

Contextualization of the Relationship of Instructional Strategies to Preservice Teachers' Math Anxiety and Achievement

Thomas J. Lipscomb & Janelle K. Lorenzen

The University of Southern Mississippi, USA

Abstract: The findings presented herein report the results of the qualitative portion of a sequential, convergent mixed methods study that focused on the effects of two instructional methods, Direct Instruction (DI) and Inquiry-based Learning (IBL), on pre-service teachers' achievement and self-reported mathematics-related anxiety over the course of a semester. These qualitative findings are intended to add contextualization to the previously reported findings of the quasi-experimental phase of the investigation which found no statistically significant difference between groups in content mastery but found a statistically significant difference over the course of the semester in self-reported levels of mathematics-related anxiety between students who experienced the two different instructional methods. Implications are discussed.

Keywords: *Mathematics Anxiety, Mathematics Achievement, Mathematics Instruction, Inquiry-based Learning.*

Introduction

Traditionally, the primary teaching method for mathematics utilized for decades if not longer, has been Direct Instruction (DI). This approach has been ubiquitous at all levels of instruction from the elementary grades to post-secondary education. In its most common form, DI consists of the teacher presenting mathematical concepts and procedures while students take notes in a relatively passive manner. These lectures are supplemented by students "working problems" related to the material presented (Ardeleanu, 2019). Procedural fluency based on repeated practice constitutes the focus and goal (Brahier, 2013). This later aspect of DI is consistent with the tenets of social learning theory which posits that, in part, learning takes place through observation and subsequent imitation (Bandura, 1977). Because it has been so prevalent at all levels within the educational strata including university level, DI is the most common form of mathematics instruction to which preservice teachers are exposed as students themselves (Althaus, 2018). DI, however, is in conflict with best practices recommendations espoused by the National Council of Teachers of Mathematics (NCTM, 1991). For decades, this organization has strongly advocated for reform in the manner in which mathematics instruction takes place.

Historically less common but gaining acceptance across a variety of disciplines is Inquiry-based Learning (IBL). This later instructional strategy is based on the theoretical foundation of constructivism, representing a student-centered, active learning approach (Prince & Felder, 2006). In DI, emphasis is placed on actively engaging learners in the discovery of new knowledge (DeJong & VanJooligan, 1998). Within the IBL model of student-centered learning, the instructor becomes a facilitator on the journey to such discovery, actively engaging learners in the process. As applied to mathematics instruction, IBL is characterized by the elucidation and discovery of mathematics principles with little

or no traditional lectures on the part of the teacher, as well as student presentation of material, and alternative means of assessing student learning outcomes. Emphasis is placed on the engagement of students in the learning process through group activities and class discussions geared toward promoting higher order thinking and problem-solving (Freeman et al., 2014).

Although DI may be more common in mathematics instruction as compared to IBL, unlike IBL it is thought to result in a relatively low level of student engagement wherein students are infrequently motivated toward inquiry or higher-level problem solving (Boaler, 2008). This stands in contradistinction to IBL-based approaches which promote engagement on the part of students with the content and with each other thereby promoting higher levels of student achievement, success, and self-confidence (Freeman et al., 2014; Kogan & Laursen, 2013; Laursen & Hassi, 2012; Smith et al., 2009). Among preservice elementary teachers specifically, IB-based teaching methods have the potential to foster a more complete and deeper comprehension of mathematical content as compared to the more traditional DI instructional methods by affording the opportunity to share with their own students once they fully enter the profession.

Moreover, both the Association of Mathematics Teacher Educators (AMTE, 2017) and the Conference Board of Mathematical Sciences (CBMS, 2012) recommend the more student-centered approach embodied in IBL. In its Standards for Preparing Teachers of Mathematics (2017), AMTE advocates for a conceptual mathematics emphasis and "...instructor use of active-learning and inquiry-based strategies." CBMS further emphasizes that the teaching style utilized in preparing preservice teachers encourage the development of abstract quantitative reasoning within an interactive flexible, supportive context that affords ample opportunity to experience success.

Mathematics Anxiety

Anxiety is well known to have deleterious effect on content mastery and can impair performance on various cognitive tasks (Clarke & McLeod, 2013). Many individuals harbor very negative attitudes toward mathematics which can manifest in the form of mathematics anxiety. Mathematics anxiety involves the experience of a high level of discomfort when engaged in mathematics-related activities (Ashcraft, 1995; Cemen, 1987; Wu et al., 2014). As such, it has the potential to impact a student's task performance negatively by impairing mathematics-related reasoning. Of relevance to the current context is evidence that preservice mathematics teachers may be particularly prone to the experience of mathematics anxiety (Hembree, 1990). Among preservice teachers specifically, triggers to mathematics anxiety have been reported to be related to course material being covered too rapidly, timed tests, and too much emphasis on providing the correct answer among others. This can be accompanied by physical and psychological symptoms of anxiety that include inability to concentrate, difficulty breathing, and sweaty palms (Burns, 1998; Bursal & Paznokas, 2006; Trujillo & Hadfield, 1999). It is of note that what some may experience as anxiety triggers are common aspects of DI mathematics instruction (Harper & Daane, 1998). It has been speculated that should individuals who as students experience mathematics anxiety continue to do so after they have entered the teaching profession it

is possible that this would inhibit their effectiveness as teachers and perhaps in some way transmit this anxiety to their students (Buhlman & Young, 1982; Karp, 1988, Karp, 1991; Middleton & Spanias, 1999; Scholfield, 1981).

A recent experimental study focused specifically on the effects of a non-traditional means of mathematics instruction at the college level that utilized IBL-related components of problem posing, divergent thought, and invented strategies (Fetterly, 2020). The results provided evidence for the reduction of self-reported anxiety levels over the course of a semester. There were two counter-balanced groups both receiving the same type of instruction but no nontreatment control group, a methodological limitation to causal inference.

Recently, Lorenzen and Lipscomb (2021) directly compared the effects of DI and IBL instructional methods on mathematics anxiety and achievement among preservice teachers using a pre-test - posttest non-equivalent control group design as part of a sequential convergent mixed methods investigation. The results indicated that over the course of a semester-long preservice mathematics course, mathematics anxiety increased for those receiving DI while decreasing for those receiving IBL. There were statistically significant gains in content mastery for both groups with no statistically significant difference between groups. Interestingly however, there was a significant negative correlation between mathematics anxiety and achievement. That is, the higher the anxiety, the lower the student learning outcomes. Further, measures of mathematics anxiety increased over the course of the semester for the DI group but decreased for the IBL students. The results reported herein represent a presentation of the qualitative component of this mixed methods investigation and is intended to enrich and provide context for the afore-mentioned quantitative findings.

Methods

The participants consisted of 103 elementary education undergraduate students enrolled in four sections of mathematics course for preservice teachers at state-funded regional university in the southeast United States. The course is the second of a three-course mathematics sequence. The same instructor taught all four sections. Two sections were taught by means of DI and two by IBL. The study utilized a convergent mixed method, non-equivalent control group quasi-experimental design. This latter feature was chosen due to its relatively high degree of internal validity (Campbell, Stanley & Gage, 1963; Cook & Campbell, 1979; Shadish, Cook & Campbell, 2002). (For additional detail concerning the design and method of the study including specifics as to how DI and IBL were operationalized, please see Lorenzen and Lipscomb, 2021).

The participants predominantly identified as female (96%). Of the participants, 2% were freshman, 36% were sophomores, 53% were juniors, and 9% were seniors. All were elementary education majors. All data collection utilized a randomly generated numerical code to protect the anonymity of the participants.

In addition to the quantitative data collected and previously reported, qualitative data were collected by means of five separate journal entries completed by each participant at equal intervals during the course of the semester. In these

journal entries, participants provided information in their own words relating to their experiences in the course, their understanding of course material, and issues related to any anxiety that they may have experienced within the context of the course. Participants rated their understanding of both course material and math anxiety for each journal entry utilizing a ten-point scale for which "1" indicated the lowest possible level of understanding or math anxiety, and on which a score of 10 indicated the highest possible level of understanding or mathematics anxiety. For the qualitative analysis, these ratings were categorized as follows: 1 – 3 = low levels of understanding or anxiety, 4 – 7 = moderate levels, and 8 – 10 = high levels.

Results

Due to the large amount of qualitative data collected from journal entries, random samples of ten percent of participants from each group were chosen for analysis. Content analysis was performed on the journal entries using open, axial, and final coding procedures and emergent themes were noted. The themes that emerged during the coding process for both groups included course content, teaching methods, assessment, and student behaviors. These themes are discussed in detail below.

Course Content

Within the course content theme, sub-themes that appeared for both groups included general course content, specific materials and models, and the conceptual nature of the course. Participants in the DI group also stated that the homework and amount of course content impacted both their mathematics anxiety and understanding.

IBL Group: There was considerable variation among the IBL participants' responses regarding course content. Whereas some attributed general course content as a reason for relatively higher levels of anxiety, others associated course content with lower levels of anxiety. For example, one participant who acknowledged high anxiety and moderate understanding reflected upon fraction problems by stating, "I am just really confused on the correct way to work them out or solve them. I do not fully understand the course material up to this point and it is very frustrating." Another who acknowledged moderate anxiety reported, "When I see fractions, I just go blank and I need to get over the fear of fractions and embrace them." A participant who was more confident regarding fractions and was concerned with how to help elementary students understand stated, "The material itself isn't complex, hard material."

A specific sub-theme that emerged within course content had to do with the use of instructional materials and models. Regarding the use of pattern blocks, one participant with moderate anxiety and low understanding stated, "I get confused knowing what each one stands for and how to multiply fractions using [them]." Another participant with high anxiety and moderate understanding reflected, "I can work with the pattern blocks because they make sense to me, but I find it hard to show problems using number lines or arrays." On the other hand, someone else remarked, "I am progressing with the understanding of using models to demonstrate my work. The pattern blocks really helped me to visualize each piece."

Some participants in the IBL classes reflected upon the conceptual nature of the course content. One participant with moderate levels of both anxiety and understanding stated that she had “a hard time getting [her] mind to work a different way than [she was] used to.”

At the end of the course, one participant who “mastered the concepts” stated, “I understand certain mathematical strategies now more than I ever could have imagined. I can answer why certain things work and do not work. To me, this is more important than just memorizing formulas or spouting off definitions. I will be able to teach with confidence.”

She later reported, “I do not feel the cutting-anxiety or the gut-wrenching stress I felt at the beginning of the semester.”

DI Group: In addition to general course content, specific materials, and the conceptual nature of the course, DI class participants also indicated that the amount of content and the required homework problems contributed to their mathematics anxiety. One participant with high self-reported anxiety stated that she was “worried about fractions,” whereas another said, “Fractions have always made me nervous, and I find them confusing and hard to work with.” A different participant with moderate levels of anxiety and understanding commented, “Probability is a subject that bewilders me.” On the other hand, during the data analysis unit, one participant with high understanding reflected, “I enjoy learning this unit because it will help me with my profession.”

DI participants had differing views on how materials and models affected their anxiety and understanding of course material. One participant with high anxiety stated,

“The pattern blocks are the hardest part to get because I’m really not use [sic] to doing that when in math. We always used pencil and paper to solve a math problem so having this hands-on way is new and a little confusing for me.”

Another participant also reflected, “An area [model] confuses me. It is hard for me to understand how to effectively use [it].” Although another participant felt her anxiety increased throughout the semester, she “did learn new approaches to teach, such as using pattern blocks and visual diagrams for teaching.” She later commented that these methods “are what is best for a student of any age to learn.”

There is evidence that participants in the DI classes also had difficulty with the conceptual nature of the course and attributed it to their anxiety. Early in the semester, one participant with high anxiety and high understanding stated, “I still am very anxious about the class and the way we have to do some of the problems is very different from what I’m used to.... My brain keeps wanting me to do it the way we learned it in school.”

In the end-of-semester journals, one participant reflected, “My overall anxiety regarding math has gone up because it has allowed me [to] see that not all math is understanding and easy...I am happy that this class has pushed me to see math in a whole different language.” Another stated that even though her anxiety was low, she was still anxious “from the thought of not being able to use a standard mathematical algorithm to solve the problems.”

As was the case with the IBL students, participants in the DI class also attributed homework problems as a source of their mathematics anxiety. One student who acknowledged high anxiety stated, “When I do the homework I am confused because the problems are not like the problems covered in class.” Another participant felt that “the homework is ten times harder than the class work,” while someone else with both moderate anxiety and understanding commented, “When I get home and do the homework I end up confused and feel like I never truly did understand what I learned.” One participant who had increasing anxiety throughout the semester reflected, “What we learned in class was completely opposite from the homework and the test and that is what caused the most of my math anxiety to increase.”

Unlike participants in the IBL classes, participants in the DI classes discussed how the amount of course content contributed to their anxiety. One participant with moderate anxiety stated, “There was so much information given, it was hard to master all of the concepts.” Another said, “I feel a bit anxious to learn the other math material because I don’t know if I’ll be able to remember it.” A different student with high anxiety felt that the class “rushed through all the course materials that needed to be covered.”

Teaching Methods

Although there was considerable variation within groups, students in both the IBL and DI groups sampled stated that aspects of the teaching method utilized affected their math anxiety and understanding of course content. Further, there is evidence from students’ comments that those who experienced relatively higher levels of mathematics anxiety were more comfortable with the traditional teaching method afforded by direct instruction, while those who experienced relatively lower levels of anxiety were inclined toward a more participatory learning experience. In some cases, views changed over time as students gained perspective of the instructional strategies employed.

IBL Group: Early in the semester, there was considerable variation in views among the participants in the IBL classes regarding the teaching methods. One participant with moderate self-reported anxiety stated that she was “comfortable with the way the class is ran (sic),” whereas another who also had moderate anxiety said, “I cannot learn the way we are being told to learn....Not having someone teach me the material has not only given me major anxiety, but it has also caused me to be very confused on what is going on.” As the semester progressed, participants gave indication of becoming more comfortable with the teaching methods. For example, one participant with high anxiety and moderate understanding commented, “Once I get used to then [sic] new method of learning that I have been introduced to I will be okay and understand better.” Another with moderate anxiety and understanding responded, “I am now somewhat

used to the routine in the classroom and it is going smoother than before.” By the midpoint in the semester, all participants responded positively toward the IBL method. One participant reflected, “I am used to the way we are learning in the setting of the class so it does not stress me out or give me any anxiety.... I am confident and comfortable with the class and its material.” Another with moderate, yet decreasing anxiety, stated,

“I have started to let my guard down in the math sense and have allowed myself to embrace the new method of math and find that there can be true joy in working through problems. Once the answer reveals itself there is such a feeling of accomplishment that absolutely cannot be beat.”

Toward the end of the semester, one participant whose anxiety had decreased to a low level said, “I stop[ped] worrying about how the information is taught, which was the barrier allowing me to have trouble processing information...I now have a complex understanding of what is being taught.” The participant later stated “I [understand] the importance of understanding information instead of reciting details that is usually taught in math classes. Another participant stated,

“The act of learning is truly amazing. You can learn anything at any time in any place. I did not need a teacher or even a textbook to learn! In fact, I carried most of the knowledge already. I just needed someone to facilitate thought and require a little thinking.”

Another IBL participant reflected,

“I was very closed to the idea in the beginning but as I opened myself up and thought positively about the instruction of the course, I began to excel in class... I was able to come to terms with the class and realize how beneficial the instruction was to my knowledge.”

Several IBL participants commented specifically on particular aspects of the teaching method, including student presentations and group work. One highly anxious participant said at the beginning of the semester, “It helps seeing someone else work but trying to understand there [sic] work and redo it is difficult.” A different participant with low anxiety throughout the semester reflected, “I took from this class...being able to get up in front of the class and talk.... [The instructor] made it so that we will be comfortable.” Another who was confident in her understanding stated, “I liked [my classmates’] thoughts and getting their opinions on different problem-solving strategies.” Lastly, a participant who was worried about the teaching method at the beginning of the semester later commented, “Getting feedback and listening to each presentation in class has really helped me to improve my understanding for each mathematical topics [sic] discussed....I am very grateful for the way the class was taught.”

DI Group: Participants in the DI classes tended to have generally positive views regarding the teaching methods early in the semester but evinced more mixed views by the end of the semester. One participant with low anxiety stated, “I am also extremely happy that I am in the traditional class. I feel like my anxiety would have a much higher rating on the scale if I was not in the traditional class.” A different participant with moderate anxiety expressed,

“I have a better understanding of how everything will work, [and] I am not as anxious about it. I find comfort in how the class works. I love that it is all very organized and I fully understand what is expected of me and when.”

A participant with moderate anxiety and high understanding expressed the belief that “Being in the traditional class definitely helps give [her] ideas and examples to follow.” One aspect of the teaching method that most students felt contributed to increased levels of anxiety was regarding the homework. One participant reflected, “The professor did not have time to review all of our homework and other exams, therefore I felt as though I did not know if I were doing certain things correctly.” Others felt that “it would be very helpful if we actually reviewed the homework problems in class” and wished “there was more class time to review the more challenging homework problems.” In the end-of-semester journals, one of the participants expressed that the teaching method “provided [her] with more anxiety than more learning.” She later commented, “I am certain that the material that we’ve learned throughout the semester should be taught in a different manner.” Others did not share that same viewpoint. Two highly anxious participants stated that they “really liked the instructional strategy [the instructor] used to teach us” and “the instructional strategy is taught well by the teacher.” Another reflected, “I find that it is the way I learn better.”

Assessment

Participants in both the IBL and DI groups believed assessments, such as tests and the final exam, and concerns over their grades impacted their anxiety levels.

IBL Group: Several participants in the IBL classes attributed course assessments as a cause of their anxiety. In her second journal entry, one participant stated, “I’m really nervous about this first test,” whereas another commented that she had high anxiety because “a test is going to be coming up soon and I’m nowhere near ready for a test.” Halfway through the semester, one participant remarked that even though her anxiety was beginning to decrease, it was still high because she was “worried to death that the next test will be as rough as the first and [she’s] heard horrible things about the final exam being worse than all of the other test [sic].” She later continued, “Most of my anxiety is related to my GPA. I’ve never made a C or below in a course; I’m wondering if I’m even going to pass this course.” Another participant, who had very low self-reported mathematics anxiety, said, “We have now taken our first test so I have experienced every aspect of the class. I know what to expect and I did well on the test.... I know what I must do to be successful.” At the end of the semester, anxiety levels relating to assessments were still high. One participant stated, “I am on the border of extreme anxiety. I came in prepared and totally went black [sic] when I sat down. I really need to work on test anxiety skills.”

DI Group: Many of the DI participants made attributions to the effect that their anxiety was specifically related to class assessments and concerns about their grades. Leading up to the first test of the semester, a participant with moderate anxiety and understanding commented, “I am a little worried about the first test just because there is a lot of material covered.... Another thing I worry about is how the test will be set up and more importantly, I wonder how the questions will be worded.”

After taking the first test, participants experienced a decrease in mathematics anxiety. One participant with moderate anxiety said, "After the first unit and test of this course, my math anxiety somewhat decreased." A different participant with low anxiety responded,

"I feel confident about the previous math test on fractions. Before I took the test, I made sure I knew the material and took the test with confidence. This lowered my anxiety a little and helped make me confident toward the tests to come."

Other participants believed their anxiety levels were "elevated in anticipation of the coming test[s]". One participant reflected, "It's getting closer to the test so I am becoming more and more nervous about it." Another participant felt high anxiety during a test as she "was panicking...and [her] mind went blank." By the end of the semester, one participant stated, "The only time I had math anxiety during this course was before tests." Other participants reported feeling anxiety because of concerns over their grades. One participant with moderate anxiety expressed, "I don't think I can get close to the grade I would want." Another with moderate anxiety said, "I need to make a little higher grade in order to keep my scholarships, which is stressing me out more."

Student Behaviors

Participants in the IBL and DI groups attributed specific aspects of their thoughts and behavior as having impact on their anxiety and understanding in both positive and negative ways.

IBL Group: At the beginning of the semester, high self-reported levels of math anxiety in the IBL classes were mostly due to participants' beliefs regarding their abilities to do mathematics. One participant stated, "I do not feel 'smart' at all while in math class.... It's a subject that doesn't come natural to me." Another commented, "It stresses me out when I try and try and still don't understand it." As the semester progressed, many participants reported decreased levels of anxiety. One stated, "In the beginning of this semester I would become frustrated and nervous as soon as I got stuck on a problem. I have noticed that I have not been giving up as easy and have been working on the problems until I figure out the solution." A different participant with decreasing anxiety also had a realization as to how to be successful. She said,

"Our very first section I did not complete the whole section...But now I understand that [the instructor] did not give us all those problems for us to not do them. [The instructor] knew it would help us by giving us more to practice on. I really wish I would have worked as hard as I do now whenever we first began."

One participant with high self-reported anxiety, acknowledged tending to second-guess herself, stated, "I also overthink a lot...I think it has a lot to do with everything."

At the end of the semester, IBL participants reflected on their overall experiences and how these affected their anxiety.

One participant commented,

“Once I was able to understand that I needed to just think a little more...I became okay. It was a great feeling when I was able to figure out the problem on my own without assistance from others.... I found it as a challenge, but I did not want to give up.... This class taught me a lot about myself as a student. It showed me that I am capable of more than I give myself credit for. If I push myself than [sic] I can really be a great student which will lead me into being a great teacher.”

A different participant stated,

“I realized throughout the semester that I was more capable that [sic] I gave myself credit for. I realized that I was able to learn more and retain more information from figuring out the problems by myself rather than just memorizing the strategy shown like in other classes....I have learned to calmly and effectively solve problems on my own and that has really helped me to grow and lessen my math anxiety.”

One participant who only experienced a small decrease in self-reported mathematics anxiety remarked, “I have learned how to cope with [math anxiety] instead of letting it define who I am.... I learned that I have to stay optimistic and have a positive mindset in order to be successful.”

DI Group: Behaviors and beliefs of the DI participants also were related to anxiety and content mastery. For instance, one participant stated that in order to improve her understanding that she would have to “keep up with this math class and practice a lot...practice makes perfect when it comes to learning math.” Another felt that her moderate anxiety was partially due to her overthinking the problems. She stated, “I over analyze [the problems] and then find myself stuck on a simple problem. I second-guess myself often.” Another moderately-anxious participant believed, “My anxiety for math never goes away because I am not and never have been a good math student and trying to cover everything in one class that I have never been able to understand before makes me really nervous and scared that I am going to miss something or forget a step and I will mess it all up.”

A participant with self-reported moderate understanding realized what she needed to do to improve her understanding. She remarked,

“I feel like I need to rework all my homework problems and figure out the ones I do not understand for test review day. Also, I think I need to meet up with my math group so we can all help and learn from each other.”

Another participant with a high understanding of course material commented, “As long as I continue to study and practice, I can apply that knowledge and understand the information that I need in order to pass the test.” Another participant with low anxiety remarked, “Helping other students understand the material has improved my confidence in my own abilities. Doing this reinforces that I really understand the material, rather than just learn the procedures.” In considering the sampled participants’ responses, a relationship was found between the self-reported levels of mathematics anxiety and understanding. For both the IBL and DI groups, all participants with low self-reported mathematics anxiety stated that they had moderate or high levels of understanding. The majority of participants who

reported moderate levels of mathematics anxiety expressed moderate or high levels of understanding. On the other hand, the majority of those who reported high levels of mathematics anxiety in their journals felt as though they had low to moderate understanding of course material.

Thus, the qualitative data are supportive of and provide context for the quantitative results as reported by Lorenzen and Lipscomb (2021). Specifically, open-ended student comments in the journal entries strongly suggest that whereas all students experienced varying degrees of mathematics-related anxiety, that experienced by the IBL group moderated over the course of the semester as they became more comfortable with and increasingly appreciated the benefit of a more participatory approach to mathematics learning. DI students' open-ended comments, on the other hand, indicated that they were generally comfortable with the material and teaching method at the beginning of the semester but became less so and increasingly anxious as the semester progressed. Part of this was related to the assessment of student learning as tests and the final exam continued to be a source of concern for both groups throughout the semester. The students' reflections regarding their own learning-related behaviors provides additional insight. Students in the IBL group seemed to gain an appreciation that the keys to their success in the course were engagement and persistence and, consequently, experienced lower levels of anxiety over the course of the semester as their self-confidence increased. Interestingly, some students in the DI group gave evidence that they too would have appreciated a more participatory learning experience.

Discussions

Historically, the primary method utilized for mathematics instruction has been Direct Instruction (DI). Such an approach places learner in a relatively passive role in which they listen to the instructor present concepts and applications, take notes, and work problems. This traditional instructional strategy is at odds with recommendations of professional advocacy groups such as the National Council of Teachers of Mathematics (NCTE) and the Association of Mathematics Teacher Educators (AMTE) that recommend a more learner-centered approach. This latter approach is exemplified by Inquiry-based Learning (IBL) in which emphasis is placed on the active engagement and participation of learners in the learning process (DeJong & VanJooligan, 1998).

It has been demonstrated that anxiety related to performing mathematical tasks can be detrimental to student learning by negatively affecting mathematical reasoning (Fetterly, 2020).

Further, there is evidence that preservice mathematics teachers may be particularly prone to the experience of mathematics anxiety (Hembree, 1990).

In a companion article, Lorenzen and Lipscomb (2021) reported the quantitative results of this convergent mixed method, quasi-experimental investigation that compared the effects of DI and IBL instructional methods on mathematics anxiety and on achievement among preservice teachers. No study had previously directly compared the efficacy of DI and IBL with preservice teachers in terms of either content mastery or mathematics anxiety. Briefly, the quantitative results indicated that both groups showed similar degrees of content mastery during the semester with

no statistically significant difference between groups. There were, however, statistically significantly different trajectories of mathematics anxiety, in which those receiving DI experienced increasing levels of mathematics anxiety during the semester while those receiving IBL experienced decreasing levels of anxiety. Importantly and as expected, there was a significant negative correlation between mathematics anxiety and achievement. Although no causal inference can be drawn from this latter finding, it adds to the growing evidence that the experience of anxiety is detrimental to mathematical content mastery.

The results presented herein draw from this same study focusing on the qualitative findings drawn from student journal entries. These qualitative data are supportive of and provide context for the quantitative results reported earlier. Content analysis of student journal entries over the semester revealed evidence for three emergent themes and how these related to both mathematics anxiety and content mastery from the subjective point of view of the students – Course Content, Teaching Methods, and Assessment. Integrating these qualitative data strongly confirm and help explain the phenomena that whereas students exposed to both instructional methods experienced varying degrees of mathematics-related anxiety, that experienced by the IBL group moderated over the course of the semester as students became more comfortable with and increasingly appreciated the benefit of a more participatory approach to mathematics learning. DI students' open-ended comments, on the other hand, indicated that they were generally comfortable with the material and teaching method at the beginning of the semester but became less so and increasingly anxious as the semester progressed. There was indication in the journal entries that participants in the DI classes had particular difficulty with the conceptual nature of the course and attributed this directly to their anxiety. In addition, the journal entries gave indication that students receiving DI tended to have generally positive views regarding this teaching method early in the semester, but that their views became more mixed as the semester progressed. The opposite trend was in evidence for those who experienced IBL wherein they gave indication in their open-ended journal entries of being resistant to and uncomfortable with being placed in a more active position in the learning process at the beginning of the semester but became more comfortable with and appreciative of the IBL approach as the semester progressed. The students' reflections regarding their own learning-related behaviors provides additional insight. Students in the IBL group seemed to gain an appreciation that the keys to their success in the course were engagement and persistence and, consequently, experienced lower levels of anxiety over the course of the semester as their self-confidence increased. Interestingly, some students in the DI group gave evidence in their journal entries that they too would have appreciated a more participatory learning experience.

Taken together, the quantitative and qualitative results of this mixed method study provide compelling evidence that although student learning outcomes may be similar for Direct Instruction (DI) and Inquiry-based Learning (IBL), the effects on the phenomenological experiences of the students are quite different. Triangulating the quantitative and qualitative results indicates that the trajectories of the experiences of mathematics anxiety over the course of the semester were essentially mirror images of each other wherein students exposed to IBL experienced a decrease in anxiety while those exposed to DI experienced an increase. Underlying these trends, those students exposed to DI expressed the view that although they were relatively comfortable with the familiarity of DI instruction at the

beginning of the semester, they became increasingly anxious as the semester progressed and by the end of the semester some indicated that they would have preferred a more-student-centered approach. Students in the IBL group in contrast expressed some discomfort with the active nature of the IBL process initially but became increasingly comfortable with the more active participatory role that it necessitates as the semester progressed.

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Corresponding Author Contact Information:

Author name: Thomas J. Lipscomb

Department: School of Education

University, Country: The University of Southern Mississippi, United States

Email: Thomas.Lipscomb@usm.edu

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