Excerpted from Navarro College's Quality Enhancement Plan (QEP)
TOGETHER EVERYONE ACHIEVES MATH MASTERY – TEA(M)^2
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Contents

Chapter 4: Literature Review and Best Practices

Upon final selection of the Quality Enhancement Plan (QEP) topic, *Together Everyone Achieves Math Mastery*, a contingent of the larger QEP Planning Committee began a review of scholarly works and effective practices relevant to successful completion of the developmental mathematics course sequence and program-specific gateway credit-bearing courses. Based upon committee dialogue and refinement of the initiative, the group expanded their review. Ultimately, the literature review led to the selection of five strategies to support achievement of the QEP goals of retention and success in developmental and gateway mathematics courses, and continued progression within the developmental mathematics course sequence to the program-specific gateway course:

- ***Early Enrollment in and Progression of Students through Their Developmental Mathematics/Program-Specific Gateway Mathematics Course Sequence***: assessment and placement of students into the appropriate course sequence per their declared program major, with consistent advising provided by faculty and staff to ensure students are both enrolling in the appropriate course early in their college career and completing the sequence in a timely manner.

- ***Engagement and Empowerment of Students***: active learning and engagement strategies embedded within the curriculum, coupled with success strategies in support of learning mathematics, specifically targeting the needs of developmental mathematics students.

- ***Integration of Technology***: use of technology both in and outside of the classroom to enhance student access, learning, and engagement and to maximize student interaction with technology applications embedded in the textbooks adopted for developmental and gateway courses (such as Hawkes Learning System and Pearson's MyMathLab).

- ***Tutoring/Learning Assistance Lab***: high quality learning support services that address the needs of students enrolled in developmental and gateway mathematics courses delivered in a manner that is accessible to all students and aligned with mathematics instruction as it is delivered in the classroom.
- ***Professional Development***: professional development targeting effective teaching and learning strategies for developmental and gateway mathematics courses, including strategies in support of engagement, empowerment, and technology applications.

Early Enrollment in and Progression of Students through Their Developmental Mathematics/Program-Specific Gateway Mathematics Course Sequence

Bailey, Jeong, and Cho (2010) identified the importance of early enrollment in developmental education courses and its impact on overall college success. The role of developmental mathematics is to prepare students for their appropriate program-specific gateway course, which in turn prepares the student for college success and completion. Bailey et al. (2010) found that two out of three students who complete their full developmental mathematics sequence subsequently enroll in a gateway course, and of those who enroll, three out of four pass the course. Bonham and Boylan (2011) found that those students who complete their developmental mathematics sequence and enroll in a credit-bearing (gateway) mathematics course do as well as those students who do not require developmental mathematics.

Further research supporting early enrollment in developmental mathematics courses, conducted by Lesik (2007), demonstrated a causal relationship between completion of the developmental mathematics sequence and overall persistence in college. Other studies found that students who delay enrollment in developmental mathematics during their first semester of college risk lower overall GPA and lower persistence rates (Bremer, Center, Opsal, Mehanie, Jang, & Geise, 2013; Fike & Fike, 2012).

Students avoid enrolling in developmental courses for a variety of reasons, including affective factors such as self-confidence and math anxiety, but the longer they procrastinate, the worse their chances are for success (Boylan, 2011; Howard & Whitaker, 2011; Pajares & Kranzler, 1995). Bonham and Boylan (2011) report that one in five students placing into developmental mathematics never enrolled in such a course over a three year period. A common strategy used by those students avoiding developmental courses is to enroll in courses not requiring demonstration of college readiness (Bailey et al., 2010); however, there is a limit to this strategy and continued avoidance of developmental courses ultimately leads to failure to progress and earn a college degree (Abraham, Slate, Saxon, & Barnes, 2014; Bahr, 2012; Boylan & Saxon, 2005).

An effective strategy emerging in recent years is the pathways model, which incorporates highly structured enrollment practices and momentum points as key indicators of success. In *A Matter of Degrees,* the Center for Community College Student Engagement (2014) identifies specific momentum points considered to be high impact practices that significantly improve a student's chances for completion. These momentum points include completion of at least one developmental education course with a grade of C or higher, completion of at least one gateway course with a grade of C or higher, and Fall to Spring and Fall to Fall student persistence.

O'Banion (2013) created a momentum points model of high impact practices that is based upon structured intake, testing and placement, and development of a structured degree plan with a clearly defined sequence of coursework that is effectively communicated with and understood by the student. It requires students to complete their developmental courses early in their college careers, and immediately enroll in the appropriate gateway course.

In a similar manner, Bailey, Jaggars, and Jenkins (2015) developed a guided pathways model that is prescriptively based upon momentum points and effective practices. It replaces the cafeteria model that allowed students to enroll in courses according to choice rather than purpose or goal. Bailey et al.'s pathways model calls for enrollment in and completion of the developmental and gateway mathematics sequence early in the student's college career. It also calls for strategies to get students on track and keep them on track to complete their degrees. Such tracking strategies include initial intake services of assessment and placement, communication of the importance of early enrollment in developmental and gateway courses, and academic advising and technology-based advising resources. Consistent with O'Banion (2013) and Bailey et al., in their study of a public two-year college in the south, Fowler and Boylan (2010) found that implementation of an all-inclusive mandatory pathways program yielded significantly higher retention and GPA among developmental students.

Advising is critical to successful completion of the developmental mathematics course sequence and program-specific gateway course early in the student's academic career (Bailey et al., 2015; Fowler & Boylan, 2010; O'Banion, 2013). Structured systems need to be in place to ensure early student advisement, degree planning, and follow-up throughout the student's college career. In colleges using a model which incorporates faculty and staff advisors, it is essential to require targeted training in support of consistent communication of accurate information and delivery of services (Bailey et al., 2015). An example of this type of training is Miami Dade College's required six hour advisor training program that includes role playing of predictable scenarios to assure that advisors are prepared to implement a pathways approach to degree planning and enforce the College's structured enrollment strategies (Bailey et al., 2015).

Engagement and Empowerment of Students

Students in developmental education courses typically have different learning styles from those traditionally addressed by faculty in higher education institutions (Barkley, 2010; Bonham & Boylan, 2011; Boylan, 2002; Boylan and Saxon, 2005; Center for Community College Engagement, 2014; Epper & Baker, 2009; Strengthening Pre-Collegiate Education, 2008; Nolting, 2014; O'Banion, 2013; Pelligrino & Hilton, 2012). Developmental students need a learning-centered approach that is holistic and includes multiple teaching and learning strategies and modalities (Barkley, 2010; Bonham & Boylan, 2011; Boylan & Saxon, 2005; Epper & Baker, 2009; Fowler & Boylan, 2010; Howard & Whitaker, 2011; Pelligrino & Hilton, 2012). Engagement and empowerment strategies emerge among numerous studies as the means by which educators can reach, teach, and advance developmental education students.

In *A Matter of Degrees,* the Center for Community College Student Engagement (2014) emphasizes the importance and impact of engagement and empowerment practices in terms of outcomes. This research found that student engagement practices of active and collaborative learning, student-faculty interaction, and support for learners “correlated to a statistically significant degree with IPEDS graduation rates,” (p. 27).

Engagement.

Engagement has been defined as a twofold approach to teaching and learning, addressing both motivation to learn and active learning, which work together synergistically to empower students to take control of their learning (Barkley, 2010). The benefits of active learning and collaborative learning have been extensively documented, particularly in relation to developmental education students. (Bonham & Boylan, 2011; Boylan, 2002; Chickering & Gamson, 1987; Kuh et al., 2005; Pelligrino & Hilton, 2012; Tinto, 1993). Learning styles for developmental students tend to be more visual and hands-on than auditory and passive (AMATYC, 2006; Bonham & Boylan, 2011; Boylan & Saxon 2005), which must be considered when designing classroom instruction. AMATYC (2006) created a table of learning style characteristics and strategies for practice to assist mathematics faculty when designing instructional activities (see Appendix L).

Bonham and Boylan (2011) recommend that when designing learning experiences, faculty are cognizant of multiple approaches, including those based in technology, and that “students actually learn math by doing math” (p. 4). Developmental mathematics students need to touch it, think about it, manipulate it, talk about it, and make meaning of it. By doing so, they take active ownership in creating their own learning (Barkley, 2010; Boylan, 2002; Boylan & Saxon, 2005; Pelligrino & Hilton, 2012).

Effective practices in support of active learning and collaborative learning indicate that the design of such activities or assignments should be structured to provide students with a firm understanding of learning and behavior expectations, rules and processes, outcomes or products expected, and performance rubrics, which are used to both reinforce learning throughout the process (feedback) and serve as an evaluation tool following the completion of the activity or assignment (Barkely, 2010; Boylan, 2002; Center for Community College Engagement, 2014; Chickering & Gamson, 1987; Fowler & Boylan, 2010; Pelligrino & Hilton, 2012; Strengthening Pre-Collegiate Education in Community Colleges, 2008). Research indicates students are more motivated if the activity is challenging and interesting to them and they believe they can achieve it. In addition, such activities should be interactive, draw on prior knowledge and experience, and provide multiple opportunities for the student to engage in the learning process (Pelligrino & Hilton, 2012; Strengthening Pre-Collegiate Education in Community Colleges, 2008).

Collaborative learning is based upon peer teaching and learning, as well as teamwork, and provides opportunities for the instructor to facilitate growth by assigning student groups with a purposeful learning activity. An effective example of such a strategy entails placing a student with strong academic or self-efficacy skills in a group to serve as a model for others who are still developing these skills (Barkley, 2010; Bonham & Boylan, 2005; Boylan, 2002; Pelligrino & Hilton, 2012; Strengthening Pre-Collegiate Education in Community Colleges, 2008). These types of strategies are effective in building community and empowering the peer learning/peer helping relationship (Barkley, 2010). Collaborative learning has been shown to raise the overall degree of accomplishment of all participants in the group, which then raises each member’s sense of self-confidence (Bonham & Boylan, 2011). This strategy has proven to be significantly effective with underrepresented groups (Bonham & Boylan, 2011).

Empowerment. Empowerment strategies include: student success and study skills such as time management, reading strategies, note taking, homework completion, and test taking (Bonham & Boylan, 2012; Boylan, 2002; Fowler & Boylan, 2010; Howard & Whitaker, 2011; Nolting, 2014; Pelligrino & Hilton, 2012). Additionally, affective considerations such as addressing math anxiety and test anxiety issues, acknowledging the relationship between student attitude toward math and achievement in math, and dealing with low student self-efficacy in learning mathematics all contribute to student empowerment, and ultimately to engagement and success (Bandura, 1997; Bean & Eaton, 2000; Benken, Ramirez, Li, & Wetendorf, 2015; Bonham & Boylan, 2011; Hall & Ponton, 2005; Nolting, 2014; Pajares & Urdan, 1996; Pajares & Kranzler, 1995; Tinto, 1993).

Students come to college with varying levels of preparation. Those students enrolling in developmental mathematics courses are often the least prepared overall (Bahr, 2012). Some students need to be taught how to learn, and this is addressed through study and organization skills. But many also arrive with low self-confidence and self-efficacy in learning mathematics. These students will need to reframe how they view themselves and perceptions related to the study of mathematics (Bandura, 1997; Bean & Eaton, 2000; Bonham & Boylan, 2012; Boylan, 2002; Boylan, 2007; Boylan & Saxon, 2005; Hall & Ponton, 2005; Nolting, 2014; Pajares& Kranzler, 1995; Pajares & Urdan, 1996; Pelligrino & Hilton, 2012; Strengthening Pre-Collegiate Education in Community Colleges, 2008).

Hall and Ponton (2005) found that mathematics self-efficacy is predicated upon a history of successful experiences in mathematics. With each course and each successful experience, the student becomes more confident in his or her ability to learn and master mathematics. This is why calculus students are more secure in their ability to learn their subject matter than are developmental mathematics students. The research shows that the best strategy to increase self-efficacy in developmental mathematics students is to get them enrolled in the appropriate courses and then scaffold learning opportunities for them to be successful. With each successful course completion, they build their sense of mathematics self-efficacy. Howard and Whitaker (2010) had similar findings in their qualitative study of the practices that successful developmental mathematics students found most useful to them.

Another area within the affective domain relates to math phobia, math anxiety, and test anxiety (AMATYC, 2006; Bonham & Boylan, 2012; Boylan, 2002; Boylan, 2007; Boylan & Saxon, 2005; Hall & Ponton, 2005; Nolting, 2014; Pajares & Kranzler, 1995; Pajares & Urdan, 1996; Pelligrino & Hilton, 2012; Strengthening Pre-Collegiate Education in Community Colleges, 2008). Pajares and Kranzler (1995) and Pajares and Urdan (1996) found that math anxiety directly correlates with math achievement, aptitude, and grades in mathematics classes. Pajares and Kranzler (1995) found that ability had a strong effect on self-efficacy and that self-efficacy has a strong effect on anxiety. These conditions should be addressed proactively with students through discussion and understanding of what the conditions are and how to cope with them.

Effective strategies, such as those provided by Nolting (2014), can help students take control of their fears and the physical response to them. These strategies include relaxation exercises, deep breathing, visualization, and positive self-talk. Classroom strategies such as the use of icebreakers and other activities to reduce stress and anxiety have proven effective as well (Bledsoe & Baskin, 2014). Howard and Whitaker (2011) found that students who have a motivation to be successful in mathematics and who used multiple effective strategies, many of which are associated with effective study skills, are able to positively change their mathematics course outcomes from previously unsuccessful course attempts.

Integration of Technology

Technology has proven to be an established and effective component of the teaching and learning process. Epper and Baker (2009) noted that in 1995 the American Mathematical Association of Two Year Colleges (AMATYC) included the use of technology as an essential part of an up-to-date curriculum in its guiding principles for the standards for college-level mathematics preparation. In its 2006 revision of the standards, *Beyond Crossroads: Implementing Mathematics Standards in the First Two Years,* AMATYC expanded upon this guiding principle:

Technology: *Technology should be integral to the teaching and learning of mathematics.*

Technology continues to change the face of mathematics and affects the relative importance of various concepts and topics of the discipline. Advancements in technology have changed not only *how* faculty teach, but also *what* is taught and *when* it is taught. Using some of the many types of technologies can deepen students' learning of mathematics and prepare them for the workplace (p. 10).

AMATYC (2006) states in its *Implementation Standard for Student Learning and the Learning Environment* that students need to use and have access to technology and that classrooms should be designed and equipped to facilitate technology. However, Epper and Baker (2009) observed that delivering upon the promise of technology has been a challenge for community colleges due to high costs, implementation challenges, and training. Both information technology infrastructure and academic technology innovations have lagged in the community college sector, despite ongoing efforts to keep pace with change.

Integration of technology into the art and science of teaching involves the intentional selection of appropriate hardware and software for the purpose of creating an optimal learning experience. In some instances this learning experience is interactive, in others it is not. It can be delivered face-to-face or virtually, and in some applications using both modalities. It serves both the producer and the consumer of learning materials and opportunities by facilitating environments in which media-rich teaching and learning can occur. And at its best, it meets the challenge of what Lyons, McIntosh, and Kysilka (2003) identify as the high tech/high touch paradox, by enhancing the connection of the student with the teacher, and ultimately to learning. Its impact reaches from serving as the patient tutor within computer-assisted instruction applications to the vehicle for engaging students in interactive teaching and learning in the classroom and online (AMATYC*,* 2006; Bonham & Boylan, 2011; Boylan, 2002; Chickering and Gamson, 1987; Epper & Baker, 2009; Kuh et al., 2005; Lyons et al., 2003; Ye and Herron, 2010).

The literature indicates that instructional technology should be used to supplement rather than replace *traditional* methods in education (Bonham & Boylan, 2011; Boylan, 2002; Boylan & Saxon, 2005; Epper & Baker, 2009; Kuh et al., 2005; Lyons et al., 2003). Boylan & Saxon (2005) found that when used as a supplemental strategy, developmental student learning and achievement increased, as did student attitudes toward computer-based learning. However, when computer-based learning became the primary method for delivery of instruction, student learning decreased.

A current application of educational technology, with a long and effective history, is computer-assisted instruction, a learning environment where students work, often independently, on practice to gain greater mastery within the subject area. It provides the student with more time on task, which has proven effective in moving course concepts from short-term memory to long-term memory, and gives autonomy to the student in terms of pace and repetition (Boylan, 2002; Boylan & Saxon, 2005; Chickering & Gamson, 1987; Kuh et al., 2005). The evolution of computer-assisted instruction within online learning systems and platforms has increased both student capability and outcomes. Ye and Herron (2010) found that computer-based instructional applications within such courseware as MyMathLab and Hawkes Learning System empower students to access pedagogically-driven assignments, participate in activities, manipulate and solve problems, verbalize their processes, and get immediate feedback, all the while working online and independently.

These strategies increase student outcomes. However, use of these strategies comes with a caveat. Boylan (2002) warns not to assume that students know how to use computer technology for learning applications. They must be taught how to access the material online and navigate the software effectively. Faculty need the capability to instruct students in the use of these systems both initially and in an ongoing manner throughout the course as they discuss out of class assignments. This requires technology presentation systems with reliable internet capability in mathematics classrooms (AMATYC*,* 2006).

Faculty are encouraged to create opportunities for students to use technology in support of their learning and in support of projects they create as class assignments; this includes strategies such as the full and robust use of online course management systems such as Blackboard, courseware applications, in-class and online presentation technologies such as computer and projection systems, tablets, SMART technologies, media-creation and other software, and resources on the internet (Boylan, 2011; Galligan, Loch, McDonald, & Taylor, 2010; Gningue, Menil, & Fuchs, 2014; Kuh et al., 2005; Lyons et al., 2003). However, Epper and Baker (2009) emphasize that only by aligning technology with learning objectives and finding the appropriate synergy between the two can increased learning be actualized. They encourage faculty to do so, as technology is the best strategy to dig deeper into the curriculum, given inadequate time to do so in class.

Effective practices documented in the literature provide insight for applications in the classroom. Martin (2009) conducted a course redesign using TI-83 graphing calculators in introductory algebra to increase student expertise in the use of graphing calculators and to apply the calculators as a higher order problem solving tool. Significant professional development was embedded in the redesign to support the many different faculty, both full-time and adjunct, and their teaching styles. Presentation technology was provided in the classrooms to project the calculator interface and model its use for students. This created a guided learning and application opportunity for students to achieve success with the calculators. Pass rates were significantly higher for the implementation years of the intervention. The author provided a "lessons learned" commentary for those interested in incorporating a calculator component into their introductory algebra curriculum.

Galligan et al. (2010) examined the use of tablet PCs and related technologies such as smart pens in the teaching and learning of mathematics. They studied applications in three environments, including the classroom, small group tutoring, and one-on-one consultation/tutoring in both face-to-face and online or virtual environments. Tablet and related technologies were chosen for the study because they are versatile and bring different benefits to each of the three applications and environments.

Tablets and related technologies provide the opportunity for both the instructor and the student to interactively communicate in writing via “digital ink” on a “digital whiteboard,” which can be projected in a classroom, shared in a small group using a collaboration table with monitor, or used synchronously online. The recorded products can be edited and rendered for upload to a website for student review. Of interest, this study was conducted at a university in Australia that serves a large number of students who are located at the university, but also to a large number who live in remote locations. Distance learning is a common delivery mode in this environment. Results of the qualitative study were positive overall for both students and faculty. One faculty member noted that the tablet had made her more “visual” in her lectures.

Galligan et al. (2010) provided a summary of advantages and disadvantages for each of the applications in their study. The ability to be spontaneous and interactive was cited as an advantage, as was the ability to capture the moment digitally and post it as a video snippet online. Ninety-eight percent of students reported that digital ink writing during the lecture helped them learn more effectively. A disadvantage of the tablet technology was the handwriting of some faculty, which was reported as illegible by some students.

Gningue et al. (2014) studied the use of virtual manipulatives in the teaching of pre-algebra and algebra concepts and its impact on students’ attitudes, confidence, and achievement in learning. Findings from the research determined that mastery of pre-algebra was the best indicator of college success for their students. The use of manipulatives by students is an active learning strategy employed in mathematics to address the difficulties students have with learning arithmetic and pre-algebra. Virtual manipulatives are based upon traditional manipulatives such as base 10 blocks, geoboards, and fraction bars. Manipulatives allow learning by discovery. Findings of the study documented that students enjoyed the online manipulatives and engaged in a higher level of constructivist learning, even experimenting on their own. They worked independently in class and some repeated the lessons online at home. The experimental group performed higher than the control group and expressed more excitement with this way of learning. They also liked the feature of instant feedback from the software, releasing them from dependence on the teacher. Delivery of a course which uses virtual manipulatives requires intense professional development on its use to ensure effective practice by all faculty.

Tutoring/Learning Assistance Centers

Tutoring and learning assistance centers have a long and effective history with supporting developmental education (Boylan, 2002; Boylan & Saxon, 2005; Casazza & Silverman, 1996; Fowler & Boylan, 2010). Casazza and Silverman (1996) provided a historical context for tutoring and learning assistance centers in American postsecondary education, and observed that with the open door policies and commitment to expanding educational opportunities to all students, including non-traditional and underrepresented students and those with learning disabilities, the question becomes not *if* the college should provide these services, but *how* they would provide them.

Learning support services have proven themselves essential to student success. Bremer et al. (2013) found that participation in tutoring during the first term of college enrollment had implications for success throughout the student’s college career, with higher GPA and persistence continued through year three. They found that tutoring significantly raised GPA in other courses within the same discipline. Perin (2004) found a significant correlation between the frequency of visits to the tutoring center and GPA, with those students receiving services at least six times within one semester having grade point averages one point higher than those students who used the center less frequently. Similar outcomes in support of student achievement have been reported by Boylan (2002) and Habley, Bloom, & Robbins (2012). The Center for Community College Student Engagement (2014) found a significant, positive correlation between tutoring and graduation rate, aligning with the national completion agenda (O'Banion, 2013).

Multiple types of delivery systems for learning assistance exist (Boylan, 2002; Boylan & Saxon, 2005; Casazza & Silverman, 1987; Habley et al., 2012; Perin, 2004). The four most common are:

- centralized general tutoring centers that address multiple disciplines
- centralized tutoring centers that support targeted disciplines such as developmental education
- centralized learning assistance centers that support multiple disciplines
- decentralized learning assistance centers that tend to serve a specific discipline, such as mathematics, and are located in the building where those classes are taught and the faculty are housed.

In their nationwide survey of postsecondary institutions, *What Works in Student Retention,* Habley et al. (2012) found that 90% of the participating colleges listed tutoring as a learning assistance program at their site. When asked to rank all programs and services offered at the college according to retention effectiveness, tutoring and learning assistance centers were ranked number one. It is apparent that practitioners at all levels recognize the importance of a strong tutoring presence on postsecondary campuses, particularly those institutions with large numbers of developmental students.

The literature is consistent in its documentation of a strong relationship between academic departments and tutoring or learning assistance centers (AMATYC, 2006; Bonham & Boylan, 2011; Boylan, 2002; Boylan & Saxon, 2005; Casazza & Silverman, 1996; Epper & Baker, 2009; Fowler & Boylan, 2010; Grubb, 2010; O'Banion, 2013; Perin, 2004). For tutoring to be effective, it must align with *what* is being taught in class and *how* it is being taught in class, and it must support the student learning outcomes of the course. It is disruptive and confusing for those students seeking learning assistance with a subject, such as math, to receive mixed messages; students need one consistent way to approach and solve the problems, which is the way the faculty are teaching it in class. This requires significant collaboration between tutoring services and the faculty in the departments. Researchers have found that the most effective model has the academic director or lead tutor of the specific tutoring service, such as mathematics, actually integrating with the department faculty through attendance at their meetings and training sessions. The academic director or lead tutor needs to have an established background and understanding of the subject area, preferably credentialed in it, and be an expert in how best to provide tutoring support for it (AMATYC, 2006; Bonham & Boylan, 2012; Boylan, 2002; Boylan & Saxon, 2005; Epper & Baker, 2009; Grubb, 2010; Perin, 2004).

Tutoring staff should be comprised of both professional level tutors and peer tutors. In this way, there is the overarching expertise and knowledge of the professional tutor, who is an expert in the subject area, and the peer opportunity for students to support each other under professional direction (AMATYC, 2006; Bonham & Boylan, 2012; Boylan, 2002; Boylan & Saxon, 2005; Casazza & Silverman, 1996; Epper & Baker, 2009; Grubb, 2010; Kuh et al., 2005; Grubb, 2010; Perin, 2004). In the case of peer tutors, there is strong research mandating careful selection and hiring practices, with an effective strategy being to ask subject-area faculty to provide recommendations for students who would be effective tutors. Once selected, peer tutors undergo extensive training prior to working with students, using such training programs as College Reading and Learning Association tutor certification or similar credentials (Agee & Hodges, 2012; AMATYC, 2006; Bonham & Boylan, 2012; Boylan, 2002; Boylan & Saxon, 2005; Casazza & Silverman, 1996; Epper & Baker, 2009; Grubb, 2010; Kuh et al., 2005; Perin, 2004). The peer tutoring curriculum typically covers learning theory, including active learning, critical thinking skill, and metacognition; assessment of students' learning; group dynamics, including collaborative and group work; the purpose and role of tutoring; and valuing diversity (Casazza & Silverman, 1996; Lipsky 2011). Kuh et al. (2005) reiterate the importance of highly structured training and highly qualified tutors in order for this practice to be effective.

Boylan (2002) stresses that tutoring services must be offered at times and locations that align with student needs. This can be accomplished with a needs assessment, but will likely indicate that students need access in the evenings, on weekends, and online, in addition to services during the day. To truly meet the needs of developmental students, colleges are urged to offer services where and when students are able to attend or participate.

Professional Development

The importance of professional development in support of effective growth and improvement is pervasive throughout the literature. Bonham and Boylan (2012) state that teaching developmental mathematics is much different from teaching more advanced college-level mathematics courses. Developmental mathematics faculty need an intensive background in mathematics, but they also need training in developmental education as well. And they must be able to implement change into their practice as effective developmental education strategies in the field emerge. To do so, they need access to sustained professional development, including those opportunities provided through conferences and workshops, but also through affiliation with professional organizations, and through local communities of practice that are inquiry based (AMATYC, 2006; Bonham & Boylan, 2012; Boylan, 2002; Boylan & Saxon, 2005; Epper & Baker, 2009; Grubb, 2010; Kuh et al., 2005; Pathways to Faculty Improvement, 2012; Pelligrino & Hilton, 2012; Strengthening Pre-collegiate Education in Community Colleges, 2008; Texas Higher Education Coordinating Board, 2014). Boylan and Saxon (2005) found that there is a correlation between sustained and effective professional development for developmental education faculty and improved outcomes in developmental course pass rates, grades, and persistence; this correlation extends to professional development of tutoring staff as well. Casazza and Silverman (1996) found a correlation between student success and professional development of all personnel working with underprepared students.

Epper and Baker (2009) document consensus across the research that professional development must be rigorous, intense, and thoughtful; it is critical to any proposed innovation in the field, whether it is content-based, classroom-based, or technology-based. AMATYC (2006) concurs that strong professional development is required for any significant change to the delivery and support of mathematics education. Consistent with this, in their study of high performing, inquiry-driven colleges, Kuh et al. (2005) found that professional development was essential for effective integration of technology and innovative practices into instruction. Whether through communities of practice, inquiry groups, or department meetings, there was strong support for faculty sharing ideas, lessons learned, and new research and strategies with their peers upon return from conferences and workshops (Bonham & Boylan, 2005; Boylan, 2002; Pathways, 2012; Strengthening Pre-Collegiate Education in Community Colleges; 2008).

Bailey et al. (2015) found that professional development, collaboration, and inquiry groups are vital to effective pathways in support of student completion. In order to learn how to more effectively grow and serve students, practitioners require professional development in their own subject areas, but they also need to work collaboratively with others at the college to create the synergistic effect of all programs and services seamlessly moving the student forward together.

Summary

Review of the scholarly literature and best practices established for improving developmental mathematics outcomes, achievement, and persistence, clearly evidences that the combination of 1) early completion of the developmental and gateway course sequence, 2) integration of engagement and empowerment strategies into the curriculum, 3) infusion of technology into learning and practice, 4) provision of research-based tutoring and learning assistance, and 5) sustained professional development to achieve these changes has proven effective in supporting achievement of the goals of the College's QEP. The College has used this research to frame the QEP implementation plan and budget, and aligned it with the College's overarching commitment to pursuing a seamless pathways approach to student completion.

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Appendix L. Selected Learning Styles Characteristics and Strategies for Students (AMATYC, 2006)

Learning Styles Characteristics		***Strategies for Students***
Active/ Tactile/ Concrete	Retains and understands information as a result of doing something manual or involving the sense of touch.	• Use mathematics as a concrete demonstration to make sense of a problem situation. • Draw a picture, make a table, or build a physical model of a problem. • Have students act out a concept
Active/ Social	Retains and understands information as a result of discussing or explaining to others.	• Participate in study groups. • Discuss concepts with the instructor and other students.
Analytic	Learns concepts and rules from experts.	• Listen to lectures. • Watch a demonstration.
Dynamic	Learns by exploring and looking for other possibilities for solving problems.	• Create and complete mathematics projects. • Use trial and error to find mathematics patterns.
Global	Learns in large jumps, absorbs material randomly, is able to solve complex problems quickly and in novel ways.	• Relate new mathematics topics to previous knowledge.
Innovative	Learns mathematics by personally relating mathematics to himself/herself using feelings.	• Discuss mathematics ideas with others. • Look for personal meaning in mathematics.
Intuitive	Discovers possibilities and relationships, is comfortable with abstractions and mathematical formulations, dislikes memorization and routine calculations.	• Seek interpretations and theories that provide proofs for theorems or formulas.
Reflective	Thinks about information quietly first and prefers to work alone.	• Incorporate reflection time as a part of study time.
Sensing/ Common Sense	Learns facts by connecting concepts to real-world situations; prefers to see the usefulness and practical application of mathematics.	• Consult other sources for specific real-world examples of mathematics concepts and procedures. • Seek hands-on learning experiences.
Sequential	Understands linear steps and follows logical paths to find solutions.	• Ask instructor to supply steps to solutions for problems.
Verbal	Prefers written and spoken explanations.	• Make summaries or outlines of course material. • Listen to classmates' explanations. • Read written explanations aloud. • Explain how to solve a problem.
Visual	Remembers pictures, diagrams, flowcharts, formulas, and procedures.	• Seek diagrams, schematics, course materials that can be viewed. • Create concept maps. • Color code notes and flashcards with highlighters.