Impact of Instructor Teaching Style and Content Course on Mathematics Anxiety of Preservice Teachers

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Abstract

Integrative-STEM methodologies entail integrating multiple disciplines with active design-centric teaching and learning methods. If math anxiety is prevalent, for teachers or students, then both the level of integration and design thinking may be limited. This quantitative study of 160 preservice teachers investigated how math anxiety was impacted by (a) a required math content course, (b) instructor teaching style, and (c) academic and disciplinary major. Significance analyses included *t*-tests, nonparametric tests, and effect sizes. Two teaching styles were compared: a direct teaching style and a more active, problem-based teaching style. The problem-based teaching style was shown to have substantial beneficial impact on math anxiety.

Keywords: STEM education, mathematics anxiety, teaching styles

Previous works have discussed the acronym STEM (science, technology, engineering, and mathematics) and K–12 STEM education in general (Sanders, 2009). Sanders (2009) and Virginia Tech (2017) faculty have discussed and defined the term *integrative-STEM education*. Additionally, the National Academy of Engineering and the National Research Council (Honey, Pearson, & Schweingruber, 2009) produced a detailed report describing many aspects of integrative-STEM (I-STEM) methods. This report addressed definitions of I-STEM, reviewed research related to I-STEM education, and discussed practice and implementation of I-STEM. Researchers have also created frameworks to guide I-STEM teaching. Wells (2016) proposed the PIRPOSAL model (which stands for Problem Identification, Ideation, Research, Potential Solutions, Optimization, Solution Evaluation, Alterations, and Learned Outcomes) that has clear ties to problem-based learning (PBL) via the central importance of questioning. Several K–12 school districts have chosen to add an *A* (arts), engaging via STEAM education, peaking the interest of art educators (Liao, 2016).

In the authors' view, if the key attributes of I-STEM teaching and learning could be compressed into two concepts, those would be (a) integrative and (b) include substantial design-centric problem- or project-based learning. These two aspects are not independent but are linked because the design-centric theme (the *T* and *E* components) provides rich contexts for the integration of STEM and non-STEM content areas. The problem- or project-based teaching and learning methods in I-STEM activities are design-centric with teachers guiding a student-centered environment where students, typically working in small groups, are designing solutions to problems, resulting in artifacts representing the solution (a physical artifact or modified process). There are a variety of items that can compromise the quality of I-STEM teaching. For example, questioning techniques are clearly important and have a central place in Wells' (2016) PIRPOSAL model. Another potential factor is mathematics anxiety. The literature indicates that high math anxiety can have several detrimental impacts in the classroom. Each of the two fundamental aspects of I-STEM methods previously listed could be detrimentally impacted. For example, if teachers have high math anxiety, then I-STEM activities may be limited in both the amount and quality of integrated math or may not encourage quantitative design decisions. Additionally, students with high math anxiety may also purposefully shy away from quantitative-based processes.

The authors could find no reported work on the impact of PBL teaching styles on math anxiety of in- or pre-service teachers. This is potentially of fundamental importance to PBL-centric I-STEM classes. For example, if PBL methods can beneficially impact math anxiety of preservice teachers, then perhaps PBL-centric I-STEM methods will also have a beneficial impact on K–12 students and teachers. In this work, a quantitative measure of math anxiety is completed for early preservice teachers before and after a required math (for educators) content course. Independent variables studied are: (a) a required content math course, (b) teaching style (active or PBL vs. direct), and (c) academic and disciplinary majors.

Literature Review

Math Anxiety

Mathematics anxiety can be defined as an intense feeling of anxiety about one's ability to understand and do math, a specific event such as a math test, or certain situations involving math. According to Brown, Westenskow, and Moyer-Packenham (2011), math anxiety reflects how an individual views his or her own ability to interact with mathematics.

More broadly, mathematics anxiety can be defined as the stress of learning and participating in the mathematics classroom or in situations that require mathematics (Richardson & Suinn, 1972) or as a fearful avoidance of mathematical situations (Wadlington & Wadlington, 2008). Math anxiety is the result of a student's previous negative or embarrassing experiences with math or a math teacher. Math anxiety is not a learning disability, but it does interfere with an individual's ability to learn math (Wadlington & Wadlington, 2008) and inhibits students' ability to understand and participate in mathematics. Isiksal, Curran, Koc, and Askun (2009) also found a significant negative correlation between math anxiety and self-concept scores. These experiences can leave students with the belief that they are deficient in math. Ashcraft (2002) believes that students with math anxiety will avoid situations requiring math, which could "result in less competency, exposure and math practice, leaving students more anxious" (p. 173). Brady and Bowd (2005) found that nearly 40% of the education students in their study reported math as their least favorite subject.

Math anxiety can develop early in elementary school (Harper & Daane, 1998). Jackson and Leffingwell (1999) reported that some students had their first negative experiences as early as third or fourth grade. Geist (2010) believes that

> Instead of helping children develop fluency at computation and become more efficient at problem solving, these policies [current educational policies] have produced students that rely more on rote memorization and have increased the level of anxiety in young children by making mathematics a high-risk activity. This tends to produce more adults with 'math anxiety' and discouraged children who understand the concept but work a little slower. (p. 25)

Finlayson (2014) believes that teacher behavior is a prime factor contributing to math anxiety.

Math anxiety of preservice teachers and impact on teaching and learning. A significantly larger percent of preservice teachers report experiencing higher levels of math anxiety than other undergraduate university students (Harper & Daane, 1998; Hembree, 1990). Frank (1990) found that many future teachers shared many of the same math beliefs held by students enrolled in math anxiety clinics. There is a particular concern in the case of elementary school teachers because a disproportionately large percentage of them experience significant levels of mathematics anxiety (Buhlman & Young, 1982; Trujillo & Hadfield, 1999). Kelly and Tomhave (1985) found that prospective elementary school teachers scored higher on anxiety rating scales than any other group in the large group of college freshmen they tested. Based on this research, it is not surprising that a considerable proportion of students entering preservice teacher training have negative beliefs and attitudes about mathematics (Uusimaki & Nason, 2004). Brown et al. (2011) also believe that teachers who do not enjoy math and who have negative feelings and less ability in mathematics would have difficulty teaching math or teaching math well.

The vast majority of elementary education majors are female and exhibit the highest level of math anxiety of any major (Hembree, 1990). Beilock, Gunderson, Ramirez, and Levine (2010) found that "teachers with high math anxiety seem to be specifically affecting girls' math achievement—and doing so by influencing girls' gender-related beliefs about who is good at math" (p. 1862). Geist (2010) found that "girls tend to feel less confident about their answers on tests and often express doubt about their performance" in math, and over time, girls' "assessment of their enjoyment of mathematics falls much more drastically than" boys' (p. 26). Moreover, studies have shown that teachers with high levels of math anxiety tend to transfer this anxiety to their students (Finlayson, 2014; Vinson, 2001). Some researchers found that such teachers are viewed as unsympathetic (Cornell, 1999) and insensitive (Jackson & Leffingwell, 1999), and Brady and Bowd (2005) found that such teachers were viewed as hostile and uncaring by their students. Furthermore, these students had memories of struggling with particular concepts and experiencing embarrassment in front of peers. Jackson and Leffingwell (1999) report that girls were ridiculed more often than boys and received less assistance from such teachers. Swetman, Munday, and Windham (1993) indicate that teachers with high measures of math anxiety spend less time planning mathematics lessons and use math instruction time for nonmath-related activities.

Additionally, Teague and Austin-Martin (1981) found that a teachers' attitude toward mathematics may affect not only the students' values and attitudes toward mathematics but also that these attitudes may affect the effectiveness of the teaching itself. Brown et al. (2011) established in their study that nearly 21% of the preservice teachers with anxiety about mathematics had negative mathematics teaching experiences with students in their field-based practicum.

Much of the research focusing on math anxiety and preservice-teacher training links math anxiety to teacher efficacy. Swars, Daane, and Giesen (2006) as well as Bursal and Paznokas (2006) found negative correlations between math anxiety and math efficacy beliefs, whereas Gresham (2008) associates low math anxiety with high levels of math efficacy. Math anxiety is also negatively correlated with confidence to teach math (Brady & Bowd, 2005). A commonality among these studies is that the participants were all in a methodology class (e.g., Brown, Westenskow, & Moyer-Packenham, 2011; Finlayson, 2014; Gresham, 2007) and near the end of their preservice training (Brady & Bowd, 2005; Isiksal, Curran, Koc, & Askun, 2009). We are in agreement with Brown et al. (2011) and Finlayson (2014) who acknowledge a weak mathematical background as a factor contributing to math anxiety. Therefore, we decided to investigate the level of math anxiety as they enter their training as teachers. Additionally, we decided to study the impact of a required math content course taken early in their program.

Another limitation in the current literature is the near exclusive focus on math anxiety among elementary major preservice teachers (Brown et al., 2011) with no consideration of other education majors (e.g., early childhood, special education, or deaf and hard of hearing majors) or academic major (e.g., math major). Zientek, Thompson. and Yetkiner (2010) believe that "it may be of value to investigate whether preservice teachers' mathematics anxiety levels are most associated with areas of certification preparation (e.g., early childhood, K–8) or by the courses in which the teachers are enrolled" (p. 430). This investigation includes these other education major populations with additional variables of disciplinary major and instructor's teaching style. By reference, Finlayson's (2014) study, 40% of the study participants identified "teaching style" as a cause for their math anxiety.

Teaching Style

Problem-based learning. Based on the work of Barrows (Barrows, 2002; Hmelo-Silver & Barrows, 2006), Walker and Leary (2009) define a PBL teaching style in which (a) "*ill-structured problems* are presented" (p. 13), (b) "a *student centered* approach in which students determine what they need to learn" is used, (c) "*teachers act as a facilitators* or tutors in the learning process," and (d) "*authenticity* forms the basis" in the selection of "problems [that] are inherently cross-disciplinary" (p. 14). In the work of Barrows (2002) and Hmelo-Silver and Barrows (2006), the importance of group work is included as a fifth element.

Researchers have found that PBL or PBL-like activities have had substantial positive impacts on student learning. PBL was first widely reported in the field of medical education. Meta-analysis of PBL have been reported both in the medical field (Strobel & van Barneveld, 2009) and outside the medical field (Walker & Leary, 2009). Strobel and van Barneveld (2009) found meaningful effect sizes for (a) "knowledge assessment," (b) "performance or skill-oriented" assessment, and (c) "non-performance or skill-oriented" attributes, including "satisfaction" and "successful assignment of first choice of [medical] residency" positions (p. 52). The meta-analysis of Walker and Leary (2009) included the addition of nonmedical field studies and variables of problem types, disciplines, and assessment levels. This meta-analysis described a large number of factors with statistical validity, too many to review here; however, it is interesting to note that the problem type "design problem" had the largest effect size (0.74), which may bode well for I-STEM methods.

Direct teaching. Mercer, Lane, Jordan, Allsop, and Eisele (1996) define *explicit* or *direct* instruction as "instruction in which the teacher serves as the [primary] provider of knowledge" and explanations, presenting "skills and concepts . . . in a clear and direct fashion that promotes student mastery" (p. 227). Additionally, Burton (1998) observed that college-level engineering lectures generally take a "'teaching is telling'" approach (p. 158).

Research Questions

We designed this study to answer the following questions:

1. What is the level of math anxiety with which prospective grade school teachers enter their teacher-training program?
2. What effect does a mathematics content course have on the level of math anxiety experienced by prospective teachers?
3. What effect does the lecturer's teaching style have on the level of math

anxiety?
4. Do different education or disciplinary majors have substantially different math anxiety?

Methodology

Population

The population consisted of 160 preservice teachers. Participants were primarily freshmen at a public liberal arts college situated on the East Coast. The mean quantitative SAT scores for education majors at the institution has varied between 600 and 630 over the past 8 years. The population in this study was made up of the following education majors: elementary (ELEM, n = 79), early childhood (EACH, n = 36), deaf-and-hard of hearing (DEAF, n = 23), and special education (SPED, n = 22). EACH students would be certified to teach K-3, ELEM students would be certified to teach K-6, and DEAF and SPED students would be certified to teach K–12. A second, disciplinary major is required for all education majors. The 160 preservice teachers in this study also spanned the following disciplinary majors: art (AR, n = 2), English (ENG, n = 40), history (HIS, n = 16), math (MATH, n = 2), music (MU, n = 3), psychology (PSY, n = 44), sociology (SO, n = 12), Spanish (SPA, n = 6), women and gender studies (WG, n = 11), and integrative STEM (I-STEM, n = 18). Four students were double disciplinary majors (for example, WG and HIS or WG and SPA), one student was a business major, and another student was an international studies major. MATH majors are certified to teach math for K–12, and approximately 90% of I-STEM majors complete the state-required coursework for middle school endorsements for both mathematics and science. Additionally, approximately 50% of I-STEM majors complete coursework for K–12 endorsement for technology and engineering (T&E) education.

Data Collection and Math Anxiety Instrument

Data were collected for two sequential semesters from students attending a compulsory math content course for elementary school teachers. The content courses were taught by only two instructors: 93 students attended Instructor A's class, and 67 students attended Instructor B's class. At the beginning and end of their course, participants were asked to voluntarily complete the Revised-Mathematics Anxiety Survey (R-MANX), created by Bursal and Paznokas (2006), enabling paired statistical analyses. Only paired data were utilized, measuring predominately the impact of the course (and teaching style). The R-MANX instrument contains 30 items to which students respond on a Likert scale from 1 (*no anxiety*) to 5 (*high anxiety*). Possible scores range from 30–150 with higher scores indicating higher math anxiety. The survey asked the student to define their level of math anxiety when dealing with daily situations and their own coursework. Cronbach's alpha for the R-MANX was calculated as 0.90 (Bursal & Paznokas, 2006).

Math Content Course Overview

The compulsory content course is designed for future teachers and is taught by mathematics education faculty. The course explores elementary school mathematics from an advanced viewpoint. Preservice teachers study patterns, numeration, mathematical systems, real numbers, and number theory. Students are required to reason mathematically, solve problems, and communicate mathematics effectively at different levels of formality, using a variety of representations of mathematical concepts and procedures. The two instructors used the same textbook and covered the same chapters. The format for both classes was in-person instruction for approximately 14 weeks. Classes were held twice per week, and each session was 80 minutes long.

Teaching Style Determination

One of the researchers visited each of the instructors' classrooms on several occasions during the year to collect data (at least three times per semester). During classroom observations, the researcher took observation notes about the classroom discourse and teaching style demonstrated by each instructor and also collected copies of the syllabi and assessments. Hence, this study was an ex post facto study design.

Instructor A, with 8 years college-level teaching experience, used a variety of physical materials and models (e.g., Cuisenaire rods, pattern blocks, tangrams, and different base blocks). Students were encouraged, through activities based on exploration, to demonstrate a willingness and ability to solve various types of mathematical problems using appropriate strategies. Students were required to explain their answers, reasoning, and problem-solving methods in class, on homework, and on assessments. Students often left their seats to collect manipulatives, work with other students on solving problems, and make brief presentations based on their explorations. Students were often encouraged to work in pairs or groups to explore, discover, and present solutions. The majority of class sessions contained one of more of the five key PBL elements presented earlier in the literature review section. It was evident that Instructor A followed a more problem-based, inquiry-driven teaching style and is referred to as a problem-based teaching style (PBT).

Instructor B, with more than 30 years of college level teaching experience, followed nearly the same procedure at each observation. The instructor presented some example (or examples) on the board, showed the steps in solving the problem (or problems), allowed time for questions, and then assigned homework (problems similar to the example or examples presented in class) to be completed in class and at home. The classroom discourse was instructor driven and blackboard and textbook dominated; no use of manipulatives was observed. Students stayed in their seats, took notes, and worked individually on assigned problems. The teacher set the pace of the discourse, with a clear focus on computation and skill in both teaching and in assessment events. From the observation notes, it is evident that Instructor B followed a primarily direct teaching style, with very little evidence of PBL. In this study, Teacher B is referred to as having a direct teaching style (Direct T).

Results

Analyses were completed only for teacher candidates that successfully completed surveys both before and after the math content course, primarily assessing the impact of the course (including teaching style). To test for normality, the Kolmogorov-Smirnov tests were utilized (with $p > 0.05$). If paired data are normally distributed, paired t-tests were utilized. If data was nonparametric, Wilcoxon Signed Rank Tests were utilized for statistical significance ($p < 0.050$). For practical significances, we utilized effect sizes (d-values 0 to 0.2, 0.2 to 0.5, and $d > 0.8$ for small, medium, and large practical significance, respectively).

Entering Math Anxiety and Effect of Content Course

To answer our first two research questions, we determined the range, mean(μ), standard deviation($\sigma_{\bar{x}}$), p-value (statistical significance), and d-value (practical significance) of math anxiety for the 160 preservice teachers before and after the content course. Results are given in Table 1.

Table 1
Math Anxiety Levels Before and After Content Course

		Entering preservice training				After content course					
	N	Range		μ	$\sigma_{\bar{x}}$	Range		μ	$\sigma_{\bar{x}}$	p-value	d-value
Pre-service teachers	160	68	128	82.91	13.94	49	112	78.48	12.39	0.000	0.34

Table 1 indicates that students entered their training with an average R-MANX score of 82.9 and exited the course with an average score of 78.5, a 4.4-point (5.3%) decrease. The standard deviation decreased from 13.9 to 12.4 after the course. The range in anxiety scores was large. For example, before the course, the lower quartile (low anxiety) spanned a narrow 5-point range, and the upper quartile extended over a much larger 36-point range (see Figure 1). After the course, the lower quartile increased to a 21-point range, and the upper quartile span decreased to a 26.5-point range. Additionally, the minimum score dropped 19 points, and the maximum score had decreased by 16 points. This freshmen-level content course had a statistically significant impact ($p < 0.05$) and a medium practical effect size (0.34).

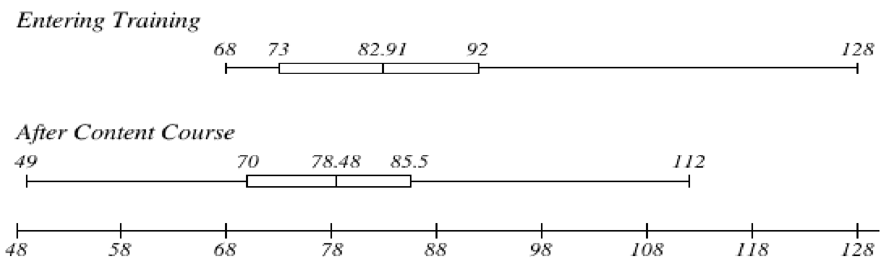

Figure 1. Math anxiety data distribution.

Teaching Style

To address our third research question, the impact of teaching style, we compared Instructor A's (PBT) students to Instructor B's (Direct T) students (see Table 2). Only if there was a statistical significant difference ($p < 0.050$) did we investigate effect sizes (see Table 2). The mean score for the Direct T students increased from 75.1 to 76.6 (about 2%). In contrast, the scores for the PBT students lowered from 88.5 to 79.9 (nearly 10%). Attending a problem-based class led to a statistically and practically significant decrease in math anxiety, but attending a Direct T class did not.

Table 2
Impact of Lecturer's Teaching Style on Math Anxiety Levels

		Entering preservice training				After content course				Impact		
	n	Range		μ	$\sigma_{\bar{x}}$	Range		μ	$\sigma_{\bar{x}}$	Points	*p-value*	*d-value*
PBT	93	68	128	88.54	12.37	53	112	79.85	12.03	-8.69	0.000	0.71
Direct T	67	48	107	75.09	12.61	49	106	76.58	12.80	+1.49	0.335	-

A comparison of the mean anxiety score before the content course indicates that the students in the PBT classes started with higher anxiety than students in the Direct T classes. A Mann-Whitney Test comparing the Direct T and PBT students before the course indicated that there was a statistically significant difference ($p = 0.000$). This is not surprising because students were not pre-filtered into classes. The reductions shown in Table 2 for the PBT population may be due to the PBT population starting with substantially higher anxiety. That is, it may be easier to decrease anxiety in high anxiety students, no matter the teaching style. This question can be addressed by assessing the impact of the course (and teaching style) on (a) the high anxiety students in Direct T courses and (b) the low anxiety students in PBT courses. The median value of 82 for the total population was used to divide students into two groups: high and low anxiety populations. These analyses showed that (a) the high anxiety students in the Direct T courses (n = 17) showed no statistically significant changes (p = 0.394 via a Wilcoxon Signed Rank Test) and (b) the low anxiety students in the PBT courses (n = 36) showed a 5-point decrease in the mean which was statistically significant (p < 0.0001 via a paired t-test with a large effect size, d = 1.03). These analyses indicate that the PBT teaching style does have a large impact for high and low anxiety students. In contrast, the direct teaching style had no significant impact on either high or low anxiety students.

Disciplinary Majors

Our expectation was that nonmath majors may start with a higher level of math anxiety, due to a possible lower level of content knowledge, and be impacted more positively by the content course as they gain knowledge to teach math. We defined math teaching (MATH-t) majors as both I-STEM (n = 18) and MATH (n = 2) majors because both will be certified to teach higher levels of math. Our expectation was that MATH-t majors would start with a lower level math anxiety and that the content course would reduce nonmath majors' math anxiety more than math majors. The analysis of math anxiety by math and nonmath majors is presented in Table 3.

Table 3
Impact of Lecturer's Teaching Style on Math Anxiety Levels of Math and Nonmath Majors

		Entering preservice training				After content course				Impact		
	n	Range		μ	$\sigma_{\bar{x}}$	Range		μ	$\sigma_{\bar{x}}$	Points	p-value	d-value
Both instructors												
MATH-t	20	62	109	85.20	13.70	53	94	77.55	10.78	-7.65	0.009	0.62
OTHERS	140	48	128	82.58	13.99	49	112	78.61	12.63	-3.96	0.000	0.30
PBT												
MATH-t	10	86	109	96.40	7.26	53	94	80.80	12.41	-15.60	0.006	1.53
OTHERS	83	68	128	87.46	12.30	63	112	79.73	11.84	-7.72	0.000	0.64
Direct T												
MATH-t	10	62	90	74.00	8.04	63	88	74.30	8.23	0.30	0.838	-
OTHERS	57	48	107	75.28	13.15	49	106	76.98	13.64	1.70	0.274	-

The results for the total population (both instructors) show that both math and nonmath majors benefitted from attending the content course because both were statistically significant. The 20 math majors showed the greatest decrease in math anxiety, 7.7-points (nearly 9%). The practical significance was medium for the MATH-t majors and small for the nonmath students.

More significant differences by disciplinary major were apparent when accounting for teaching style. Instructor B (Direct T) had no statistically significant impact on either MATH-t or nonmath students. By contrast, Instructor A (PBT) had a large positive impact on MATH-t and nonmath majors, which was statistically significant with large to medium effect sizes.

Education Majors

The analysis of math anxiety by different education majors is presented in Table 4. A one-way ANOVA test, using the total population, resulted in a *p*-value of 0.344 indicating that the four groups were not statistically significantly different before the content course. Using the total population, all four education major groups showed decreases on anxiety of 4 to 6 points, three of which were statistically significant with medium practical significance. (The fourth group, DEAF, was close to significant with $p = 0.057$.)

More significant differences by education major were apparent when separating teaching style. All education majors in the PBT courses had statistically significant decreases in anxiety, which had medium to large effect sizes. The students in the Direct T courses had a substantially smaller impact, with predominately increases of anxiety. Only one subgroup (ELEM) had a statistically significant difference ($p = 0.049$), an increase in anxiety of 2.65 points.

The SPED group did appear to be unique in that anxiety reductions were observed for both Direct T and PBT classes (but with only the PBT group being statistically significant).

Table 4
Impact of Lecturer's Teaching Style on Math Anxiety Levels of Different Education Majors

		Entering preservice training				After content course				Impact		
	n	Range		μ	$\sigma_{\bar{x}}$	Range		μ	$\sigma_{\bar{x}}$	Points	*p-value*	*d-value*
Both instructors												
EACH	36	63	123	85.22	14.56	58	112	81.03	13.68	-4.19	0.008	0.30
ELEM	79	49	128	81.34	13.82	51	106	76.68	11.24	-4.66	0.000	0.37
DEAF	23	57	109	86.00	13.87	63	107	82.04	13.96	-3.83	0.057	-
SPED	22	48	103	81.50	13.25	49	94	75.77	11.39	-5.73	0.004	0.46
PBT												
EACH	24	69	123	90.25	13.90	63	112	82.04	13.55	-8.21	0.000	0.60
ELEM	48	68	128	87.17	11.71	53	106	77.79	10.45	-9.38	0.000	0.85
DEAF	10	74	109	91.50	11.77	70	107	84.30	16.05	-5.00	0.009	0.51
SPED	11	71	103	88.09	10.84	66	93	78.64	10.39	-9.45	0.004	0.89
Direct T												
EACH	12	63	90	75.17	10.25	58	106	79.00	14.30	3.83	0.290	-
ELEM	31	49	100	72.32	11.96	51	101	74.97	12.34	2.65	0.049	0.22
DEAF	13	57	107	81.77	14.29	63	105	85.80	13.59	4.03	0.625	-
SPED	11	48	89	74.91	12.49	49	94	72.91	12.11	-2.0	0.286	-

Summary

Students entering their training had an R-MANX math anxiety level of 82.9. A required math content course (for educators) was useful in reducing math anxiety. Reductions in math anxiety were observed across education and disciplinary majors. Teaching style had a large beneficial impact on math anxiety, with a PBL style exhibiting statistically significant decreases and medium to large practical differences. In contrast, a direct teaching style had either no impact or a detrimental impact on anxiety. All subgroups were beneficially impacted by a PBL teaching style, but only SPED majors were beneficially impacted by a direct teaching style (not statistically significant).

Discussion

We agree with Mercer et al. (1996) that a single instructional method is seldom effective for all students; however, in this study, a PBL-centric teaching style profoundly decreased math anxiety in an education contextualized math content course. This has substantial implications for both the implementation and impact of I-STEM methods as well as how we train T&E teachers. In general, our T&E teacher preparation programs have limited math, science, and engineering (each having important math contexts). This lower emphasis on math likely results in higher math anxious T&E teachers and limited implementation of PBL methods, and it certainly limits how much engineering (vs. technology) can be effectively addressed in classes. Litowitz (2014) found that 75% of our T&E teacher preparation programs required only lower level math courses. Additionally, Litowitz (2014) found only one program with a required contextualized (engineering) math course. A lower emphasis on math has also been evident in our certified teachers. When investigating familiarity with the grade level of mathematics standards, Flowers and Rose (2014) found that T&E teachers were (a) only accurate 40% of the time and (b) off by two or more grade levels 30% of the time. Additionally, mathematics is also not represented substantially in field research. Of the 97 papers published in this journal from spring 2007 through spring 2016, only seven had the word *mathematics* in the title. Strimel and Grubbs (2016) also discussed several of these observations, as well as other observations, when suggesting a larger emphasis on engineering in the field. Because I-STEM teaching utilizes design-centric PBL methods, this study indicates that I-STEM activities may lower math anxiety and therefore increase mathematical skills in both K–12 students and preservice T&E teachers. If T&E teacher preparation programs generally required more education-centric or contextualized math courses (especially utilizing a PBL teaching style), then I-STEM (or Engineering) methods might be more effectively be implemented. Burghardt, Hecht, Russo, Lauckhardt, and Hacker (2010) also suggests that mathematically integrated PBL-centric I-STEM methods be modeled in preservice T&E teacher programs.[1]

Future Work

Questions that remain include inquiries on the longevity of this impact as well as extending the study to specific preservice or in-service elementary or secondary teachers in T&E or STEM and extending the study to other institutions.

[1] It should be noted that technology education has worked on integrated curricula math projects (LaPorte & Sanders, 1993; Satchwell & Loepp, 2002).

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