Mastery-Based Course Design Reduces Exam Anxiety in Undergraduate Engineering Students

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Introduction

Anxiety is one of the most common problems college students face today (CCMH, 2018). Test anxiety is a specific form of state anxiety that can occur before, during, or after a test (e.g., poor study skills, becoming distracted during a test, worrying about mistakes after a test; Cassady, 2004). Test anxiety affects 10-40% of college students and is associated with negative outcomes such as reduced academic achievement (Cassady, 2004; Lowe, 2015). One potential way to reduce test anxiety is through mastery-based education (MBE), a teaching approach which involves identifying a set of essential concepts within the course then giving students multiple chances to demonstrate "mastery" over each skill. MBE may be particularly effective in STEM courses due to their sequential nature and preliminary evidence of an inverse relationship between test anxiety and academic achievement in Engineering students (Nelson, 2013; Seabi, 2013). Despite this, little research has been conducted on anxiety in Engineering students or how MBE may improve anxiety and academic achievement.

The purpose of this study was to test how MBE compares to traditional education and how MBE impacts test anxiety in Engineering students.

Method

Participants

The current study looked at undergraduate students at a small, liberal arts college (N = 66, 72.7% male, 86.4% White, 21.4% first-generation college student) enrolled in at least one of three engineering courses: Circuit Analysis (EGR210), Statics (EGR260), and Dynamics (EGR360). A subset of participants were enrolled in both a mastery-based and a traditional course (n=22). Students in these three classes were recruited to take part in this study. Participant demographics were representative of the overall population of engineering majors at this institution.

Instruments

Survey measures consisted of The State-Trait Anxiety Inventory (STAI; Spielberger, Gorsuch, & Lushene, 1970), the Revised Test Anxiety Scale (RTAS; Benson & El-Zahhar, 1994), and demographic items.

Procedure

Participants completed the STAI, RTAS, and demographic items at the beginning of the fall semester to establish baseline anxiety levels. The State Anxiety subscale of the STAI and RTAS were given immediately prior to taking an exam in the middle of the semester and the final exam. A subset of 9 students completed a semi-structured interview (mean length = 8.89 minutes) about their experiences in mastery-based and traditional courses the previous fall. Interview data were analyzed using consensual qualitative research protocols (Hill, 2012).

Results

Dual Enrolled Completer Analyses

Among the dual-enrolled completers, a repeated measures MANOVA revealed a significant main effect of course design [Wilks's λ = .518, $F(2,13)$ = 6.05, p = .01, η_p^2 = .48]. Follow up RM-ANOVAs revealed a significant effect for state anxiety [$F(1,14)$ = 13.03, p = .003, η_p^2 = .48], such that students had lower state anxiety in their mastery-based class (M = 43.28) than their traditional class (M = 49.04). The interaction between course design and time was not significant, but the effect size was very large [Wilks's λ = .495, $F(4,11)$ = 2.80, p = .08, η_p^2 = .50; see Figure 1].

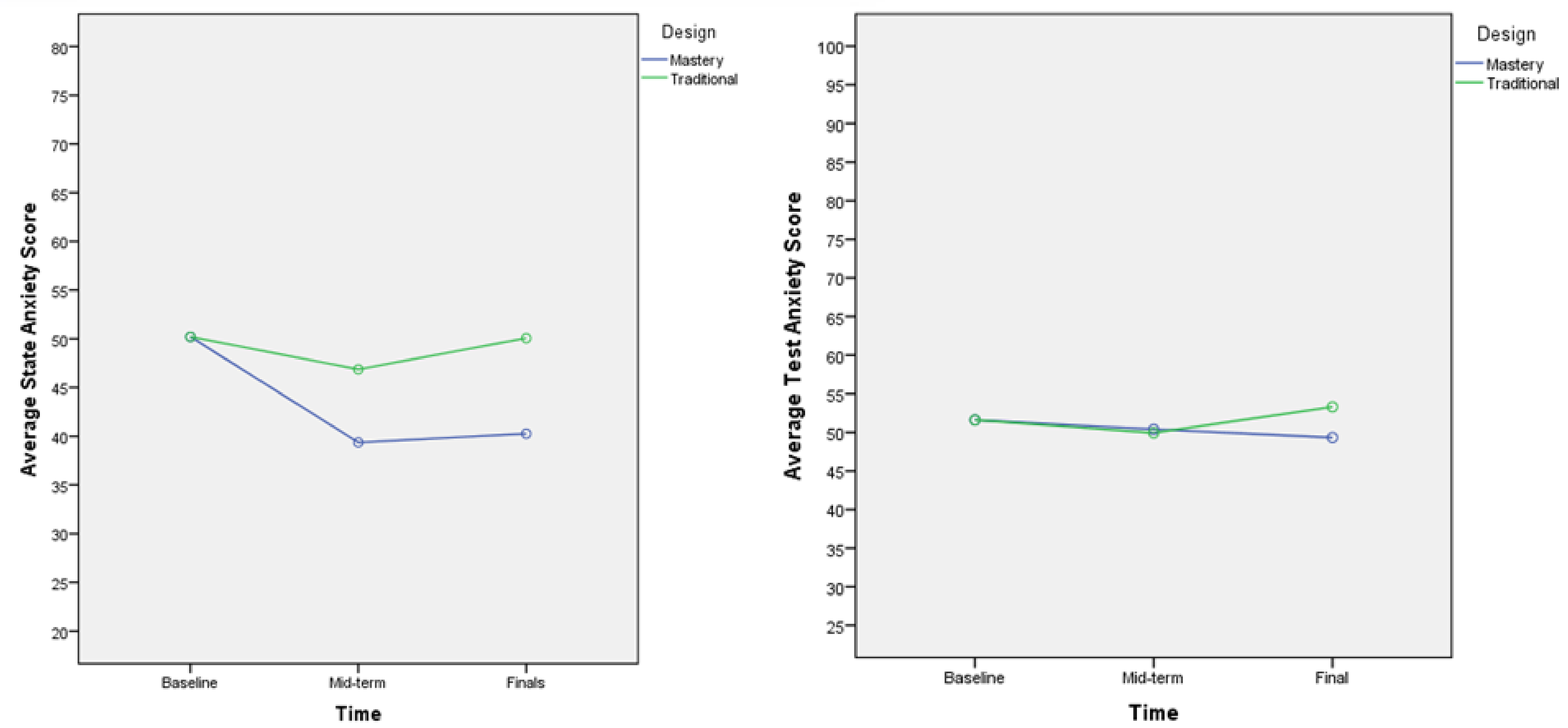

*Figure 1.*Interaction plot of time and course design for state and test anxiety scores among dual-enrolled completers (n=15).

Full Sample Interaction Analyses

There were stronger interaction effects between demographic variables and time in traditional courses as compared to mastery-based courses for race and gender, but not for first-generation status (see Table 1).

Table 1. *Significance and Effect Size Comparisons for 3 (Time Point) x2 (Demographic Group) MANCOVA Interaction Effects for Students in a Mastery-Based Course (*n=48*) or Traditional Course (*n=21*).*

Demographic Variable	Course Design	State Anxiety		Test Anxiety	
		p	η_p^2	p	η_p^2
Race[a]	Mastery	.42	.02	.001	.14
	Traditional	.40	.06	.002	.35
Gender[b]	Mastery	.76	.01	.89	.00
	Traditional	.23	.09	.28	.08
First-Generation Status[c]	Mastery	.76	.01	.89	.00
	Traditional	.75	.02	.84	.01

Note. All analyses included baseline trait anxiety and grade earned in the course as covariates. [a]Coded White vs. student of color; [b]coded male vs. female (no students reported other gender identities); [c]coded first generation vs. not.

Qualitative Analyses

The Advantages of Mastery-Based Course Design domain (n=9; General) included 3 categories:

- Singularity (n=8; General). Learning skills one at a time made the material in the mastery-based course more manageable to study, especially due to more targeted exams.
  - *With the mastery based, you knew what type of problems you're getting, so you knew what exactly you had to study in order to get it right…whereas with the traditional one, there's a lot of information and some of it might be tested and some of it might not.*
- Repetition (n=4; Rare). Having multiple chances to practice and demonstrate mastery of the material.
  - *You kind of just do problems repetitively and I think it's a better way of learning, in my opinion.*

Results (cont.)

Qualitative Analyses (cont.)

- Depth of learning (n=3; Rare). Mastery-based course design helped students learn and understand the material better.
  - *It really forced you to understand how to do that problem and you actually had to learn that skill, whereas a traditional based class, sometimes you won't learn everything just because you might be focused on one part of the unit and you just might skip over something and it causes you to not learn as much of the material.*

The Anxiety domain (n=9; General) included 4 categories:

- Anxiety decreased with mastery-based (n=7; Typical). Aspects of mastery-based course design decreased stress/anxiety in some students.
  - *With the mastery-based it's definitely beneficial in that sense. You're not going in thinking like, "Oh if I fail this, I'm done for." You know what I mean? So, like, you're able to keep redoing them, and have less anxiety.*
- Test anxiety (n=7; Typical). Mastery-based course design influenced some students' feelings of stress/anxiety specific to test anxiety.
  - *Definitely less stressful…usually, like before tests, I kind of get all worked up and all anxious and stuff. But with the mastery-based skills, I didn't really feel that.*
- Feeling behind (n=4, Rare). Some students experienced more anxiety when they failed a skill or were not ready to test a recent skill.
  - *I felt anxiety because I felt like I was behind it and I was playing catch-up the whole rest of the semester.*
- Anxiety increase with mastery-based (n=4; Rare). Aspects of mastery-based course design increased stress/anxiety in some students.
  - *My anxiety levels towards the end of the semester sort of increased because I felt like I was running out of time to pass all the exams.*

Discussion

Findings

Initial data provides support for the hypothesis that mastery-based courses can reduce anxiety levels in engineering students compared to traditional courses. Mastery-based design may also reduce disparities in anxiety between majority and underrepresented groups. Students generally focused on positive aspects of mastery-based courses in post-semester reflections.

Limitations

This small-scale pilot makes results highly tentative. Self-reported anxiety levels may not represent actual anxiety at the time of the exams. Potential confound with one instructor going on medical leave with 4 weeks remaining in the semester.

Recommendations

Replicating these findings in larger samples at multiple institutions and with a broader range of engineering disciplines, student demographic populations, and instructors is necessary. Further exploration of these effects, particularly with underrepresented groups in STEM, may be especially relevant to efforts to further diversify the field.

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