of students are female. Ethnic minority enrollment is 15.3% (excluding high school concurrent enrollment), which is comparable to the local population with the exception of Hispanics who are underrepresented (but the gap is closing). Forty-two percent of students are over 25 years of age. Nearly 70% of entering students (5-year average) have needed at least one developmental or remedial mathematics course.

LPU Organization

The president is the top position at LPU. The Academic Affairs Division is headed by a senior vice president and there are eight schools or colleges, each headed by a dean. The Mathematics Department is housed in the College of Science and Health. For the 2012-2013 academic year, there were 24 full-time faculty, including 17 who are tenured. Of the tenured, most have doctorates in mathematics or statistics. Four have master's degrees in mathematics with one of those having an Ed.D. in Curriculum and Instruction. These four have been at the institution since it was a community college

when a minimum of a master's degree was required at that time.

The Mathematics Department offers a BS in both mathematics and mathematics education. A new emphasis has been added in actuarial science. Students at LPU can get AS/AA degrees in mathematics as well as a minor in mathematics. For the 2012-2013 year, there were 465 student credit hours taken in upper-division mathematics courses and 15,883 in lower-division courses. There were 204 students majoring in mathematics.

LPU has always chosen to have departments for faculty who are specifically interested in teaching developmental and remedial programs in mathematics and composition. These programs are a part of University College (UC), which also includes academic counseling, tutoring, English as a second language, and student leadership and success studies. The Developmental Mathematics Department is part of UC. In 2012-2013, there were 26 full-time faculty and 55 adjuncts. Of the 21 faculty that are tenured or on the tenure track, most have master's degrees, which is the minimum requirement for teaching developmental courses. One faculty member has a doctorate in mathematics education. Two more faculty have doctorates in education. Three others are actively working on doctorates in education or mathematics education. Six of the faculty have undergraduate degrees in engineering. The department offers a range of courses (Basic Math to Intermediate Algebra) in a variety of formats (face-to-face, distance, hybrid, self-paced) intended to meet a wide range of student needs and circumstances.

Course prefixes for the Mathematics Department are MATH while the Developmental Mathematics prefixes are MAT (without the "H"). Developmental Math courses are MAT 920 (Basic Math), MAT 950 (Pre-Algebra), MAT 990 (Beginning

Algebra), and MAT 1010 (Intermediate Algebra). There was also a MAT 980 course, which combined 950 and 990 for students who could move faster through the courses as well as MAT 1000, which combined 990 and 1010. *Remedial* courses, by the state's definition, are those numbered below 1000. MAT 1000 and 1010 are *developmental* courses and can count as elective credit towards a degree. Often in this report, the courses are referred to only by their number. For example, MATH 1050 is College Algebra but will frequently be referred to as 1050.

General Education

General education at LPU has undergone a recent review over a period of 4 years, which has resulted in the establishment of essential learning outcomes expected for all graduates, regardless of major. The six outcome areas, in line with the AAC&U's LEAP initiative, are: knowledge foundation, people of integrity, stewards of place, professional competency, integrative and applied learning, and intellectual/practical skills. QL is primarily found in the latter area's outcome: "A student will acquire a foundation of intellectual and practical skills including communication, quantitative reasoning, qualitative reasoning (critical, analytical, and creative thinking), and technical and information literacies." Within its liberal education context, this is what LPU hopes all students, regardless of major, are able to do by the time they graduate. General education courses form a foundation for the essential learning outcomes.

The 2012-2013 catalog specifies a list of general education choices similar to what is found in most institutions of higher learning. There are two categories of courses: core and distribution. Core courses "provide basic skills in logic, math, written and oral

communications, health, and fitness.” The mathematics requirement is met through taking MATH 1030, Quantitative Reasoning; MATH 1040, Introduction to Statistics; or MATH 1050, College Algebra. A student can also satisfy the requirement with a course that requires MATH 1050 as a prerequisite or a score of 3 or higher on the Advanced Placement (AP) Mathematics Test. The mathematics core requirement is often referred to as the QL requirement.

The distribution general education courses provide breadth to the bachelor’s degree and fall into four categories: science (one biology course required, one physical science course, and a third course in either area of the sciences), humanities (one course), fine arts (one course), and social/behavioral science (one course). There are no mathematics courses in any of the distribution areas.

QL Curriculum

In the early 1980s, the QL requirement for the associate of science degree was either Intermediate Algebra or College Algebra. In 1988, associate of arts degrees were added. The QL requirement for the AA degree was a combination of Intermediate Algebra and language credits. The AS degree required College Algebra. In 1992, LPU created two versions of College Algebra: one for engineering, math, and science majors at 4 credits and one for the other majors at 3 credits. The engineering-math-science version became what is now the MATH 1050 College Algebra course.

Following a decision by the state higher education system in 1998, all public institutions agreed to offer MATH 1030, 1040, and 1050 as QL courses (as noted above). It was also agreed that each institution would have comparable content for the respective

courses, for purposes of transferability of credits between institutions. A Math Majors Committee, with representatives from the mathematics departments at each institution, meets periodically to discuss state-wide curriculum issues. Essentially then, the QL curriculum consists of taking a state system “approved” mathematics courses.

As noted above, the courses are supposed to be comparable from institution to institution; however, there are some significant differences. Appendix C shows a comparison of the content for MATH 1050 taken from the catalog descriptions of the seven state institutions. There is certainly a common core consisting of the family of functions (i.e., polynomial, rational, exponential, and logarithmic). After that many differences can be seen. Two of the institution’s catalogs noted that graphing calculators were required. LPU did not allow the use of a calculator for MATH 1050.

LPU’s content for MATH 1050 has changed little over time. The curriculum, according to the most recent catalog, “includes inequalities, functions and their graphs, polynomial and rational functions, exponential and logarithmic functions, conic sections, systems of linear and nonlinear equations, matrices and determinants, arithmetic and geometric sequences, the binomial theorem.” Prior to 2011, the list also included mathematical induction, permutations and combinations, and introduction to probability. As the only curriculum change in 15 years, those topics were removed to allow more time for the other topics. As a matter of interest, I compared the content of three College Algebra textbooks: Robinson’s *New University Algebra* from 1862, Davis’ *College Algebra* from 1942, and the textbook used most recently by LPU’s mathematics department, Stewart, Redlin, and Watson’s *College Algebra* from 2009. Appendix D

compares the table of contents of the textbooks and one can see many similarities. LPU's College Algebra is a traditional math education approach.

MATH 1030, Quantitative Reasoning, also has curricular differences between the various state institutions as shown in Appendix C. LPU's curriculum is more algebra-based. Other institutions emphasize real-life situations, modeling, and applications to modern society.

The majority of LPU students take MATH 1050, College Algebra, for their QL course. In the fall of 2012, there were 1,622 students in MATH 1050 compared with 306 in 1040 and only 150 in 1030. The DWF rates for that term are 35% for MATH 1050, 23% for 1040, and 13% for 1030. MATH 1050 has the 11th highest DWF rate of college-level courses on campus. Incidentally, MAT 1010, Intermediate Algebra, had a 30% DWF rate and MAT 1000 (a combination of Beginning and Intermediate Algebra) had a 38% rate. In terms of numbers of students, in lieu of percentages, MAT 1010 was the second most failed course (failures only) and MATH 1050 was fourth.

Curriculum Change Efforts

Since the addition of MATH 1030, 1040, and 1050, there has been little change to the curriculum. As noted above, a few topics were dropped from MATH 1050 in 2011. There have, though, been two concerted efforts to look at the curriculum. One was a seven-month task force in the 2005-2006 academic year. The other is a part of a recent state effort as part of the national Complete College America initiative. Both are described below.

Math Task Force

In 2004 and 2005, LPU's math program had been facing significant pressure from students and the community. Complaints were rolling in. An April 12, 2004, front-page headline in the student newspaper read, "Solving for F: Math 1050 continues to be one of the toughest classes on campus." An enterprising student formed Easiest Math Ever, a company that sought out a few relatively easy independent-study algebra courses at other institutions and provided tutoring services geared to those courses for which students could transfer math credits to LPU. When a disproportionate number of students began transferring in math credits, the LPU math department found out what was going on and they were up in arms at what they deemed were unethical practices that allowed students to bypass the LPU QL requirement by taking less rigorous courses. Easiest Math Ever was scrutinized, as was the LPU math department. It was quite a battle and even the state attorney general's office got involved as questions were raised about the company. Incidentally, the company still exists, after going through two name changes.

In response to the turmoil, a Mathematics Task Force (MTF) was formed with broad-based representation across the campus involving 40 faculty, staff, administrators, and students. There were also four external reviewers, each from an institution of higher education in the state. The charter for the task force, dated October 11, 2005, recognized "the considerable attention and anxiety from students, parents and other community members" (LPU Mathematics Task Force, 2005-2007, Mathematics Task Force Purpose and Charges, October 11, 2005). It further stated that the MTF "has been appointed to help us address both the substantive and perception problems associated with

mathematics at this time.” In addition to an Oversight Committee and Executive Committee, the MTF had seven subcommittees: Perception and Image; Data; Curriculum; Pedagogy; Advisement; Placement, Policies, and Practices; and Interdepartmental Coordination. The objectives were as follows.

Prepare a report for the Vice President of Academic Affairs, the Deans of General Academics, Education, and Science and Health making recommendations for mathematics education at LPU, and relating especially to quantitative literacy courses and mathematics courses for education and business majors. The report should address how we can improve alignment of our mathematics courses, curriculum, and delivery with the educational and career goals of our students. It should also address how we can better and more positively convey the commitment of our mathematics faculties to helping students learn and meet high standards. (LPU Mathematics Task Force, 2005-2007, p. 1)

The specific MTF charges included 29 issues divided into four categories: policy, curricular, organizational, and state-wide issues.

The task force worked on these issues for 7 months. No significant changes were made to the curricula of the three QL courses but there were a significant number of recommendations including the following from the final report.

- Provide intervention to assist students through additional support and math advisors.
- Move the last official day to withdraw to the seventh week of classes.
- Provide a mathematics orientation to inform students of support and responsibilities.
- Work with high school counselors about how our programs help students succeed in mathematics and to address their concerns.
- Advise more students into MATH 1030 and 1040.
- Determine ACT cutoff score for placement, based on data.
- Require campus placement test for students who do not place into QL courses.

- Publicize options for students with excellent mathematics preparation (AP, credit by exam, CLEP, etc.)
- Students use scientific and graphing calculators in situations where the integrity of the skills or concepts is not compromised. Promote understanding of appropriate use of calculators.
- Improve outcomes assessment.
- Help departments review appropriate QL for their majors.
- Focus the energies of faculty best suited to the QL courses toward teaching and improving them.
- Provide adequate funding for professional development of math faculty focused on improving math education. (LPU Mathematics Task Force, 2005-2007, pp. 1-5)

As one can see, most of the recommendations involved better support, communication, and advising for students while the curriculum remained unscathed.

Complete College America

Complete College America (CCA) is a nonprofit organization founded in 2009 and funded by several foundations: Bill & Melinda Gates Foundation, Carnegie Corporation of New York, Ford Foundation, Lumina Foundation for Education, W. K. Kellogg Foundation, and USA Funds. The CCA mission is “to work with states to significantly increase the number of Americans with quality career certificates or college degrees and to close attainment gaps for traditionally underrepresented populations” (CCA, n.d.).

LPU’s state higher education system decided to collaborate with CCA and the National Governor’s Association to help improve graduation rates. In March of 2012, they held a 2-day CCA Academy with representatives from all of the state institutions.

While there were several plenary sessions, most of the time was spent in institution-level meetings brainstorming ideas that might work at their respective institutions. The stated purpose of the Academy was for institutions to “participate in institution-specific action planning in order to develop strategies to improve success in gateway courses and transform remedial/developmental education at each campus.” Regular progress reports are still provided to the state.

The primary focus was on getting students through remedial/developmental classes faster. The assumption was that the longer students spend in the math path, the more opportunities for students to drop out. One of the best practices shared by the state was to:

Align math requirements and student needs (e.g., only STEM students need a pre-Calculus curriculum, others are better served learning statistics and applied mathematics). Review all programs to determine the best math requirements for each program and align remediation accordingly. (State-provided handout)

LPU’s focus was on remedial/developmental education with some attempt to get department chairs to review and consider changing a 1050 requirement to a 1030 requirement. The content of 1030, 1040, and 1050 was not addressed at all.

One effort at shortening the path through math was tried, with some success. That was using a corequisite model where students take one 8-credit course that combines Intermediate Algebra with College Algebra rather than taking those two 4-credit classes separately. That experiment continues. Again, the content of the courses was not changed.

Another potential change resulting from CCA was attempted but never implemented. The premise for this change was that students taking 1030 or 1040 for their QL course did not need some of the material in the prerequisite, MAT 1010, Intermediate

Algebra. A joint committee comprised of faculty from both the Math Department and Developmental Math Department developed a new course, MATH 1020, which would be the new prerequisite for 1030 and 1040 in lieu of 1010. Presumably this would help more students get to their 1030 or 1040 required courses. The committee gave their proposal to the Mathematics Department faculty for a vote. The initial vote was split, 10 in favor and 10 against. The administrative assistant and department advisor (also an adjunct professor) were then allowed to vote and the proposal was rejected 12 to 10. Recently, under a new department chair, the proposal was voted on again but it lost support and was rejected a second time.

Summary

LPU has been a rapidly growing institution of higher education. It is rather unique with a broad mission that includes bachelor's and master's degrees and yet has retained its open-access, community college role. The open-access aspect accounts for a large remedial and developmental program to help those who are underprepared for college.

The QL curriculum is largely unchanged since 1998. MATH 1050, College Algebra, is the prominent QL course that most students take and most majors require. It is very much a traditional algebra curriculum that has been in existence in the US for at least 200 years.

CHAPTER IV

METHODOLOGY

This chapter lays out the purpose of the study and its qualitative approach. Also, three conceptual frameworks are discussed. These frameworks are used to help inform the data collection and analysis. Finally, the procedures section will discuss the participants, the interview questions, and issues related to trustworthiness and ethics.

Purpose and Approach

Despite past urgent calls for the reform of general-education college mathematics, curricular changes have been slow, particularly in large institutions. The purpose of this study is to make specific recommendations designed to improve the general education, QL curriculum at a large public university (referred to in this study as LPU). The central research question is: What hinders curricular change in general education mathematics at LPU? Answers to this question lead to my recommendations for how LPU might be able to affect change. While this study focuses on one institution, and being very cautious about the generalizability of this study, it is hoped that this study will provide some insights that may be of value to other institutions.

Following Creswell's (2007) guidance of having an overarching question combined with additional subquestions, the following questions will support the central research question.

- What is the history of general education mathematics at LPU?
- What curricular decisions have been made and how have those decisions been

made and by whom?

- What do faculty and administrators believe is the purpose of a first-year, quantitative literacy course?
- How satisfied are they with student performance and academic success?
- What do they believe hinders curricular change and how do they think changes, if any, should be made in the future?

The research question and subquestions are best answered using a qualitative approach. Merriam (2009) described this approach as the “basic qualitative research” type of study in which the researcher is “interested in (1) how people interpret their experiences, (2) how they construct their worlds, and (3) what meaning they attribute to their experiences” (p. 23). This study examined how key individuals at LPU interpreted the QL aspects of its general education program.

The primary data source was interviewees at LPU from faculty, staff, and administrators. They are identified more specifically below. Interview questions were designed to answer the research questions. In addition, to establish a context, the study also examined the history of LPU’s general education mathematics curriculum using past catalogs and the official curriculum records as maintained by the Curriculum Office, as well as other important archival material.

Procedures

The semistructured interview data were gathered from key faculty and administrators. In this section the following are described: the participants, the interview

questions, the site selection and description, and issues related to trustworthiness and ethics.

Participants

Interviewees were all assigned pseudonyms to protect their anonymity. All agreed to have their interviews recorded. Each was given a chance to review the *findings* chapter to check for accuracy of the statements quoted in this report. For convenience to the reader, participants were given a name starting with a letter that represented their position type. In other words, those in the Mathematics Department have names starting with *M*. Names beginning with *D* are from the Developmental Mathematics Department, and finally administrators and staff have *A* names.

The initial list of interviewees included those in key positions with some responsibility for mathematics instruction, QL, or general education. Other interviewees were identified during the process. As noted by Merriam (2009), qualitative research calls for some simultaneous data collection and analysis:

A qualitative design is emergent. The researcher usually does not know ahead of time every person who might be interviewed, all the questions that might be asked, or where to look next unless data are analyzed as they are being collected. (p. 169)

Each participant was asked for recommendations of others who might be a good source for additional pertinent information. Several interviewees were added as a result. In all, interviews were conducted with sixteen participants. Seven were females and nine were males. All have been at the institution for 5 years or more. The interviewees, with their pseudonyms, will be introduced below.

Interview Questionnaire

There were two versions of the questionnaire, one for faculty (see Appendix A) and the other for administrators (see Appendix B). The appendices include a rationale statement for each question. The two versions are similar. Both questionnaires ask for the participant to tell about their math autobiography (i.e., earliest memories of mathematics and experiences since then). This proved to be a good introductory question to help the participants to feel comfortable in answering questions. Both groups were also asked about how satisfied they were with the level of mathematical skills and conceptual knowledge of LPU graduates, as well as the purpose of a first-year, quantitative literacy course. The faculty were asked more specifically about their level of awareness of recommendations by national organizations for teaching mathematics, of the literature on QL, and of any reforms that other institutions have made in teaching general education mathematics. These interviews were conducted as semi-structured, meaning that the questions were used as a basis for the conversations.

Site Selection

LPU is selected as the site of the study for two reasons. The first is that it was an institution that followed the traditional algebra curriculum and pushed most students through College Algebra for their QL requirement. In fall semester of 2011, 80% of students taking their required QL course were enrolled in College Algebra. The course had a D-W-F rate of 37% that semester. This makes LPU a good candidate for a site because it demonstrates problems addressed above where too many students are taking College Algebra when they do not need it. Also, the high D-W-F rate should warrant a

hard look at the curriculum, among other issues. Yet, no change is on the horizon. LPU is one of several four-year institutions within a state higher education system. It is regionally accredited by the Northwest Commission on Colleges and Universities (NWCCU).

The second reason was the opportunity for access to interviewees. I am a faculty member at LPU with 50% release time to serve as an administrator, Director of Institutional Effectiveness and Planning. I am in a unique situation in which I have developed a rapport with both faculty and administrators. Being at LPU, I have my biases and those are recognized and explained below.

Mathematics Department participants. The Mathematics Department originally had six participants. Please note that two decided to withdraw from participation after reading a draft of the findings. This will be explained later in the report. The four remaining participants had significant time in the department. The chair was Malcolm who was near the end of his 3-year assignment as chair and preparing to go back to full faculty status. He had a Doctor of Philosophy in Mathematics, specifically in set-theoretic topology. As chair, he served on LPU's Complete College America committee. Melissa was a previous chair and associate professor. Melissa was very outspoken in response to the Easiest Math Ever controversy noted above, which led to the formation of the Math Task Force. She was an associate professor with a master's degree in mathematics.

Each mathematics course had a director. Michael, with a PhD in mathematics (statistics), was serving as course director for College Algebra, MATH 1050. The fourth participant was Matt, who had a PhD in mathematics (algebra). He had successfully

initiated and followed through on a curriculum change for mathematics majors.

Developmental Mathematics Department participants. Dan was chair of the Developmental Math Department. He had a master's degree in mathematics and was serving on the Complete College America committee. Debra was the assistant chair; she had an EdD (curriculum and instruction). Dylan, with bachelor's and master's degrees in engineering, served on the Complete College America committee and was an LPU representative for the state mathematics tuning initiative. He was very vocal on having a more relevant QL curriculum and was a former assistant department chair.

Administrators and staff participants. The deans of both University College (UC) and the College of Science and Health (CSH) were interviewed. Amanda, at UC, had a master's degree and was a long-time member of the developmental mathematics department prior to serving as UC associate dean and finally dean. Austin, CSH dean, had a PhD in botany/geology (paleoecology) and by his own admission was not particularly strong in mathematics.

Two vice presidents with LPU were participants. Andrew was the Senior Vice President of Academic Affairs. His PhD was in sociology and he had a distinguished academic career working in schools of business. He first came to LPU as Dean of the School of Business in 1989. Alex was Vice President of Finance and Administration and had worked at LPU for 25 years. His PhD was in Educational Leadership.

Finally, three others agreed to be interviewed who had connections to the QL curriculum. Alisa was the former Associate Dean of UC and was currently the Associate Vice President of Academic Affairs for Academic Programs. In this role she oversaw the

Math Initiative Committee as part of her large portfolio of responsibilities. Ann served as Director of Academic Scheduling and Curriculum and managed the curriculum process. Adam was the Director of Career and Academic Counseling where, among other things, he helped students navigate through the appropriate math curriculum.

Sampling

Purposeful sampling was used for the decisions on whom to interview in order to include faculty and administrators who had knowledge of the issues and had been at LPU for several years. To some extent, a type of sampling referred to by Bernard and Ryan (2010) as *network sampling* was used. As noted above, interviewees were asked to refer other potential key informants with opposing views and other types of pertinent experience.

For the mathematics department, as mentioned above, participants were key individuals: the outgoing department chair, the outgoing College Algebra Course Director, a previous department chair, and one other faculty member who had been recommended during the interviews. Three participants were chosen from the Developmental Mathematics Department because the developmental math curriculum is completely driven by the Math Department's QL offerings, particularly College Algebra, MATH 1050. Developmental Math faculty reflected often on the purpose of QL so that their students could be appropriately prepared. As will be explained below, they have more faculty with degrees that were not pure mathematics, including mathematics education, applied mathematics, education, and engineering.

Administrators in the chain-of-command for both the Mathematics and

Developmental Math Departments were interviewed, including both deans, an associate vice president, and the senior vice president for academic affairs. Directors involved with curriculum were interviewed, one on recommendation of the associate vice president. The additional vice president, outside of academics, was also interviewed due to a recommendation.

Trustworthiness

A number of steps were taken to improve the trustworthiness or authenticity of the study. Several of the validation strategies identified by Creswell (2007) were used, including clarifying researcher bias, negative case analysis, and triangulation.

Positionality (researcher bias). I recognize and state my biases as this study begins. I currently work at LPU teaching developmental mathematics. Therefore, I am aware of many of the issues related to student success in math at the institution. Each semester, I face students and have to deal with the issues of the personal relevance (or lack thereof) of math. I am preparing them for College Algebra knowing that some are not even going to take that course and, for those who do, knowing that most are taking it for their QL requirement and will probably never use it again. It is difficult to face the students and tell them that taking College Algebra is good for them (yes, of course, there is value to learning algebra but I think of the math they are not learning that would prove much more valuable to them). I strongly agree with the recommendations of the various professional organizations noted in Chapter II.

Another aspect of my background is my relationship with mathematics and math education. The Soviet Union launched their first Sputnik satellite 1 month after I started

kindergarten. National attention was focused on competing with the Soviet Union and as a result I seemed destined to be an engineer because I enjoyed and excelled in math. As an engineering undergraduate in the freshman honors calculus program I almost switched to becoming a mathematics major. However, in a sophomore linear algebra class, I started to feel like I was just playing around with numbers. The intrinsic value of studying math was not enough. To have more meaning for me, I needed the math to be grounded in practical application. After graduating in engineering, I never actually worked as an engineer but used my undergraduate study as a basis for later graduate work in science and education. I am now several years into a second career and have chosen to teach something I have always enjoyed. I see my role as a developmental mathematics teacher as helping underprepared students to be successful in math and also in college (and also in life).

I believe that by not being a pure mathematician, but using mathematics through my engineering and science degrees, allows me to stand in a rather unique position from which I can be critical of current math education. As I challenge colleagues on the relevance of algebra, I can see defensiveness on their part: "Of course what we teach is relevant." Yet, they struggle with specific practical relevance examples in significant areas of the curriculum. They also accept the transference of problem-solving skills learned in math to other domains as axiomatic: "Of course math increases critical thinking skills." I think I can stand apart from mathematics and use my vantage point to question current practices. In addition, I have served as a dean of instruction at a community college and currently serve as a full-time faculty member. I have both

perspectives in looking at potential policy recommendations.

Negative case analysis. Given my biases, I sought out interviewees who had different opinions than my own. This included several faculty in the Mathematics Department and one in the Developmental Math Department.

Triangulation. This study used different angles or perspectives including interviewing both faculty and administrators, math faculty and developmental math faculty, and those within and outside the formal math organizational hierarchy.

A member-checking procedure was used. Rough drafts were provided to selected interviewees to give them the opportunity to “judge the accuracy and credibility of the account” (Creswell, 2007, p. 208). The results of this study have the potential to affect them and this provides an opportunity for their participation. Thirteen of the sixteen participants responded and this study includes their input.

Ethical Issues

Given that this study included an examination of parochial interests and personal beliefs, there was a concern for protecting the anonymity of the informants. This was done to the extent possible through the use of pseudonyms and by controlling the data to keep it confidential. Even taking those steps, given the nature of some of the positions of the interviewees, it may be possible for the reader to make a conjecture about the identity of certain individuals. Informants were told what the risks were, in writing, before they were interviewed. Approval of the Institutional Review Board (IRB) was obtained from both the institution sponsoring the research and LPU.

Coding

Bernard and Ryan (2010) described two approaches for building a codebook, inductive or deductive (or a combination of the two). My codebook was initially set up using a deductive, a priori approach based primarily on my conceptual frameworks. The complete codebook is in Appendix E. There are five overall categories. The first category is *change*, which most directly addresses the research questions. The other four categories include one for each of the four frames. They are described below, along with their subcategories.

Category: Change

One of the interview questions specifically asks about barriers to curricular change. Given that this is the primary research question, *barriers* is a subcategory under change. One of the most obvious potential reasons for little curricular change is that change is not needed or not perceived as needed. Therefore, another subcategory was created to capture comments related to the *need for change*. Interviewees were asked their opinion about how well the current curriculum meets their goals for QL.

Participants were also asked about any curricula changes with which they had been involved to see what might be learned from their experience and placed in a subcategory of *changes made*. I created a subcategory, *promotes change*, for comments that might be related to promoting curricular change, as a counter to barriers.

Categories: Four Frames

The remaining four categories are directly related to Bolman and Deal's (2008)

four frames. For each of the four frames, I chose three to five subcategories that seemed to best represent the theme in the context of higher education.

One metaphor of the symbolic frame is that of a temple where “meaning, belief, and faith are its central concerns” (Bolman & Deal, 2008, p. 248). *Values* and *beliefs* are subcategories as are ceremonies or *symbolic events*. Faculty and administrators do what they do, in part, because of what they value and believe in a number of areas including how students learn and what they should learn.

The political category is primarily about *power relationships* and *decision-making* with each serving as a subcategory. I also decided to look for mention of *control from the top* as well as *bottom-up change*. Finally, I decided to also look for any attempts to take *control of meanings* as a way to exert some power.

Human Resource is the third frame and category. Included in this frame or *group norms* and *informal roles* played by the faculty or administrators. The ways in which the various people interact within the organization are captured by *interpersonal* issues. Finally, I decided to look at how individual *human needs* are being met and any potential for that to impact curriculum change.

The structural frame is set up to code aspects of a rational curriculum development process to include the subcategories of *roles* and *goals* as well as the organized *hierarchy* to fulfill the roles and accomplish the goals. *Communication* as a way for groups to work together in the curriculum process is the final subcategory.

Here is a summary of the category structure of the codebook:

- Change

- Barriers
- Need for Change
- Changes Made
- Promotes Change
- Symbolic
 - Beliefs
 - Symbolic Events
 - Values
- Political
 - Power Relations
 - Decision-making
 - Control of Meanings
 - Control from Top
 - Bottom-up Change
- Human Resources
 - Norms
 - Informal Roles
 - Interpersonal
 - Human Needs
- Structural
 - Communications
 - Goals

- Roles
- Hierarchy

Coding Procedure

The category structure was built into QDA Miner Lite (version 1.0.2). Transcripts of the interviews were uploaded into the software. Passages of text were then tagged with a subcategory code. Some passages were coded with more than one subcategory. For example, a passage related to Changes Made (under the Change category) might also be an example of Decision-making (under the Political category). Overall, there were 722 coded texts from the interview transcripts. The 16 interviews averaged 52.8 minutes each.

Through QDA Lite, the tagged passages were printed out by subcategory. Each passage was numbered, for future reference, within the respective subcategory. Each tagged segment of text was then examined a second time to verify that the coding was correct (in a few cases the text was deemed not relevant or was moved to a more appropriate subcategory). Each tag number was recorded along with the name of the interviewee and a short phrase summarizing the point being made. Because “coding is supposed to be data reduction and not data proliferation” (Bernard & Ryan, 2010, p. 86), similar quotes were listed together and thus themes emerged. In the next iteration, a statement is made that defines each theme and captures the meaning of each text segment in the theme. The final codebook (see Appendix E) has columns for categories; subcategories; themes; and then three columns for each of the interviewees’ positions: administrators/staff, mathematics department faculty, and developmental mathematics faculty.

Conceptual Frameworks

Three conceptual frameworks are used in this study. Rogers' (2003) *Diffusion of Innovations* provides important insight through his innovation-decision process, which serves as a change model and helped inform the questions asked of the participants. Bolman and Deal's (2008) *Reframing Organizations* provided four frames, or perspectives, in which to view organizations. Use of this meta-framework helps prevent a one-sided view of the issues and proved helpful in the analysis of the data as well as in the types of questions to ask the interviewees. Finally, Kliebard (2004) described the interplay between four interest groups in *The Struggle for the American Curriculum: 1893-1958*. His description of four purposes for the school curriculum directly applied to the ways in which general education can be conceived in higher education today. This proved helpful in understanding the perspectives of the participants in this study. I will describe each of the conceptual frameworks and then show how they can be folded together.

Diffusion of Innovation

Diffusion is probably an apt way to talk about curricular innovation in higher education, given the independent nature of faculty (through tenure and academic freedom) as well as accreditation mandates for shared governance and strong faculty involvement in curricular matters. Changes in the curriculum do not, or should not, get decided by administrators in top-down fashion. One could make a case for curricular changes following Rogers' (2003) conception of *diffusion*. He defined diffusion as "the

process in which an innovation is communicated through certain channels over time among members of a social system” (p. 5), which results in a social change, “defined as the process by which alteration occurs in the structure and function of a social system” (p. 6). Giddens and Walsh (2010) used Rogers’ (2003) framework to examine nursing education but few other recent examples from higher education were found in the literature.

As seems to be the case with improving the general education mathematics curriculum, Rogers (2003) stated:

Getting a new idea adopted, even when it has obvious advantages, is difficult. Many innovations require a lengthy period of many years from the time when they become available to the time when they are widely adopted. Therefore, a common problem for many individuals and organizations is how to speed up the rate of diffusion of an innovation. (p. 1)

The central research question could be seen in the light of this framework as: What is holding up QL innovation at the university?

Rogers’ (2003) model of the innovation-decision process seemed particularly helpful to this study. The model included five stages: knowledge, persuasion, decision, implementation, and confirmation. In other words, the stages progress from “gaining initial knowledge of an innovation, to forming an attitude toward the innovation, to making a decision to adopt or reject, to implementation of the new idea, and to confirmation of this decision” (p. 168).

I am particularly interested in a number of the pre-decision elements of the model, which informed the types of questions that I asked the interviewees. Figure 2 is adapted from Rogers’ (2003, p. 170) work and shows how the innovation-decision model was

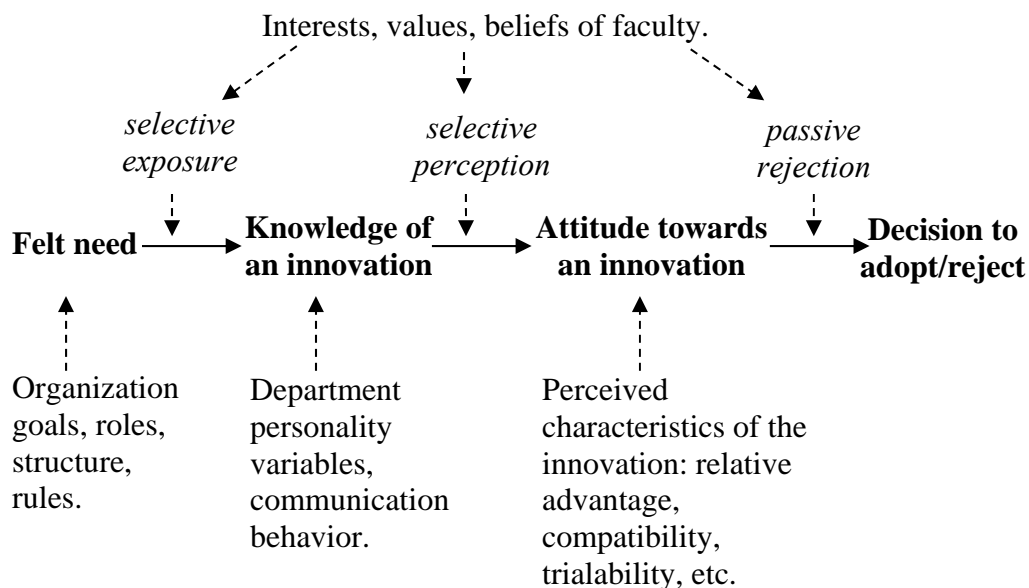


Figure 2. Model of an innovation-decision process for an academic department at a college or university.

conceptualized for this study. The first element in Figure 2 is a *felt need*, which is an important aspect of Rogers' *prior conditions*. To what extent at LPU do faculty and administrators believe that there is a problem? Other prior conditions include innovativeness, previous practice, and norms. I have captured these conditions as organizational goals, roles, structure, and rules. These influence that felt need (indicated by a dotted arrow to felt needs). In other words, to what extent is LPU or its mathematics department clear on the purposes of general education mathematics and everyone's roles? Is there a structure in place with roles and rules that allow for innovation? There will not be a perceived need to change if goals are not clear or too vague. Likewise a need may not be recognized or acted upon if no one sees it as their job to consider changes and the status quo is comfortable.

Rogers' first stage after his preconditions is *knowledge* or the seeking of knowledge about an innovation. He saw this as being influenced by the characteristics of the decision-making unit, which in this study is the Mathematics Department. Figure 2 includes two of those characteristics: personality variables and communication behavior. Rogers (2003) discussed three types of knowledge with the first being *awareness-knowledge*. Are faculty or administrators aware of alternative models of general education mathematics? The second type of knowledge he calls *how-to knowledge*. For this study, that would mean the extent to which the interviewees are aware of what it would take to make curricular reform work at LPU. The third category is *principles-knowledge*. This is an understanding of underlying principles of how the innovation works. I interpret this to mean, in this study, an understanding of the potential alternatives for general education mathematics.

Rogers' *persuasion* stage was where attitudes are formed towards the innovation, or in this case, college mathematics education reform (Figure 2 gives a title of "attitude towards an innovation"). If there is knowledge of the innovation, either favorable or unfavorable attitudes are formed. Factors that determine how an innovation is perceived are: (a) perceived advantages of the innovation, if any; (b) compatibility with values, past experience, and needs; (c) trialability—the degree to which the innovation can be tried out on a limited basis before adoption; and (d) observability—the degree to which the results of the innovation are easily seen.

Figure 2 also shows three factors, according to Rogers (2003), that can impact a potential innovation decision and serve as barriers for change. One is *selective exposure*,

which is defined as “the tendency to attend to communication messages that are consistent with the individual’s existing attitudes and beliefs” (p. 171). The implication here is that alternative models of mathematics reform may not even be considered because no one would be attending to that information. Another potential barrier is *selective perception*, which is defined as “the tendency to interpret communication messages in terms of the individual’s attitudes and beliefs” (p. 171). So, even if noticed, a potential innovation might be interpreted as not applicable or helpful, given underlying beliefs and values. Finally, the third barrier in the process could be *passive rejection*, where a formal decision is never made. Instead, the potential change is forgotten or never fully considered.

In summary, if curricular reform can be seen as an innovation in an educational setting in higher education, then Rogers’ (2003) diffusion of innovation model points to information that is important to this study. Questions for interviewees addressed any perceived needs, willingness to innovate/change, awareness of the calls for reform and efforts at other campuses, and their favorable/unfavorable attitudes towards reform.

Reframing

Bolman and Deal’s (2008) *Reframing Organizations* is a framework that provides four different frames from which to view organizations: structural, human resource, political, and symbolic. The authors provide a convincing rationale for the importance of leaders to be able to see their organizations through multiple lenses. Bolman and Deal provided a concise description of each lens or frame.

The structural approach focuses on the architecture of the organization—the

design of units and subunits, rules and roles, goals and policies. The human resource lens emphasizes understanding people, their strengths and foibles, reason and emotion, desires and fears. The political view sees organizations as competitive arenas of scarce resources, competing interests, and struggles for power and advantage. Finally, the symbolic frame focuses on issues of meaning and faith. It puts ritual, ceremony, story, play, and culture at the heart of organizational life. (p. 21)

Metaphors are given for each frame and the following are most applicable to this study:

factories (structural), families (human resource), jungles (political), and temples (symbolic).

The authors also gave examples of potential barriers to change for each of the frames (Bolman & Deal, 2008, p. 379, exhibit 18.1). Some of the barriers, by frame, included:

- Structural: loss of direction, clarity, and stability.
- Human resource: anxiety, uncertainty.
- Political: conflict between winners and losers.
- Symbolic: loss of meaning and purpose, clinging to the past.

All of those can be seen in this study.

Use of these four frames served as a helpful way to analyze the data. This prevented a myopic view of the situation and led ultimately to better recommendations.

The four frames are part of the initial coding scheme, as explained above.

Curriculum Purposes

Kliebard (2004) described four interest groups that competed for dominance in the American school curriculum from 1893 to 1958. Each group saw a different primary purpose of education. I would contend that each of these four purposes is alive and well

in higher education and still competing today. So, why do college students have to learn some mathematics? One can answer the *why* question in one or more of the following ways.

- Students need to be prepared for work and life and should be educated in only those things needed for their future roles in society, thereby eliminating waste in the education system. This *social efficiency* approach, as Kliebard (2004) called it, places an emphasis on job preparation. Improving mathematics education is often cited as a way to help the United States better compete economically with the rest of the world.
- Education's purpose should be to help improve society. The *social meliorist* movement started in the 1920s in reaction to the prominent social efficiency movement at a time of rising inequities in society. Based on this approach, students should learn critical thinking skills in order to better address social problems. Lynn Arthur Steen's (2001a) *Mathematics and Democracy: The Case for Quantitative Literacy* speaks to the importance of understanding numbers in today's society.
- Students should be allowed to pursue their own educational interests according to their own desires and capabilities. *Developmentalists* would argue that students' needs and interests should drive the curriculum. This philosophy favors individualization over standardization and favors interdisciplinary studies over the subject/discipline approach. It also advocates learning through authentic activities. This is somewhat evident in current math

education efforts to increase modeling and the solving of real-world problems.

- Everyone needs a classic, well-rounded liberal education. That traditional Western education will discipline the mind and help develop reasoning power. Kliebard (2004) referred to those who have espoused this philosophy as *humanists*. When I press colleagues on the value of the more obscure aspects of algebra, this is the argument they use when all else fails.

The latter of the four purposes seems to be the predominant rationale for the traditional algebra-heavy general education mathematics curriculum. Without reform, an institution can be stuck in the traditional, humanist form of mathematics education at the expense of the other, perhaps more important, purposes. However, the calls for reform are not all consistent. Some advocate primarily for better preparation for a career (social efficiency) while others advocate for preparing better critical thinkers in order to better society (social meliorist). All efforts, though, seem to try for greater relevance to increase student interest.

Kliebard's (2004) competing purposes serve as a useful way to think about the fundamental reasons behind requiring students to take a QL course. A professor's or an administrator's belief about purpose would seem to affect, from Rogers' (2003) perspective, their perception about whether or not there is a problem with the current curriculum and to the relative advantages of any alternatives. Therefore, this conceptual framework is useful in the analysis of the data.

Composite Framework

Figure 3 shows an attempt to consolidate the above three frameworks into one.

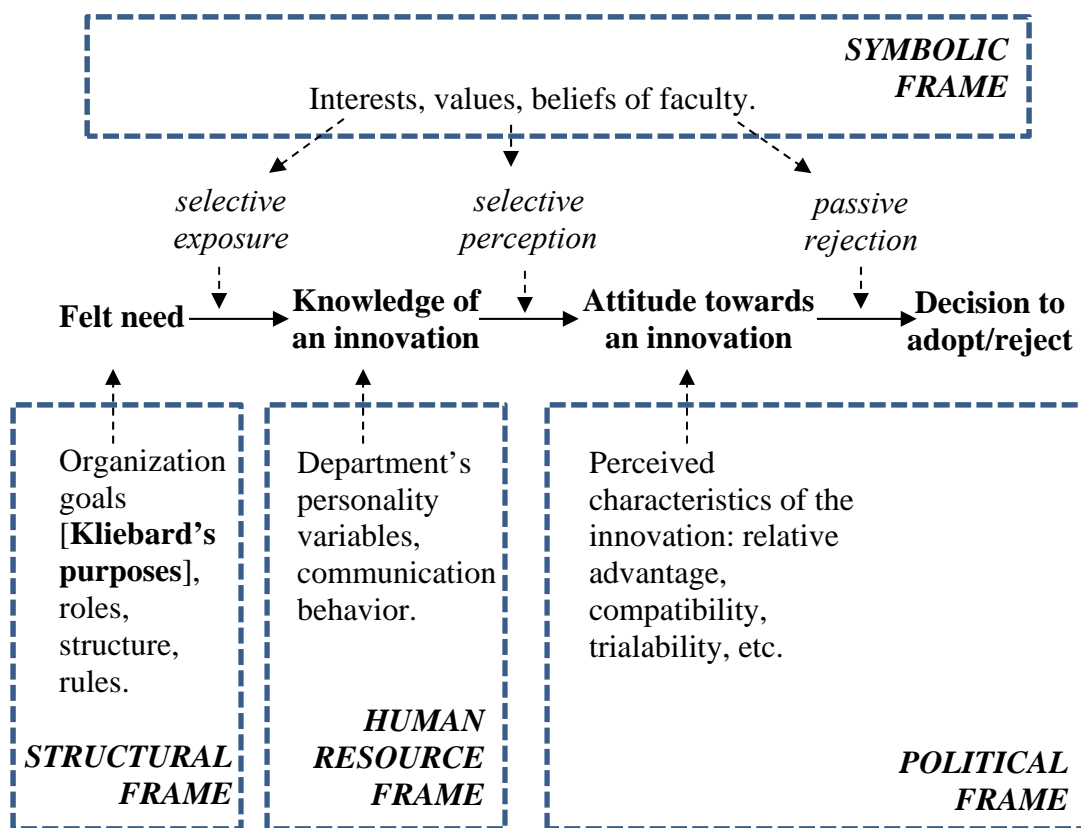


Figure 3. Model of an innovation-decision process for an academic department at a college or university, overlaid with four frames. The decision process is adapted from *Diffusion of Innovations* by E. M. Rogers, 2003, p. 170. The four frames are adapted from *Reframing Organizations* by L.G. Bolman and T.E. Deal, 2008.

Bolman and Deal's (2008) four frames are superimposed on the depiction of Rogers' (2003) innovation-decision process in Figure 2. The boxes for the frames are not attempting to show exact boundaries but rather the primary connections between the two frameworks. Bolman and Deal's frames add a level of depth to the work of Rogers that allows for a more detailed examination by the researcher. Kliebard's (2004) four purposes are acknowledged in the structural frame with organizational goals and this is a key aspect of the entire innovation-decision process. Perceived needs implies a gap

between goals and current performance. If the purposes of QL are vague, unclear, or inconsistent, then a gap is harder to see.

Organization of Results

The findings are presented in the next four chapters, one chapter for each of the four frames. The results of the *change* category are woven into the appropriate frames. Following the findings, a chapter is devoted to discussing the meaning and significance of the results. The discussion is organized around the Bolman and Deal's (2008) four frames, but also looks at the potential interactions among the frames.

CHAPTER V

FINDINGS: STRUCTURAL FRAME

Explanation of Findings

The findings for this study are divided into four chapters. Each chapter is devoted to one of the four frames from Bolman and Deal (2008): structural, symbolic, political, and human resources. The data selected for each chapter are based on the relevance to the respective frame with regards to potential barriers to change. While some data are from LPU's institutional records, the majority of the data is from the participant interviews. The primary focus, and source of data, is the Mathematics Department faculty because of their central role in the general education mathematics curriculum. To summarize, the four math faculty members were: Malcolm, Melissa, Michael, and Matt. Another faculty member is referred to as Mona, a former department chair, who did not respond to several attempts to schedule an interview.

Other key sources of data were interviews with three developmental mathematics faculty: Dan, Debra, and Dylan. Several administrators participated as well, including two deans and two vice presidents. Their pseudonyms and positions are included when cited.

LPU's current QL requirement consists of three courses: MATH 1030, Quantitative Reasoning; MATH 1040, Introduction to Statistics; and MATH 1050, College Algebra. In this study and in some of the quotes from the interviews, the courses are often identified by just their number. Also as a reminder, the prerequisite for 1030,

1040, and 1050 is the Developmental Mathematics Department's MAT 1010, Intermediate Algebra. The developmental courses use the prefix MAT (no "H") while the QL and other Mathematics Department courses use the MATH prefix.

Structural Frame Overview

The structural frame uses the factory metaphor. Its view is a rational perspective focusing on goals and roles plus the ways in which employees are organized and connected in order to get the job done. I am not trying to compare a higher education institution to a factory, but using this frame helps one see the extent to which members of an organization agree on their goals and the degree to which the members are organized and communicate to accomplish the goals in, one hopes, an efficient and effective way.

The findings in this frame show that there are structural "cracks" that may have had the effect of preventing curriculum change. The foundation of an organizational structure is its mission and goals. At LPU, I found the purposes and goals of general education mathematics nebulous and there appeared to be no consensus on what they should be. The channels of communication, by which changes could be facilitated, were problematic. The findings concerning goals, roles, and communications are detailed below.

Goals

Participants were asked about the purpose of a general education QL requirement. A number of potential purposes were noted in the data. Participants were also asked how

well LPU's program actually meets their opinion of the QL purposes. The goals were found to be varied and vague. But there was also a sense, especially by the math faculty, that the goals are being met, despite the vagueness and despite no formal assessment. Hence, the mathematics faculty would have not felt the need to change the curriculum; this serves as a barrier to change.

Quantitative Literacy Purposes

As shown in the codebook (Appendix E), there were 28 themes under the *goal* category. In addition, there are a number of themes in the *change* category that are also pertinent. These various themes related to goals can be combined into the theme classifications described below. Each theme describes what the data show as potential goals or purposes of the general education, QL curriculum. The participants attributed numerous potential goals or purposes to the current curriculum.

Critical thinking. The purpose most often mentioned was the ability of mathematics to improve critical thinking and problem-solving skills. Regardless of the particular QL course, many of the participants believed that learning math helps students to think and reason better. For example, Melissa spoke of students learning a “more logical approach to things.” The course descriptions for 1030 and 1040 (but not 1050) include the statement: “Emphasizes problem-solving and critical thinking” (LPU 2013-2014 catalog).

There is a strong sense that, even if there is no other purpose or practical use, at least the QL courses help with critical thinking. Debra further demonstrated this in her interview, describing reasoning power as being “embedded in what we teach.” The

argument that students will never use the math they are learning can always be answered with the purpose of developing critical thinking. Hence, this overriding purpose leads to a sense of fulfillment for faculty that would not indicate any need to change on their part.

Austin, the dean over the Math Department, said, in his interview, that students “develop part of the brain that’s important to be developed” but added that even a logic course would help that same type of development. He essentially posed an interesting question: If critical thinking is a primary goal of a QL course, then is the current curriculum the best way to accomplish the goal? If the belief is that the current QL courses meet that goal, then there is little felt need on the part of faculty to change.

Patterns and connections. Somewhat related to critical thinking, the notion of helping students to see patterns and make connections came up in several of the interviews. “What could stick with a person are the skills of solving and seeing patterns and things like that,” said Matt. “So, I would expect that to be, I mean for all those three [QL] courses, that would be, I think, a main objective.” Melissa also addressed this idea of what “sticks” or what is enduring when she said, “I think that they should take patterns of thinking, which is really hard to assess, but I think—you know, there’s all of the—because I don’t expect that there are any specific technical things that they will remember very long.” She is assuming that the patterns are a byproduct of learning math. Amanda, the dean with responsibility for developmental mathematics, tried to articulate this concept but it still was fairly vague.

I think in just knowing and understanding the mathematical foundation of a lot of things that we do. And connections, and patterns especially. Understanding that you can express patterns through math. I think that makes you a better thinker. I think it helps you to see the world, and frame the world in a different way. In a

way that's, in a lot of times, much more logical.

It is not clear that the curriculum is intentionally designed for students to see patterns. As long as the goal remains vague and hard to assess, as Melissa noted above, any informal assessment of goal accomplishment can be vague as well. This can be a barrier to change if a faculty member does not specifically or systematically assess whether goals are being met.

Conceptual understanding. A perennial debate, when it comes to math education, is whether courses should stress content and skills or conceptual understanding. Several of the participants see conceptual understanding as an important goal. For example, Matt stated that “the content isn’t as important as the kind of skills you learn in terms of analyzing situations [as opposed to learning math facts].” He expressed some frustration when he said the department tries “to shove as much stuff down their [the students’] throats as possible in 15 weeks and I just think it’s nuts.” He would like more time for group work and exploration by students. Matt is trying to look at what endures after the content and facts are long forgotten. He would like to add a goal of group work and promoting students’ ability to work in teams.

The developmental mathematics perspective is interesting in that the majority of their students are non-STEM majors and the developmental curriculum is driven by the MATH 1050, College Algebra curriculum. The 1050 course is reportedly jammed with content and skills, which is then mirrored in developmental classes. Amanda, the dean with responsibility for the developmental programs, stated, “I’d almost prefer that they know less, but know it better.” Dylan cynically stated that the purpose of the QL

requirement at LPU is to “make people jump through some hoops and to demonstrate a level of proficiency, primarily with algebraic skills and procedures; we want our students to be little algebots.” He advocated for conceptual understanding.

Now, what it should be doing, in my opinion, is focusing far less on procedures and skills, and far more on concepts, conceptual understanding of math, and then applications of math. We should do fewer topics in more depth. We should do fewer skills. We should use technology tools to grapple with real problems and real quantitative issues that people deal with today. It should get everybody to a level of quantitative literacy where they are comfortable understanding quantitative concepts, where they are comfortable if presented with a new kind of quantitative situation, doing a little research and digging on their own and figuring it out. They should understand the basics of math, but they do not, in my opinion, need to know a wide range of algebraic skills. They don’t need to factor. They don’t need to be able to reduce rational expressions. They don’t need to be able to turn the square root of 72 into $6\sqrt{2}$.

Like Dylan, many of the comments made regarding conceptual understanding as a goal also expressed dissatisfaction with the current high amount of content. Like *critical thinking* and *patterns and connections*, it is not completely clear what is intended by *conceptual understanding*.

Life skills. The category of *life skills* includes themes related to basic number sense along with an understanding of consumer math, personal finances, and other ways in which students might use math in modern society. Amanda, as dean and professor of developmental mathematics, would like to see college graduates know the basics of consumer math (e.g., interest, mortgages, health plans, etc.) and “something they can also apply to life and to an occupation” and that can make them “better informed, and better capable of managing their own lives.” In addition, there is the idea of having some type of number sense when Amanda noted that students should also be able to “see what’s reasonable, what’s not reasonable, what’s logical, and what’s not logical.” Dan got very

specific when he stated three outcomes for students in the QL courses: (a) the ability to estimate, (b) the ability to interpret data, and (3) the ability to understand and apply algorithms. It appears that none of the QL courses are designed to teach life skills, with the possible exception of 1030, Quantitative Reasoning. Life skills are not specifically mentioned in the 1030 course description, which describes the content as: “Introduces major topics in the field of mathematics. Includes sets, algebra, geometry, and statistics” (LPU 2013-2014 Catalog). But, instructors have some latitude in the degree to which they want to include quantitative life skills.

Preparation for students’ majors versus gatekeeping. Another major goal that participants mentioned is that the QL requirement should help students learn skills that will help them in their upper-division classes. Ideally, each student takes the QL course appropriate to their major. Andrew, the Senior Vice President for Academic Affairs, stated in his interview that aligning the QL requirement with majors is “a big problem for us.” Math faculty agree and have made unsuccessful attempts to get departments to pick the appropriate QL course for their respective students.

A goal for some departments was that MATH 1050, College Algebra, served as a gatekeeper course. This is suspected by some of the math faculty and confirmed by two staff members. Ann, the director who oversees the curriculum process, has heard from departments requiring 1050 that “we want our students to be smarter so they’re looking for, they’re using it like, a benchmark for any intellectual activity, even though it’s a whole different skill that they’re using in their degree.” Alan, Director of Career and Academic Counseling, described in his interview an academic program in which the

faculty want their degree to be rigorous so they require 1050 and “it’s sort of a check system, a gatekeeper, to see if they’re really serious about wanting to do” that program. In other words, the faculty believed 1050 would scare some students away and only the “smart” ones would go into the program.

Meeting state system requirements. The seven state institutions have agreed, through the State Higher Education Commission’s Math Majors Committee, that the QL requirement consists of 1030, 1040, or 1050. The common numbering system and rough alignment between institutions ensures transferability of credits for students. Regardless of how some of the participants feel about QL goals, one goal certainly is to provide the QL courses consistent with the other institutions in the state.

Amanda refers to articulation as one of the biggest barriers to curricular change. Interestingly though, there is considerable variance in the QL course descriptions of the state institutions. For example, Appendix C shows a listing of MATH 1050 topics from the catalogs of all of the state institutions. The only topics that are consistently covered across the institutions are the various types of functions. Yet, there was a certain amount of resignation expressed by participants that LPU is not allowed to make curricular changes. As an example, Malcolm stated: “Even if you pass something at the department level, you still have to convince the chairs [on the State Math Majors Committee]. And if the other chairs won’t do it, you can’t do it” because it affects the students’ ability to transfer to other institutions.

Perseverance. The two directors mentioned above, Ann and Alan, saw a worthwhile goal in students having to work hard and do something that is hard. Ann said,

“In many ways it’s the math class that makes you buckle down as a student and say, okay I’ve got to study, I have to practice this, I’ve got to do it.” Alan, in his advising role and having struggled himself with QL as an undergraduate, has an interesting response to students complaining about the math requirement in general education: “Let’s focus on eat your broccoli before you get to your steak.” The argument seems to say that it is okay for students to be forced to take a hard course, simply because it is hard. Others deplore this but if the rigor of the course is considered an important purpose, then this can be seen as a barrier to change given that any changes to the curriculum could be seen as reducing the rigor. More will be said about this in the *symbolic frame* chapter.

Views on Goal Accomplishment

Participants were asked if they believed that the QL curriculum satisfied the purpose(s) they described. The math faculty expressed that they believed the QL courses were accomplishing their goals, even if those goals or purposes were vaguely described and with little actual verification based on an assessment of goal or learning outcome accomplishment. Malcolm, who incidentally did not necessarily agree with the concept of general education, said dryly that the QL purpose was being met if general education meant that “you know a bunch of stuff in small quantities, or at least you did very briefly.” Yet, he further stated:

So, 1040 and 1030 are highly applicable. They serve the important purposes of general education. 1050 does that and a little bit more. In a way it’s less suited to what general education should mean. It’s more about how to get students ready for later courses. But yes, they suit the objective well. There’s nothing wrong with any of them as a general education course. They’re perfectly good quantitative literacy courses.

Melissa, a former chair when the department was receiving a lot of criticism and administrative pressure to change, said, “We’re doing actually a really good job, and nobody will believe us.”

Dylan countered the claims of goal accomplishment and blames the situation on poor curricular design: “A lot of math faculty believe that this [MATH 1050] is actually relevant, useful stuff. I don’t think math faculty are evil; I just think they don’t think critically very well.” However, some faculty have suggested that it may be time to rethink the curriculum or consider some smaller scale changes. Michael explained:

I think now really, for us, we do need to go back and look at what kind of students are we serving? What kind of courses are they going into? What would be some of the more important topics that might be useful and help prepare them? And maybe go back—right now a lot of people feel like factoring higher degree polynomials should be deemphasized, and we should look at other kinds of issues more. Maybe put probability back in.

Matt made a similar statement and even the dean, Austin, said, “I think we ought to look at the whole gamut of the developmental math and then at GE [general education] math and see where we really are and where we really need to be. That’s what I would like.” Yet the curriculum has not changed.

Roles

Based on the data, this section looks at two aspects of roles. The first is that of ownership and the extent to which the math faculty, in particular, see themselves with a curriculum development and QL role. The other aspect is the faculty’s self-prescribed role to maintain academic quality.

Ownership

Officially, the Mathematics Department described its role in a vision statement on their web site:

The LPU mathematics programs are designed to provide a strong foundation in mathematics that will support our students in many disciplines. The Department of Mathematics offers a wide range of courses to the student planning to complete an AS or BS degree in Mathematics or the sciences.

A QL role is not even mentioned in the statement. Further, it says they support “students in many disciplines” but does not acknowledge a general education role for all disciplines. This does raise a question as to how seriously the faculty see themselves as being responsible for the QL curriculum. There seems to be a math focus rather than a QL focus. Michael, the outgoing course director for College Algebra, admitted that MATH 1050 is “more of a math major’s algebra.”

The math versus QL focus can be seen in some of the interviews of the mathematics faculty. They spoke as if they were exposing students to the beauty of mathematics, as if the QL courses were *distribution* courses designed to broaden a student’s knowledge base. However, there was no mathematics courses designated as distribution courses. The QL courses are *core* courses designed to “provide basic skills in logic, math, written and oral communications, health, and fitness” (LPU 2013-2014 Catalog).

Also, faculty workload and interests are not necessarily conducive to curriculum review and design according to Michael. LPU is a teaching institution, but like other institutions, faculty have obligations to teach, provide service, and conduct research. Michael reported that some faculty teach up to 15 credit hours per semester. Outside of

teaching, it is the faculty member's choice to focus more on service or research.

Curriculum changes depend on faculty who have the time and inclination to work on curriculum and pedagogy rather than conduct research in their discipline - the scholarship of teaching versus the scholarship of mathematics. Dylan believes that "we have done a terrible job of being intentional about our curriculum." Specifically, he states, "In terms of going out and actually looking at learning outcomes, looking at what people need to be able to do, and then backwards designing the curriculum to meet those needs, I just don't think that's happened."

Dylan also made an interesting point about whether or not the mathematics faculty are even the best qualified to design a QL curriculum. "You have pure mathematicians, PhD mathematicians, teaching gen ed math. They're not trained to do that. They don't know what kind of math skills these people need. It just doesn't make sense." With perhaps little attention paid to curriculum development due to other competing needs and interests of the faculty, the traditional algebra-calculus path is already paved and few changes are made.

Academic Quality Control

The data shows that there is a role in which in which the department has taken a strong position. That role is to ensure academic quality and appropriate rigor in the QL courses. As an example, there was significant controversy related to the Easiest Math Ever episode described above where students were bypassing the LPU QL courses by enrolling in the private Easiest Math Ever tutoring program. Through that program students were able to get academic credit from accredited institutions through online

programs that Easiest Math Ever had found easy for students to pass. As described by Melissa, the effort by her and the Mathematics Department to derail that effort showed that the math faculty cared about quality and rigor and were concerned about not letting students take the low road. The term “low road” refers to any math path that is considered lower in rigor.

There were several themes related to rigor, which was mentioned as the source of much of the tension around any potential curriculum change. This will be discussed more extensively in the *symbolic* frame below. Some of the math faculty participants expressed concern that any changes to the curriculum will result in a loss of rigor and academic quality and this is therefore a serious barrier to reform. They see administrators concerned with the bottom line and graduation rates and therefore the pressure to make math easier. As a result, the faculty naturally resist any change on that basis. In talking about working with administrators, Michael believes that administrators like to be able to work things out “like people in Congress where you give and take.” He stated however, that his department does not want to “give too much, and I feel like that ought to be the case.”

Some believe that the QL requirement has already been lessened by the addition of 1030 and 1040 to the state QL list years ago. Melissa believes that 1030 was initially sabotaged by the chair at the time so that fewer students would want to take 1030. Even today there is only a small minority of students who take 1030 instead of 1050.

It can be argued that MAT 1010, Intermediate Algebra, does not line up well as a prerequisite for MATH 1030. Hence, there was an attempt at a new 1020 prerequisite

course as described in Chapter III. Melissa and others were against the proposed 1020 course. Even though she described herself as somewhat more open than others in her department to alternatives, 1020 reduced the rigor too far for even her to support. Debra, from the Developmental Math Department and supporter of 1020, assumed the math faculty thought that 1020 was “dumbing down” the math. She suspected that may be the way other institutions saw any effort to reform algebra or create a new QL course even though she has seen examples of alternative courses that were not dumbed down but could, in fact, “be more difficult in some respects.”

There is another aspect of the department not wanting to “weaken” the curriculum. There is a desire for respect that seems to stem from being a community college just a short time ago. LPU still has the open-enrollment, community college mission in its service region. Matt’s understanding is that a department chair, years earlier, had wanted to set a high bar. Michael stated that “we still have that chip on our shoulder that says we have to cover everything.” After reviewing a draft of these results, Michael added some additional comments about that quote. In his opinion:

Our problem is not our own faculty setting high standards, but the requirements from other universities that we include all the topics they taught in order to have their approval. We ended up teaching more topics than any other USHE school in math 1050. We are still new enough as a university that getting rid of some topics is still hard. We want other universities to realize our program is strong. (Personal communication, March 25, 2014)

The faculty have resisted any effort that might hint of lowering the rigor and hence their perception of the quality. Alex, a vice president, referred to the math faculty role as such: “They see themselves as the keeper of academic quality. You know, ‘we’re here to be the roadblock, we’re here to make sure our students are true academicians.’”

Administrators want quality too but see the faculty as being too elitist.

The faculty perceived their role as the keepers of quality because someone has to do it. This is a role they must take because administration cannot be completely trusted when it comes to making the call on mathematical rigor and quality. Andrew said of the faculty:

Oh bless their hearts, you know, they're awfully rigid, and I think elitist to some extent. You know, they get on their high horse of "We're not going to use calculators, and we're not going to do this, and this is what real math is all about, and our students should have it, and everything else is inferior."

Calculator use becomes an interesting issue. The administrators see other institutions allowing calculators (for two state institutions, including one research university, their catalogs specifically require calculators for MATH 1050). So, that is something tangible that administrators, who do not have degrees in mathematics, can look at and wonder why LPU does not allow calculators. This leads them to think the math department might be setting the bar a little high since the curriculum exceeds even what the research universities require.

There was an incident that reinforced administrators' beliefs that the faculty were being elitist. The LPU Accessibility Services Office occasionally asks faculty to accommodate students with learning disabilities. A few years ago, a student came to the department with an official accommodation request to allow use of a calculator in MATH 1050. The department was told that the student could not be denied that request unless it was determined that it was absolutely essential that all students complete the course without calculators. To keep this student from using the requested accommodation from Accessibility Services, the department officially declared in writing that calculators were

not allowed for all MATH 1050. The accommodation was therefore disallowed. As

Malcolm explained:

Some people in our department are annoyed at the current disabilities they get. A big part of the reason for the calculator policy is just so that the students with disabilities couldn't produce their disability, and say, "I have a disability that lets me use a calculator." They wanted to make sure they can say no, you have to not be able to use one anyway. And the only way they could do that is if we had a policy that everyone not use the calculator so that we could say it's essential to the course, so that disability was not applicable. Yeah, I didn't like that.
(Interview and Personal correspondence, April 2, 2014)

The interviews show that the faculty have assumed a quality-control role, a role questioned to some degree by administrators. The Mathematics Department's role in quality control has served as a barrier to change in an effort to not degrade what they consider to be an appropriate level of rigor.

Communications

Communication was part of the structural frame and also Rogers' (2003) innovation-decision model in which communication channels affect every stage of the process, including awareness of innovations. This section deals with two aspects of communication: (a) that which is internal to the organization for decision-making and (b) that which involves taking part in the national dialog on curriculum issues.

Internal to the Organization

Several of the participants talked about the new prerequisite course that was proposed, MAT 1020, and its failure to be adopted. It serves as an example of communication issues regarding curriculum change. MAT 1020 was to be used in lieu of

the traditional MAT 1010, Intermediate Algebra, as a prerequisite for the 1030 and 1040 courses. The logic was that students taking 1030 or 1040 did not need all of the content of 1010. A joint committee was formed with members of both the Mathematics and Developmental Mathematics departments. A detailed proposal was eventually presented to the Math Department after 4 months' worth of effort. Better communication may not have saved the proposal, but there was wide acknowledgement that poor communication certainly was not helpful.

The 1020 course was an idea inspired by the Complete College America effort being championed by the State Governor, the State Commissioner for Higher Education, and the LPU administration. The idea is based on the experience of other colleges around the country. Some faculty felt that the administration was pushing for this, and there was already distrust by some, given that MATH 1030 had been mandated many years earlier.

Once a joint committee of the Math and Developmental Math Departments was formed, there was little ongoing, effective communication with the Math Department. As a result, when the proposal for 1020 was made, several of the interviewees from the Math Department felt that they were caught off guard, which raised a lot of ire in the department, especially because of the way in which faculty found out. Melissa, for one, explained it this way:

And here's how we found out. It was posted on the advisor forum and our advisor saw it. And so the advisor said, "Have you heard about a MAT 1020 class?" And I said no. He said, "Well it's ready to go, and it's a prerequisite for 1030. Do you know what that is?" I said no. I had no idea.

Malcolm, the chair at the time and supporter of at least trying 1020, agreed that it could have been handled better:

And so I think that when doing these things it's important to bring it up in more than one meeting, and make sure that there's a vote that's done by ballot, that's been recorded, and to record the meetings, because then everybody knows exactly what everybody said. It just seems, I think that's something I probably would have done differently if I'd done this over.

At the same time, others could be at fault for not paying attention as closely as they could have. Malcolm noted that some faculty do not read their emails. Also, sometimes faculty would miss a meeting or would have disagreed about what was said at a meeting, hence the need for minutes and reminding faculty at more than one meeting. It did not help, as Melissa mentioned, that the committee had a 1-year lecturer in her first year with the department. Some of the more experienced math faculty on the committee were not that involved apparently.

The Developmental Math Department fully supported the idea of 1020 and the representatives on the committee worked hard on it for those four months. Hearing of the result and apparent lack of communication, Dan said, out of frustration, "I'm also very disappointed in academia and I was happy to leave for a week after spring break and say, 'Screw you guys. I'll clean up the mess when I get back if this is how you're going to behave.'" The lack of communication on this project certainly created a barrier to the potential change and played a part in the demise of 1020.

The National Conversation

Another issue involved the extent to which the mathematics faculty was aware of the national conversation and recommendations. Some were vaguely aware of the national dialog. Malcolm had some knowledge but was resigned to the status quo saying: "I don't look too much at their recommendations and what-not. I find them interesting,

and it would be nice to do something using them, but the opportunity just doesn't seem to be there." The two participants who opted out of the study after reviewing the draft findings had the most connection with national organizations but they were not that knowledgeable on the specific recommendations and considered the guidance to be general in nature. Dylan agreed about the generality but believes that LPU could be following the spirit of the law.

They are kind of vague, but just because they're vague doesn't mean you can ignore them. And it doesn't mean there's not enough substance in there for you to tell if you're doing what that says. And we clearly, clearly are not.

Change has apparently been hampered due to faculty's lack of information on innovative alternatives or to faculty quickly discounting any alternatives.

Structural Frame Summary

Several assertions were made in this chapter, based on the data: (a) the underlying goals of the QL curriculum were not articulated or agreed upon; (b) despite the varied and vague goals, along with no formal assessment, many of the participants believed the goals were being achieved; (c) the Mathematics Department exercised quality control of the curriculum, because they defined quality; (d) the Mathematics Department did not necessarily embrace QL; and (e) communications within the Mathematics Department had been problematic. Each of these assertions was connected to this study's primary research question by contributing to barriers of curricular change.

The findings in this frame show that there are various opinions at LPU about the purpose or goals for a QL curriculum and many of those goals are vague and without

consensus. Despite this, or because of this, the math faculty were individually satisfied that the current QL offerings were effective in helping students. There is then no *felt need* to change and this is potentially a reason for the faculty not making any significant changes to the curriculum.

The math faculty has taken a strong position on rigor in reaction to pressure to help improve graduation and retention rates. Their perceived role is to resist any curriculum changes that would make it easier for students to take what the faculty considers to be the low road to graduation.

As demonstrated in their vision statement and lack of participation in the national conversations about first-year college mathematics QL, the math faculty appear to not fully embrace QL. This may be due to their pure math backgrounds and lack of training in QL as well as a lack of individual interest in curriculum development or even general education. Communication within the department about curricular matters proved to be an issue with the demise of the 1020 proposal and was not conducive to change. In addition, faculty are not connected with the national conversations.

CHAPTER VI

FINDINGS: SYMBOLIC FRAME

Bolman and Deal (2008) used a temple as a metaphor for the symbolic frame. The findings in this frame consider beliefs, values, myths, and ceremonies of the mathematics faculty. This section describes several key beliefs expressed in the interviews including the importance of rigor and algebra's connection to rigor. These beliefs drove decisions and behaviors that protected the status quo and became barriers to change. The beliefs are upheld by a myth and an annual ceremony. The relevant data for this chapter include 23 themes in the symbolic frame (see Appendix E), additional pertinent themes in the *change* category, and information from LPU's website.

Revered Rigor

As noted already in the structural frame, the findings show that the math faculty has a strong belief in the importance of rigor and in ensuring high academic quality. Some participants outside of the math department considered the math department to be elitist and particularly harsh in their standards. The themes show some possible historical reasons for this that shed some light on how this affected the curriculum. The data also show that there is a lack of consensus on how the participants define rigor.

History

When LPU was a community college, the Mathematics Department wanted the respect of the other state institutions. This was necessary for LPU's QL courses to be

accepted by the other institutions when students transferred. An early department chair, Mona, wanted the curriculum to have high standards. This was Matt's perception:

So from what I understood she [Mona] basically went and looked at what every school did for 1050 in the state, and she took the union of all the topics. And so that's what we had. We had just a ridiculous amount of material.

This was also corroborated by one of the faculty who opted out of the study after the interview. Most realized that there were too many concepts in 1050, so one of the only official changes in the last twenty years was to drop two topics in 2011.

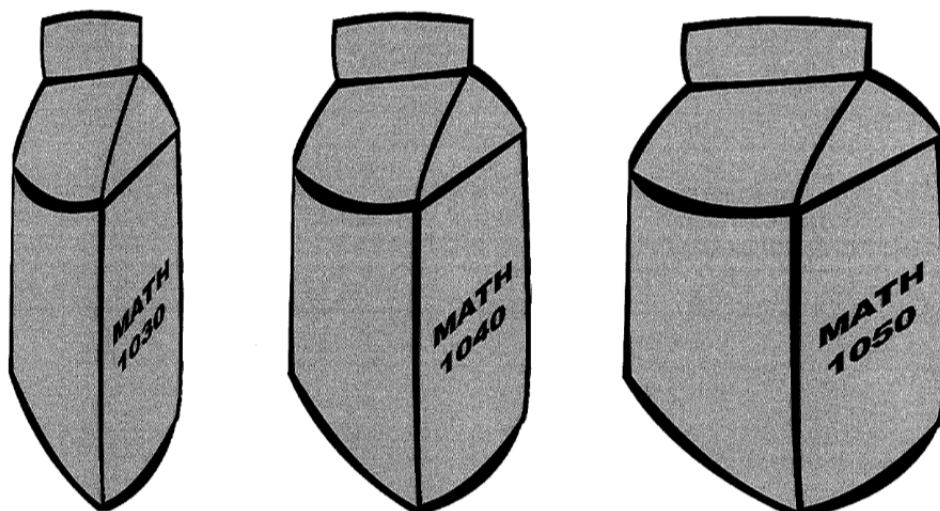
Some of the faculty believed that rigor was lost as a result of adding 1030 and 1040 to the QL requirement in 1998 to follow the state guidelines for transferability. When those two courses were agreed upon by the state, Mona was reportedly not happy. Melissa said that Mona was "violently opposed" to the idea and, in Melissa's opinion, the chair intentionally created a situation so that as few students as possible would take 1030.

So if you look back there was one section of math 1030 that never filled once. Never filled. I think the most students it ever had was 19. And it would hover around like 6 and 19. ... So it would alternate between the most hard-nosed teacher we have in the faculty, to the softest, most compliant, easy-going person, back to the most hard-nosed, another one of the really hard noses, back to somebody real easy and compliant. So you talk to the students, and the advisors, and they didn't trust the course. They said, "We get feedback that math 1030 is harder to pass than math 1050 is."

Melissa eventually became chair and efforts were made to encourage departments and students to consider 1030.

One of the results of the Math Task Force initiative in 2005 was to promote the alternatives to 1050. In some files of the task force, I found a proposed design for a poster to advertise the QL alternatives. The design is shown in Figure 4. Pictured are three milk cartons with the caption "Got Math?" The left carton is labelled 1030 and much smaller

GOT MATH?



**IT DOES A BRAIN GOOD.
PICK UP THE COURSE YOU NEED!**

Figure 4. Proposed poster for advertising the three alternative quantitative literacy courses.

than the middle carton labeled 1040 while the largest carton, on the right, 1050. In the end, the task force chose not to use the poster because of its design—not the message. It does visually convey that 1050 is considered by the faculty to be the best and most rigorous in terms of doing “a brain good.”

Despite efforts to promote 1030 and 1040, MATH 1030 continued to have few sections of students compared to 1050. In fall semester of 2013, there were five sections of 1030 and 44 sections of 1050. When asked why non-STEM majors were required to take MATH 1050, Amanda said, “Oh, I’ll tell you the truth about that. Some of them [department chairs for programs not needing calculus] feel that they just want their

students to be smart enough to have passed a rigorous math course.”

The data reflects an attitude of pride in some of the faculty and LPU department chairs who want a rigorous and respected math program. Some who are perhaps not as extreme as Mona still have strong feelings against efforts to, in their opinion, lower the bar for students.

Change Equals Loss of Rigor

According to the data, any push for curricular reform in 1050 is seen by some in the Math Department as an effort to lower standards to let more students pass and eventually graduate. Andrew’s belief is that the math faculty “already feel that MATH 1030 and 1040 are watered down, that that was forced on them by the state” and renewed efforts by administration to see some changes are perceived as trying “to make it even easier for these kids to get out of math.” Debra attributed that to one of the reasons the MATH 1020 proposal was rejected, as noted in the previous chapter.

Rigor is yet another poorly defined concept that has surfaced in this study. It was spoken of as if everyone knew what it was. The consequence is that there is no consensus. As an example, Austin, the dean, stated that “I usually think of rigor as learning new material, and learning it in a way such that it allows you to build upon so that you can move into the future with a good base.” He added, with reference to the Math Department’s reputation: “I don’t think it means doing double hard equations.” He also mentioned two faculty, not by name, with apparent pass rates below 50%. “In fact, we have a person with a pass rate of 25%. That costs the students, it costs the University, it costs good will, and that’s his definition of rigor—‘Fail ‘em.’” This was corroborated

by one of the participants who opted out of the study. While this attitude may be present in some faculty, it does not appear to be pervasive in any way according to the interviews.

The data show that, just as QL is undefined and without a consensus on definitions, the same applies to rigor. Although ill-defined, it is a big part of the mathematics faculty belief system. That belief system includes a strong tie to algebra as noted in the next section.

Altar of Algebra

The data show a fundamental belief that algebra is necessary for QL. This is evidenced by the reluctance of some in the Math Department to include 1030 and 1040 as QL. There are the themes related to 1050 being perceived as the optimal QL course when compared with the “weaker” 1030. There also is a belief in the traditional algebra-calculus path. While calculus is not the point of QL math at LPU, the QL program is based on the traditional algebra-to-calculus curriculum. For Dan, algebra would serve more of a purpose “if the point of algebra was a bridge to having everyone understand calculus, or at least try to understand calculus, then I’m in.” However, because calculus is not the QL requirement at LPU, then it does beg the question of why the calculus prerequisite, College Algebra, is so important to QL. Those faculty who believe strongly in 1050 seem to believe that students are better off the farther they go on the path, even if they do not reach, or never intend to reach, calculus.

The strong faculty belief in algebra seems correlated with a strong belief in rigor.

Dan, Chair of the Developmental Math Department, said, “Melissa will insist that you need algebra to have mathematical rigor.” He went on to say though that “I don’t think this could be further from the truth.” Dan gave an example of the Prisoner’s Dilemma and how challenging and useful that might be for students. Dan made an interesting argument for decoupling algebra and mathematical rigor.

If we believe that math is endowing our students with critical thinking skills that they’re going to take with them even if they don’t remember the algebra, then I don’t see a difference between teaching them rigorous non-algebra versus algebra and trying to achieve the same thing.

Dylan is another voice of dissent from the Developmental Mathematics Department. He said, “The real issue is that we’re still teaching a nineteenth century curriculum.” That curriculum is hard to make relevant, and so some students do not see the point in having to learn it and therefore trudge through or struggle in developmental math classes. Dylan made a distinction with this comment: “We have a crisis: we call it developmental **math**, but that’s not what it is. We have a crisis in developmental **algebra** [bold added]. That is the problem.” His belief is that math can be more relevant without being so algebra-heavy. But the Math Department faculty have a strong attachment to algebra that provides a barrier to reform College Algebra and its prerequisites.

Myth of QL Effectiveness

Despite expressing differences in the purpose of QL courses, when most interviewees were asked if they believed that 1030, 1040, and 1050 met their expectations, they responded in the affirmative. Their beliefs were that they thought the courses did, in fact, serve a purpose. However, little evidence was provided other than

anecdotal. Melissa stated:

And the 1030 and the 1050 serve different purposes, but in the end, yeah I think that they learn a more logical approach to things. I think—I can just tell you what my students have said, which is they come in and they say why do we have to learn this? Nobody ever uses this. But at the end of the semester, I have so many students that say, I see math all around me now that I know what it is. Conic sections in math 1050, and suddenly they see them everywhere they go. Or the sequences, series, logarithms really kind of get them. Finance. So the math 1030 we really hit finance, and I think that's one of the most useful things that we teach them. You know, comparing interest rates, and mortgage payment amounts, and so on. That's something that hits everybody. So I'm trying to give them just a broader overview of math, and to help them to reason through problems.

Debra, in a qualitative research study where she interviewed developmental math students who were successful now but had done very poorly earlier in school, recounted something from one of her interviews where a student said, "I figured out math is everywhere." As she described:

And it was kind of a light bulb moment for him when he came back to school and started working in it. He said, "I realized in my Chemistry class I'm using some of this math that I'm just learning in 1010," he said. And he said, "And I'm using it in my job. This job that I just got. I'm using some of the ratios and the proportions in my job that I'm just doing."

These anecdotal cases seem to reinforce faculty beliefs in effectiveness, but they are only anecdotes. How many students learn to see math everywhere? Is that the purpose of QL?

How many students learn to dislike math as a result of being forced into algebra?

Andrew, the academic vice president, was asked about the quantitative literacy of LPU's graduates. He replied, "I have no data, but I think they're fine." However, when pressed, he had to say that he did not know. "Nobody's ever checked it out."

Some of the mathematics faculty are convinced that their students, or the students who matter to them, realized important outcomes through the QL courses. This is

anecdotal evidence and LPU has not assessed the effectiveness of the QL courses.

Annual Ceremony

Bolman and Deal (2008) said that “ceremonies serve four major roles: they socialize, stabilize, reassure, and convey messages to external constituencies.” Math Week at LPU is an annual ceremony designed to celebrate math, preach its value, and attract “converts” by sparking interest in math. It is a week-long event with games, contests, prizes, and usually a well-known speaker. The first was held in 2005 with a theme of “Mathematics is Everywhere.” Themes and speakers listed on the LPU website included:

- We Got Game (2008) featured David Irvine, a former member of MIT’s Blackjack Team as chronicled in Ben Mezrich’s book, *Bringing Down the House: The Inside Story of Six MIT Students Who Took Vegas for Millions*.
- Infinite Beauty: Math & Art (2009) where everyone at the university was invited to participate in creating a geometric zone art sculpture.
- Math in Space (2011) where Mario Livio, an astrophysicist from the Hubble Space Telescope Science Institute, addressed the question: “Is God a Mathematician?”
- Math Rocks Music (2013) included a showing of “Calculus: The Musical” and a talk by David Wright, Washington University, on “Mathematics in Music.”

Typically during the week, there are activities like a Sudoku tournament, a factoring bee,

cooking contests, and chocolate math therapy. An assessment of Math Week's impact has never been conducted. The ceremonial aspects of the activity are designed by the Math Initiatives Committee to try and reassure math faculty, students, and administrators of the value of mathematics and the current curriculum. These events and activities appear to have little direct correlation with the actual QL curriculum. This annual event is designed to fend off any criticism of math by showing that math is fun, beautiful, and relevant.

Symbolic Frame Summary

Central to this chapter is the assertion that math faculty hold strong beliefs in rigor and academic quality coupled with belief in the traditional algebra-to-calculus path. The data shows that rigor, although vital to the faculty belief system, is undefined and without consensus in its definition. In the name of rigor, the math faculty have resisted any curricular change because any change, especially if encouraged by administrators, could involve making it easier for students and therefore not as rigorous. The faculty use anecdotal evidence of QL effectiveness to reinforce their beliefs. This is also the case with the annual math week festivities.

CHAPTER VII

FINDINGS: POLITICAL FRAME

The political frame uses the jungle metaphor. This view looks primarily at power relationships (*power relations* subcategory of the codebook) and decision-making (*decision-making* subcategory). I also looked for any text referring to *control from the top* or any change that has occurred from lower in the organizational hierarchy (*change from below* subcategory). Finally, I coded for *control of meanings* where some might try to exercise some political power by trying to control the messaging; however, for this study, the data showed that there were few instances of this.

The findings show that the math faculty held the academic power by nature of the mathematics discipline. They have been able to preserve a traditional, algebra-heavy, math-centric, general education curriculum. Power struggles have existed within the department that has served to resist curricular change. The mathematics department has also had a poorly defined decision-making process not conducive to considering curriculum changes.

Power—Academic Degrees in Mathematics

The data show various aspects of power differentials that could potentially create barriers to curricular change. The most obvious, perhaps, is the power that the faculty has when it comes to the curriculum in their discipline. The regional accrediting body states that faculty “exercise a major role in the design, approval, implementation, and revision of the curriculum” (NWCCU, 2010). If QL is accepted to be strictly within the domain of

the Mathematics Department, administrators with degrees in other disciplines simply do not have the credibility to be suggesting changes to the mathematics curriculum. Austin, the dean with responsibility for the Mathematics Department and having a background in biology, admits that he is no mathematician and, with regard to QL, stated:

Some of the mathematicians have kind of tanked at my opinion. They say, “He’s not a mathematician, he doesn’t know.” And that kind of thing. And I’m not, but I do know some things that they don’t know. And I’ve told them, hey, we’re going to do better at this. Let’s give it some thought, let’s look this over.

Without the mathematics expertise, the administrators who would like to see changes do not believe they have the power to direct that change. They are not the experts in mathematics. Dan, chair of the Developmental Mathematics Department, derided the Math Department a bit when saying, “They’ve done it this way for so long and it’s worked, and ‘what we’re doing is working well so why would you come along and suggest that we, the experts, change what we’re doing.’”

Dylan recognized the power of the Math Department and blamed them for the static curriculum, stating, “They are the single biggest impediment because they’re the ones that control the curriculum.” As noted above in the Structural Frame chapter, he questioned the assumption that QL should even be in the domain of the Mathematics Department since they, as pure mathematicians for the most part, are not trained in QL. From Dylan’s perspective, the Mathematics Department holds too much academic power over the QL curriculum and may not have a sense for the types of changes that some are calling for nationally. Hence, the status quo has been maintained.

Power—Doctoral versus Master’s Degrees

The findings show that differences in academic credentials played a role in the history of the QL curriculum and partly explains why the curriculum looks like it does today. In LPU’s early days as a community college, instructors were not required to have a PhD but had to have at least a master’s degree. Initially, there were no faculty members with PhDs in the Math Department. The first faculty member with a PhD in mathematics to be hired was Mona. She had a significant role in the history of the general education mathematics courses, writing a rigorous curriculum to her liking. Mona exercised a lot of power, especially after she was made chair. According to Melissa, Mona “did everything and nobody else in the department really knew or had a say.” Melissa also felt the wrath of the department chair and still has some fear even though Mona has not been a chair for some time.

She has files on each faculty member where if there’s anything that she can use on them in the future, she saves it. And I know because it came back to me, and she dug up stuff from 10 years ago.

The chair’s control was corroborated by one of the faculty who opted out of this study.

Mona did not agree to participate so the above is one-sided. I believe it is appropriate to add this comment from Malcolm, which he provided after his review of the draft findings.

I recognize that there are those who were offended by Mona and I am genuinely sympathetic to their feelings. It is also true that Mona and many who worked with her were offended by things that some department members did or said to them, a fact to which I am also sensitive. I choose to believe that many of those hurtful things were results of misunderstandings because I have a high opinion of all parties involved. (Personal correspondence, April 2, 2014)

Power—Faculty versus Administration

The data show an interesting relationship between administrators and faculty that can generally be characterized as very positive at LPU. There is some mutual respect but also some mutual distrust, but each side knows their boundaries. As already noted above, the perspective of some math faculty is that the administrators have been more concerned with the bottom line and the institution looking better by increasing graduation rates, a known weakness at LPU. On the other hand, administrator interviews show that they believe the math faculty has unrealistic standards and that MATH 1050, in particular, is unduly harsh both in content and pedagogy.

The curriculum is cordoned off by the faculty as theirs, which it essentially is. For other matters strictly outside the curriculum, the administrators exercise more control. An example of this from the data is a recent case in which LPU leadership wanted to work more closely with local high schools. One way of doing this was to offer MATH 1050 through the high schools, with high school teachers, but giving LPU credit concurrently. Michael was the 1050 course director at the time had this to say about the situation.

They have experience teaching, of course, but—and even though some of them are great teachers, and would be fine, we found that administration was really—it was—and I shouldn't say this, this wasn't every administrator, but there was enough administration that made it very difficult for us to say, well, we don't want to do this because we don't think it's being successful. Or we don't want to relax our standards so that more of these students can get through earlier, because that was it. The push was, we want our students to have taken these courses before they come to college, so that they have that college [credit], can get done quicker, and we found that most of the teachers were less rigorous in high school. That their motives weren't really being that tough, although I've seen both, and you can't always say that. But they have a lot of pressures from parents, and from their own administration, to make sure that it wasn't that hard and that they weren't failing out students.

The administration pushed hard and it was tried as a pilot program. When asked if they could have just said “no” and dug their heels in, Michael said, “I don’t think that would have ever worked. There was so much pressure from the school districts that—I don’t know. I think not.” When pressed further and asked what administrators could have done to them if they had insisted on not doing it, he replied:

Well, certainly you don’t get raises if they don’t want you to. There’s tenure, there’s rank advancement. It all goes through those same people. So I don’t know. I don’t know if I ought to feel pressure, but basically we’ve been told several times, no you won’t change this, you will not do this, we will be running this, kind of thing. So they don’t necessarily say how that’s going to happen, but it ends up not being exactly what any of us would rather want, I think. And, I’ve got to admit, for most other things they’ve been very supportive.

Concurrent enrollment is an area where administrators felt they could apply some pressure. The faculty did not have as strong a position as they would have had on a strictly discipline-related curriculum matter where administrative-driven changes would have been futile.

At the highest level of the institution, it is understood that administrators must engage the faculty. Alex, a vice president of long standing at LPU, stated:

If you go back to [Andrew] right now, he’ll tell you, well, the department is resistant to change. And this has been a common discussion I’ve had, with especially newer presidents. How come I can’t just—I’m the president. I should be able to change. But then you have the faculty, right? And the faculty are the keepers of academic quality. Faculty are the keepers. Faculty determine the curriculum. And it’s not easy for a president to change the views of the faculty. Now, the president can change almost anything administratively.... But when it comes to a president trying to influence curriculum, he basically has to convince the faculty—But to change curriculum is a much harder thing to do for a president.

Alisa, an associate vice president in Academic Affairs, said it takes “Dialogue. Endless dialogue. It’s sticky because the more the administration pushes, the more resistant the

faculty become.” She added, “You definitely have to convince people of the need to change. So you have to have compelling data or information, and it has to be pretty compelling; otherwise, they see no reason to do anything differently.” In addition, an administrator who is not from the math discipline has a disadvantage by having little academic credibility with the faculty.

Power—Doctorate-Granting Versus Master’s Universities

There are two state universities that are classified as doctoral-granting institutions, one of which is an institution of very high research activity and the other is high research activity. They are research-oriented and generally have a higher profile than other institutions in the state. LPU is the most recent in the state to become a bachelor-degree-granting institution. In 2008, LPU’s mission changed to allow master’s degrees and LPU is now classified as a Master’s university. Austin believes that when LPU was still a state college), it was looked down upon. Later, a representative from the state commissioner’s office spent two days looking at LPU’s programs and came away impressed. Austin stated:

And [LPU] the new kid on the block, and to the [tier-1 institutions], they’re just a damn junior college, and we don’t want them nicking in to our enrollment. That’s all changed. They like us now, even those other schools. They consider us to be pretty decent partners, which is important.

As noted above, it is possible that LPU overcompensated the rigor of its math to gain respect within the state’s higher education system.

If LPU were to adopt changes to their QL program, they could potentially lose some respect within the state system and there is some precedent for feeling that way.

Another tier-2 institution in the state created a MATH 1020 course to prepare students for their statistics QL course, similar to the MAT 1020 proposal at LPU. It would have bypassed MATH 1010, Intermediate Algebra, which the State Majors Committee required as a prerequisite to any course that could be considered QL. The institution had to drop the course because other institutions in the state would not accept it. Malcolm said that the Majors Committee “thought it [MATH 1020] made the program weaker, so they probably would have seen us in that way [speaking of LPU’s potential 1020 course].” This reinforced the idea that LPU cannot really change any of the QL or prerequisite courses; this is another potential barrier to change. LPU has a seat at the table of the State Math Majors Committee but may believe they need to show strength through a rigorous (some would say overly rigorous) math curriculum.

Decision-Making Process

The decision-making process is another aspect of the political frame. With a flat organization such as an academic department, decisions require a lot of communication. According to the data, this sometimes has been a little muddled in the LPU Math Department.

For ideas generated within the department, it takes patience and much dialog to build consensus among the faculty. Participants were asked about any experiences they have had at LPU in making a curriculum change, whether QL or not. Matt began thinking of a potential curriculum change shortly after he was hired in 2002. This did not involve QL but an addition of a discrete mathematics course. Once he understood how the classes

and topics were arranged at LPU, he thought that a discrete mathematics course was needed. Matt kept trying to push for it. “I just couldn’t get anywhere. And then finally I guess enough people got the idea that yeah, maybe that would be a good idea, and so we get talking about it and decided yeah, let’s do it.” It took 10 years from the initial idea until there was actually a new course. It was a very slow collegial process in which the idea eventually was approved through consensus.

Sometimes a vote was taken if the consensus did not exist. Malcolm explained the process.

So somebody has an idea, like [creating a new course], and we say okay, sure, let’s try that. And we hold a department meeting, talk about it, people care or they don’t care. Most people don’t care. A few people care, they may or may not say. So then we say, alright why not? We’ll make the course. And so somebody makes the course, and once it’s done we submit it [through the LPU curriculum process]. And we try to do things by vote as much as possible, because otherwise people—it seems to be the best way to avoid people being upset. Sometimes I don’t know what it is that we voted on, though. Sometimes when I thought it achieved or reached consensus, well general agreement to go forward on something, it turns out there’s people that either weren’t in the discussion or didn’t see it that way, and that doesn’t happen after all.

Recently, when the Math Department voted on MAT 1020, the vote was 10 in favor and 10 opposed. The voting rules had not been fully developed and there was no contingency for a tie. So, they let the department administrative assistant and a department advisor (who was also an adjunct) vote. MAT 1020 was defeated 12 to 10. Some outside the department called foul. Malcolm had these thoughts afterward.

And so I think that when doing these things it’s important to bring it up in more than one meeting, and make sure that there’s a vote that’s done by ballot, that’s been recorded, and to record the meetings, because then everybody knows exactly what everybody said. It just seems—I think that’s something I probably would have done differently if I’d done this over.

Poor communications, as noted in the Structural Frame Chapter, and a poorly defined process were a detriment to changes at LPU.

Political Frame Summary

This chapter asserted that power differentials and the current decision-making process have been conducive to maintaining the status quo. The findings showed power relationships in four pertinent areas: academic degrees in math versus nonmath degrees, doctoral versus master's degrees, faculty versus administrators, and tier-1 versus tier-2 institutions. Clearly, those with mathematics credentials hold power over the curriculum; therefore, the Mathematics Department controlled the QL curriculum. The curriculum is a very traditional, math-centric curriculum based in algebra. As a tier-2 institution, the LPU Math Department maintains credibility with other institutions by having a rigorous program and may not want to make changes for fear of losing respect within the state system. Administrators exercise some control of noncurriculum matters, but without the math expertise, cede control of the curriculum to the department.

The department's decision-making process has been disorganized. The following is evidence of the disorganized decision-making process: voting rules were not clearly established (especially in breaking a tie), communication between faculty was lacking, and minutes were not taken at meetings and published for all to see.

CHAPTER VIII

FINDINGS: HUMAN RESOURCE FRAME

Bolman and Deal (2008) used a family metaphor for the human resource frame which, “rooted in psychology, sees the organization as an extended family, made up of individuals with needs, feelings, prejudices, skills and limitations” (p. 16). The Mathematics Department is the primary “family” in question. The findings show that it has been somewhat dysfunctional and thereby detrimental to any potential change efforts. There were 14 themes for this frame (see Appendix E) and they are discussed below in the two sections of this chapter: culture and interpersonal relationships.

Informal Groups Within the Math Department

Andrew, Senior Vice President of Academic Affairs, had wanted to encourage some curricular change but has not been successful. He reflected on the Math Department culture, which seemed to impede his efforts. He stated:

It’s very strange that there’s some culture that has developed in the math department, and from a sociology point of view it’s got to focus on one, or two, or three people. And it’s probably [two vocal faculty], from what I can tell, and who else, that—and I don’t know where that comes from. I don’t know whether it comes from their background. There are two camps, but this more rigid, or, I don’t know how to describe it, it seems to win out.

Andrew noted two camps within the department and this is evident in the data. The split is essentially one camp that is very hardline and believed in only one math path for students. They were not happy about having to add 1030 as a QL course or even 1040. The other camp holds to some high standards but believes in a little more flexibility. In

reference to a split department, Malcolm said, “It’s never going to be unified, which, I don’t know, in some ways it could be a good thing because otherwise it might be unified in the wrong direction.”

The origins of the split go back two decades. Several participants talked about the early chair, Mona, who set the tone in the department. As discussed above in the political frame chapter, this chair was an early PhD hire who took the reins, and she chose to exercise a heavy-handed approach as chair, apparently making all of the curricular decisions single handedly.

The participants noted an improvement over the early work environment but it has been a progression through a few different department chairs. When Melissa became the next chair after Mona, she chose to “make it a more informational process” but tensions were still too high to accomplish what she wanted. She noted:

So everybody kind of knew, and then we’d discuss things about prerequisites, but I didn’t really make any changes to previous prerequisites, because there were some very vocal dissent. So then when the new chair came in he [Malcolm] made a lot of changes.

So, it took several years and two new chairs for the culture to become a little more cooperative. Melissa’s comment was supported by the interview of one of the faculty members who opted out of the study.

There still seems to be some vestiges of the earlier harshness, as it pertains to the rigor of the curriculum. As mentioned earlier, there was Michael’s comment about the department faculty having a chip on their shoulder. Austin, the dean, believed that the department was swayed by the most vocal faculty: “And we have some strong personalities; one, two, three or so that can influence the department and they’ve done a

bunch of that. But, as new people are coming in, things are getting better.”

There is little wonder why the QL curriculum remained largely unchanged over the last 20 years given an authoritarian chair, initially, and then followed by years with two vocal and opposed camps. Some of the participants talked about their divided department. Malcolm, and others, noted that there is no consensus among the faculty, with many having strong opinions.

Interpersonal Relationships

Imbedded in the culture are some troubling interpersonal relationships where various faculty members felt hurt and even threatened. Although things seem to be improving, it was bad for quite a while. While Mona served as chair, she exercised considerable power, as has been noted. The dean, Austin, referred to her as a “bully.” This was confirmed by one of the participants who withdrew from the study. Without going into great detail, the situation had been bad enough to warrant two faculty being placed on administrative leave for a time. One faculty member sued another, twice, and also filed a grievance. The lawsuits and grievance were eventually thrown out but they involved other faculty testifying and so the department was in turmoil for a period of time. Melissa, who had been chair at the time, was tired of the conflict and stepped down as chair. In her words:

But in the end she [Mona] can make life so miserable that you don’t care enough to try to make changes. So I think, and again, if she was gone this would be a completely different department. But she’s not going to go anywhere and nobody’s going to have her go anywhere, so you get what you get.

The contention between these two faculty members had an amplifying affect because

both were considered informal leaders of the two factions in the department. Melissa, referring to Mona's stint as chair stated: "So the math department was seen as very elitist, and very hard to work with, and I think that was all true because whoever's the chair is the face of the department."

Things are getting better over time as mentioned in the previous section on culture. Currently, relationships between faculty and administrators are seen as positive. Austin stated that he has mellowed out a bit.

I am learning. I'm very confrontational in the past, and in the last several years I've learned to listen. But I also will—boy, when the wrong thing happens in the deans council there's hell to pay. So I'm kind of both, but I'm much more of a listener now and a facilitator. Yeah, I think so. I'm kind of proud of that. Not that I won't speak my words. I will.)

Dylan was especially positive in his comments about the current relationship with administrators saying that the leadership team at LPU was "exceptional; I think we are very fortunate." In the past, personalities got in the way of any change; however, with new chairs and some mellowing in the last few years, the work climate was, according to the participants, getting better.

Human Resource Frame Summary

Any potential curricular change did not have much of a chance given the harsh culture and the interpersonal tensions that existed at one time. There are still significant differences of opinion among some of the faculty, resulting in continued tension. However, participants believed that the situation was improving as time went on and as new faculty were hired.

CHAPTER IX

DISCUSSION

This discussion will first summarize each frame separately, paying particular attention to potential barriers to curricular change, in the context of the conceptual framework for this study. Then, the frames will be integrated in preparation for making recommendations to affect change. The integrated picture will provide a more complete and holistic look at the situation and the barriers to curricular change at LPU. Bolman and Deal (2008) referred to “harmonizing the frames and crafting inventive responses” (p. 311). While each frame provides a different perspective, the authors caution that “each [lens] has its blind spots and shortcomings” (p. 339). For example, a focus just using the structural frame would ignore “everything that falls outside the rational scope of tasks, procedures policies, and organization charts” (p. 339). The situation is similar for the other three frames. Therefore, it is necessary to use each of the four lenses and then harmonize them in a way that gives a clearer picture of the issues from which recommendations can be made.

Summary and Analysis of the Findings

Each frame is addressed below. The summaries pay particular attention to the primary research question for the study (i.e., potential barriers to changing the general education, QL curriculum at LPU). Figure 3 (shown earlier) depicted the three conceptual frameworks for this study as a consolidated framework showing the general connection between Bolman and Deal’s (2008) four frames and an adaptation of Rogers’ (2003)

innovation-decision model. As shown in the consolidated framework for this study, barriers are considered to be anything that: (a) prevents a *felt need* to improve or innovate, (b) leads to *selective exposure* or *selective perception*, (c) disrupts communication related to change, or (d) results in passive or active rejection of a new alternative curriculum.

Structural Frame Barriers

Through the structural frame we can view the organization's goals and the way in which those are decided and acted upon, the delineation of roles, and any needed communication to enact change or innovation. An analysis of the findings shows four key barriers and each are described below.

First, however, I note the participants' reactions to the draft findings, particularly their reaction to the Structural Frame Chapter. Two math faculty members withdrew from the study. They did so by emails that were sent the same day, 6 minutes apart, with nearly identical wording. Both started with "I have reread Chapter V [structural frame] from your dissertation" and both said, "I am uncomfortable with the use of my comments and wish to revoke my consent for this project" (Personal correspondence, March 26, 2014). Chapter V included the findings for the structural frame, which questions the purpose of QL and the lack of evidence of course effectiveness. I believe they disagreed with my conclusions and did not want to be a part of the study. Three other math faculty members responded to the draft findings. They did not agree with all of my conclusions but stated that the use of quotes was accurate, or they offered clarification to what they said in the interviews. I have used their feedback, as appropriate, to improve the accuracy of the

findings. Their comments do not necessarily reflect agreement with the findings. I stand by the conclusions I have reached, recognizing my biases. I believe that some of my statements are critical of past and current practice and are therefore somewhat controversial to the Mathematics Department. Administrators, staff, and developmental math faculty who responded offered only minor corrections, if any at all.

Vague goals with no assessment. The Mathematics Department has not articulated a purpose for QL. There is no common underlying QL philosophy among math faculty upon which to clearly determine goals, assess goal accomplishment, and determine if changes are needed in the program. The findings show a number of different informal QL goals. All of Kliebard's four purposes were mentioned to some extent. Preparation for courses in mathematics or in students' majors would be a social efficiency approach where students are preparing for their careers. Critical thinking and life skills might be classified as social meliorist with the basic intent of helping students become better critical thinkers and thereby improve society. The traditional humanist approach can be seen in the perseverance goal and also with critical thinking as a way to develop the brain and its reasoning power. The developmentalist approach is not as strong, but it is evident in the three choices of QL courses that allows students, theoretically, to take the course that best suits their individual needs, although, that need is usually defined by their major. Because LPU does not have a formal QL philosophy, it has an informal amalgamation of the four approaches. The Math Department's QL program lacks clear purpose and intent.

When there is no definitive purpose to math education, other than having students

pass one of the three courses, there can be no real assessment of QL accomplishment. Faculty members can feel like the goals are being met through anecdotal evidence they choose to see, as was noted in the findings. There was mention of students being able to see math all around them. The examples given included only simple concepts like conic sections and seeing circles. I am doubtful that students are able to see the more abstract aspects of algebra (e.g., third degree polynomials or complex rational expressions).

In this case, there is no *felt need* among faculty, as Rogers described, to serve as a motivation to seek out or at least be receptive to innovations or alternatives. In fact, the findings show that faculty have some confidence that the needs of students are being met and the existing curriculum is sufficient. Without clear measurable goals, there can be no assessment of student performance gaps that might result in a search for alternatives.

Little ownership over QL and curriculum development. The mathematics faculty seemed to have a math-centric view, rather than a QL view, of the curriculum and their role. The field of mathematics is a priority rather than a focus on the interdisciplinary aspects of QL. The findings show that some faculty may not take ownership of curriculum development because of their workload and professional interests in mathematics. As evidence of this and as noted in Chapter V of the findings, the Mathematics Department's vision statement does not include QL and speaks to helping "most" students, presumably STEM students or those with a MATH 1050 requirement for their major. When faculty have a math-centric perspective, traditional algebra is the key to the curriculum and other alternatives are not sought (selective exposure). Nor would they give favorable consideration to an alternative that is not so

heavily based in algebra, a case of selective perception. This is apparent with the faculty's lack of knowledge and/or dismissiveness of alternatives suggested in the national conversation on QL.

As noted by Dylan, and mentioned in the findings, there is some question as to whether or not mathematics faculty are qualified to design a QL curriculum. Does someone with a PhD in topology necessarily have expertise in QL? Steen (2004) recognizes that responsibility for QL is a highly debated issue as is its priority in higher education. What is problematic to him is that QL is interdisciplinary, and, therefore, no one takes a leadership role. That role then falls to math departments:

Inevitably, mathematicians will be at the center of this debate and—for good or ill—their actions will greatly influence the outcome. With no discipline naturally exercising leadership, there is neither an insistent nor a consistent call to make quantitative literacy a priority of education at the college level. (p. 15)

Steen sees QL as different than mathematics. He is, however, in favor of mathematicians leading a coalition of faculty from other disciplines. He warns of QL being the sole responsibility of mathematics departments, “especially if it is caged into a single course such as ‘Math for Liberal Arts’—students will see QL as something that happens only in the mathematics classroom” (p. 18).

Resistance to perceived reductions in rigor. Some faculty members from the Mathematics Department were adamant about maintaining academic quality and rigor in the general education program. Their role was to maintain high standards and, in so doing, work to block any efforts to let students take the perceived “low road,” as noted in the findings. Some faculty were not even happy about the state system adding 1030 and 1040 to the QL list, with 1030 being a “dumbed down” course that allows certain non-

STEM students to at least get some math and obtain a degree. Faculty perceive further changes in the curriculum as lowering academic standards and therefore then tend to reject alternatives. Steen (2004) saw this in some faculty: “Another worry—especially strong among mathematicians—is that QL is (or may become) merely a remedial enterprise” (p. 16).

Poor communications within the Mathematics Department. Rogers’ (2003) described three types of innovation decisions by organizations. The applicable one for the LPU Math Department is what Rogers referred to as *collective innovation decisions*, which were “choices to adopt or reject an innovation that are made by consensus among the members of the system” (p. 403). Consensus was more difficult when there were communication issues between members. As noted in the findings, communications within the department were problematic. Poor communications can result in passive rejection when alternative innovations are not be discussed effectively by a group. Or, as was the case with the failed MAT 1020 initiative, an active decision to reject it was made partly out of frustration with whether or not faculty believed they were left out of the information loop even though some missed meetings and left emails unread.

Symbolic Frame Barriers

Through the symbolic frame one views the culture and beliefs of an organization, in this case, the Mathematics Department. A part of this frame also looked at the myths and symbolic events used to reinforce beliefs. An analysis of the findings showed three key barriers and each are described below.

Belief in undefined rigor. The findings showed that rigor is an important belief

among most of the faculty participants. The faculty might consider almost any change as a loss of academic quality. The faculty had an element of pride in having a rigorous program respected within the state system. This appears to be why some administrators considered the faculty to be elitist and accused them of setting the bar unreasonably high. The faculty had a loyalty to their discipline and believed they had to uphold the standard of rigor; otherwise, the pressure to improve graduation rates might lead to a degradation of the QL program.

In the past, some faculty placed emphasis on being tough and high failure rates were evidence of proper rigor. The strong belief in rigor and lack of consensus on a definition of rigor becomes a barrier because it leads to selective perception. In other words, faculty evaluate potential innovation or change against their standard of rigor. The result is an unfavorable impression of any alternatives. Further complicating matters is the fact that there is no consensus on what *rigor* means. If rigor is not defined then it is harder for administration or individual faculty to know how to frame the rigor of an alternative that could compare with the current QL courses.

Belief in the traditional algebra-calculus path. The findings showed a belief in rigor that appeared to be tied to a strong belief by the faculty in the traditional algebra-calculus path. While calculus should be the ultimate goal for those taking College Algebra, having students just heading in the direction of calculus appeared to be enough for some of the faculty. Some faculty believed students should go down the algebra-calculus route as far as they could go, even though the majority of students stop at College Algebra.

As noted in the structural frame, many participants believed in the ability of the current curriculum to teach critical thinking and reasoning skills. Debra had stated that reasoning power is embedded in the curriculum and, listening to the participants, there does seem to be some sense of value that is embedded in algebra. Gaze (2014), President of the National Numeracy Network and Director of the Quantitative Reasoning Program at Bowdoin College, drew a distinction between algebra and QL and stated, “The unquestioned super-importance of algebra has been close to gospel in the mathematics education community” (p. 2). That was certainly true with the LPU Math Department.

This strong belief in algebra for QL was reinforced by the state system’s agreement between institutions that any QL course must have an Intermediate Algebra, MAT 1010, prerequisite. This has resulted in a MAT 1010 prerequisite for MATH 1040 introduction to statistics, even though much of the 1010 content was not specifically used in 1040. Faculty’s belief in an algebra-heavy QL curriculum was a barrier to change in that they would not consider alternative QL courses that de-emphasize traditional algebra topics (selective perception) or sought out alternatives (selective exposure).

Reinforcement of beliefs through myths and so forth. Faculty’s belief in the effectiveness of the current curriculum reinforced their strong beliefs in rigor and algebra. The findings showed that faculty had anecdotal evidence of the effectiveness of the current courses. The findings also showed there as currently no objective, measurable data because no formal assessment had ever been conducted. As long as the myths survived and got retold each year through the annual math week event, these myths would be a barrier to changing the status quo.

Political Frame Barriers

Through the political frame, this study looked at power differentials and the Mathematics Department's decision-making process. An analysis of the findings shows three key barriers and each are described below.

Complete control of the QL curriculum by the Math Department. The findings show that the Mathematics Department exercised exclusive control of the QL curriculum. The administrators, while they would like to see some changes, left all curricular decisions to the faculty. They suggested that the department give consideration to certain ideas but were reluctant to push too hard. The faculty had to take the initiative to seek out potential new QL innovations or alternatives. The faculty saw no need to make changes, and they had the power to defend the current practice against changes.

The power of the faculty over curriculum decisions was based on their advanced degrees in mathematics. None of the administrators in the LPU hierarchy had math degrees, so they lacked the academic credibility to have much influence. The mathematics faculty had created a math-centric, QL curriculum that focused on what they knew—pure mathematics. In addition, they had the State Math Majors Committee to back them up.

Overcompensation on content for respect within the state system. The findings show that the content for LPU's College Algebra had covered more topics than any other in the state. A few topics were dropped in 2011, but the course was still content-heavy as noted in the findings. The emphasis on traditional content areas may be connected with looking for respect within the state system. LPU was a new master's

institution. Going further with College Algebra than any other institution could be evidence of overcompensation. As long as that attitude existed, it served as a barrier to change. Alternatives that had less content than the current curriculum, especially College Algebra, would not be looked at favorably.

Muddled departmental decision-making process. The findings include the decision that was made by the Mathematics Department to reject the proposed new MAT 1020 course. The process uncovered a number of communication issues that did not help the proposal. The issues included lack of updates from the committee developing the proposal and faculty not attending departmental meetings or not paying attention to their emails. The department chair at the time realized that he should have called for more updates and brought the topic up at more of their faculty meetings. The department used a voting system when consensus was not clear, but there was no procedure for a tie in the voting. Also, the department did not keep meeting minutes to keep a record of discussion and what was voted on.

Human Resource Frame Barriers

The human resources frame deals primarily with interpersonal needs and conflicts. The Mathematics Department had been somewhat dysfunctional in the last 20 years but was less so now according to participants. The findings for the human resource frame center around two potential barriers and each is discussed below.

Informal Groups within the Math Department. The findings show that there were two informal groups in the department, each headed by a vocal leader. Each of these informal leaders had been department chair at one time. One of those leaders had exerted

strong control of the curriculum when she was chair. The other was more open but found it very difficult given the adverse relationship with her counterpart. There was even some fear by one of them of vindictive actions by the other. Both groups did come together in voting against the MAT 1020 proposal. However, this type of atmosphere in the department could serve as a barrier to meaningful discussion of potential curricular changes.

Malcolm, after reviewing the draft findings, added this contrary opinion and gave more weight to the state system as a barrier rather than the informal groups:

Rather, those obstacles are based in a fairly universal (both camps in similar proportions) aversion to change or looking weak or lowering standards (as you described), and most importantly (in my opinion) they are the result of the state's desire to make the process of the curriculum more uniform across the state and thereby create an impediment to any school making a new route through QL without the approval (and possibly the participation) of the rest of the state. (Personal correspondence, April 2, 2014)

Interpersonal conflicts within the Math Department. Related to the informal groups, the department has had more than its share of interpersonal conflicts. These were especially bad for a few years that included litigation, a grievance, and bringing in a neutral mediator. Vestiges of those years remain to some extent.

The culture and interpersonal conflicts can affect communication within the department that is critical for innovative change. Rogers (2003) described *interpersonal channels* of communication as face-to-face exchanges that do two things particularly well. The first is that "One individual can secure clarification or additional information about an innovation from another individual. This characteristic of interpersonal networks often allows them to overcome social-psychological barriers of selective

exposure, selective perception, and selective retention (forgetting)” (p. 205). The second is “in persuading an individual to adopt a new idea” (p. 205). The Math Department’s interpersonal channels of communication had been closed off or greatly restricted. This, combined with the usual independence of faculty in academe, inhibited chances of considering a reform of QL.

There was some concern expressed by those who reviewed the draft findings that too much of the dirty laundry was being expressed in the draft report. In fact one who opted out of the study stated that “re-hashing the details of this time will be destructive to the educational and emotional climate in the Math Department” (Personal communication, March 27, 2014). This was also noted by a dean in the study as well as a department chair. I believe that the strong reaction to the draft is indicative of how bad the situation was for a period of time. I underestimated the emotional scarring and sensitivity that some still have today. Here is a comment from Malcolm after reading the draft.

There is a lot of blame to go around, very little of which is helpful. I strongly believe we need to forgive each other and move on. This is difficult to do if people keep renewing the volatile feelings when they start to subside. (Personal correspondence, April 2, 2014)

Accordingly, I left out some of the details in deference to the feelings of math faculty. Of course, some information about the interpersonal conflict is provided to give a sense of the work climate.

Integration of the Four Frames

As noted above, an integrated picture will provide a more complete and holistic

view of the situation and the barriers to curricular change at LPU. This harmonizing is necessary to develop appropriate recommendations. Bolman and Deal (2008) suggested some questions for managers and policy makers to help choose appropriate frames to use, recognizing that choosing frames is a “combination of analysis, intuition and artistry” (p. 317). The authors provided a number of guidelines to show when some frames are used or emphasized in resolving an issue. Those guidelines indicate the use of all four frames in this study. For example, the guidelines call for using the human resource and symbolic frames when individual commitment and motivation are important to a solution. Surely any recommendation for reform would need to have the backing of the faculty. The political and symbolic frames are called for when there are high levels of ambiguity, such as the vague goals and undefined levels of academic quality. Finally, the technical and rational aspects of any policy decisions would need the structural frame perspective with articulation of goals and roles and an intentional curriculum designed to meet the goals. This study identifies a number of change barriers in each of the four frames. All four frames will be used in outlining appropriate recommendations.

Table 1 summarizes by frame all of the barriers identified above. The table also includes a primary rationale for why each is a barrier. The rationales are based on Rogers’ (2003) innovation-decision process model and the consolidated conceptual framework for this study. “No felt need” means that faculty would see no problem with the status quo and thus no need to seek out or investigate other alternatives. “Selective exposure” refers to seeking out only those alternatives that are consistent with existing beliefs. This could be the reason why LPU’s math faculty is not more involved with the

Table 1

Barriers to Curricular Reform of the Quantitative Literacy Program

Frame	Barrier	Rationale	Other barriers impacted
Structural	1. Vague goals; no assessment	No felt need to change	#5
	2. Little ownership over QL and curriculum development	No felt need to change	#8
	3. Resistance to perceived reductions in rigor	Active rejection	#6, 9
	4. Poor communication within the Math Department	Disruption of communications making consensus difficult	#11
Symbolic	5. Belief in traditional algebra-calculus path	Selective exposure Selective perception Passive/active rejection	#1,7
	6. Lack of definition and consensus on rigor.	No felt need to change	#3, 7, 11
	7. Reinforcement of beliefs through myths	No felt need to change	#5, 6
Political	8. Complete control of the QL curriculum by the Math Department	Passive/active rejection	#2
	9. Overcompensation on content, for respect within state	Active rejection	#3
	10. Muddled departmental decision-making process	Disruption of communications making consensus difficult.	#11
Human resource	11. Interpersonal conflicts within the Math department	Disruption of communications making consensus difficult.	#3, 4, 10, 12
	12. Informal groups	Disruption of communication.	#11

national discussion or discounting of recommendations. Similarly, “selective perception” refers to analyzing any potential change with existing beliefs. The administration could suggest an alternative to the existing curriculum but fail to persuade the department due to the selective perception with which the faculty would evaluate the suggestion. “Passive rejection” might suit the situation that occurred with the LPU 2005 Math Task Force.

There was a curriculum subcommittee, but no substantive curriculum changes resulted.

The changes involved mostly additional support for students and the establishment of Math Week, as described in more detail in Chapter III. The MAT 1020 alternative was an example of “active rejection,” where the proposal actually came down to a vote. Finally, “disruption of communications” was indicated as a rationale for barriers that prevent flows of ideas between faculty members or preventing meaningful discussion about curriculum development. This could be one of the reasons behind the lack consensus on goals, content, and rigor.

There are several connections between the barriers and across the frames. Those are indicated in the right column of Table 1. Figure 5 is an attempt to show those same connections between the barriers. The arrows represent support or influence on another barrier. This diagram also shows the necessity of paying attention to all four frames. Attempts to remove a barrier that is connected to other barriers requires that all be considered. For example, you could not effectively address establishing QL goals (structural) without also dealing with the beliefs of the faculty (symbolic). With the help of the diagram, it is possible to see four clusters of barriers in the integrated framework: goal, control, quality, and communication. Each is addressed below.

Goal Cluster

This cluster, whose barriers are connected with arrows in Figure 5, includes *vague goals with no assessment* (structural), *belief in the traditional algebra-calculus path* for students (symbolic), and the math faculty’s *reinforcement of beliefs* (symbolic). The findings make a strong case for the lack of articulated QL goals as well as a lack of consensus on what those goals should be.

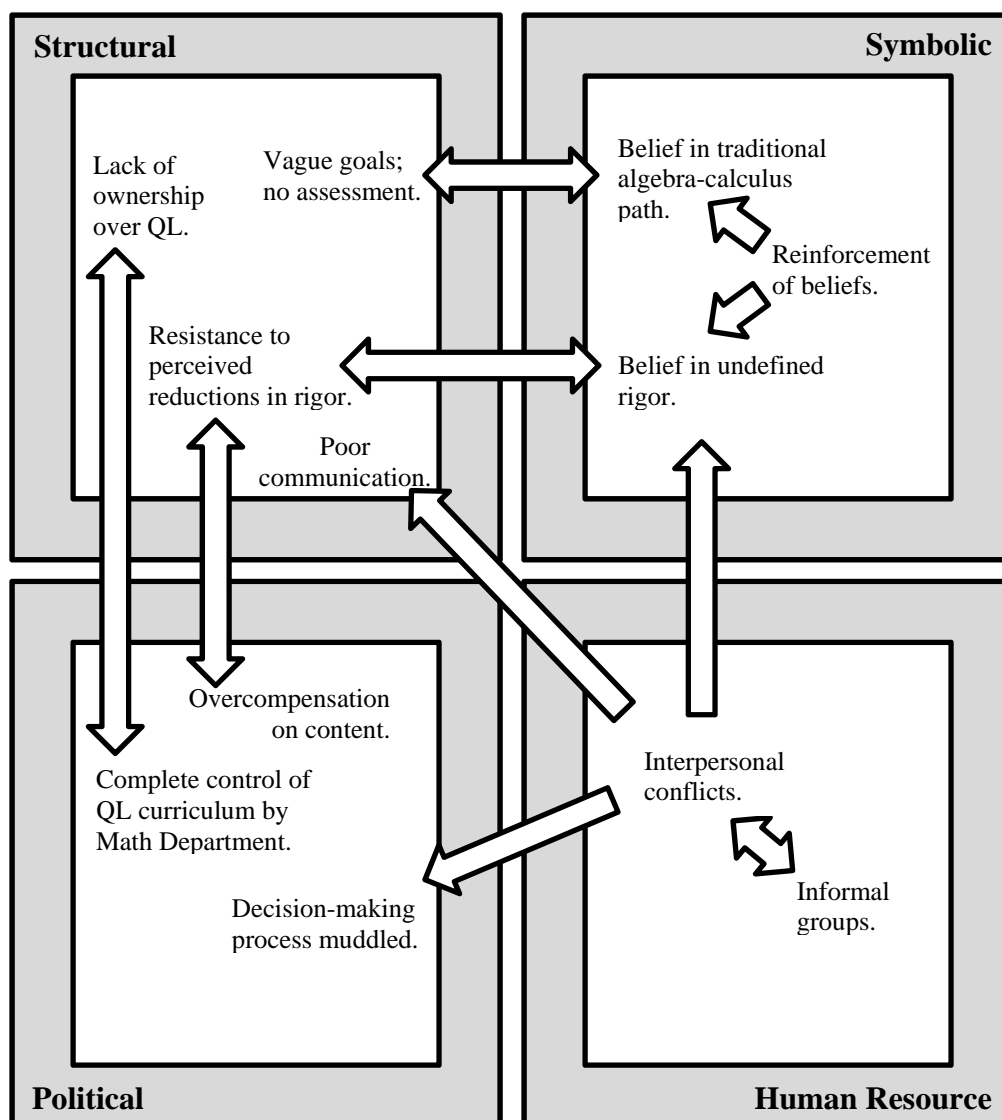


Figure 5. Barriers to curriculum reform and their connections.

Perhaps the vague goals are associated with respecting the long tradition of rigorous math education and what an educated person should know. With so much history behind the traditional curriculum, does it need any other purpose? In this way, the belief system may trump the more rational approach of the structural frame, which would look at student needs, design a curriculum around those needs, and then develop an

assessment to evaluate how well those needs are being met. It would be difficult to design an assessment unless the needs or goals were established first.

There has never been an assessment of QL at LPU. Faculty can cite anecdotal cases of students now being able to see math all around them and getting a glimpse of what mathematics is all about. Even if students do not reach that level of understanding, faculty reinforce their myths about the critical thinking and mental discipline skills that students gain from math courses, despite the lack of evidence for those claims. Therefore, the faculty remain satisfied with the current curriculum and they have the state system, which they have a voice in, to reinforce their position. They also reinforce their own ideas through the Math Week activities, hoping to convince students and administrators that the traditional curriculum has value and that math can be interesting and fun.

Control Cluster

The control cluster, connected by arrows in Figure 5, consists of the following barriers: *lack of ownership over QL* by the faculty (structural) and *complete control of the QL curriculum by the Mathematics Department* (political). Interestingly, in this cluster there are seemingly counter-acting barriers. One barrier is that the Math Department has complete control but another is that the department does not take ownership of QL. By that I mean that although the Math Department exerts its control on the QL curriculum, it does not necessarily own or embrace QL as evidenced by its own vision statement and a 1050 course that admittedly is a College Algebra for a math major. By academic training, the math faculty members were more versed in mathematics as a discipline; hence, they may not take control of QL because they do not have the complete QL qualifications, if

one considers QL an interdisciplinary effort. The extent to which QL is not pure mathematics depends on the QL goals from the goal cluster.

Quality Cluster

This cluster includes the following barriers: resistance *to lowering rigor* by the Mathematics Department (structural), *belief in undefined rigor* (symbolic), *reinforcement of beliefs* (symbolic), and *overcompensation on the content* of QL courses (political).

Rigor is the term used for academic quality, but is not defined, so there are differences in how administrators and the math faculty view rigor, although everyone is for high quality in higher education. Belief in rigor through traditional math courses like College Algebra is very strong among some faculty. Steen (2004) may have hit on a reason why faculty members, and not just math faculty, believed that anything less than College Algebra was not worthy of QL:

Faculty in all disciplines are easily tempted to believe that since the underpinnings of quantitative literacy appear to be topics from middle school mathematics—percentages, ratios, rates—college faculty (and even some high school faculty) are not responsible for QL. This argument might be plausible if QL were a skill such as long division or factoring. But it is not: it is a literacy whose functionality grows throughout life. As faculty from different disciplines come to appreciate the subtleties of QL and as they see it used in a variety of contexts, they will increasingly appreciate its power as a college-level literacy. (p. 19)

As noted in the findings, MATH 1030 Quantitative Reasoning seems to get little respect from the math faculty as well as some LPU department chairs. Although it is recognized as perhaps the best course to address math-for-life goals, it is seen by some faculty as just a high school course.

Politically speaking, the department also has an interest in looking strong in the

eyes of their peers at other state institutions. This has the added benefit for students of ensuring that their QL courses will transfer to any of the other schools in the state system. This has been an excuse used by math faculty. Even if the math faculty wanted to reform the curriculum, they claim that the state committee would not accept any changes. Faculty fear that presenting an alternative to the state Math Majors Committee could be seen as LPU wanting to have a weaker program.

Communication Cluster

The communication cluster includes *poor communication* (structural), *muddled decision-making process* (political), *belief in undefined rigor* (symbolic), *interpersonal conflicts* (human resource), and *informal groups* (human resource). As the arrows indicate, the interpersonal conflicts and informal groups in the Math Department help create the poor communications, the lack of consensus in defining rigor, the lack of consensus on QL goals, and the ineffective decision process within the department. If a curricular change is going to be made, it has to rise out of faculty discussions with the hope that consensus can be reached, as shown in the findings. Another possible source of reform is from suggestions the administration gives to faculty. So far, the culture in the math department has not supported communication for good decision making.

The participants in this study indicated that things are improving in the department since the intense years of interpersonal conflict. The department chair has been even-keeled and helped make the department a more comfortable place to work. Also, new faculty had been hired over the past few years who were not a part of the earlier history. So, there is some optimism that information will flow better and that the

decision-making process will be more effective as they move forward.

Research Questions

Before discussing the recommendations, I want to revisit the research questions. There were five subquestions in support of the primary research question. The first two concern the history of general education mathematics at LPU and any curricular decisions that have been made. These were answered in Chapter III, primarily through a review of past catalogs and curriculum documents. This helped provide a historical context for the study.

The next two questions were: What do faculty and administrators believe is the purpose of a first-year, quantitative literacy course? And, how satisfied are they with student performance and academic success? The answers to these questions are found in the structural frame findings in Chapter V. There were numerous goals for QL with little consensus. Yet, there was a general satisfaction with the current curriculum but with little data to support those opinions.

The final subquestion was: What do they believe hinders curricular change and how do they think changes, if any, should be made in the future? This is directly related to the primary research question: What hinders curricular change in general education mathematics at LPU? Using the four frames, 12 barriers to curricular change were found in the data and discussed above. The barriers were arranged into interconnected clusters and recommendations for removing the barriers are discussed below.

Recommendations

Curricular reform from within the Mathematics Department is not likely in the near future without removing barriers and without encouraging a clarification of goals and an exploration of alternatives. Based on the analysis above, I have made the following recommendations for action from the perspective of the Senior Vice President of Academic Affairs. The recommendations are informed by the four frames of Bolman and Deal (2008). Regarding organizational change and reframing, the authors stated:

The human resource view focuses on needs, skills, and participation, the structural approach on alignment and clarity, the political lens on conflict and arenas, and the symbolic frame on loss of meaning and the importance of creating new symbols and ways. (p. 378)

Bolman and Deal (2008) gave general strategies for reframing organizational change. For example, the structural frame strategies typically are “communicating, realigning, and renegotiating formal patterns and policies (p. 379).” For the symbolic frame, the strategies include: “create transition rituals; mourn the past, celebrate the future (p. 379).” The essential strategy for the political frame is to “create arenas where issues can be renegotiated and new coalitions formed (p. 379).” Finally, the human resource frame strategies include: “training to develop new skills; participation and involvement; psychological support” (p. 379).

The recommendations are grouped by the four barrier clusters. Each recommendation has an action and a rationale. Key reframing strategies are indicated in brackets.

Goal Cluster Recommendations

The primary expectations from the goal cluster are to achieve clarity on the philosophical basis and purpose of QL and to use a more rational approach to designing a QL curriculum, while paying close attention to closely-held beliefs of the math faculty. The barriers addressed in this cluster refer to vague goals, faculty beliefs in the traditional model, and reinforcement of those beliefs by the state system and their own annual celebration. The recommendations use primarily structural and symbolic perspectives, but not exclusively as seen below.

- State system:
 - Action: Approach the state's Higher Education Commissioner about whether or not support could be granted to (a) alternative QL courses, (b) a rethinking of QL within the state system, and/or (c) letting LPU be the lead in testing some alternatives.
 - Rationale: This could help eliminate the barrier of the state requirements and a fatalistic belief by some math faculty that they cannot change the curriculum, even if they want to. The state would no longer serve as a reinforcement of traditional beliefs. If the state system sanctioned an exploration of change by LPU, the faculty could take some pride in leading the way. [creating new meaning, celebrating the future—symbolic] The political climate with recent legislative concerns would favor the State Commissioner of Higher Education looking for QL alternatives, which is already the case with the Complete College America

initiative. [realigning and renegotiating—structural]

- Foundational purpose:
 - Action: Give a charge to the LPU General Education Committee (or a separate QL-across-the-curriculum committee) to establish a foundational purpose for QL.
 - Rationale: Critical to the structural frame is having a clear goal that everyone understands and the faculty can support. The work of Kliebard (2004) or some other model could be helpful in seeing different perspectives. This needs to be an interdisciplinary campus discussion perhaps well-suited for the LPU General Education Committee. [Create an arena where issues can be renegotiated and new coalitions formed—political; participation and involvement, training—human resources] QL versus mathematics will need to be addressed. Bringing in a faculty member from an institution using a non-traditional curriculum may be helpful, perhaps someone affiliated with the MAA or NNN. For Rogers (2003) this would be facilitating external communication with others who have innovative ideas. [Creating new meaning—symbolic; realigning and renegotiating—structural]
- Outcomes and assessment:
 - Action: With a foundational purpose in hand, establish student learning outcomes for QL and design an appropriate curriculum and an assessment plan.

- Rationale: This should include a reexamining of the quantitative reasoning outcome that is currently a subset of Intellectual and Practical Skills, which is one of six areas of general education outcomes at LPU. Based on those outcomes, a practical and authentic assessment plan can be developed. The adequacy of current QL courses should be addressed and changes or new courses should be proposed. [Create an arena where issues can be renegotiated and new coalitions formed—political; participation and involvement—human resources; realigning and renegotiating—structural]
- Math Week:
 - Action: Rebrand Math Week as QL Week.
 - Rationale: A lot of work and planning goes into Math Week and that good work needs to be honored. However, it could be rebranded with an interdisciplinary QL perspective and the tradition could continue. [Create transition rituals and celebrate the future—symbolic]

Control Cluster Recommendations

The primary expectations from the control cluster are to clarify and establish ownership over the QL program. The barriers addressed in this cluster are related to a lack of ownership over QL by the Math Department, despite their total control over the curriculum and their lack of knowledge of the national conversations. The recommendations use primarily the structural and political perspectives.

- Ownership:

- Action: Decide who owns QL and is responsible for the curriculum and its assessment. For faculty, expect scholarship and service in this area. There are at least three choices: (a) solely under the purview of the Mathematics Department, as is the case now; (b) solely under the purview of the Developmental Mathematics Department (their degrees are generally more broad than faculty in Mathematics; e.g., mathematics education, mathematics, engineering, education, and applied mathematics), or (c) an interdisciplinary group of faculty with the Math or Developmental Math Department as the lead.
- Rationale: Again, this necessitates a mathematics versus QL debate and hinges on the results of the Goal Cluster recommendations above. QL is part of general education and therefore even those without mathematics degrees can have pertinent ideas and input. Administrators should be able to follow the logic of the curriculum design and assessment; it should not be just a “math thing.” [Create an arena where issues can be renegotiated and new coalitions formed—political; participation and involvement—human resources; realigning and renegotiating—structural]
- Support:
 - Action: Provide resources, support, and rewards for faculty professional development in QL, as well as recruiting for QL expertise in filling future faculty positions.
 - Rationale: QL can be seen as its own discipline and requires expertise in

this area. The specific actions in this recommendation could include funding for membership and travel for national/international organizations with QL interests; e.g., Mathematical Association of America, the National Numeracy Network, American Mathematical Association of Two-Year Colleges, and Adults Learning Mathematics. [Training to develop new skills—human resources; alignment and clarity—structural; create an arena where issues can be renegotiated and new coalitions formed—political]

Quality Cluster Recommendations

The primary purpose of the quality cluster is to address the issue of rigor which, although undefined, becomes one of the major barriers to any proposed changes at LPU. The recommendations use primarily the structural, symbolic, and political frames.

- Rigor:
 - Action: Define rigor and academic quality broadly, using an interdisciplinary committee of faculty and administrators at LPU.
 - Rationale: One of LPU’s core themes, based on its mission, is “Serious.” That core theme provides a basis for a campus-wide discussion of academic quality and rigor. A QL curriculum that is rigorous needs to meet LPU’s definition of rigor. [Create an arena where issues can be renegotiated and new coalitions formed—political; participation and involvement—human resources; realigning, and renegotiating formal policies—structural]

- QL Program:
 - Action: Establish QL as a program (rather than just a core course requirement) and provide reassigned time to faculty for curriculum development and assessment.
 - Rationale: QL currently is just students taking a math course. As a program, QL would take on more importance as it relates to general education and possibly as QL across the curriculum. LPU can take the lead in the state system by setting an example with QL as a way to show professional expertise and continue to have good standing with peers from the other state institutions. [Realigning and renegotiating—structural; create arenas where issues can be renegotiated and new coalitions formed—political]

Communication Cluster Recommendations

The primary expectation from the communication cluster is to facilitate communication, which the lack of has hindered potential change efforts in the past. Communication issues, along with a harsh culture in the Math Department, have interfered with dialog and decision-making. The situation is improving but there are still some lingering problems. The recommendations use primarily structural and human resource perspectives.

- Procedures:
 - Action: Ensure, through the dean and the department chair, that the Mathematics Department develops voting procedures, keeps accurate

meeting minutes, and renews a commitment to communicate often and effectively.

- Rationale: This action will help prevent some of the miscommunication of the past. [Communicating—structural]
- Communication:
 - Action: Provide a neutral facilitator, if needed by the Mathematics Department, to even out participation among the faculty.
 - Rationale: There are some dominant personalities, particularly in two factions within the department. A facilitator from time to time could help when there is a potential for contentious discussion. A trained facilitator could provide some ideas to the department chair in facilitating discussions. [Communicating and renegotiating formal patterns—structural; training to develop new skills, participation and involvement—human resources]

Overall Strategies

The recommendations above are meant to help counteract barriers to curricular change through four main strategies. The first is to get clarity on QL. What is it? How well does LPU facilitate student QL? Can LPU design a more intentional curriculum based on students' needs? Who is responsible for it? How should it be assessed? Does LPU have the state's backing? The second strategy is to challenge, yet recognize, the role and beliefs of the Mathematics Department in answering those questions. General education mathematics should be a concern of all departments, and, therefore there needs

to be an interdisciplinary effort in improving current practices. Institutional expertise in QL is required for LPU to be more connected with national efforts and any innovative models at other institutions. The third strategy is to work towards what faculty and administrators both want, and that is to provide students with a high quality learning experience by defining quality and assessing it. Finally, the fourth strategy is to facilitate good communication to improve clarity, improve participation, and allow for the open and regular discussion of new ideas and innovations.

The initiation of the recommendations could be problematic if the Mathematics Department sees this as a potential threat. There are some noticeable inconsistencies though that can be seen in the findings that the faculty can recognize. For example, College Algebra is pre-calculus but two participants admitted that not all of the topics are needed for calculus. The problem still exists that many majors require 1050 despite not needing calculus; in addition, a potentially good 1030 course is underutilized. Several believe that there is still too much content in 1050. So, it seems that the math faculty themselves see some of these issues as problematic and that may help convince them that it is worth an effort to consider some changes.

Once the process is initiated, it cannot turn into the Math Task Force of 2005. The validity of the curriculum was never even addressed. The recommendations above must be carried out with a directness that challenges faculty beliefs and, working with faculty, leads to a more effective and intentional curriculum.

Importance

It is certainly easier for administrators to wash their hands of the issues and allow

the status quo to continue. They can simply say that the mathematics faculty are in charge of the curriculum—end of story. On the other hand, the Senior Vice President of Academic Affairs will certainly have some opposition if he tries to follow through on the recommendations. Is the pain worth the gain? I would answer that with a resounding, “Yes!” Approximately 1,000 LPU students each semester take MATH 1050 as a terminal math course. Many are unsuccessful; many will have to repeat the course if they have the will to persevere; some will give up on getting a degree. I suspect many will learn to hate math even more than they did before and will tell their children not to worry if they are not good at math—it is not in their genes. It really can be a matter of hurting generations of students. Meanwhile there is much truly beautiful, relevant math that these students are not learning.

For those students who succeed in passing a QL course, is it really a success? Do they have QL? Can they reason quantitatively? LPU cannot even answer these questions right now. In fact, one can argue that there really is no QL program at LPU; there is just a required math course. This study showed that the math faculty believed there were inherent benefits from a math course. Most of the participants believed that an essentially 200-year-old math course would improve critical thinking as it supposedly has done over the decades. I can argue just the opposite when the focus of the LPU MATH courses was on memorizing rules and procedures to solve contrived “real world” problems with exactly one correct answer.

The following comment by Steen (2004) seemed to fit LPU’s situation perfectly, as discovered in this study: “Only rarely is QL thoughtfully integrated into general

education, in part because QL is not a central priority for any discipline and general education is rarely a central priority for mathematics departments” (p. 31). The result is that students are required to take a math course and the QL box gets checked off. LPU has a chance to change that if the administration has the will and if faculty from all of the departments are willing to engage in building an intentional, interdisciplinary QL program.

Final Thoughts

I found that the conceptual framework worked well for this study of a rather complex situation. Rogers’ (2003) innovation-decision model was helpful as a change model for this study. It helped provide a way to identify the ways in which barriers block innovative change in higher education. I believe that the Bolman and Deal’s (2008) four frames proved necessary to capture the various perspectives and provide a more holistic understanding. In talking with Dylan recently, I learned that he was lamenting that the whole situation with QL and the Math Department did not make any logical sense, especially from a department that should have some of the best critical thinkers by their own estimation, given their math backgrounds. Dylan, an engineer by training, was looking at the problems from a strictly rational viewpoint characterized by the structural frame. I was able to explain the other sides of the issues, including that faculty beliefs in tradition seem to trump rationality, as can be seen through the symbolic lens. Future researchers in higher education change should consider using a reframing approach.

The interviews seemed to work well with faculty members being very frank. In

my opinion, that was in part due to the opening question on their earliest recollections of doing or learning any kind of math. Their remembrances were delightful to hear and they seemed genuinely pleased to talk about them. It was an excellent ice breaker and helped them to open up when it came to the other questions.

The situation at LPU is unique in many respects and the findings and analysis from this study are not meant to generalize about other institutions. However, LPU is certainly not the only institution in the US with QL issues. Many colleges and universities continue to rely on College Algebra as a QL course. There is a mystique about College Algebra that is hard to fight. It is hoped that this study may encourage other institutions to take a look at their own QL programs, remembering to consider not just a rational approach to reform but to include consideration of the people involved, their beliefs, and the existing power structures.

I want to end with the story of a student in one of my MAT 1010 classes this semester. I will refer to her as Susan. She is a senior majoring in Behavioral Science. Susan is a nontraditional, international student. She will walk at graduation at the end of the semester but will still have to take her QL course this summer. She readily admits that she put off her math and should have taken it earlier. However, she did successfully take a 3000-level (junior year) Statistics for the Behavioral Sciences course and the follow-on Research Methods course. I would submit that she has as much QL as LPU expects from any other student under the current curriculum. But Statistics for the Behavioral Sciences is a BESC-prefix course, not a MATH designated course and only MATH courses can be QL courses. She must take MATH 1040, Introduction to Statistics, which includes many

of the same topics she has already had in her major's statistics course. But, since she had not taken math in a while she had to take MAT 990, Beginning Algebra, the previous semester and MAT 1010, Intermediate Algebra, this semester in order to get into MATH 1040, which does not even require much of what she is learning in 1010. Dylan is right: it does not make any sense. LPU is doing Susan a disservice. LPU can and should do better for all students.

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APPENDICES

Appendix A

Interview Questions for Faculty and Administrators from Mathematics
and Developmental Mathematics

Interview Questions

Faculty and Administrators from mathematics and developmental mathematics

1. Tell me about your math biography. When do you remember first encountering math and what was your math experience through school and your undergraduate and postgraduate studies?
2. Do you recall any major curricular changes within the mathematics department since you have been at the university? If so, how were the decisions made? What factors would you say were important?
3. In your opinion, what is the purpose of a first-year, quantitative literacy course? Describe to what extent you believe MATH 1030, 1040, and 1050 satisfy that purpose?
4. How satisfied are you with the level of mathematics skills and conceptual knowledge that your students have received when they come to your program from MATH 1030, 1040, or 1050?
5. How aware are you of recommendations by national organizations (MAA, AMATYC, NCTM) for teaching mathematics? Do you agree or disagree with what you know about the recommendations? Why?
6. How aware are you of the literature on quantitative literacy?
7. How aware are you of reforms that other institutions have made in teaching general education mathematics? Do you see any advantages or disadvantages for making similar reforms here?
8. How would you describe the willingness and the ability of the mathematics department, as a whole, to consider making any type of change? curricular change? How willing are you and why?
9. What changes, if any, would you like to see in the general education mathematics curriculum? To what extent do you believe others agree with you? Are you personally involved in any change initiatives now?
10. How do you see the relationships between faculty and administrators regarding curriculum issues? between faculty of different departments? between administrators from various areas and levels throughout campus?
11. In your opinion, what are the barriers to curricular change?
12. Is there anyone that you would recommend that I interview?

13. Is there anything else you would like to add?

Table A1

Rationale for Questions for Faculty and Administrators from Mathematics and Developmental Mathematics

Question	Rationale
1	A warm-up, non-threatening question to start the conversation. There may be interesting information here regarding an individual's philosophy of mathematics and/or education. This may have a bearing on how they see the curriculum "problem" which is addressed later.
2	Helps with context and whether or not there has been success with change in the past, which could inform the present situation.
3	Kliebard's work shows the importance of how one views the purposes of education. This may be a factor in how satisfied the interviewee is with the current curriculum.
4	Both the Lit Review (summary p. 23) and Rogers' model indicate the importance of a common understanding of any perceived problems.
5, 6, 7	Both the Lit Review (summary p. 23) and Rogers' model indicate the importance of knowing about the latest recommendations and alternatives.
8	Innovativeness is a factor in Rogers' model.
9	As with question #4, both the Lit Review (summary p. 23) and Rogers' model indicate the importance of a common understanding of any perceived problems.
10	The lit review (summary p. 23) speaks to the importance of cooperation. Complexity thinking would indicate that the nature of the relationships is important.
11	While the other questions may lead to barriers, this is directly asking.
12	As noted in the proposal, this is asked per the interview strategy (network sampling), plus seeking those with different opinions than mine and others I have interviewed (triangulation and negative case example).
13	This is a nice way to end where the interviewee can add any comments.

Appendix B
Interview Questions for Faculty and Administrators Serving in
Key Educational Positions

Interview Questions

Faculty and Administrators serving in key educational positions

1. Tell me about your math biography. When do you remember first encountering math and what was your math experience through school and your undergraduate and postgraduate studies?
2. How satisfied are you with the level of mathematics skills and conceptual knowledge of graduates?
3. In your opinion, what is the purpose of a first-year, quantitative literacy course? Describe to what extent you believe MATH 1030, 1040, and 1050 satisfy that purpose?
4. On what basis should programs pick the QL course which will be required?
5. What changes, if any, would you like to see in the general education mathematics curriculum?
6. How do you see the relationships between faculty and administrators regarding curriculum issues? between faculty of different departments? between administrators from various areas and levels throughout campus?
7. If you wanted to see changes, what barriers would there be, in your opinion? How should the curriculum change process work? Who decides if changes are to be made?
8. Is there anyone that you would recommend that I interview?
9. Is there anything else you would like to add?

Table B1

Rationale for Questions to Faculty and Administrators Serving in Key Educational Positions

Question	Rationale
1	A warm-up, nonthreatening question to start the conversation. There may be interesting information here regarding an individual's philosophy of mathematics and/or education. This may have a bearing on how they see the curriculum "problem" which is addressed later.
2, 5	Both the Lit Review and Rogers' model indicate the importance of a common understanding of any perceived problems.
3, 4	Kliebard's work shows the importance of how one views the purposes of education. This may be a factor in how satisfied the interviewee is with the current curriculum.
6	The lit review speaks to the importance of cooperation. Complexity thinking would indicate that the nature of the relationships is important.
7	While the other questions may lead to barriers, this is directly asking.
8	As noted in the proposal, this is asked per the interview strategy (network sampling), plus seeking those with different opinions than mine and others I have interviewed (triangulation and negative case example).
9	This is a nice way to end where the interviewee can add any comments.

Appendix C

Comparison of Catalog Topics for College Algebra

Table C1

Comparison of Catalog Topics for College Algebra

Institutions	Content		
	Functions	Matrices	Other
Institution A (research)	Functions, inverses and graphs; polynomial, rational, radical, exponential and logarithmic functions.	Systems of equations and matrices.	Arithmetic and geometric sequences and series.
Institution B (research)	Functions: graphs, transformations, combinations, and inverses. Polynomial, rational, exponential, logarithmic functions.	Systems of equations and matrices.	Arithmetic and geometric sequences. Partial fractions.
LPU (teaching)	Inequalities, functions and their graphs, polynomial and rational functions, exponential and logarithmic functions.	Systems of linear and nonlinear equations, matrices and Determinants.	Arithmetic and geometric sequences. Conic sections. Binomial Theorem. <i>[dropped in 2011: mathematical induction, permutations and combinations, and introduction to probability]</i>
Institution C (teaching)	Absolute value, polynomial and rational inequalities, and nonlinear systems, polynomial, rational, exponential and logarithmic functions, equations.	Matrices, matrix algebra and inverses, determinants.	Sequences and series, counting techniques. Rational zero and binomial theorems [briefly]. Introduction to probability [briefly]. Finance [briefly]. Mathematical induction [briefly].
Institution D (teaching)	Explores the concept of functions: polynomial, rational, inverse, logarithmic and exponential; with an emphasis on graphing.	Solving systems of equations using matrix methods.	Sequences [may include]. Conic sections. Binomial theorem [may include].
Institution E ¹ (teaching)	Reviews fundamental algebra; explores polynomial and rational functions; introduces exp. and logarithmic functions.		Trigonometric functions dealing with graphs, identities, and equations, including inverse functions.
Institution F ² (teaching)	Polynomial, rational, exponential, and logarithmic functions.	Matrices;	Sequences and series. Conics. Mathematical induction.

¹ College Algebra/Pre-Calculus² Course may be taught with a Service Learning component.

Appendix D

Comparison of College Algebra Textbooks

Table D1

Comparison of College Algebra Textbooks

New University Algebra Robinson (1862) ¹	College Algebra Davis (1942) ²	College Algebra ³ Stewart, Redlin, Watson (2009)
I. Definitions & notation. Entire Quantities. includes operations for polynomials Fractions [rational expressions].	I. Preliminary Topics (<u>review</u>) includes purpose/history of algebra, elementary operations, polynomials	P. Prerequisites (<u>review</u>) real numbers, exponents, radicals, factoring, rational expressions
II. Simple Equations includes linear equations of one variable, systems of equations with 2 or more variables	II. Process of Algebra (<u>review</u>) includes simplifying equations, factoring, fractions (rational expressions)	1. Equations & Inequalities (<u>review</u>) includes linear and quadratic equations, complex numbers
III. Powers and Roots includes polynomials, nth roots	III. Laws of Exponents and Logarithms (<u>review</u>)	2. Coordinates & Graphs (<u>review</u>)
IV. Radical Quantities includes radical operations, imaginary quantities, rationalization, radical equations	IV. Arithmetic and Geometrical Progressions	3. Functions
V. Quadratic Equations	V. Functional Relationships— The Equation	4. Polynomial and Rational Functions
VI. Proportion, Permutations, & Combinations.	VI. The Linear Function— Linear Equations	5. Exponential & Logarithmic Functions
VII. Of Series includes Binomial Theorem, decomposition of rational fractions, logarithms, exponential equations	VII. Quadratic Equations—The Quadratic Function	6. Systems of Equations & Inequalities
VIII. Properties of Equations. includes division of polynomials, synthetic division, Rule of Des Cartes	VIII. The Binomial Theorem— Mathematical Induction	7. Matrices & Determinants
IX. Solution of Numerical Equations of Higher Degrees includes limits of real roots, Sturm's Theorem, Horner's Method	IX. The Theory of Investment	8. Conic Sections
	X. Permutations and Combinations—Probability	9. Sequences & Series 9.4, mathematics of finance & 9.5, mathematical induction <u>optional</u> at UVU
	XI. The Theory of Proportion— The Ratios of Trigonometry	10. Counting & Probability <u>optional</u> at UVU
	XII. Complex Numbers	
	XIII. The Theory of Equations	
	XIV. Determinants	
	XV. Inequalities	
	XVI. Infinite Series	
	XVIII. Special Topics (<u>optional</u>)	
	XIX. Mathematical Recreations (<u>optional</u>)	
	XX. The Meaning of Mathematics (<u>optional</u>)	

¹ Title page indicates the book is “for Colleges and High Schools.”

² “This text on College Algebra presents in the first sixteen chapters the material usually treated in a first course in American colleges and universities.” (p. v)

³ Used by UVU for lecture classes during 2012-2013.

Appendix E

Codebook

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
Change	Barriers	1. Restricted to following state system guidelines	Alan (12) Amanda (101)	Malcolm (1,7,8,70)	Dan (67)
		2. Desire to be respectable (institutional peer pressure)	Alex (91) Austin (93)	Malcolm (20,98) Michael (37) Matt (86)	
		3. Strong department demand for 1050 and there are already two options, 1030 and 1040	Ann (5) Alissa (55) Austin (74,78)	Malcolm (3,18,89) Michael (42) Matt (76) Melissa (77,80,88)	Dylan (111)
		4. No consensus or recognition of a problem	Alex (92) Ann (16,94) Austin (27)	Malcolm (4,13,73) Matt (31) Michael (32) Melissa (57)	Dylan (110) Debra (22)
		5. 1030, 1040, 1050 serve important purposes		Malcolm (nc 2, nc 87) Melissa (nc 20a)	
		6. Faculty unaware or dismissive of national recommendations		Malcolm (8) Matt (nc 23)	Debra (nc 6,26) Dan (69,84) Dylan (nc 14,107)
		7. Faculty do not know practical, relevant QL			Dylan (105,110)
		8. Attitude of Math Dept faculty; intransigence; fear of change; culture of academia	Alex (15,30,82, 87, 90,96) Andrew (102,103, 104)		Dylan (110) Dan (62,63,99)
		9. Faculty need to change minds	Amanda (100)		Debra (21,43)
		10. No system for reviewing curriculum			Malcolm (13) Melissa (41)

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		11. No ownership of curriculum		Melissa (54)	
		12. Wrong faculty were assigned to help with 1020 proposal			Dan (50)
		13. Tradition; inertia	Austin (6,47) Amanda (100,101)		Dan (59) Dylan (106)
		14. Faculty workload		Michael (24)	
		15. Bureaucracy and curriculum process	Alisa (79)		Dan (99)
		16. Dean leaves curriculum to the department	Austin (39,78) Alisa(52,54,85)	Malcolm (7)	Dan (60)
		17. Curriculum already “weakened,” do not want to weaken further	Alan (23) Alex (90)	Malcolm (10,11,14) Michael (17) Melissa (51,80,83)	Debra (28,29) Dan (58,65)
		18. Textbooks drive curriculum	Amanda (nc 73)		Debra (21,43)
		19. Communication			Debra (33) Dan (49,53)
		20. Not worth it for given potential wrath of some in the dept	Austin (48)	Melissa (44,56)	
		21. Having a general education course solidifies role in institution (therefore changing QL to Dev Math Dept not acceptable)	Alex (75)		
	Need for change	22. Build curriculum from what students actually need; much of the current content is not relevant	Alex (15,16) Austin (37,40,46) Andrew (70)	Malcolm (10,32,51,57, 75) Matt (23,66,72) Michael (89)	Dylan (7,41,56, 58,59,60) Dan (11,12,24,30)
		23. Why algebra? Calculus or other topics important	Austin (38,55)		Dan (4) Dylan (31,81)
		24. 1050 has too much content; university seems to have something to prove	Amanda (25) Alex (74)	Matt (45, 49, 66,68,76) Michael (89)	Dan (69)

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		25. Some content in 1050 not needed		Malcolm (5) Matt (67) Matt (77)	
		26. 1050 not aligned with Calculus			
		27. Not aligned with K-12	Alex (18)		
		28. Pioneers need to step up and promote change	Amanda (1)		
		29. Change is needed or this generation of students are spoiled	Alan (3,27,36)		
		30. Too much focus on procedures and "little things;" more problem solving, analysis, and use of technology	Alan (43)	Matt (39)	Dylan (7,8)
		31. Lack of consistency with other state institutions on content, courses, and use of calculators	Andrew (13,64) Austin (79)		
		32. 1050 is not a college course			Dylan (81)
		33. 1050 is required by most majors but not needed by some	Alan (27) Austin (50,52,54) Alan (44)	Malcolm (75)	Debra (63) Dylan (84)
		34. 1030 is not really QL			
		35. 1030 is best QL course		Matt (65) Malcolm (87)	Debra (53, 63)
		36. 1040 not as effective as QL course	Andrew (70)		Dan (26)
		37. 1030, 1040, 1050 not inherently good		Malcolm (86a)	
		38. university's math has a negative reputation	Alex (29)		
		39. Attitude of math faculty (not necessarily curriculum) needs to change	Alex (33,47,71)		
		40. Data shows 1050 students not learning at the 1050 level			Dylan (48,82)
		41. QL courses are seen by students as just a hoop to jump through			Debra (61) Dylan (62)
		42. Curriculum has not significantly changed - ever	Alex (80)		
		43. Most changes minor to include number of credits and prereqs		Malcolm (6)	Dan (3) Debra (9)
		44. Discrete math course added - taking 10 years to do		Matt (5)	

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		45. Successful combo 1010/1050 course through Complete College Utah initiative		Melissa (7)	
		46. Calculator policy change		Malcolm (100)	
		47. Additional emphases for math major; stats degree next year		Malcolm (12)	
		48. Faculty continually assessing and communicating	Ann (3)	Matt (16)	Debra (11)
		49. Time for faculty to get comfortable with a potential change			Dylan (4)
		50. Attendance at conferences; reading of journals	Amanda (5)		
		51. Openness to try a change			
		52. Responsive and flexible curriculum process	Alisa (12)		Debra (10)
		53. Push from the General Education committee	Ann (13)		
		54. Grants; resources			Debra (15)
		55. Administrators want give and take but faculty do not want to give anymore than they have (with 1030,1040)		Michael (5) Melissa (b51)	
		56. Administrators want what is best for the bottom line, not necessarily what is best for students in this case			Debra (13,17)
		57. Math dept is rigid and elitist; UVU math has a bad reputation	Andrew (64,66, 68,70,72)	Michael (15)	
		58. 1050 is the "smart" QL class	Amanda (61) Andrew (65)		
		59. Curriculum is based on personal biases; process is not systematic	Andrew (73)		Dylan (74)
		60. Algebra is the problem, not mathematics			Dylan (75)
		61. 1050 is pre-calc, not College Algebra	Andrew (63)		
		62. QL is minimal mathematical competency		Malcolm (2)	
		63. Many students are able to see math all around them after taking 1050; only anecdotal evidence of effectiveness	Amanda (60) Andrew (69)	Melissa (9)	
		64. QL is embedded in learning math			Debra (12)
Symbolic	Beliefs				

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		65. Rigor is learning new material in a way that allows student to build upon it	Austin (1)		
		66. Rigor does not mean doing double-hard problems	Austin (1,6)		
		67. Rigor means complexity, not amount; more steps, challenge where you have to show dedication to get through	Alan (b2, b9)		
		68. Algebra does not equate to rigor			Dan (8)
		69. state Tuning project			Dylan (1,9) Dan (4)
		70. 1030 was initially sabotaged; 1050 is king	Austin (10)	Melissa (3,6)	
		71. faculty teach what they want to, regardless of any stated curriculum	Austin (8)		
		72. Administratively play the game in terms of potential changes; token efforts, minor changes		Malcolm (14)	Dan (13)
		73. Math Task Force		Malcolm (15)	
		74. Culture in the math dept was such that faculty were afraid to speak up			
		75. Math faculty are the keepers of academic quality	Alex (1)		
		76. Rigor		Melissa (4)	
		77. Power exerted by one of the early math dept chairs		Melissa (34,46)	
		78. Administrators exert power in other areas rather than with the curriculum	Alisa (12) Ann (14) Alex (27,35)	Michael (15)	
		79. Hard to say "no" to administration		Michael (15,36)	
		80. Math dept solidifies role at university with Gen Ed course	Alex (13)		
		81. Administration must convince faculty on curriculum changes; be collaborative	Alisa (16) Andrew (20) Austin (26)		
		82. PhD vs. Masters		Melissa (40,42)	Dan (17)
		83. Degrees in mathematics vs. other	Austin (18,19,21)	Melissa (47)	Dan (b60)
Political					

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		84. Tier 1 institutions vs. others	Austin (41)	Malcolm (24, 28) Melissa (45) Malcolm (25)	
		85. State math majors committee			
		86. People with connections	Austin (41)	Melissa (31,38)	
		87. Tenured vs. lecturer		Melissa (40)	
	Decision Making	88. Must coordinate with state math majors committee; administrators can support state system changes	Alisa (5)	Malcolm (3)	
		89. Math Dept: idea-discussion-vote; need core nucleus and then majority; who votes?	Ann (20)	Malcolm (1,22) Melissa (14)	Dylan (32, 33) Dan (36, 37,38)
		90. Endless dialogue is necessary	Alisa (7)		
		91. Perception of political decisions		Melissa (9)	
		92. In the past, one person made all decisions		Melissa (11,13)	
		93. Decisions based on textbooks			Dylan (15)
		94. Some decisions not made due to vocal dissent		Melissa (16)	
		95. Sometimes consensus rather than vote		Melissa (17)	
		96. Indecisiveness		Michael (26)	
		97. Administrators want give and take but harder for faculty		Michael (30)	
		98. Decision on calculator policy to prevent those with disabilities from using them		Malcolm (43)	
	Control of meanings	99. "weakening" of 1010		Malcolm (1)	
		100. "water down"		Melissa (2)	
		101. "dumbing down"			
	Control from Top	102. Administrators choose not to be involved; academic freedom	Austin (1,2,20) Alex (10,16) Andrew (21,24)	Malcolm (5,6)	Debra (3,5)

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		103. Administrators can orchestrate structures and give money to initiatives, perhaps to no avail; try to influence; dialog	Andrew (3,21,24) Alisa (12,13) Amanda (30)	Malcolm (5)	
		104. Administrative and legislative pressure			Dan (4)
		105. Shared governance but want administrator to step in	Austin (20)		Dylan (7,23)
		106. Administrators do have some power		Malcolm (8) Michael (25)	
		107. Administrators have made decisions on other than curriculum	Alisa (13) Amanda (27)	Michael (25, 26)	Dan (14,15,18)
		108. Some administrators characterized as only caring about the bottom line		Melissa (17,29)	
		109. Great leaders at the institution now			Dylan (22)
	Bottom-up Change	110. Dean leaves curriculum up to faculty who know the discipline	Alisa (7)	Malcolm (1)	
		111. Advising could provide feedback on students questioning 1050 as required - but would not be listened to	Alan (2)		
		112. Transfer articulation decisions made by dept		Melissa (4)	
		113. Dev math dept has attempted working around math dept			Dan (5)
Human Resources	Norms	114. Chip on their shoulder; harsh culture; retaliation	Andrew (4)	Michael (2)	
		115. One person used to make all decisions		Melissa (5)	
		116. Split department		Malcolm (9)	
		117. Strong vocal contingent who advocate for algebra	Austin (8)		Dan (3)
	Interper-sonal	118. Tension; faculty member sued chair and dean, another sued; grievance		Melissa (16,19)	
		119. Getting better			
		120. It matters who is chair	Austin (11,12)		
				Melissa (3)	

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)	
Structural	Human Needs	121. One faculty member in particular has been a problem, could make life miserable; bully	Austin, (12)	Melissa (4,19)		
		122. Several strong personalities; stubbornness	Austin (8,9)	Michael (2)		
		123. Faculty time to teach, research, and give service		Malcolm (1)		
		124. Hates coordinating with people		Malcolm (5)	Debra (23)	
		125. No notes at math dept meetings		Melissa (2,7)	Dan (20,26)	
		126. No interim reports from 1020 committee		Malcolm (3,22)	Dan (13)	
		127. False consensus		Melissa (25)	Dan (6)	
		128. Depends on dean-chair relationship	Alisa (9,14)	Malcolm (8,16)		
		129. Emails are not read			Debra (21,23)	
		130. Lack of communications			Dan (20)	
	Goals		131. Students to learn hard work, perseverance, and learn to learn	Ann (1,43,45,96) Alan (41)		
			132. 1030: useful, interesting		Michael (10) Matt (93)	
			133. 1030: Gives a chance for less capable to get a degree		Matt (98) Malcolm (104)	
			134. 1040: applicable to many things in life	Alan (3,33)	Michael (2)	Debra (38)
	135. 1050: STEM prep; math majors; pre-calc	Alan (28) Austin (91) Andrew (26)	Matt (37) Michael (84, 85) Malcolm (100, 103)			
	136. 1050: not needed for pre-calc; some topics not needed		Malcolm (103)	Dan (22,77)		
	137. 1050: prep for GRE and grad school	Ann (42)				
	138. 1050: goals not consistent state-wide and nationally		Michael (81)	Debra (65) Dan (70,71,72)		
	139. 1050: goal is unknown			Dylan (r16)		
	140. 1050: Should have probability, induction (recently dropped)		Malcolm (103)			

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
		141. Reasoning/thinking skills, problem-solving, logic	Amanda (20,76) Alan (29,40) Austin (90) Ann (96) Andrew (27a)	Melissa (50,53) Matt (92)	Dylan (35) Dan (71) Debra (55,58,59, 60)
		142. Brain development	Austin (90)		
		143. Knowing how everything fits together	Amanda (20)	Melissa (50)	Dan (23,24) Debra (109)
		144. See patterns		Melissa (52,54) Matt (92)	
		145. Number sense, estimating, interpreting data		Malcolm (99)	Dan (69,70) Dylan (108)
		146. Fractions, percents, decimals	Amanda (78)		
		147. Less content, more conceptual	Alisa (13)	Matt (18,48)	Dylan (35)
		148. Skills will be forgotten	Alan (16)	Matt (17) Melissa (54)	
		149. Practical life skills	Amanda (24,25, 75,76) Ann (45) Alisa (79)	Michael (14,27, 30) Melissa (50) Malcolm (99) Matt (106)	Dan (21, 74) Debra (51)
		150. Open students minds to new things	Amanda (24)		
		151. Job/Career skills	Amanda (24) Andrew (31)	Michael (27)	
		152. A hoop to jump through; weed out less capable students	Ann (42) Alan (44, se2)	Michael (r12)	Dylan (32, 39, 56, 61) Debra (65,68)
		153. Use technology			Dylan (35)
		154. Confidence			Debra (57)
		155. Should be built to students' need			Dylan (61,64)
		156. Both skills and conceptual understanding		Michael (80)	Debra (63,65)
		157. Rigorous non-algebra math can be just as good			Dan (71)
		158. What an educated person is expected to know		Malcolm (105)	

Category	Subcategory	Theme	Administrators/ Staff (7)	Mathematics Faculty (6)	Developmental Mathematics Faculty (3)
	Roles	159. Dept: Ensure quality curriculum and that what transfers is quality	Alex (1,2,4,6,14) Austin (5)	Melissa (8)	
		160. Faculty: Teach higher-level math	Alex (11) Austin (15)	Michael (3)	
		161. Administrators: Influence	Austin (5) Alex (6)		
		162. Dev Math dept: Prepare students for 1050			Dan (7)
		163. Students serve the math dept, should be other way around			Dylan (9)
		164. No ownership by faculty		Melissa (13)	
		165. Pressure, sometimes, from president to VP to dean to dept	Austin (3)	Malcolm (12)	
		166. Administration stays out of curriculum process	Ann (7)	Malcolm (14)	
		167. State has system-wide control	Alissa (8)	Malcolm (13)	
		168. Academic hierarchy		Melissa (11)	

CURRICULUM VITAE

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- Education
- Ph.D. (Curriculum and Instruction), 2014
Utah State University, Logan, UT
 - M.S. (Instructional & Performance Technology), 2000
Boise State University, Boise, ID
 - M.A. in Liberal Studies (Science emphasis), 1978
Wesleyan University, Middletown, CT
 - B. S. (Ocean Engineering option), 1974
U.S. Coast Guard Academy, New London, CT
- Teaching Experience
- Developmental Mathematics, Utah Valley University, 2007-present
 - Developmental Mathematics, Utah Valley State College, 2006-7 (adjunct)
 - General Chemistry, U.S. Coast Guard Academy, 1978-1982
 - Pre-calculus, U.S. Coast Guard Academy, summer 1978
- Employment History
- 2013 to present Associate Professor, Developmental Mathematics, Utah Valley University, Orem, UT
Teaches department courses and serves on various departmental and institutional-level committees.
 - 2009 to 2013 Assistant Professor, Developmental Mathematics, Utah Valley University, Orem, UT
Teaches department courses and serves on various departmental and institutional-level committees.
 - 2007 to 2009 Instructor, Developmental Mathematics, Utah Valley University, Orem, UT
Teaches department courses and serves on various departmental and institutional-level committees.

- 2009 to present Director of Institutional Effectiveness & Planning, Utah Valley University, Orem, UT
Responsible for facilitating the systematic evaluation of how well the institution accomplishes the mission, goals and intended student outcomes. Internal consultant for strategic planning and assessment. 50% release time basis.
- 2006 (Fall term) Developmental Mathematics Adjunct, Utah Valley State College, Orem, UT
Taught MAT 1010.
- 2006 to 2007 Director of Institutional Effectiveness, Utah Valley State College, Orem, UT
Responsible for facilitating the systematic evaluation of how well the institution accomplishes the mission, goals and intended student outcomes. Internal consultant for strategic planning and assessment.
- 2005 to 2006 Dean of Instruction for Computing, Mathematics, and Science, Spokane Falls Community College, Spokane, WA
Responsible for managing four departments: Computer Science/Information Systems, Math, Physical Sciences, and Life Sciences; 27 full-time faculty, 30 part-time faculty, three classified employees; and a \$3 million dollar budget. Duties include strategic planning, educational assessment and program evaluation, faculty evaluation and hiring, student issues, facilities issues, curricula changes, scheduling, etc. Served on the campus Curriculum Committee, the Strategic Planning and Institutional Effectiveness Committee, the Fiscal Committee, The Title III committee, Math Transition Committee, and the Institutional Teaching and Learning Improvement Coordinating (ITALIC) Committee.
- 2001 to 2005 Dean of Instruction for Business, Computing, Mathematics, & Science, Spokane Falls Community College, Spokane, WA
Responsible for managing seven departments: Computer Science/Information Systems, Math, Physical Sciences, and Life Sciences, Accounting/Economics, Management, Administrative Office Systems; 40 full-time faculty, over 30 part-time faculty, six classified employees, and a \$4 million budget. [Note: Campus reorganized and added a dean for the business programs in 2005.]
- 1974 to 2001 Served in the following positions with the U. S. Coast Guard:***
- 1998 to 2001 Chief Operating Officer, Training Center, Petaluma, CA
Responsible for entire Training Center operation including training, administration, budget, facilities maintenance, medical clinic support, and police/fire safety. More than 4,000 students

trained per year in various subjects including culinary arts, electronics, law enforcement, dental assisting, computer systems, etc. Staff of 360; \$8M budget.

- 1996 to 1998 Director, Distance Learning Center, Oklahoma City, OK
Responsible for operation of the Coast Guard's distance learning center (accredited by Distance Education and Training Council). Provided over 100 courses to 30,000 students - courses were approved by ACE for college credit. Managed the Coast Guard's "off-duty" education program for obtaining college degrees. Maintained library of audio-visual college-level courses. Staff of 30; \$800K operating budget.
- 1995 to 1996 Regional Director, Coast Guard Auxiliary (civilian volunteers) & Regional Civil Rights Specialist for District Office, Honolulu, HI
Responsible for Auxiliary program in Hawaii, Guam, and Saipan. Also responsible for the Civil Rights program (training, conflict resolution) in region.
- 1991 to 1995 Manager, International Policy/Operations, Coast Guard Headquarters, Washington, DC
Supervised international affairs staff of four. Served as primary point of contact within Headquarters for international policy issues and chaired the International Advisory Group.
Developed/implemented international strategic plan. Oversaw the Micronesian Training Program. Coordinated visits of international dignitaries. Conducted training needs assessments in Haiti, India, and Thailand.
- 1990 to 1991 Chief, Training & Performance Analysis, Coast Guard Headquarters, Washington, DC
Responsible for oversight of all training for the 12,000 member Coast Guard Reserve force. Approved all curricula. Planned for the development of a special emergency, temporary training center for Reserve units deployed during the Gulf War. Also, served as director of that training facility.
- 1987 to 1990 Director, Regional Training Teams, Pacific Area, Alameda, CA
Managed 25 instructors on six traveling teams providing skills and team training to 100 operating units in the Pacific region including the West Coast, Hawaii, Alaska, and Guam. \$500,000 operating budget.
- 1983 to 1987 Assistant Chief of Training & Educational Specialist, Training Center, Petaluma, CA
Supervised six technical training schools and 100 instructors.

Implemented instructional systems design methodology based on a student-centered, hands-on approach. Overcame obstacles and helped instructors realize the benefits of the new approach. Worked with subject-matter experts to revise curricula. Facilitated job-analysis panels to ensure that jobs were accurately described and that the curricula matched the job requirements. Established evaluation system.

- 1982 to 1983 Graduate Student, Human Resource Education, Boston Univ., Boston, MA
Received instruction to prepare for duties as an educational specialist.
- 1978 to 1982 Instructor (Chemistry), U.S. Coast Guard Academy New London, CT
Taught freshman Chemistry. One year as Assistant Dean of Academics (50% release time) and two years as Director of the Educational Media Center. As such, my duties included orientation training for new faculty. I also served on a faculty committee as part of the self-study for regional accreditation.
- 1974 to 1978 Various junior executive positions
Held several junior executive positions including communications officer on a ship, commanding officer of a patrol boat, and assistant branch chief on a district headquarters staff.

Publications

- Refereed Journal Articles
- Jorgensen, M. E. (2010). Questions for practice: Reflecting on developmental mathematics using 19th century voices. *Journal of Developmental Education*. 34(1), 26-35.
- Jorgensen, M. E. (2010). Suuroji puzzles: Sudoku-like logic with a twist. *MathAMATYC Educator*. 1(3), 18-23.
- Jorgensen, M. E. (1984). Effective and efficient use of classroom time. *Journal of Chemical Education*. 61, 523.
- Conference Proceedings
- Jorgensen, M. E. (in review). Using mathematics autobiographies to help students identify critical moments important to their success. *Conference Proceedings for the 20th Annual Conference of Adults learning Mathematics*.
- Jorgensen, M. E. (2011). Relevance as a bridge between college-preparation adults and the world. *Conference Proceedings for the 18th Annual Conference of Adults learning Mathematics*.

- Other publications
- Jorgensen, M. E. (2008). Have you been flossing? An analogy for educational program assessment. *Assessment Update*. 20(5), 9-10.
- Jorgensen, M. E. (2005). Quantity versus quality: Finding time for innovations in the classroom. *NISOD Innovation Abstracts*. XXVII, 1.
- Jorgensen, M. E. (1999). Why go to a trainer for non-training solutions? Eight reasons why trainers make good performance technologists. *Performance Improvement Journal*. 38(1), 20-24. [Article selected for inclusion in the American Society for Training and Development's 2000 *Handbook of Training and Performance*.]
- Jorgensen, M. E. (1987). We need 'born-again' trainers. *Performance and Instruction*. Dec/Jan issue. [Article addresses need for student-centered training; selected as a finalist for Article of the Year in the "how-to" category at the 1988 annual convention of the National Society for Performance Improvement.]
- Presentations
- Marcus Jorgensen**. "Using mathematics autobiographies to help students identify critical moments important to their success." Southwest Association of Developmental Education. South Jordan, UT. Oct. 2013.
- Marcus Jorgensen**. "Using mathematics autobiographies to help students identify critical moments important to their success." 20th Annual Conference of Adults learning Mathematics. Caerleon, Wales. July 2013.
- Marcus Jorgensen**. "Relevance as a bridge between college-preparation adults and the world." 18th Annual Conference of Adults learning Mathematics. Dublin, Ireland. June 2011.
- Marcus Jorgensen**. "Reflecting on Current Practice Using 19th Century Voices." American Mathematical Association of Two-Year Colleges. Boston, MA. Nov. 2010
- Marcus Jorgensen**. "Connecting with the Past: Lessons Learned from 19th-Century Textbooks." National Council of Teachers of Mathematics. San Diego, CA. Apr. 2010
- Marcus Jorgensen**. "Developmental Math: Building on a 19th Century Foundation." Poster Session. National Association of Developmental Education. Columbus, OH. Feb. 2010
- Marcus Jorgensen**. "Developmental Math: Building on a 19th Century Foundation." Southwest Association of Developmental Education. Las Cruces, NM, Nov. 2008

Marcus Jorgensen. “Accreditation: Don’t worry; be happy.” Assessment Institute annual conference. Indianapolis, IN, Nov. 2007.

Mark Bezzant, **Marcus Jorgensen**, Linda Makin, Cameron Martin, and Robert Loveridge. “Accreditation: Solid assessment.” Assessment Institute annual conference. Indianapolis, IN, Oct. 2006.

Ronni Hendel-Giller, Diane Gayeski, **Marcus Jorgensen**, and Don Winiecki “Webs of Learning: Student and Instructor Perspectives on Online Distance Education.” International Society for Performance Improvement annual conference. San Francisco, Apr. 2001.

Marcus Jorgensen. “Do You Have What It Takes to be a Performance Technologist?.” International Society for Performance Improvement annual conference. San Francisco, Apr. 2001.

Marcus Jorgensen. “Do You Have What It Takes to be a Human Performance Technologist?.” Poster session. International Society for Performance Improvement annual conference. Cincinnati, OH, Apr. 2000.

Awards

Trio Instructor of the Year Award, Utah Valley University, for the 2012-2013 academic year.

Faculty Excellence Award, University College, Utah Valley University, for the 2011-2012 academic year.

J.C. Penney Golden Rule Award and the Military Outstanding Volunteer Service Medal for outstanding support given to a disadvantaged elementary school in Oklahoma City (tutoring, student-of-the-month awards, playground & grounds maintenance).

Coast Guard Commendation Medal for service as Director of the Institute and, among other things, “employing a team approach to problem-solving ... in the deploying of the new centrally managed tuition assistance program delivering equal access to educational funds by all personnel....”

Coast Guard Commendation Medal as the head of a special temporary training detachment that was critical to the successful deployment of Reserve Forces in support of Operation Desert Storm.

Coast Guard Commendation Medal for outstanding service as Director of the Pacific Area Training Team and helping to improve the performance of operational units through outstanding training and job-aids.

Coast Guard Commendation Medal for “ground-breaking efforts” in assessing the status of Haitian Navy and helping to develop an assistance plan “that was approved at the highest levels of U.S. leadership” in connection with Operation Uphold/Support Democracy.

Coast Guard Achievement Medal for service as the Assistant Chief of Training for a technical training center. Among other things, worked with each of the programs to successfully institute an Instructional Systems Design methodology.

Coast Guard Meritorious Unit Commendation for implementing six major training initiatives at the Coast Guard Institute while serving as Director. Unit Commendations were also received at other units with which I served; i.e., the Pacific Area Training Team, Training Center Petaluma, the Coast Guard Academy, and a special Training Detachment during the Gulf War. [The latter was presented to me personally by the Secretary of Transportation.]

Coast Guard Meritorious Team Commendation as a member of the Diversity Summit Support Team for serving as a panel member on women’s issues.

Interests

Spending time with family, writing, and bicycling.