The Effects of Curricular Change on Student Learning and Well-Being in Biomedical and Clinical Education

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The Effects of Curricular Change on Student Learning and Well-Being in Biomedical and Clinical Education

Rachel Jalaire Tomco Novak

A dissertation submitted to the faculty of Brigham Young University in partial fulfillment of the requirements for the degree of Doctor of Philosophy

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ABSTRACT

The Effects of Curricular Change on Student Learning and Well-Being in Biomedical and Clinical Education

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Doctor of Philosophy

The implementation of curriculum change, and innovative pedagogical theory, can help educators and administrators in higher education further the learning gains of students in the sciences. But the introduction of new methods of teaching, or curricular restructuring, can be interpreted by students differently, potentially affecting students' emotional states as well as their relationships with peers. To support not only the learning of students, but also their emotional and social well-being, pedagogical and curricular theory should be enacted in ways that take into consideration the full scope of the student experience.

In this dissertation, the implementation of curriculum and pedagogical theory, and the effects of the usage of active learning methods, are examined through student learning gains as well as through any reported social and emotional affects. In the first chapter we examine the history and realization of the integration of clinical and biomedical sciences in the field of predoctoral dental education. In the second chapter, the effects of early experiential learning opportunities are examined via students' progression to clinical competence and students’ self-reported confidence in a predoctoral dental program. In the third chapter, we consider and review how curricular change may affect students' emotional states, their relationships with peers, and if the concept of stereotype threat played any role in the complication observed. Lastly, in chapter four we explore how active learning may benefit, or hinder, the learning of students in an undergraduate anatomy course with social anxiety in a virtual learning environment. Throughout this dissertation, we seek to promote student learning through the use of educational best practices and consider how curriculum and pedagogical changes might also affect the feelings and emotional states of students, for the purpose of building a considerate and effective educational environment.

Keywords: student learning, curricular change, learning gains, cognitive and attitudinal change, biomedical sciences, clinical sciences, science education, peer mentorships, stereotype threat, student anxiety, student relationships, early experiential learning, integrated national board dental examination
ACKNOWLEDGEMENTS

I would like to express my appreciation for the guidance, support, and mentorship of my advisor, Dr. Jamie Jensen, as well as my committee members, Dr. Liz Bailey, Dr. Ken Plummer, Dr. Clark Dana, and Dr. Frank Licari. I am also grateful for the help of my manuscript writing support team, Bethany Blinsky and Dr. Burke Soffe.

I wish to also thank my mentors, colleagues, and students at Roseman University of Health Sciences, Brigham Young University, University of Utah, and University of Washington, who have supported my development as an educator and human for the past twenty years.

Lastly, I am especially grateful for the support of my family. My parents, Bob and Dot Tomco; and my husband, Jim Novak; and daughters, Elizabeth (7) and Rebecca (3). I am also thankful for the support of my siblings, in-laws, extended family, and friends.
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Chapter 1: The Integration of Biomedical and Clinical Sciences in Preparation for the INBDE: A Systematic Review

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This research was not sponsored by any grants or special funding. The authors are employed by Brigham Young University and Roseman University of Health Sciences.
ABSTRACT

Throughout the United States, predoctoral dental programs are in the process of restructuring curricula to better integrate the biomedical sciences and clinical sciences in preparation for the Integrated National Board Dental Examination (INBDE). In this systematic review of the literature, we examine the current state of curricular integration in the field of predoctoral dental education. We found that administrators and faculty reported to support integration; but students, faculty, and administrators all felt apprehensive about how it would be implemented and what the results would be. For instance, the barriers identified in achieving integration include faculty shortages, a lack of applicable training, and faculty already feeling strained with current workloads. After reviewing the relevant literature, we identified several recommendations for integration, including combining biomedical and clinical science courses, providing early patient care opportunities, discussing biomedical concepts in the student clinic, creating integrated seminars, utilizing case-based assessments, and implementing case-based and problem-based learning methods in the classroom. Though these recommendations could all be used to integrate a curriculum, we found the relevant published research on these methods to be sparse. Future research should examine the efficacy of these methods of integration in greater detail to identify best practices.

Key Words (MeSH Terms)

Dental, Education, Teaching Method, Integrated Curriculum, INBDE
INTRODUCTION

Thirty years ago, the field of dental education was in a dilemma. Dental schools were losing funding and government support, struggling to retain faculty, experiencing a reduction of student applicants, and schools were closing.\textsuperscript{1, 2} Dentistry was splintered from the healthcare field with its role as part of the medical team virtually unrecognized.\textsuperscript{1, 2} To begin addressing these issues, leaders in dental education reached out to the Institute of Medicine.\textsuperscript{1, 2} They requested the Institute to complete an independent and objective review of academic dentistry to help assess the current state of the field and find potential solutions.\textsuperscript{1, 2} Over the next few years, an eighteen-member committee completed site visits, created and dispersed surveys, and held public hearings.\textsuperscript{1, 2} One major outcome of this years-long review is a 360-page report titled, “Dental Education at the Crossroads: Challenges and Change”, which chronicles the history of dental education, the purpose of the field, dental curriculum, patient care, and more.\textsuperscript{1, 2}

In 1995, Field and Jeffcoat published an article summarizing the major themes of this mammoth report to help succinctly disperse the information within it.\textsuperscript{1} To summarize the first theme, Field and Jeffcoat stated, “Dental practitioners will use more medical knowledge in the future and will need to work more closely with other health professionals.”\textsuperscript{1} Moreover, they interpreted that dentists will need more comprehensive medical knowledge “to continue to forge links between dentistry and medicine.”\textsuperscript{1} These two themes highlighted the need for dentistry to become more integrated and understood as part of the overall medical team.\textsuperscript{1} Other major themes included the need to change accreditation and licensure, the creation of higher quality assessments, and a need to experiment with different educational models.\textsuperscript{1}
In 2006, a decade after the Institute of Medicine issued their vital publication, the American Dental Education Association’s Commission on Change and Innovation in Dental Education (ADEA CCI) published the first of twenty-one commissioned articles in the *Journal of Dental Education*. titled the Perspectives and Reflections in Dental Education (PRIDE). The PRIDE articles were created to address the issues outlined within the Institute of Medicine report. Specifically, in the PRIDE articles the leaders in academic dentistry identified a need for greater integration of biomedical and clinical learning to help better prepare students to apply their knowledge to patient-centered care rather than focusing on rote memorization of isolated facts. Integration is defined by van der Hoeven et al. as, “a regular manifestation of clinical relevance in basic science teaching and regular manifestation of basic sciences in clinical teaching, including delivery of patient care.” In response to the PRIDE articles call for clinical and biomedical integration, there has been an increased focus in the dental literature relating the oral cavity to organ systems, connecting dentistry with medicine, increasing evidence-based dentistry, and including educational best practices in dental education.

In response to the need for greater integration between the biomedical and clinical sciences, a new Integrated National Board Dental Examination (INBDE) was created. In 2021, all students take the new integrated exam. The INBDE assesses dental students’ understanding of biomedical, behavioral, and clinical sciences through integrated clinical cases, using a patient-box format with multiple-choice questions, as opposed to the previous NBDE which tested biomedical knowledge in isolation. Because of this change, it is imperative that U.S. dental schools reevaluate and redesign their curricula to better prepare their students for the integrated exam. The curriculum needs to be intentionally intertwined across all four years of
dental education, integrating the biomedical and clinical sciences both horizontally and vertically.3, 4, 7, 10, 12, 13, 16, 19-28

Addressing this need for curriculum change may be challenging due to the novelty of the INBDE as well as the fundamental reorganization integration could require within schools.19-21 Furthermore, much research has been done on the integration of biomedical and clinical sciences in medicine and other health professions, but few studies have been done in dental education. Because of this lack of research, it is crucial that dental schools share examples of how they are making this curricular shift to document the best practices of integration in the field of dental education.

This review analyzes the recent and relevant literature in dental education to assist in facilitating the integration of the biomedical and clinical sciences within dental education. In our review, we focus on the following three questions: 1) What are the attitudes of students, faculty, and administrators toward an integrated curriculum and the INBDE? 2) How are schools integrating the biomedical and clinical sciences in their curricula? and 3) What are the barriers to successful integration?

METHODS

This review utilizes the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) to structure the review process (see Figure 1).32,33 We began by seeking articles relevant to our research questions, and both Medline (EBSCO) and ERIC (EBSCO) were searched for peer-reviewed literature. The key search terms utilized are as follows: Dental and (integrated or integration) and (basic sciences or biomedical sciences) and (curricula or curriculum). The
databases were also searched for Integrated National Board Dental Examination or INBDE. Furthermore, all JDE abstracts were searched for Integrated and Curriculum.

In addition to database searches, we reviewed the most recent INBDE information on the following websites: American Dental Education Association (www.adea.org) and the Joint Commission on National Dental Examinations (www.ada.org/en/jcnde/inbde). After identifying our primary articles (n=172), we removed duplicates, leaving us with 153 articles (see Figure 1).

FIGURE 1. PRISMA flow diagram. This figure describes the systematic review process used for article selection. Adapted from Moher, et al.33
To determine which articles to include in our systematic review the title and abstract of each article was examined using inclusion and exclusion criteria (see Table 1). Then each article’s reference list was inspected to find additional related research (n=5). Since the first PRIDE article was published in 2006, we included articles from 2006 to 2021 that specifically referenced integrated curriculum in predoctoral dental programs, excluding all other student populations (n=16). A substantial number of articles were excluded from this review (n=105) because they did not meet our inclusion criteria. Many of the articles found were thought or opinion pieces and did not contain original research. Or the articles contained research that was focused on student populations outside the scope of this review, such as undergraduates, hygienists, or residents. Another common reason for exclusion was that the article centered on integration within the biomedical curriculum or integration within clinical courses exclusively, not integration between biomedical and clinical courses.
TABLE 1. Inclusion and exclusion criteria.

<table>
<thead>
<tr>
<th>Criterion</th>
<th>Inclusion</th>
<th>Exclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time Period</td>
<td>2006-February 2021</td>
<td>Studies before 2006. ADEA began publishing a series of 21 articles, calling for major changes in dental education (PRIDE), in 2006</td>
</tr>
<tr>
<td>Language</td>
<td>English</td>
<td>Non-English studies</td>
</tr>
<tr>
<td>Type of Article</td>
<td>Original research, published in a peer-reviewed journal</td>
<td>Literature reviews or perspective pieces and articles that were not published in a peer-reviewed journal</td>
</tr>
<tr>
<td>Ethics Clearance</td>
<td>Studies with approved ethics notification</td>
<td>Studies without approved ethics notification</td>
</tr>
<tr>
<td>Study Focus</td>
<td>Articles relating to the integration of biomedical and clinical sciences in predoctoral dental education. Articles that mention the new Integrated National Board Dental Exam</td>
<td>Any other topic, including clinical research</td>
</tr>
<tr>
<td>Population and Sample</td>
<td>Graduate students enrolled in a doctoral dental program (DMD or DDS)</td>
<td>All other student settings including undergraduate students, medical students, and dental hygiene students</td>
</tr>
</tbody>
</table>

Ultimately, this literature review is limited by the relatively few peer-reviewed studies published regarding the integration of biomedical and clinical sciences in dental education (n=16) (see Table 2).
<table>
<thead>
<tr>
<th>First Author</th>
<th>Title</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abdelkarim, A.</td>
<td>Attitudes and Perceptions of U.S. Dental Students and Faculty Regarding Dental Licensure</td>
<td>2015</td>
</tr>
<tr>
<td>Ahmad, F.</td>
<td>Stress Level of Dental and Medical Students: Comparison of Effects of a Subject-Based Curriculum versus a Case-Based Integrated Curriculum</td>
<td>2017</td>
</tr>
<tr>
<td>Ali, K.</td>
<td>Transfer of Basic Science Knowledge in a Problem-Based Learning Curriculum</td>
<td>2020</td>
</tr>
<tr>
<td>Baghdady, M.</td>
<td>Integration of Basic Sciences and Clinical Sciences in Oral Radiology Education for Dental Students</td>
<td>2013</td>
</tr>
<tr>
<td>Callis, A.</td>
<td>Application of Basic Science to Clinical Problems: Traditional vs. Hybrid Problem-Based Learning</td>
<td>2010</td>
</tr>
<tr>
<td>Duong, M.</td>
<td>U.S. Dental Schools' Preparation for the Integrated National Board Dental Examination</td>
<td>2018</td>
</tr>
<tr>
<td>Elangovan, S.</td>
<td>Integration of Basic-Clinical Sciences, PBL, CBL, and IPE in U.S. Dental Schools' Curricula and a Proposed Integrated Curriculum Model for the Future</td>
<td>2016</td>
</tr>
<tr>
<td>Haden, N.</td>
<td>Curriculum Change in Dental Education</td>
<td>2010</td>
</tr>
<tr>
<td>Henzi, D.</td>
<td>In the Students' Own Words: What Are the Strengths and Weaknesses of the Dental School Curriculum?</td>
<td>2007</td>
</tr>
<tr>
<td>Kingsley, K.</td>
<td>The Integration Seminar: A First-Year Dental Course Integrating Concepts from the Biomedical, Professional, and Clinical Sciences</td>
<td>2007</td>
</tr>
</tbody>
</table>
RESULTS AND DISCUSSION

After applying our inclusion and exclusion criteria we were left with sixteen articles that met the standards set to be included in this review (see Table 2). In our review of the literature, we found an overwhelming lack of research discussing the topic of clinical and biomedical integration within predoctoral dental programs. Due to the monumental nature of these curricular changes, as well as the novelty of the INBDE, it does not appear that there are obvious best practices in place to achieve an integrated curriculum in dental education.\textsuperscript{34} To assist in the process of exploring potential paths towards integration, this section examines our three review questions: 1) What are the attitudes of students, faculty, and administrators, toward an integrated curriculum and the INBDE? 2) How are schools integrating the biomedical and clinical sciences in their curricula? and 3) What are the barriers to successful integration?
What are the Attitudes Toward Integration?

Academic deans and administrators representing fifty-seven of sixty-four U.S. dental schools were surveyed in 2016 to assess their attitudes toward integration and the INBDE. Duong, et al. found that most academic deans, administrators, and faculty are in support of an integrated curriculum and board exam. For example, most of the survey respondents agreed in several areas: they supported the creation of the INBDE (60%), and they felt that their institutions would be prepared for the exam (72%). Furthermore, the deans and administrators felt an integrated exam would motivate schools to integrate the biomedical and clinical sciences and place a greater focus on application of knowledge. In 2016, van der Hoeven, et al. surveyed ninety-nine faculty members at a large public university to determine their attitudes toward integration. They found that almost all biomedical and clinical faculty felt that an integrated curriculum was valuable. Most biomedical faculty (80%) and clinical faculty (86.9%) reported that they already include integration in their courses.

Administrators, faculty, and students have concerns about the new exam. Duong, et al. found that although the academic deans and administrators they surveyed were supportive of the INBDE, they also felt that the changes to the board exam have created strain for their institutions (74%). Faculty and administrators acknowledge that changing the curriculum will take a lot of time, effort, and resources. They are worried that the exam may have too little biomedical sciences. As a repercussion, biomedical sciences may become less emphasized within the curriculum, potentially making it more difficult for students to make connections between the oral cavity and the rest of the body. Abdelkarim and Sullivan surveyed faculty and students at ten U.S. dental schools in 2014 regarding the integration of the board exam. In their
survey, both students and faculty felt that the new exam could contain an overwhelming amount of information and be overcomplicated. They felt it would be hard for students to remember biomedical content from previous years.

Overall, the attitudes from faculty and administrators towards the INBDE and integration as concepts are positive, and the research indicates that they are supportive of the changes. However, despite their reported support of integration and the INBDE, the literature also expresses that faculty and administrators feel apprehensive, nervous, and concerned about preparing their curriculum and students for this new exam.

How are Schools Integrating their Curriculum?

Research demonstrates that the bulk of U.S. dental schools have been working towards integration in some capacity. In 2020, van der Hoeven et al. sent a survey to academic deans at all sixty-seven U.S. dental schools to determine how they were preparing for the INBDE. Forty-two participants responded. In their research, van der Hoeven et al. discovered that 39% of dental schools are adjusting curricula, and 61% of participants reported that their institutions will be implementing changes soon. van der Hoeven et al. found that curricular integration was completed in three to four years at most schools. Many programs avoided completely redesigning their curriculum (56%), but they did change course sequencing, such as combining, adding and subtracting courses, and making changes to existing courses.

The process of change can be overwhelming and intimidating, especially in relation to making curriculum and institutional changes to prepare students for a new board exam that faculty and administrators have never seen. It seems likely that this process could include much
trial and error. As a result, programs are experimenting with many approaches to integration.\textsuperscript{19-21} This section serves as an overview of different integration methods published in the recent literature. However, due to the limited published research on integration in dental education, and the novelty of the INBDE, it does not feel apparent that any best practices have been established. As a result, the methods of implementation discussed here are not listed in any distinct order of effectiveness. Instead, the purpose of this review is to examine and explore how each of these methods could be used to increase clinical and biomedical integration within the curriculum of a predoctoral dental program.

**Combine Courses**

Baghdady, et al. compared the diagnostic accuracy of students after combining a biomedical and a clinical course to understand the impact of curricular integration.\textsuperscript{36} They did so by first dividing their students into two treatments, where one treatment learned basic bony landmarks in isolation, with traditional basic science descriptions. The other treatment learned bony landmarks with the same basic science descriptions combined with clinical features that are typically learned in a radiology or oral pathology course, with additional clinical experiences.\textsuperscript{36} Baghdady, et al. found that integrating the course improved students’ diagnostic abilities on exams.\textsuperscript{36}

One can imagine that this method would work well with a head and neck anatomy course combined with oral surgery, or a dental anatomy with a restorative course, or even combining immunology with endodontics or periodontics. This method of integration has many possible applications and combinations, and as a result, it seems like it may be a method of integration accessible to many dental programs.
Early entrance to clinic

Henzi, et al. surveyed 605 dental students across the nation on their perceived strengths and weaknesses of the dental school curriculum. The survey was open ended and students expressed that they want to be in the clinic as early as possible in their program. Moreover, early access to the clinic helps students integrate their biomedical knowledge with their clinical experiences. Exposure to patient interactions helps provide real-world context for the biomedical course content, as it aids their acquisition of biomedical knowledge not to be focused on memorization, but current and future clinical application. However, there is a gap in the literature in exploring this as a true possibility for integration. Further research needs to be conducted to determine the outcomes of early clinical entrance.

Biomedical sciences in the clinic

Baghdady et al. suggested that reemphasizing biomedical concepts on the clinic floor may be useful for students as they are building their diagnostic abilities, especially in radiology, anatomy, and pathology. As an example, before a student gives an oral injection, a clinical faculty could ask what blood vessels are near the injection site or ask the student to identify the name of the branch of the trigeminal nerve they are attempting to anesthetize. But van der Hoeven, et al. found that clinical faculty might be intimidated to present biomedical sciences because they have forgotten the biomedical details they learned as a student. Based on van der Hoeven, et al. findings, appropriate faculty development opportunities could be provided to give clinical and biomedical faculty a chance to learn and discuss topics together.

Integrated Seminar Series
Kingsley, et al. established a seminar series for their first-year students where they discussed basic sciences and clinical sciences. The goal of the seminar was to create a space to generate conversation surrounding how both topics coincide with each other, and their relation to direct patient care in their clinics. The researchers found that the students that participated in the seminar series scored significantly higher on the NBDE-part-1 than students that did not participate in the series.

Courses or seminars that help students make these connections between biomedical sciences and clinical sciences early on may potentially help students make the same connections later in school, during board exams, and throughout their careers.

Case-based Assessments

To evaluate student understanding before entering the clinic, Trowbridge, et al. designed a case-based integrated oral examination to evaluate students’ understanding of integrated biomedical and clinical concepts. They designed the oral exam similar to the INBDE, using patient-box cases, including a common medical condition. In addition to the clinical scenario, the students were provided a full mouth series of radiographs, maxillary periodontal chart, mandibular periodontal chart, and intraoral photographs. They found that the examination was “a very useful tool in evaluating students critical thinking ability.” Moreover, the examination also gave them insight into which students may need additional help and remediations.

Although creating and administering an examination of this caliber is not a small endeavor, giving students the opportunity to practice answering quick, informal case-based questions could potentially also help faculty to identify struggling students, while also helping
students build confidence in their ability to apply their biomedical knowledge to clinical scenarios. Further research into the application of a more informal assessment process is warranted to better understand the usefulness of this proposed idea.

**Integrated case presentations**

Intertwining course topics horizontally and vertically has been suggested as a method of curricular integration. Townsend, et al. surveyed students and faculty in a “dental rounds” course that was designed specifically to vertically integrate the biomedical and clinical sciences at their institution. In the course, third and fourth-year students were tasked with presenting interesting clinical cases from patients they treated in the clinic, and all other students, the biomedical faculty, and clinical faculty, were required to attend. Many students who attended reported that the course improved their clinical knowledge. Recent graduates and D4 students reported that the course directly impacted the quality of their patient care.

This study highlights the exciting potential of biomedical and clinical faculty partnering on clinical cases and topics. It also models professional behavior, fosters community and respect, as well as highlights the importance of interprofessional collaboration for students.

**Case-based Learning (CBL)**

In their survey to identify the strengths and weaknesses of the dental school curriculum, Henzi et al. found that some students wished to apply their biomedical knowledge to clinical scenarios, rather than focusing entirely on memorization and regurgitation. One way of learning applied biomedical knowledge is through case-based learning (CBL). CBL is a method of learning where students are introduced to new concepts, scenarios, and knowledge through the
application of clinical cases. Lantz and Schuler noted that 100% of schools reported some level of CBL in 2010.42 The reported benefits of using CBL to augment the learning of the biomedical sciences in dental education include increased self-directed learning, increased focus on application of knowledge, improved horizontal and vertical integration, and an invigorated active learning process.19-21, 23, 25, 37, 38, 43-45

Problem-based Learning (PBL)

Problem-based learning (PBL) is a learning method where students learn about a subject by working through an open-ended problem. There are no traditional lectures or slides; instead, faculty members serve as facilitators and guides. A major benefit of PBL is that it allows the integration of biomedical and clinical sciences to happen naturally.38 The outcomes of PBL are mixed.43 A large meta-analysis of thirty-five studies analyzing PBL in medical education over two decades showed that some students who trained using PBL did not perform as well on medical board exams as students that received traditional lectures.43 Furthermore, few programs have a curriculum entirely based on PBL.13

Reported downsides to PBL include the need for additional classrooms, increased student stress, faculty time to develop cases and facilitate small group learning, and questionable effectiveness.19-21, 23, 25, 37, 38, 43-45 Ahmad, et al. reported that changing to a case-based integrated curriculum from a subject-based curriculum raised the students’ stress levels in most categories.44 Due to the difficult nature of implementing a PBL model, using PBL may be more reasonable within a single isolated course, instead of designing an entire curriculum around this method.
What are the Barriers to Integration?

Based on faculty and administrator surveys conducted by Duong et al., van der Hoeven et al., and van der Hoeven et al., it was found that in most cases, it is the rank-and-file teaching faculty, not the university administrators, that carry the weight of redesigning courses to increase curricular integration. The undertaking of curriculum integration can be overwhelming for already overworked educators, bringing on feelings of fear and frustration. The research shows that the primary reported barriers for curricular integration are lack of faculty time and the need to retrain faculty. Additional issues which range in complexity, include resistance to change from faculty, lack of opportunities for interaction between biomedical and clinical faculty, and a general unfamiliarity with what is being taught in the curriculum.

The workload of integration is heavy and needs to be distributed equally across all faculty. This could possibly be alleviated by adjusting requirements for teaching, research, and service while faculty are actively working on redesigning their courses. Additionally, successfully integrated courses could be incentivized financially or with professional recognition.

CONCLUSION

Thirty years after the Institute of Medicine was asked to evaluate the field of academic dentistry, and fifteen years after the first PRIDE article was published, the new Integrated National Board Dental Examination has replaced the previous NBDE. This change will continue to require a fundamental, systemic transformation to traditional dental education. As a field, we have entered a pivotal moment and are witnessing the vision of this study, over thirty years later, becoming realized.
To continue the legacy of this change, U.S. dental schools must adjust their curricula to reflect the new INBDE.\textsuperscript{20} Despite trial-and-error efforts and progress made at individual universities, research available on integration in dental education is sparse. To truly discover the best practices of integration for our students, patients, and the dental education field, we need to share our ideas, successes, and failures. Some recommendations from the current literature include combining biomedical and clinical science courses, providing early patient care opportunities, discussing biomedical concepts in the student clinic, creating integrated seminars, utilizing case-based assessments, and implementing case-based and problem-based learning methods in the classroom. However, due to the limited research available, further research must be performed and published on biomedical and clinical integration in predoctoral dental programs. As a community, let us help each other find ways to continue to train our students to provide evidence-based, compassionate, person-centered care in the best ways we know how.
ACKNOWLEDGEMENTS

For guidance on designing, creating, and organizing a systematic review, the authors would like to express their gratitude to Dr. Rick West of Brigham Young University for providing gracious mentorship and instruction.
REFERENCES


Chapter 2: Early Patient Care and Biomedical Science Integration Increases Predoctoral Dental Student Competence and Confidence

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This research was not sponsored by any grants or special funding. The authors are employed by Brigham Young University and Roseman University of Health Sciences.
ABSTRACT

Purpose: In response to the new Integrated National Board Dental Examination, predoctoral dental education programs are striving to find best practices and methods to integrate the biomedical and clinical sciences. Our study investigates early experiential learning as a method of curricular integration by allowing students to begin their clinical experience in the first year of the program, as well as distributing biomedical classes throughout the predoctoral dental school curriculum. Methods: This study utilizes a quasi-experimental design with two different treatments, Standard Curriculum Treatment and Integrated Curriculum Treatment, n=87. Data were collected from 2017-2021. Results: We found that, on average, it took 608 hours less for the participants in an integrated curriculum treatment to reach clinical competence in comparison to peers who did not experience the same methods of integration in their program. These data were collected through daily faculty evaluations of students' progression as well as participants' own self-assessment. Our results indicate that those in the Integrated Curriculum Treatment also had an increased sense of confidence in their ability to apply the biomedical sciences to patient care. Conclusions: The findings of our study demonstrate that by providing opportunities for patient care from the beginning of the program, as well as integrating the biomedical sciences throughout the curriculum, students were able to reach clinical competence half a year earlier than their peers. This suggests that early experiential learning may be a viable option not only for integration, but for sequencing the curriculum to best support students' progression towards clinical competency.

Key Words / MeSH Terms: Integrated National Board Dental Examination (INBDE), Integrated Curriculum, Dental Education, Clinical Competency, Early Experiential Learning
INTRODUCTION

Throughout the course of the past century, the sequencing of the curricula in dental and medical education has remained relatively unchanged.¹ This is likely due in part to the fact that these curricula were designed around the prevailing “2+2” model developed in the Flexner Report in 1910, wherein students are to complete two years of biomedical sciences and then progress to two years of clinical sciences.¹ Medical education began diverting from this design in the 1980s, but only in 2006 did a major shift in thought and purpose emerge within the field of dental education, and in dentistry at large, with the publication of the first paper in the twenty-one article PRIDE series.¹⁻⁴ In the realm of dental education, this change in thought developed as a need to restructure the predoctoral dental school curriculum, through the greater integration of the biomedical and clinical sciences.³⁻⁷

Due to the increased focus on integration in the field, the National Board Dental Examination (NBDE) was replaced with the Integrated National Board Dental Examination in 2021 (INBDE).⁸ The newer INBDE focuses on the integration of the sciences and tests the entirety of students’ applicable knowledge in a single examination as opposed to the two exams that made up the NBDE.⁹ As a result of this change, there is now no inherent need for dental programs to compress all biomedical coursework into the beginning of the program while relegateing all clinical education to the end.

In response to the call for integration, and to prepare students for the new INBDE, universities around the nation are employing different methods to better integrate the sciences in the predoctoral dental school curriculum.⁵⁻⁷ These varying approaches include combining biomedical science and clinical science courses, reinforcing the biomedical sciences on the clinic floor, introducing integrated seminar series, utilizing case-based assessments, developing
integrated case presentations, and applying the methods of case-based and problem-based learning in the classroom.5-7, 10-24

The discipline of predoctoral medical education endeavored to increase the integration of the sciences through the use of early experiential learning.1, 25 Early experiential learning is a teaching method which can be defined as the method of learning by doing.25 This method was implemented in a medical program through the use of student clinical clerkships that took place early in the program and granted time for students to learn biomedical knowledge in the classroom while also being involved in a clinical setting.25, 26 From this experience, it was inferred that the opportunity for early clinical experiences in the curriculum can give space for students to learn and process information individually, helping to build a scaffolding of understanding from which they can pull from in future clinical contexts.25

Applied to dental curricula, experiential learning could involve designing the program to ensure that students begin in the university’s student clinic in methods that are appropriate for their knowledge level early on and throughout the entirety of the dental program. Our study examines a method of increased clinical and biomedical integration through the use of early experiential learning. Specifically, we examine the effects of distributing biomedical courses throughout the first three years, while also allowing for experiences with patients in the university’s dental clinic to begin in the first year of the program. We seek to understand if these curricular sequencing changes can have a positive effect on predoctoral dental students’ confidence, competence, and learning gains as a method of increased biomedical and clinical science integration. The research questions guiding this study are as follows:

1. Will earlier exposure to the clinic lead to students reaching clinical competency earlier?
2. Will earlier exposure to the clinic lead to increased numbers of completed procedures?

3. Will earlier exposure to the clinic lead to increased confidence (in their clinical skills, to integrate biomedical sciences with clinical practice, to treat patients with complicated medical histories, to treat patients requiring complicated dental procedures)?

**METHODS**

**Ethics Statement**

The Roseman University of Health Sciences Institutional Review Board reviewed and approved the study protocol with an assigned study number of 1619406. Written consent was obtained from all participants in this study.

**Description of Participants**

Participants in this study are students enrolled at a non-profit institution of higher learning. This university houses the College of Dental Medicine (CODM) which offers a four-year Doctor of Dental Medicine (DMD) program, and all participants in this study are students within this specific program. The CODM has four classes of students per academic year with first year, second year, third year, and fourth year students; and each of the four classes in the DMD program have between 82 and 102 predoctoral students. In total, there are 87 participants in this study with 44 students in the Integrated Curriculum treatment (ICT; Class of 2022), and 43 students in the Standard Curriculum treatment (SCT; Class of 2021).

**Study Design**

This study utilizes a quasi-experimental design with two different treatments, SCT and ICT. For the SCT, the students completed much of their biomedical coursework during the first
year of the DMD program (Figure 1A). Beginning in their third year, much of their program time was spent in the clinic. These students took Part I of the NBDE at the completion of the first year of the program and Part II at the end of their third year. For the ICT, the students completed their biomedical coursework over the span of three years, with a heavy emphasis on biomedical sciences in their second and third years (Figure 1B). They were exposed to the patient clinic in their first year of dental school. Unlike the students in the SCT, these students took the INBDE at the end of their third year (see Figure 1).

FIGURE 1. Curriculum Model by Treatment. (A) Standard Curriculum Treatment, Class of 2021 (B) Integrated Curriculum Treatment, Class of 2022

Data Collection

Group Equivalence and Quantity of Procedures

We established group equivalence through data that was collected from admissions records including gender, age, Dental Admissions Test score (DAT), and undergraduate grade point average (GPA) of all our participants. To compare the quantity of procedures completed by each treatment, data were pulled on the clinical activities of all 87 study participants from the CODM’s clinical electronic health record system. These data encompassed the total number of comprehensive exams, direct restorations (including composite, amalgam, buildup), and
periodontal therapies (including prophylaxis, scaling and root planing, periodontal maintenance) completed by the study participants.

Clinical Hours to Reach Competence

To compare the number of clinical hours it took each participant to reach clinical competence, assessment data was taken from the CODM student assessment database which includes results of student daily evaluations completed by faculty on each clinical procedure performed by the participants. At the CODM, students are evaluated on each procedure completed using an Entrustability Scale as defined by Rekman, et al. in *Entrustability Scales: Outlining Their Usefulness for Competency-Based Clinical Assessment*, designed to evaluate medical residents. Instead of students receiving a letter or number grade relating to their deficiencies, they are rated on a scale that indicates their readiness for independent clinical practice. Based upon the theory reported by Rekman et al., the scale utilized by the CODM contains five levels of supervision: unable to perform, direct supervision, indirect supervision, independent, and entrustable. All faculty participated in multiple training sessions to increase grading calibration and interrater reliability. In this study, we compare the number of clinic hours needed for each student to reach the independent level which is required for graduation and program completion.

Survey Data

Lastly, our participants completed an online survey which included 52 multiple choice questions. The survey measured multiple latent factors including when the students felt they reached competence in various clinic skills as well as their confidence in several factors including the following: clinical skills, applying biomedical sciences to clinic, treating patients
with complicated medical histories, and treating patients requiring complicated dental procedures. The students were also asked which curricular model they felt best prepared students. The students in the SCT completed the survey in the fall of 2020, at the beginning of their fourth year. The students in the ICT completed the survey in the fall of 2020, at the beginning of their third year, and again in the fall of 2021, at the beginning of their fourth year.

To illustrate the most compelling comparison between the two treatment groups, we have chosen to report the survey results that the ICT took in the fall of 2021. By doing so, we can compare, contrast, and analyze the data of both treatments from the beginning of their final fourth year as students of the CODM.

Due to the highly specific nature of the research topic at hand, no valid survey instrument was readily available for this project. Thus, the survey utilized in this study was constructed by the research team led by an expert in educational survey design (JJ). To test content and face validity of the survey, three current dental students (ET, GJ, AH) and three subject experts (RN, BS, CD) read each question and discussed the relevancy and clarity of each item. Though we did not have a large enough sample size to conduct analysis through confirmatory factor analysis (CFA), we utilized this method to determine relationships between multiple variables and to test construct validity using Mplus software ver. 8, see Supplemental Table S1.28

RESULTS

Equivalence of Treatment Groups

Due to the quasi-experimental nature of our study, we tested to see that our two treatment groups were equivalent. To test gender equivalence, we did a Chi-Square Test of Independence. There were proportionally equal males and females in the two treatment groups ($K^2(1)=0.103$,
p=0.749, n=87). As shown in Table 1, the two treatment groups were also statistically equivalent at the beginning of the program in terms of Age, Grade Point Average (GPA), and Dental Admission Test score (DAT).

### TABLE 1. Equivalence of Treatment Groups. Compared via independent samples t-tests.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard Curriculum (SCT)</th>
<th>Integrated Curriculum (ICT)</th>
<th>t (df)</th>
<th>p-value</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>29.91 (3.571) 43</td>
<td>29.43 (3.944) 44</td>
<td>-0.589 (85)</td>
<td>0.558</td>
<td>0.126</td>
</tr>
<tr>
<td>GPA</td>
<td>3.535 (0.281) 43</td>
<td>3.499 (0.296) 44</td>
<td>-0.582 (85)</td>
<td>0.562</td>
<td>0.125</td>
</tr>
<tr>
<td>DAT</td>
<td>20.064 (1.708) 43</td>
<td>19.728 (1.389) 44</td>
<td>-1.010 (85)</td>
<td>0.315</td>
<td>0.217</td>
</tr>
</tbody>
</table>

### Quantity of Procedures

To determine whether students in our two treatment groups completed different quantities of procedures, data were collected regarding numbers of procedures the students had completed from the beginning of the program through their third year (see Table 2). An independent-samples t-test showed that students in the ICT completed significantly more periodontal treatments (66) compared to the students in the SCT (58). There was no significant difference between the two curricula for comprehensive exams or restorations.

### TABLE 2. Quantity of Procedures. Number of procedures completed by the student by the end of their third-year, compared via independent samples t-tests.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Standard Curriculum (SCT)</th>
<th>Integrated Curriculum (ICT)</th>
<th>t (df)</th>
<th>p-value</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td># Comp Exams</td>
<td>27.020 (8.686) 43</td>
<td>27.910 (8.319) 44</td>
<td>0.486 (85)</td>
<td>0.628</td>
<td>0.104</td>
</tr>
<tr>
<td># Restorations</td>
<td>55.740 (18.663) 43</td>
<td>61.410 (14.510) 44</td>
<td>1.578 (79.261)</td>
<td>0.119</td>
<td>0.339</td>
</tr>
<tr>
<td># Periodontal</td>
<td>57.740 (12.803) 43</td>
<td>65.770 (14.589) 44</td>
<td>2.726 (85)</td>
<td>0.008*</td>
<td>0.585</td>
</tr>
</tbody>
</table>
Clinical Competence

To compare the number of clinical hours it took each student to reach clinical competence, we analyzed data from the participant’s academic records. We calculated the number of hours it took each of our participants to reach clinical competence, defined as reaching clinical independence (see Figure 2 and Table 3). By independent samples t-test, we saw a significant difference between treatments ($t(85)=-8.953$, $p=0.001$, $d=1.920$). Students in the SCT took an average of 3,247 hours to reach clinical competence (SD=273). Students in the ICT took an average of 2,639 hours to reach clinical competence (SD=354).

FIGURE 2. Clinical Competence. (A) Clinical hours to reach clinical competence, as assessed through daily faculty evaluations. Clinical competence is defined as reaching clinical independence on an entrustability scale. This scale contains five levels of supervision which include: unable to perform, direct supervision, indirect supervision, independent, and entrustable. (B) Point in program reached clinical competence, as self-assessed by students.
Through our survey, students were asked to self-report when they felt they had reached competence in several clinical areas (see Figure 2 and Table 3), they did so through ranking their competence timing on a scale of 1 to 8 (1-first half of first year, 2-second half of first year, 3-first half of second year, 4-second half of second year, 5-first half of third year, 6-second half of third
year, 7-first half of fourth year, 8-second half of fourth year). As shown in Figure 2 and Table 3, all results were statistically significant by independent samples t tests. The ICT group self-reported reaching competence in comprehensive exams, direct restorations and periodontal therapy an average of half a year earlier for treatment type. This difference was significant for each type of procedure.

**Confidence in Clinical Skills and Applied Biomedical Sciences**

Students were asked to report their levels of confidence in various situations. The questions were Likert-style, scored on a six-point scale (1=strongly disagree through 6=strongly agree). The students in the ICT reported significantly more confidence than students in the SCT in applying biomedical sciences to the university clinic, treating patients with complicated medical histories, and treating patients requiring complicated dental procedures (see Figure 3 and Table 3). The students in the SCT and ICT did not have significantly different levels of confidence in their overall clinical skills. The students were also asked if they felt that the curriculum model they experienced was superior to the curriculum model experienced by the other treatment group. The students in the ICT slightly agreed that they received a better model while the students in the SCT slightly disagreed that they received a better model (p=<0.001).
FIGURE 3. Attitudinal Results. (A) Students’ level of confidence compared by treatment group. (B) Students’ level of agreement that the curricular model they experienced was superior to the curricular model experienced by the other treatment group.

DISCUSSION

Our study examines the impact of a curricular design which utilized early experiential learning as a method of increasing the integration of the clinical and biomedical sciences. We analyzed the effects of scheduling clinical courses in the first year and throughout the program, while also distributing biomedical courses throughout the first three years. We measured the impact of these changes on students’ confidence and competence.

In the ICT treatment, students completed biomedical coursework throughout their program (see Figure 1B). This group of students also began in the clinic during the first program year with faculty supervision and only practiced at the appropriate level for their attained knowledge and skill. In the SCT treatment, students completed much of their biomedical coursework in the first year of the program with much of their clinical education taking place beginning in their third year (see Figure 1A). Though the clinical hours were scheduled...
differently in each treatment’s program, the total amount of hours in the clinic for the two treatments was approximately the same.

**Progression to Competence**

One facet of the student’s clinical education examined was their progression towards competence in the university’s dental clinic. For the first treatment, ICT, we found that it took these participants, on average, 2,639 hours (see Figure 2) in the student dental clinic to reach competence as defined by the established CODM entrustability scale. In comparison, those in the SCT took on average 3,247 hours in the student clinic to reach competence. This signifies that it may have taken close to 608 hours less for the participants in the ICT to reach clinical independence. This was still true after accounting for other student-level variables such as gender, DAT score, and number of procedures completed (see Table S2 in Supplemental Materials). This also suggests that participants in the ICT became independent in the beginning of their fourth program year, meaning that this treatment became independent nearly half a year earlier in their program than participants in the SCT who reached independence in the middle of their fourth year.

Our data support the findings from other health professions, such as predoctoral medical education, about the importance of the integration of biomedical and clinical sciences. For instance, in the field of predoctoral medical education, it was found that students who began in early clinical clerkships in their medical program reached clinical competence earlier as determined by external clinical experts when compared to students who did not experience the early clinical clerkships.
To provide further narrative, we asked each study participant to self-assess and report on their own perceived progression towards competence regarding their clinical experience (see Figure 3 and Table 3). In the ICT, participants reported reaching clinical competence in comprehensive exams, direct restorations, and periodontal therapy half a year earlier than the SCT. This finding directly correlates with the data collected from faculty assessment which shows that participants in the ICT, on average, reached competence nearly half a year earlier than those in the SCT, providing concurrent validity.

**Confidence in Knowledge and Application**

Our results demonstrate that the students in the ICT were significantly more confident in their ability to apply biomedical sciences in clinical settings, their ability to treat patients with complicated medical histories, and their ability to treat patients requiring complicated dental procedures (see Figure 3 and Table 3). We theorize that this difference may be because the ICT was able to have clinical experiences early in their program, and that all their didactic courses were restructured to utilize patient-box cases to increase the clinical relevance. Similar results have been reported in predoctoral medical education, where researchers found that the integration of the sciences helped students find the biomedical sciences to be more meaningful and relevant to their clinical experiences.29

**Implications for Dental Education**

It appears well accepted that the methods of curriculum integration, and experiential learning, are important pedagogical and curricular design tools that can be used to aid in increasing learning gains and bettering learning outcomes for students.1, 5-7, 25, 26, 29 In our study
we found that it took 608 hours less, on average, for students who experienced an integrated curriculum, through early clinical experiences and biomedical courses distributed throughout the predoctoral program, to reach clinical independence when compared to peers in a treatment who did not experience these integration methods. Moreover, our findings are supportive of those in the medical education literature which also illustrate similar learning gains for students in predoctoral medical programs who were able to begin in clinical settings early in their respective programs.26

The validity of the data collected in our study may have been affected by factors such as faculty variance in grading, the ongoing COVID-19 pandemic, and our small sample size. However, it still appears significant enough to warrant further inspection and inquiry. Future research may examine how early experiences of patient care can impact predoctoral dental students’ learning gains across many universities, or how this method compares to other popular methods of integration such as case-based, or problem-based learning.

CONCLUSION

At this time, predoctoral dental education programs around the country are experimenting to discover the best practices of curricular integration.5-7 Our study and findings help to provide further insight into this incredible undertaking and highlight the need for more research to be done on introducing students to clinical settings, and patient care, early on in their programs. Our data suggest that it may not take more overall program time in the university dental clinic for students to reach competence. Instead, if the clinical time already allotted in a program is sequenced in an integrated manner, and students are given the ability to start their progress in the dental clinic in the first year, they may be able to reach clinical competence earlier than anticipated.
ACKNOWLEDGEMENTS

The authors of this study would like to extend their sincerest gratitude to all the students who participated in this study. Without their shared perspective and insight this work would not have been possible, and their contribution is incredibly appreciated. This research was not sponsored by any grants or special funding.
REFERENCES


SUPPLEMENTAL MATERIALS

Appendix 1: Tables S1 and S2

TABLE S1. Fit statistic for each latent variable

<table>
<thead>
<tr>
<th>Latent Variable (Number of Associated Items)</th>
<th>RMSEA</th>
<th>CFI</th>
<th>TLI</th>
<th>SRMR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clinical Competence (3)</td>
<td>0.058</td>
<td>0.955</td>
<td>0.944</td>
<td>0.078</td>
</tr>
<tr>
<td>Clinic Confidence (9)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Curricular Preference (9)</td>
<td>0.081</td>
<td>0.962</td>
<td>0.946</td>
<td>0.050</td>
</tr>
<tr>
<td>Confidence in Applying Biomedical Sciences to Clinic (4)</td>
<td>0.097</td>
<td>0.936</td>
<td>0.907</td>
<td>0.055</td>
</tr>
<tr>
<td>Confidence Treating Patients with Complicated Medical Histories (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Confidence Treating Patients with Complicated Dental Procedures (3)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TABLE S2. Results of multiple linear regression with Hours to Reach Clinical Independence as target.

<table>
<thead>
<tr>
<th>Adjusted R²</th>
<th>Unstandardized B</th>
<th>Coefficients Std. Error</th>
<th>Standardized Coefficients Beta</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.552</td>
<td>(Constant)</td>
<td></td>
<td></td>
<td>2.987</td>
<td>0.004*</td>
</tr>
<tr>
<td>Female</td>
<td>213.539</td>
<td>71.961</td>
<td>0.245</td>
<td>2.967</td>
<td>0.004*</td>
</tr>
<tr>
<td>Age</td>
<td>-1.833</td>
<td>9.014</td>
<td>-0.016</td>
<td>-0.203</td>
<td>0.839</td>
</tr>
<tr>
<td>Undergraduate GPA</td>
<td>130.331</td>
<td>120.034</td>
<td>0.085</td>
<td>1.086</td>
<td>0.281</td>
</tr>
<tr>
<td>DAT</td>
<td>7.590</td>
<td>23.223</td>
<td>0.027</td>
<td>0.327</td>
<td>0.745</td>
</tr>
<tr>
<td># Comp Exams</td>
<td>-1.379</td>
<td>4.750</td>
<td>-0.027</td>
<td>-0.290</td>
<td>0.772</td>
</tr>
<tr>
<td># Restorations</td>
<td>0.332</td>
<td>2.321</td>
<td>0.013</td>
<td>0.143</td>
<td>0.887</td>
</tr>
<tr>
<td># Periodontics</td>
<td>-2.670</td>
<td>2.927</td>
<td>-0.087</td>
<td>-0.912</td>
<td>0.364</td>
</tr>
<tr>
<td>Standard Curriculum Treatment</td>
<td>588.229</td>
<td>69.997</td>
<td>0.674</td>
<td>8.404</td>
<td>&lt;0.001*</td>
</tr>
</tbody>
</table>

*Suggests p<0.05
Chapter 3: Changes to the University Curriculum Can Cause Negative Social and Emotional Impacts on Peer Mentorships and Relationships, Including Stereotype Threat

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This research was not sponsored by any grants or special funding. The authors are employed by Brigham Young University and Roseman University of Health Sciences.
ABSTRACT

Purpose: Altering the curriculum of a program can have negative repercussions for the student experience, including peer mentorships and interclass relationships. This study seeks to investigate what those consequences could be for students’ emotional and social well-being in a predoctoral dental program, and if any of these consequences could be related to the theory of stereotype threat.

Methods: This study utilizes a quasi-experimental design with two different treatments, New Curriculum Treatment and Past Curriculum Treatment, n=87. Data were collected using mixed methods via survey and semi-structured interviews.

Results: Findings from our survey suggest that student relationships and peer mentorships were impacted by the curriculum changes implemented by the program. In our interviews, each participant indicated that they did believe that stereotype threat may have played a role in the difficulties experienced.

Conclusions: When making changes to the structure, sequencing, or content of a program, administrators need to be aware of the potential ramifications these changes could have on students' relationships with their peers. Stereotype threat, in particular, can have negative consequences for mental well-being, and working to address this issue when implementing change could help mitigate any potential repercussions.

KEY WORDS

Curriculum change, stereotype threat, peer mentorships, health professions education, dental education
INTRODUCTION

At the university level, changes made to the curricula of programs are often implemented to improve course sequencing, reflect new theoretical developments, and to apply best educational practices for the benefit of student learning gains (1). However, the effects of curriculum change are not always entirely positive. Aspects of an educational program, like peer mentorships, and the social and emotional well-being of students, including interpersonal relationships, can all be negatively affected as a consequence of altering the curriculum (1, 2). Changes to the curriculum can seriously alter the educational environment as a whole and may negatively affect student perceptions of the college or program (1-6). Furthermore, though changes are often put forth with good intention, the outcomes of curriculum change can adversely affect aspects of the student educational experience (1-6).

The potential negative consequences of curriculum change are exacerbated by the structure of professional graduate programs (1, 2). Unlike undergraduate education, students in professional graduate programs are not typically progressing through a program with courses involving many students in other majors or disciplines (1, 2). Instead, students in these focused programs matriculate into the school in a cohort and spend the majority of their time with these individuals over the course of several academically rigorous years (1, 2). This adds an additional layer of complication to any type of curriculum change implemented by the university as these students are interpersonally connected and deeply aware of the environment of their program and may potentially compare their own academic experience to other graduating classes (1, 2).

In graduate medical programs such as dental medicine, students in higher years, such as the fourth year, may work to mentor students in lower years, such as first-year, second-year, and third-year students, during clinical education courses (7-9). Clinical peer mentorships have been
shown to have bidirectional benefits for students, furthering the learning of both the mentor and mentee (7-9). As such, it is probable that any change made to a graduate medical curriculum with peer mentorship structures could complicate these important interclass relationships if the curriculum changes made during the transition year allow for the mentee to access learning gains in a way that makes it appear as if they have outpaced their mentor in knowledge and skill (1, 2, 7-9). This situation could cause interpersonal conflict harming not only learning gains, but also the social and emotional well-being of both the mentor and mentee (1, 2).

One theory that delves into how intellectual functioning, performance, and interpersonal relationships can be affected and complicated by group perception is the concept of stereotype threat (10-16). Stereotype threat is defined as a fear of confirming a negative stereotype about a group with which you personally identify or belong in a significant way (10-16). Experiencing stereotype threat can cause feelings of intense self-doubt; complicate interpersonal relationships; induce anxiety, stress, and unease; and even increase blood pressure (10-22). Worrying about validating a negative stereotype can put a great mental and emotional burden on the psyche, especially when working at the limits of one’s own skill and knowledge (10-16). For example, feeling stress about confirming a stereotype can increase cognitive load, reduce working memory, and use different neural pathways (19, 21, 22).

To better understand the potential consequences of introducing curriculum change in professional graduate programs, we seek to investigate if and how the implementation of significant curriculum changes impacted peer mentorships and relationships in a Doctor of Dental Medicine (DMD) program. We use the concept of stereotype threat as the theoretical rationale guiding our inquiry, to investigate if any aspect of interpersonal relationship complication could be related to the reported effects of stereotype threat, and to better understand
what this might mean for students’ emotional well-being. We chose to use stereotype threat as
our lens because it has been shown to adversely affect individuals at many levels of the medical
system: patients, medical students, and doctors in academic medicine (23-26). For instance,
stereotype threat has increased the likelihood of health disparities for patients, has led to
underperformance for predoctoral medical students, and in academic medicine contributed to
gender disparities in leadership positions (23-26).

At the institution examined in our study, administrators drastically restructured the
curriculum through altering the sequencing of clinical and biomedical courses. The biomedical
courses were moved from primarily the first year, to being dispersed throughout the program,
and clinical courses were adjusted from students fully beginning in the clinic in their third and
fourth year, to students beginning in their first year and completing clinical courses throughout
the program. This meant that though students were not receiving additional time in clinical
courses compared to other graduating classes, they were having clinical courses during their
entire experience as dental students. Hence, because of how vastly different these curriculum
models are, we seek to explore the potential ramification of these changes in relation to student
well-being, and peer relationships and mentorships.

The research questions guiding this study are as follows:

1. Did the changes to the curriculum affect relationships between the third- and fourth-year
   students in their clinical peer mentorships?
2. If relationships were affected, was stereotype threat a component of the complication? If
   yes, how does it affect students' confidence, anxiety, clinical outcomes, and relationships
   with each other?
3. What can be done differently to decrease the negative effects of curriculum change on student relationships and clinical peer mentorships?

**METHODS**

**Ethics Statement**

Permission for use of human subjects was obtained from Roseman University of Health Sciences Institutional Review Board (Protocol #1619406). Written consent was obtained from all participants in this study.

**Description of Participants**

Participants in this study were predoctoral dental students who were enrolled at a non-profit institution of higher learning which offers a Doctor of Dental Medicine (DMD) degree (n=87). At the institution, each of the four classes has between 82 and 102 predoctoral students. This study includes participants from the Class of 2021 (n=43) and participants from the Class of 2022 (n=44).

**Study Design**

Our study utilized a quasi-experimental design. Participants included students from two graduating classes and were categorized into two treatments based upon their graduating class. The first treatment, Past Curriculum Treatment (Past-CT; the Class of 2021), became fully immersed in their clinical education experience during their third year, and this treatment also finished most of their biomedical science classes within the first year of their program (n=43). The second treatment, New Curriculum Treatment (New-CT; the Class of 2022), began their tenure at the investigating institution through a newly introduced curriculum model where they
began in clinic earlier than any previous class in addition to completing their biomedical coursework over the span of three years (n=44).

**Data Collection**

Data gathered in this study were collected through a mixed methods design. To compare group demographics, we collected quantitative data on the gender and age of all study participants. Both treatments of student participants completed a survey with eight Likert-style questions, as well as four open-ended questions, on the socioemotional effects of curricular change. The survey was completed in the fall of 2020.

After initial analysis of the open-ended survey responses, a theme emerged with participants expressing feelings of anxiety, stress, and worry resulting from the curriculum changes made at the university (see Table 3). Due to the nature of this recurring theme, we chose to investigate this phenomenon further by conducting semi-structured interviews with study participants who expressed feelings of anxiety, stress, or worry in their open-ended responses (n=6). RTN conducted all interviews in person or over videoconferencing software with each of the six participants between September and October 2021. The interview guide and questions asked followed a framework influenced by the theory of stereotype threat (14). Participants were asked if they felt that the curriculum changes affected their relationships with students in other classes, if they felt they were trying to avoid confirming a negative stereotype, to give examples of how stereotype threat affected behaviors in the clinic, and to share any ideas on how to decrease stereotype threat from curriculum change in the future (See Semi-Structured Interview Questions in Supplemental Materials).
Data Analysis

The Likert-style survey questions each contained six answer choices and were analyzed via Mann-Whitney U tests using SPSS software, v. 27. The open-ended questions were reviewed, analyzed and coded for emergent themes by two teams of researchers between December 2020 and January 2021 using an inductive approach to the analysis. The first team was comprised of four undergraduate students and one faculty member (RTN). To establish interrater reliability, the team went through calibration training focused on coding and practiced on example cases before beginning analysis on the research data. All members of the research team read through the four open-ended responses from each participant (n=87) to first get an initial sense of the tone of the participant’s responses. Then, each researcher read all responses again, and began the process of initial independent coding of repeating ideas. After this step of the process was completed, the team met and discussed the repeating ideas and identified five emergent themes, and each emergent theme was discussed until group consensus was reached. Each member of the team returned to the repeating ideas found and independently assigned each repeating idea to one of the five identified themes. The entire team then met to ensure group consensus on how each repeating idea was assigned to one of the five identified themes.

Because the participant responses involved a great amount of dental terminology, a second team was created to review the participant responses and was composed of predoctoral dental students and one faculty member (RTN). The purpose of this second team was to ensure that all repeating ideas, and identified themes, were not misconstrued by the first team due to the nature of the complicated dental terminology. This team followed the same review process as the first team, and independently came up with identical emergent themes as the first team.
Our analysis of the open-ended survey question responses used a fully inductive approach. In this review, we noticed a recurring phenomenon in the participant responses that seemed related to the concept of stereotype threat. As a result, we chose to design semi-structured interviews using a deductive approach, to specifically ask participants about how stereotype threat may have played a role in the interclass conflict examined. All participants chosen for interviews had specifically mentioned feelings, or scenarios, in their open-ended survey responses that seemed related to stereotype threat. The interview transcripts were first read for an initial sense of tone, and then re-read to find pertinent quotes that seemed related to the theory of stereotype threat.

RESULTS

Quantitative Results

Both treatment groups were similar in terms of gender and age (see Table 1). Attitudinal data were gathered to investigate if the curriculum changes had social and emotional effects on the participants, including negative effects on their interpersonal relationships. As seen in statement 2 in Table 2 and Figure 1A, the participants in the Past-CT agreed more with the statement that participants in the New-CT were overconfident in their clinical abilities than did those in the New-CT \((p=0.001, \, t(84)=4.624)\). Participants were asked if they felt pressure to perform when participants of the other treatment were present. Both treatments agreed with this statement, but participants of the New-CT agreed more strongly with this statement than participants of the Past-CT \((p=0.015, \, t(84)=2.502)\) (see statement 4 in Table 2 and Figure 1B). Both treatments agreed that they felt they had to prove their competence more than their peers in the opposite treatment (See statement 3 in Table 2). They also both agreed that they felt that the
faculty did not believe their treatment was as well prepared as the other treatment (See statement 5 in Table 2).

TABLE 1. Demographics of Participants

<table>
<thead>
<tr>
<th></th>
<th>New-CT</th>
<th>Past-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>21 (48%)</td>
<td>22 (51%)</td>
</tr>
<tr>
<td>Male</td>
<td>23 (52%)</td>
<td>21 (49%)</td>
</tr>
<tr>
<td>Age</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Range</td>
<td>24-39</td>
<td>26-45</td>
</tr>
<tr>
<td>Mean</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

TABLE 2. Attitudinal Results for Eight Likert-style Questions. Compared via Mann-Whitney U tests. Six-point Likert scale, 1=strongly disagree through 6=strongly agree.

<table>
<thead>
<tr>
<th>Survey Statement</th>
<th>New-CT</th>
<th>Past-CT</th>
<th>U Test</th>
<th>p-value</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>1) The students in the Past-CT group have a false sense of confidence in the clinic.</td>
<td>3.48 (1.389)</td>
<td>3.24 (1.100)</td>
<td>852.0</td>
<td>0.522</td>
<td>0.190</td>
</tr>
<tr>
<td></td>
<td>45.14</td>
<td>41.79</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2) The students in the New-CT group have a false sense of confidence in the clinic.</td>
<td>3.55 (1.022)</td>
<td>4.60 (1.083)</td>
<td>463.0</td>
<td>&lt;0.001*</td>
<td>0.998</td>
</tr>
<tr>
<td></td>
<td>33.02</td>
<td>54.48</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3) I feel like I have to prove my competence more than students in the other treatment.</td>
<td>3.89 (1.243)</td>
<td>3.79 (1.220)</td>
<td>907.5</td>
<td>0.883</td>
<td>0.082</td>
</tr>
<tr>
<td></td>
<td>43.88</td>
<td>43.11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4) I feel pressure to perform well in situations where members of the other treatment are present.</td>
<td>4.41 (1.263)</td>
<td>3.71 (1.312)</td>
<td>650.5</td>
<td>0.015*</td>
<td>0.540</td>
</tr>
<tr>
<td></td>
<td>49.72</td>
<td>36.99</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
5) I feel like the faculty have the impression that my treatment is not as well-prepared, so I have to work harder to show that I am.

6) I feel like the culture fosters positive relationships between the treatments.

7) I feel like the curriculum change negatively affected my performance.

8) I feel like the curriculum to which I was exposed has put me at a disadvantage.

*Suggests p<0.05

FIGURE 1. Attitudinal Results. (A) False Sense of Confidence of the New-CT Treatment. Agreement with the Statement, the New-CT participants are overconfident. (B) Performance Pressure. Agreement with the Statement, I feel pressure to perform well in situations where members of the other treatment are present.
Qualitative Results

Open-ended Survey Questions

We analyzed our open-ended survey questions through a thematic analysis and all responses were coded for emergent themes, n=87. The first of the survey questions analyzed asked participants to describe their ideal clinical mentorship. We coded all responses to this question into one of five identified themes: 1) teaching and communication skills, 2) knowledge, 3) empathy and respect, 4) patience and humility, and 5) trust (see Table 3).

Across the two treatments, many participant responses about ideal mentorships were both positive and extremely similar (see Table 3). However, for the scope of this study, we reviewed the responses from participants that negatively refer to the opposite treatment. Specifically, several participants of the New-CT described that a clinical mentorship should involve Past-CT students giving New-CT students many opportunities to practice and learn. One participant shared, “A good clinical mentor does not talk down to the class below them. They look for opportunities to involve the underclass [persons] with patient treatment” (Participant 16, New-CT). In comparison, we found that several Past-CT students mentioned that a clinical mentorship should involve New-CT students respecting the authority of Past-CT students, as well as understanding that New-CT students are not currently competent in clinic, and to wait for their turn to contribute when appropriate. For example, “Successful mentorship involves lack of ego and respect of the knowledge and experience of the mentor” (Participant 71, Past-CT).

<table>
<thead>
<tr>
<th>TABLE 3. Emergent Themes and Sub-themes of Open-ended Questions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define the ideal clinical mentorship</td>
</tr>
<tr>
<td>Themes:</td>
</tr>
<tr>
<td>1) Teaching and communication skills</td>
</tr>
<tr>
<td>Example Sub-themes:</td>
</tr>
<tr>
<td>Dedicated, allows underclassman to be involved, good communication in the presence of the patient, speaks</td>
</tr>
</tbody>
</table>
The second survey question asked our participants about the perceived positive and negative effects of the curriculum change. We coded all responses to this question into one of five identified themes; 1) increased integration between the biomedical and clinical sciences, 2)
increased opportunities to apply biomedical knowledge to clinical skills, 3) earlier opportunities to provide patient care, 4) frustration relating to many schedule changes, and 5) feelings of competition and lack of trust between the two treatments (see Table 3). Though many views were shared by participants about how the curriculum changes were positive, what we found to be the most pertinent to our study was critique relating to the social and emotional impact of the changes. For instance, a participant of the New-CT shared, “The [Past-CT] class does not trust us even though we entered the clinic shortly after they did” (Participant 8, New-CT). Another participant in the same treatment stated, “There was a bit of tension with our class and the [Past-CT] because our new curriculum made them feel they were falling behind” (Participant 86, New-CT). Hence, participants of the New-CT appeared to relay experiencing some issues between their treatment and their mentors, the Past-CT, specifically mentioning that their mentors lacked trust in them or that their mentors may have felt inadequate due to their educational experience.

Simultaneously, participants of the Past-CT shared views that also suggest that there was conflict, but disagree on what the cause of the conflict was or how it manifested. For example, a Past-CT participant shared, “The [New-CT] call themselves ‘accelerated’ because they are receiving the new curriculum. This mentality has created a bad relationship between our two classes” (Participant 52, Past-CT). This participant acknowledges the curriculum difference between the two treatments, but does not mention feeling inadequate themself. Another Past-CT participant recognizes the relationship strain occurring, stating, “The change in the curriculum created animosity between the classes and harboring of a competitive atmosphere” (Participant 38, Past-CT). This concept of interclass tension was furthered by a different participant who said, “The idea that the curriculum change made the underclass [persons] competent before us created more tension between classes and classmates” (Participant 42, Past-CT).

<table>
<thead>
<tr>
<th>New-CT</th>
<th>Past-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The [Past-CT] class does not trust us even though we entered the clinic shortly after they did.” (Participant 8)</td>
<td></td>
</tr>
<tr>
<td>“There was a bit of tension with our class and the [Past-CT] because our new curriculum made them feel they were falling behind.” (Participant 86)</td>
<td></td>
</tr>
<tr>
<td>“The [New-CT] call themselves ‘accelerated’ because they are receiving the new curriculum. This mentality has created a bad relationship between our two classes.” (Participant 52)</td>
<td></td>
</tr>
<tr>
<td>“The change in the curriculum created animosity between the classes and harboring of a competitive atmosphere.” (Participant 38)</td>
<td></td>
</tr>
<tr>
<td>“The idea that the curriculum change made the underclass[persons] competent before us created more tension between classes and classmates.” (Participant 42)</td>
<td></td>
</tr>
</tbody>
</table>

Semi-structured Interviews

After reading these varied responses from participants discussing negative consequences of the curriculum changes, specifically referencing the strain it caused on their relationships and mentorships, we decided to conduct individual interviews with participants (n=6). The first interview question asked the participant if they felt that the curriculum changes had affected relationships between students in their treatment and the other treatment (See Semi-Structured Interview Questions in Supplemental Materials). Each of the six participants separately reported that the changes made to the curriculum did affect their clinical mentorships and relationships with other students. We then defined stereotype threat for participants as, “the fear of confirming a negative stereotype about a group with which you identify or belong” (Steele, 2010). After this definition was provided, we inquired if they felt that stereotype threat, as defined by Steele (2010), was a component of that interclass relationship complication (10, 11, 13-15, 20). We found that again all six interviewees separately concluded that they felt that what
they experienced as a result of the curriculum changes could relate to the concept of stereotype threat.

Our interviews identified several varying stereotypes from the participants. For example, one assumption made was that the students in the New-CT, who experienced the new integrated curriculum model, surpassed their clinical mentors in the Past-CT in biomedical knowledge and clinical skills because of the curriculum changes made. This was furthered by the perspective that students in the New-CT were generally overconfident in their clinical abilities because of the curriculum changes, and as a result were too eager to contribute in the clinic and were unwilling to wait for the appropriate time to contribute.

In the next question, if participants indicated that they believed the concept of stereotype threat related to the tension experienced, we further inquired if and how stereotype threat affected students’ confidence, anxiety, clinical outcomes, and relationships. For those in the New-CT, we found that participants felt the need to prove their intelligence and worked to not upset their peers in the Past-CT (see Table 4). Simultaneously, after asking the same question to participants in the Past-CT, we found that these participants often felt inferior, nervous, and a desire to prove their competence to their mentees in the New-CT.

**TABLE 5. Comparing Participant’s Perceptions of their Peers in Opposite Treatment. Quotes from Interviews.**

<table>
<thead>
<tr>
<th>Comments from Interview Participants of the New-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>“The [members of the New-CT] were always trying to avoid stepping on the toes of their mentors... The mentors would try to exert dominance over their mentees.” (Participant 25)</td>
</tr>
<tr>
<td>“[Members of the New-CT] were always trying to prove their competence. Some would avoid asking to do a procedure, stepping back to not be seen as too eager... Some were afraid to ask questions because they wanted to prove they belonged in the clinic.” (Participant 23)</td>
</tr>
<tr>
<td>“The [members of the Past-CT] were constantly trying to establish dominance. They felt threatened and would argue over semantics. They would use words they knew the [members of the New-CT] wouldn’t know.” (Participant 12)</td>
</tr>
</tbody>
</table>
Comments from Interview Participants of the Past-CT

“It seemed that the [members of the Past-CT] were nervous with a [member of the New-CT] around. They felt the need to show the underclass[person] that they were confident... There was a lot of contention and awkwardness... [Members of the Past-CT] on my team would get to clinic really early to set up their operatory. They would do a lot of research, more than they needed to, to feel confident with a [member of the New-CT] watching.” (Participant 42)

“I saw [members of the New-CT] using words that they knew the [members of the Past-CT] didn’t know because our class took the course before them because of the new sequencing... I also saw [members of the Past-CT] anxious to work with certain [members of the New-CT] that tried to make them feel inferior.” (Participant 52)

“I observed [members of the Past-CT] not asking questions, even when they needed and wanted to, because they needed to show that they knew more than the [members of the New-CT]. They didn’t want to show weakness so they would fake confidence to avoid being vulnerable.” (Participant 57)

We concluded the interviews by asking the participants for ideas on how to decrease the negative socioemotional effects of curricular change. Participants in our study suggested that universities should work to acknowledge curriculum changes with students openly, and to create a space for open dialogue and discussion (see Table 5). Participants also suggested several ideas such as teaching emotional intelligence skills, creating ways for all students to bond and share experiences, and creating additional mentorship opportunities for students of differing graduating classes.

Quotes from Interviews

<table>
<thead>
<tr>
<th>Comments from Interview Participants of the New-CT</th>
</tr>
</thead>
<tbody>
<tr>
<td>“It would help if the two classes had many activities together, from the very beginning of the program. This would help them see each other as people instead of competitors... It would be good to provide additional mentorship opportunities, even in biomedical courses, to help build relationships and friendships between the classes... It would be helpful to deliberately teach students more emotional intelligence skills.” (Participant 25)</td>
</tr>
<tr>
<td>“So much of this is just humans being humans. Humans are naturally competitive... Expectations need to be set for the group. There should be discipline if students are mean to each other” (Participant 23)</td>
</tr>
<tr>
<td>“The focus should be on making both groups feel valued and successful.” (Participant 12)</td>
</tr>
</tbody>
</table>

Comments from Interview Participants of the Past-CT
“Communication is everything. Don’t pretend there isn’t potential conflict. Acknowledge it. Let everyone know that it is ok to feel the conflict. We just need to be respectful and work through it” (Participant 42)

“The deans should talk openly with the students about the importance of being flexible. It is not only going to help them through their time in school but throughout their entire career... They need to understand that they will be dealing with change and competition and disappointments throughout their life. They need to learning coping mechanisms.” (Participant 52)

“The students need the faculty and administrators to actively guide the students through the transition... It takes a lot of emotional maturity and flexibility... Get everyone in the same room as often as possible to help everyone see each other as real people with feelings... We need to acknowledge that it is happening from the beginning... Be open and honest and face it head on, rather than reactionary.” (Participant 57)

**DISCUSSION**

Our study sought to investigate if stereotype threat played any role in the emotional complication that students experienced or witnessed in interclass peer relationships and mentorships as a result of the curriculum changes implemented by the university. In all six interviews conducted, each participant acknowledged that they felt that stereotype threat could have been a component of the observed interclass division. This infers that students in either treatment may have felt that a negative stereotype had been created surrounding the graduating class to which they belonged, and they felt a pressure to not live up to whatever that negative stereotype entailed (see Table 4). For instance, one major theme in both our quantitative and qualitative data is that participants felt extra pressure to perform well in the clinic when they were in the presence of the other treatment (see Figure 1B and Table 2). This is similar to the findings of Spencer et al (2016), who report that people who experience stereotype threat are greatly motivated to disconfirm the stereotype and feel additional pressure to succeed (12).

The occurrence of stereotype threat is problematic for both students and the program. Worrying about confirming a stereotype can affect one’s ability to perform, which feels troublesome for students who are working diligently to learn and carry out complicated clinical procedures (12). Feeling stereotype threat can also cause conflict in interpersonal relationships,
and similar to Burgess et al. (2010), we found that students who reported experiences related to stereotype threat felt increased anxiety and encountered communication issues with peers in the other treatment (see Table 4) (24). Furthermore, this complicates students’ learning when considering that students in the Past-CT are entrusted to mentor the students in the New-CT. It has been shown that mentorships can be greatly complicated when there is a lack of mutual respect, commitment, personality differences, and feelings of competition between the mentor and mentee; all of which were reported throughout our collected data (7, 8). Moreover, feeling the weight of confirming a stereotype about a group with which you belong bears greatly on the mind, potentially affecting the ability to function at one’s best capacity intellectually (24). Stereotype threat may have caused potential negative consequences for students learning in all areas of the program.

To mitigate the complications found in our study, participants suggested that programs should work to acknowledge curriculum changes with students openly, and to create a space for dialogue and discussion (see Table 5). This relates to the perspective shared by Genn (2001) who argued that administrators, students, and faculty all need to be included in any conversation regarding curriculum change (2). Participants also suggested several ideas that were consistently reflected in the literature such as teaching emotional intelligence skills, creating ways for all students to bond and share experiences, and creating additional peer mentorship opportunities for students of differing graduating classes (3, 4, 6). To decrease the likelihood of stereotype threat occurring, Burgess reports that openly teaching medical students about stereotype threat could help students identify it and work to decrease the potential of stereotypes being created (23, 24). By utilizing some of these suggestions mentioned, programs may be able to help counteract
some of the negative social and emotional consequences of change which can enhance student satisfaction and quality of life (1-4, 6).

It is crucial that programs change and adjust curricula to new theory, continuously update best practices, and evolve to meet the changing needs of students (1, 2). Nevertheless, when change is implemented even for the most just and well-informed reasons, it can still cause negative social and emotional consequences for students (1, 2, 4). Through our research, we found that students felt ill effects of curriculum change in regard to interclass relationships and peer mentorships, and reported feelings of fear, anxiety, and worry from the effects of experiencing stereotype threat. Though our study was limited by a small sample size focused on one program, our survey which was self-designed by our research team, the breadth of the curriculum changes made, as well as the Covid-19 pandemic potentially influencing emotional states, we believe that the experience examined here still highlights the need for those in education to take this matter into consideration when planning for change.

Future research could examine how to implement curriculum change with student social and emotional well-being in mind, how curriculum change processes can work to include students, or how any negative social impacts of change might affect learning outcomes. As administrators, faculty, and staff in higher education work diligently to provide the best educational experience possible for students, it is important to carefully consider the emotional and social well-being of students to ensure that the field of education continues towards building a better, more transformative, more equitable educational experience.
ACKNOWLEDGMENTS

The authors of this paper would like to extend their gratitude to all the students that participated in this study. We would also like to thank the undergraduate students in the Jensen Lab and dental students in the Novak Lab that participated in the thematic analysis of the qualitative data.
REFERENCES


SUPPLEMENTAL MATERIALS

Appendix 1: Semi-Structured Interview Questions

Research Question 1: Did the changes to the curriculum affect relationships between the third- and fourth-year students in their clinical mentorships?

1. The administration overhauled the curriculum for the entering class in 2018, which is the graduating class of 2022. As a result, the changes allowed the class of 2022 to enter the clinic earlier than the class of 2021 had been able to. Hence, did you ever feel that the curriculum changes made by the administration affected your relationship with those in the class of 2022? (Switch numbers for the other class)
2. [if yes] Please give some specific examples.
3. Did you ever feel that the curriculum changes affected your relationship with the attending faculty?
4. [if yes] Please explain.

Research Question 2: If relationships were affected, was stereotype threat a component of the complication? If yes, how does it affect students' confidence, anxiety, clinical outcomes, and long-term professional relationships with each other?

1. In the field of social psychology there is a concept called stereotype threat. Stereotype threat is defined as, “the fear of confirming a negative stereotype about a group with which you identify or belong” (Steele, 2010). Stereotype threat can affect the psyche, it can cause worry and stress, and affect the relationships between different groups of people. After hearing this, I'd like to know a little more about your thoughts on potential stereotype threats that may have occurred between the class of 2021 and 2022, due to the major differences in curriculum. First, did you ever feel like you were trying to avoid confirming a stereotype about your class?
2. [If yes] What was the stereotype? Without divulging any names or personal identifiers, can you share examples of confirming stereotypes?
3. Did you ever feel as if your classmates had stereotyped individuals in the class of 2021? [switch numbers for other class]
4. In the book *Whistling Vivaldi* by Dr. Claude Steele, Dr. Brent Staples recounts an instance of stereotype threat he experienced (Steele, 2010). As a Black man, Dr. Staples noticed that when he was walking to the University of Chicago in Hyde Park his presence caused white people in the area to react negatively, indicating that they were fearful of him due to his race. He began whistling to combat his own nervousness, specifically popular tunes such as Vivaldi, which he noticed seemed to placate the white people and put them at ease. In this way, Dr. Staples notes that by continuing to whistle, he was trying to dissociate himself from the negative, racist, stereotype the white people obviously and erroneously associated with Black people. This is an example of how stereotype threat can impact deep-seeded ideas on racism. But stereotype threat is not...
limited to race. Have you ever changed any of your behaviors because of stereotype threat?

5. [if yes] What specific behaviors did you exhibit in your efforts to avoid confirming a stereotype?

6. Did you ever feel like others in your class were experiencing an instance of stereotype threat? What was the stereotype? Without divulging any names or personal identifiers, can you share examples of stereotype threats that you observed?

7. Did you ever see them exhibiting behaviors in an effort to avoid confirming the stereotype?

8. Did you ever feel like students in the other class (not yours) were feeling stereotype threat? Without divulging any names or personal identifiers, can you share examples of stereotype threats that you observed?

9. [If yes to stereotype threat being present] Do you believe that experiencing this stereotype threat affected …your confidence? Did you experience feelings of self-doubt or inferiority?

10. …the anxiety felt during your clinical experiences? Did you experience feelings of fear, stress, worry or exhaustion?

11. …the quality of your clinical outcomes? Did you experience brain fog or difficulty remembering details?

12. …your long-term professional relationships with your classmates? Did it complicate your relationships?

Research Question 3: What can be done differently to decrease the negative effects of curriculum change on student relationships and clinical mentorships?

1. What can we do next time we have a major curriculum shift to decrease stereotype threat?
Chapter 4: Verbalized Studying and Elaborative Interrogation in the Virtual Classroom: Students with Social Anxiety Prefer Working Alone, but Working with a Peer Does Not Hurt Their Learning

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This research was not sponsored by any grants or special funding. The authors are employed by Brigham Young University and Roseman University of Health Sciences.
ABSTRACT

Due to public health measures enacted in response to the Covid-19 pandemic, educators and students alike have been suddenly thrust into the realm of online learning. To better understand how active and collaborative learning methods can apply to students studying in isolation, we compared the effects of two teach-and-question assignments: one that utilizes the active learning method of reciprocal peer tutoring and a solo version that required individual verbalized studying and elaborative interrogation. We used a quasi-experimental design, with student participants enrolled in an online introductory human anatomy course. The first treatment group completed regular teach-and-question study assignments virtually with a peer, and the second treatment group completed the same assignment independently. We found no differences in exam scores between treatments, even for students with high social anxiety; however, student attitudes about the social versus individual assignment did differ for specific types of students. Students who reported experiencing high social anxiety preferred completing the active learning exercise by themselves, and students with low scientific reasoning ability preferred the partnered assignment. This research has potential implications for online classrooms. For instance, our results indicate that students who study independently, or in isolation, may have similar learning outcomes as those who study with a peer as long as they study actively. Because we found no negative impact on examination results, it also could be that virtually partnered or independent teach-and-question assignments could be helpful for instructors teaching large online classes, to ensure all students are getting individualized feedback and attention.

Key Words

Reciprocal peer tutoring, verbalized studying, social anxiety, elaborative interrogation, online instruction, active learning, collaborative learning, scientific reasoning ability
INTRODUCTION

In the wake of the first U.S. Covid-19 restrictions on gathering, higher-education programs across the nation abruptly pivoted from an in-person educational model to emergency remote teaching, with some classes being held live on virtual conferencing software or through asynchronous recordings [1, 2]. Due to these precautions, many students suddenly began studying in isolation, potentially even thousands of miles from their classmates and schools [1]. This led to a myriad of pedagogical challenges for teachers in higher education, including questions about how to include active and collaborative studying and learning methods within the virtual learning environment [3].

The benefits of active and collaborative learning methods are well established [4, 5]. One such method of active and collaborative learning is reciprocal peer tutoring, which is when two students, who are often enrolled in the same course, take turns explaining course content to one another to further their own understanding and knowledge [6]. Reciprocal peer tutoring has been found to be an effective method of learning and studying in pharmacology courses, physiology courses, and anatomy courses [7]. It is also widely used in medical schools and nursing programs [6].

In a large introductory biology course, Bailey et al., found that reciprocal peer tutoring in the form of a teach-and-question assignment (TQ) increased learning gains for students and improved examination scores [8]. In the TQ assignment, one student acts as a tutor and explains the course content to a peer from memory, and the peer inquires about the tutor’s content knowledge and asks further questions to probe their understanding [8]. In this way, TQ is used as a studying method between students outside of initial content attainment from the instructor or teaching assistant. In its simplest understanding, the TQ assignment is ultimately the
combination between the active learning methods of verbalized studying and elaborative interrogation. Verbalized studying, or thinking aloud, is the simple effort of speaking out loud during the learning process [9]. Elaborative interrogation is the process of asking “how” or “why” to increase active learning [10, 11]. Both of these methods have been shown to lead to a higher level of understanding and retention and help the learner make connections that they may not otherwise create through just reading [9-13].

Collaborative learning methods, such as reciprocal peer tutoring, can be effective at helping to further learning gains for students, as well as allowing students to practice social and emotional skills, and giving students space to build relationships with peers [6, 7]. But despite these positive reported effects, some students may feel uncomfortable with the social situations encountered during these learning environments [14-17]. For example, some students with social discomfort in group learning situations showed lower cognitive awareness in group activities, and during these activities may feel apprehension, stress, and fear [18]. Due to these factors, collaborative learning methods may not offer the same learning benefits for all populations of students [14-17].

The Covid-19 pandemic has been challenging, destructive, and detrimental in countless ways, and the field of education has certainly felt the impact of this weight [3]. To assist educators in implementing active and collaborative learning and studying strategies virtually, this research seeks to understand if the positive effects of reciprocal peer tutoring can be experienced by students who are studying online, potentially isolated from their classmates. Specifically, we investigated the outcomes of a series of TQ assignments that require students to utilize verbalized studying (the tutoring portion of the assignment) and elaborative interrogation (the questioning portion of the assignment) to build their knowledge. In this study, some sections of
the course were assigned to complete the TQ assignments remotely with a peer, and others were assigned to complete the assignment independently. All students in the study, regardless of treatment, were required to speak and describe course learning objectives out loud, ask higher-order questions out loud, and upload an audio recording of each assignment to the learning management system. This study also seeks to understand if outcomes from the TQ assignment are different for certain populations of students, based on factors such as extroversion, social anxiety, and scientific reasoning ability.

The research questions guiding this study are as follows:

1. Does reciprocal peer tutoring increase student learning above verbalized independent studying? Do certain student characteristics predict greater benefit from reciprocal peer tutoring (extroversion, scientific reasoning, social anxiety)?
2. Does reciprocal peer tutoring increase student attitudes above verbalized independent studying? Do certain student characteristics predict greater attitudes toward reciprocal peer tutoring (extroversion, scientific reasoning, social anxiety)?

METHODS

Ethics Statement

The primary author’s Institutional Review Board reviewed and approved the study protocol (IRB2020-467). Written consent was obtained from all participants in this study.
Participants and Context

Participants in this study were undergraduate college students enrolled in one of eleven course sections of a 200-level human anatomy course for pre-health science majors at a large private university in 2021. In total, 189 students enrolled in the course, and 167 students gave written consent to participate in this study. Typically, this course would meet once a week for a two-hour class in a large lecture hall. However, due to the public health measures enacted in response to Covid-19 in early 2021, the lectures were pre-recorded, and students watched the videos asynchronously. All activities included in this study were required of every student in the class regardless of study participation; moreover, no additional activities were given to students involved in this study.

Experimental Design

To answer our research questions, we utilized a quasi-experimental design. Students self-selected their section and then we randomly assigned each of the eleven sections to a treatment. Six sections were assigned to the Teach-and-Question with a Peer (TQ-P) treatment group and five sections were assigned to the Teach-and-Question Independently (TQ-I) treatment group (see Figure 1). During the semester, students completed one to two TQ assignments each week of the class, for a total of 23 TQ assignments overall. Aside from the difference in assignment type, virtually all other course characteristics were identical among treatment groups (instructor, exams, learning outcomes, textbook, lab assignments).
At the beginning of the semester, students took a pre-survey assessing multiple factors including demographics, interest in anatomy, scientific reasoning abilities, belongingness in the sciences, communication and social anxiety, and extroversion. In the survey, students were asked a single Likert-style question to gauge their interest in anatomy. Because interest was assessed using a single item, the conclusions we can draw about interest changes are more limited than our other variables. To test students scientific reasoning abilities, students took the 24-item Lawson’s Classroom Test of Scientific Reasoning (LCTSR) that has previously been validated in college student populations [19, 20]. To assess belongingness, the students took a 7-item survey of students’ belongingness in the sciences, using a 5-point Likert scale, adapted from Good et al. [21]. Social and communication anxiety was assessed through a 12-item survey, using a 5-point Likert scale, adapted from McCroskey and Papanastasiou et al. [22, 23]. To assess extroversion,
students took a 10-item survey of extroversion, a portion of the big-five personality test, using a 5-point Likert scale, from Goldberg [24]. Responses for Belongingness (7-items), Anxiety (12-items), and Extroversion (10 items) were summed in their respective categories and treated as continuous variables. At the end of the semester, students took a post-survey that included Likert-style attitudinal questions about the Teach-and-Question (TQ) assignment, in addition to re-answering the interest in anatomy and belongingness in the sciences questions.

**Teach-and-Question with a Peer (TQ-P) treatment group**

In the TQ-P assignment (see Figure 1), students began by watching a segment of a fifty-minute pre-recorded lecture with a peer through video conferencing software. Approximately every ten-minutes in the lecture video, a slide would appear on the students’ screen with learning outcomes. The instructor then prompted students to pause the recorded lecture to participate in the TQ portion of the class. Students began by deciding who would begin as the tutor and who would be the questioner in the assignment. It was the duty of the tutor to instruct their partner on a learning objective from the lecture solely from their own memory, and the duty of the questioner was to investigate the knowledge of the tutor, specifically by inquiring and seeking further information on the content that the tutor was explaining. The purpose of the assignment was for the questioner to help guide the tutor to aspects of the learning objective that they might not fully understand and to discuss that together. After the objective was fully reviewed, the students would then watch the next ten minutes of the video together until it was time to do the next TQ portion, with the former questioner acting as the tutor.

**Teach-and-Question Independently (TQ-I) treatment group**
In the TQ-I assignment (see Figure 1), students watched the same fifty-minute pre-recorded lecture as the TQ-P treatment, but unlike the TQ-P treatment, students in TQ-I treatment watched independently. At the same ten-minute intervals of the lecture, a slide would appear on their screen with outcomes that the student was to review. The student would then begin by explaining the content of the learning objectives out loud from their own memory as if there was an audience or peer in the room. To mimic the questioner in TQ-P, the student in TQ-I would inquire and interrogate their own understanding of the content that they just taught aloud. After this sequence was completed, the student would then watch the next ten minutes of the video until it was time to do the next TQ-I portion and repeat the process over.

**TQ Assignment Grading**

For both TQ-I and TQ-P assignments, the entire session was audio-recorded and uploaded to the learning management system for credit. Teaching assistants would listen to portions of each recording and provide feedback to the students to help improve the quality of teaching and questioning. However, the recordings were ultimately only graded for completion. Thus, we did not gather data on the quality of the TQ sessions. We had hoped to record data about the length of the TQ session. However, some students only recorded when they were talking, and others recorded the whole time they were watching the lecture. Thus, the length of the audio recordings did not always represent the length of their TQ sessions.

**Statistical Analysis**

The following assumptions of each linear regression were met; linearity, normality, equality of variance, and multicollinearity. Due to the nested nature of the data (students were
not independent, they were grouped in sections and sections were grouped into treatments), we considered using mixed modeling with a random effect for course section to account for nesting. We used two methods to test whether such a random effect was needed in regressions predicting exam performance (as suggested in Theobald 2018) [25]. First, we calculated the intraclass correlation coefficient (ICC) of the course section random effect in an empty model with no fixed effects. We found an ICC = 0.085, suggesting the nesting by section did not explain much variance in exam performance. To confirm this, we compared complete models (including all fixed effects of interest) with and without the random effect of course section. Because adding the random effect (AICc= 927.27) did not improve the model compared to the full model without the random effect (AICc = 925.55), we moved forward with standard multiple linear regression without random effects. We also tested whether accounting for nesting by section was needed in regression models predicting overall assignment attitudes. Similarly, a low ICC (ICC = 0.0) and inability of the random effect to improve the model (AICc = 612.00 compared to AICc = 614.07) led us to use standard multiple linear regression to predict attitudes.

RESULTS

Equivalency of Treatment Groups

Due to the quasi-experimental nature of our study, we tested whether our treatment groups were equivalent at the beginning of the semester. As shown in Table 1, the two treatment groups, TQ-P and TQ-I, were statistically equivalent at the beginning of the course in terms of year in school, scientific reasoning ability, anatomy interest, sense of belongingness in the sciences, level of communication and social anxiety, and level of extroversion.
TABLE 1. Equivalency of Treatment Groups, TQ-P and TQ-I.

<table>
<thead>
<tr>
<th>Variable</th>
<th>TQ-P</th>
<th>TQ-I</th>
<th>Test</th>
<th>p-value</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean ± SD</td>
<td>n=</td>
<td>mean ± SD</td>
<td>n=</td>
<td></td>
</tr>
<tr>
<td>Year in School</td>
<td>1.930 ± 0.869</td>
<td>68</td>
<td>1.700 ± 0.796</td>
<td>77</td>
<td>Mann-Whitney U</td>
</tr>
<tr>
<td>Reasoning (LCTSR)</td>
<td>17.00 ± 4.729</td>
<td>73</td>
<td>17.46 ± 3.787</td>
<td>70</td>
<td>Ind. Samples T</td>
</tr>
<tr>
<td>Interest-Pre</td>
<td>3.889 ± 0.920</td>
<td>87</td>
<td>3.848 ± 1.014</td>
<td>79</td>
<td>Mann-Whitney U</td>
</tr>
<tr>
<td>Belongingness-Pre</td>
<td>3.957 ± 0.576</td>
<td>80</td>
<td>3.996 ± 0.605</td>
<td>78</td>
<td>Ind. Samples T</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>3.197 ± 0.420</td>
<td>80</td>
<td>3.205 ± 0.446</td>
<td>78</td>
<td>Ind. Samples T</td>
</tr>
<tr>
<td>Extroversion</td>
<td>3.109 ± 0.832</td>
<td>80</td>
<td>3.027 ± 0.909</td>
<td>78</td>
<td>Ind. Samples T</td>
</tr>
</tbody>
</table>

Research Question 1: Assessment Outcomes

We used exam scores to compare learning outcomes of TQ-P and TQ-I. Throughout the semester, six exams were administered and each of the exams were identical for both treatment groups. Figure 2A shows scores for both treatments on each exam given. By split-plot ANOVA, we saw no significant difference between treatment groups (p=0.745; $\eta^2_p$=0.001) and no interaction between treatment and time (p=0.343; $\eta^2_p$=0.006). Figure 2B shows the students’ Average Exam Percent Score, with scores from all six exams averaged together. The mean performance was compared using an independent samples t-test, and we again found no difference by treatment (p= 0.505; Cohen’s d= 0.104).
Research Question 1: Predictors of Assessment Outcomes

We next wanted to see if the treatment helped specific populations of students. To determine which variables predicted Average Exam Percent Score, we performed a multiple linear regression analysis. As shown in Table 2, treatment still had no effect on exam scores when other predictors were also included. Students’ scientific reasoning ability (LCTSR Score) was the only significant predictor of Average Exam Percent Score. We also tested whether adding interactions between treatment and LCTSR, social anxiety, and extroversion improved the model (to see if our treatment helped specific student populations). As shown in Appendix 1, adding in these interactions did not improve the model (Table S1).
TABLE 2. Results of multiple linear regression with Average Exam Percent Score as target.

<table>
<thead>
<tr>
<th></th>
<th>Adjusted R²</th>
<th>Unstandardized B</th>
<th>Coefficients Std. Error</th>
<th>Standardized Coefficients Beta</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>0.061</td>
<td>79.442</td>
<td>12.827</td>
<td>6.193</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Reasoning (LCTSR)</td>
<td>0.745</td>
<td>0.215</td>
<td>0.310</td>
<td>3.470</td>
<td>&lt;0.001*</td>
<td></td>
</tr>
<tr>
<td>TQ-I</td>
<td>1.224</td>
<td>1.687</td>
<td>0.064</td>
<td>0.726</td>
<td>0.469</td>
<td></td>
</tr>
<tr>
<td>Year in School</td>
<td>0.760</td>
<td>1.123</td>
<td>0.064</td>
<td>0.677</td>
<td>0.500</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>-1.523</td>
<td>1.975</td>
<td>-0.075</td>
<td>-0.771</td>
<td>0.442</td>
<td></td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>-2.135</td>
<td>2.658</td>
<td>-0.095</td>
<td>-0.803</td>
<td>0.423</td>
<td></td>
</tr>
<tr>
<td>Extroversion</td>
<td>-0.516</td>
<td>1.244</td>
<td>-0.048</td>
<td>-0.415</td>
<td>0.679</td>
<td></td>
</tr>
</tbody>
</table>

*Suggests p<0.05

Research Question 2: Attitudinal Outcomes

Attitudinal data were gathered at the end of the semester to investigate student perceptions of both TQ assignments, as well as other aspects of the course. Students in both the TQ-P and TQ-I treatments reported that they would use TQ as a method to study in future courses (73% of all students) and preferred the role of “teacher” over “questioner” (87% of all students). Our data hint that students with high social anxiety or low sense of belonging may prefer the “questioner” role (see Appendix 1, Table S2), but we are unsure how reproducible this difference would be since only fifteen students preferred the role of “questioner”. Both groups reported an increased Sense of Belongingness (p=0.002; Cohen’s d=0.254) and Interest in Anatomy (p<0.001; Cohen’s d=0.674) over the course, tested by paired-samples t-test. Change in belongingness and change in interest in anatomy are shown in Figure 3A. A split-plot, repeated measures ANOVA was run to see if there was a statistical difference between the treatments in
relationship to the pre and post surveys. For Sense of Belongingness, we saw no significant difference between treatment groups (p=0.753; $\eta^2_p=0.001$) and no interaction between treatment and time (p=0.472; $\eta^2_p=0.003$). For Interest in Anatomy, we saw no significant difference between treatment groups (p=0.613; $\eta^2_p=0.002$) and no interaction between treatment and time (p=0.804; $\eta^2_p=<0.001$). As seen in Figure 3B, the students were asked three questions to determine their overall attitude toward the Teach-and-Question assignment using a 5-point Likert scale. Treatment groups were compared via Mann-Whitney U-test. There was no statistical difference in attitudes toward the assignment between the two treatment groups for any of the three questions: Liked Assignment (p=0.436; Cohen’s $d=0.121$), Worth Time (p=0.774; Cohen’s $d=0.044$), and Comfort with Assignment (p=0.248; Cohen’s $d=0.180$).

![Figure 3](image)

FIGURE 3. Attitudinal Outcomes. (A) Change in belongingness and change in interest, compared by treatment group. (B) Liked Assignment, Worth Time and Comfort with Assignment, by treatment group.

**Research Question 2: Predictors of Attitudinal Outcomes**

Again, we were also interested in whether the two treatments affected students differently based on student characteristics such as social anxiety, extroversion, and scientific reasoning ability. To estimate overall attitude toward the TQ assignment, we summed students’ answers to the three questions of Figure 3B, and we used linear regression to predict this overall attitude.
We first compared two regression models to predict overall attitude: one without interactions between treatment and student characteristics and the second one with these interactions. As shown in Appendix 1 (Table S3), including interactions with treatment significantly improved the model. Thus, the full model with interactions is shown in Table 3. We found that students with high social anxiety preferred the TQ-I assignment (interaction between treatment and social anxiety: \( p = 0.004 \)), and this interaction is shown visually in Figure 4A. Students with low scientific reasoning ability at the beginning of the course preferred the TQ-P assignment and students with high scientific reasoning ability preferred the TQ-I assignment (interaction between treatment and LCTSR: \( p = 0.012 \)), as shown visually in Figure 4B.

### TABLE 3. Results of multiple linear regression with Overall Attitudinal Score as target.

<table>
<thead>
<tr>
<th>Adjusted R²</th>
<th>Unstandardized B</th>
<th>Coefficients Std. Error</th>
<th>Standardized Coefficients Beta</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.188</td>
<td>(Constant) 31.431</td>
<td>4.874</td>
<td>-0.295</td>
<td>6.448</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Reasoning (LCTSR) -0.207</td>
<td>0.089</td>
<td>-0.295</td>
<td>-2.333</td>
<td>0.021*</td>
</tr>
<tr>
<td></td>
<td>TQ-I 0.911</td>
<td>0.459</td>
<td>0.162</td>
<td>1.984</td>
<td>0.050*</td>
</tr>
<tr>
<td></td>
<td>Year in School -0.281</td>
<td>0.307</td>
<td>-0.081</td>
<td>-0.916</td>
<td>0.362</td>
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<td></td>
<td>Female -0.290</td>
<td>0.541</td>
<td>-0.049</td>
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<td></td>
<td>Social Anxiety -4.350</td>
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<td>-0.666</td>
<td>-4.323</td>
<td>&lt;0.001*</td>
</tr>
<tr>
<td></td>
<td>Extroversion -0.526</td>
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<td>-1.103</td>
<td>0.272</td>
</tr>
<tr>
<td></td>
<td>LCTSR*Tx 0.296</td>
<td>0.116</td>
<td>0.310</td>
<td>2.544</td>
<td>0.012*</td>
</tr>
<tr>
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<td>Social Anxiety*Tx 4.117</td>
<td>1.394</td>
<td>0.447</td>
<td>2.953</td>
<td>0.004*</td>
</tr>
<tr>
<td></td>
<td>Extroversion*Tx 0.647</td>
<td>0.678</td>
<td>0.141</td>
<td>0.954</td>
<td>0.342</td>
</tr>
</tbody>
</table>

*Suggests \( p<0.05 \)
FIGURE 4. Attitudinal Interactions between treatment and social anxiety or scientific reasoning. For both panels, overall attitude was calculated by adding together the three Likert style attitudinal questions on the post-survey and shown on the y axis. The x axis shows social anxiety score from pre-test (A) or scientific reasoning (B; LCTSR score from pre-test). Raw data are shown by treatment and lines are from simple linear regression to show trends.

DISCUSSION AND IMPLICATIONS FOR INSTRUCTORS

An aim of this study was to find out whether or not the collaborative and social aspect of TQ is needed for students to experience learning benefits, or if the learning benefits can be brought about through an independent activity. We found that neither the TQ-P or TQ-I participant groups performed better on examinations than the other (Figure 2). In contrast, Bailey et al. found that participants in a TQ treatment had ~6% higher exam scores compared to participants who studied on their own [8]. However, in that study, the students who studied individually were allowed to study on their own in any way they chose. Although Bailey et al. did not track what study strategies they used, previous studies suggest that the majority of college students primarily use passive strategies such as re-reading or watching material [26]. In contrast, we compared the reciprocal peer tutoring treatment (TQ-P) to an individual assignment where students were required to verbalize and generate questions (TQ-I) and did not find the
learning gains reported previously [8]. This may imply that the social aspect of the TQ method may not be necessary if students still verbalize and ask questions. This suggests that educators could instruct students to complete TQ assignments independently without decreasing student’s learning gains. Alternatively, it is possible that the benefit of a partnered assignment would be more social than academic. However, we saw no difference in students’ change in belonging between the treatments (see Figure 3A). It may be that there were social benefits from the partnered assignment that we did not quantify. Anecdotally, teaching assistants noticed there were more off topic conversations aimed at relationship building in the TQ-P group.

Unlike past studies we did not see decreased performance in the social treatment (TQ-P) for students that reported high social anxiety (Table 2 and Appendix 1: Table S1) [14-17]. However, we did find that students with high social anxiety preferred the TQ-I assignment over the TQ-P assignment (see Table 3 and Figure 4A). Because we found no difference in exam results between the two treatments, it may be helpful for those who experience social anxiety to be given the option to engage independently in active learning methods, to help increase their attitude towards the assignment. This may be important as it has been demonstrated that forcing students with social anxiety to participate in group activities can negatively affect their ability to learn [27-29]. However, our study found no interaction between treatment and social anxiety on tests scores.

We also found an interesting interaction between treatment and scientific reasoning ability (Table 3): students with low scientific reasoning abilities preferred the TQ-P assignment, and students with high scientific reasoning abilities preferred the TQ-I assignment (see Figure 4B). Although this interaction predicted attitudes rather than performance, our results parallel those of Bailey et al., who found that students with lower scientific reasoning ability had greater
learning gains from the TQ assignment than those with high scientific reasoning ability [8].

Together these two studies support the idea that implementing a partnered TQ assignment could help increase course scaffolding for students who may need additional learning and studying support.

In summary, we found that an active learning assignment that requires verbalization and questioning leads to similar positive attitudes (Figure 3B) and exam performance (Figure 2) whether done in partnerships or as individuals. This makes the individual TQ assignment a simple and effective active learning option for students with high social anxiety who prefer working alone (Figure 4A) or for all students in virtual learning environments when group work is less feasible. However, partnerships can be formed even when students learn remotely, and this might be especially beneficial for students who enter the classroom with poor scientific reasoning skills (Figure 4B).

Limitations and Future Research

It is important to note that the course utilized in this research was not originally intended to be delivered in a virtual learning format and was only delivered in this manner as a safety measure in response to the Covid-19 pandemic. Thus, our results reflect emergency remote teaching rather than classic online learning, and further research on this topic could focus on courses intended to be delivered virtually. Further research should also examine if implementing these learning methods in person, as opposed to virtually, could have any differing outcomes. It is possible that partnered assignments completed online, often in the comfort of students’ homes, do not elicit the same social anxiety that would be triggered in a classroom with more time constraints and social pressure. Moreover, the need for collaboration in addition to verbalization
and questioning should also be investigated with different types of student populations such as in a university with open enrollment, in different disciplines, or with graduate students. Future studies may also seek to compare three treatments simultaneously: teach and question with a peer, teach and question individually, and individual studying with no mandated teach and question assignment. Finally, it would be interesting to study the effects of homogeneous versus heterogeneous pairs in terms of scientific reasoning. This study could be repeated with purposeful and consistent pairings rather than allowing students to self-select and change their partners throughout the course.
ACKNOWLEDGEMENTS

The authors of this paper would like to extend their gratitude to all the Teaching Assistants involved in the undergraduate anatomy class in which this research took place. Their work on grading, reviewing, and assisting with the management of the class was imperative for the success of this project and the authors commend and sincerely appreciate their diligence and hard work. The authors would also like to thank the students who participated in this study.
REFERENCES

1. Quintana, C., 'The virus beat us': Colleges are increasing going online for Fall 2020 semester as COVID-19 cases rise., in USA Today. 2020.


SUPPLEMENTAL MATERIALS

Appendix 1: Tables S1, S2, and S3

TABLE S1. Alternate model including interactions. Results of multiple linear regression with Average Exam Percent Score as target.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Adjusted R²</th>
<th>Unstandardized B</th>
<th>Coefficients Std. Error</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>(Constant)</td>
<td>0.080</td>
<td>102.801</td>
<td>17.808</td>
<td></td>
<td>5.773</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Reasoning (LCTSR)</td>
<td></td>
<td>0.304</td>
<td>0.324</td>
<td>0.126</td>
<td>0.938</td>
<td>0.350</td>
</tr>
<tr>
<td>TQ-I</td>
<td></td>
<td>0.897</td>
<td>1.677</td>
<td>0.047</td>
<td>0.535</td>
<td>0.594</td>
</tr>
<tr>
<td>Year in School</td>
<td></td>
<td>0.938</td>
<td>1.121</td>
<td>0.079</td>
<td>0.837</td>
<td>0.404</td>
</tr>
<tr>
<td>Female</td>
<td></td>
<td>-0.937</td>
<td>1.977</td>
<td>-0.046</td>
<td>-0.474</td>
<td>0.637</td>
</tr>
<tr>
<td>Social Anxiety</td>
<td></td>
<td>-4.985</td>
<td>3.676</td>
<td>-0.222</td>
<td>-1.356</td>
<td>0.178</td>
</tr>
<tr>
<td>Extroversion</td>
<td></td>
<td>-3.037</td>
<td>1.744</td>
<td>-0.282</td>
<td>-1.741</td>
<td>0.084</td>
</tr>
<tr>
<td>LCTSR*Tx</td>
<td></td>
<td>0.703</td>
<td>0.425</td>
<td>0.214</td>
<td>1.654</td>
<td>0.101</td>
</tr>
<tr>
<td>Social Anxiety*Tx</td>
<td></td>
<td>5.763</td>
<td>5.094</td>
<td>0.182</td>
<td>1.131</td>
<td>0.260</td>
</tr>
<tr>
<td>Extroversion*Tx</td>
<td></td>
<td>4.788</td>
<td>2.477</td>
<td>0.304</td>
<td>1.933</td>
<td>0.056</td>
</tr>
</tbody>
</table>

TABLE S2. Preference for “Teacher” Role or “Questioner” Role.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preferred “Teacher” Role</th>
<th>Preferred “Questioner” Role</th>
<th>Statistical Test</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean ± SD</td>
<td>mean ± SD</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n=</td>
<td>n=</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>3.199 ± 0.410</td>
<td>3.472 ± 0.545</td>
<td>Welch’s T</td>
<td>t(16.4)=1.865; p = 0.080</td>
</tr>
<tr>
<td>Reasoning (LCTSR)</td>
<td>17.570 ± 3.881</td>
<td>16.640 ± 5.719</td>
<td>Welch’s T</td>
<td>t(14.8)=0.590; p = 0.564</td>
</tr>
<tr>
<td>Sense of Belonging</td>
<td>4.072 ± 0.552</td>
<td>3.543 ± 0.574</td>
<td>Ind. Samples T</td>
<td>t(114)=3.449; p &lt; 0.001*</td>
</tr>
<tr>
<td>Extroversion</td>
<td>3.065 ± 0.885</td>
<td>101</td>
<td>2.707 ± 0.861</td>
<td>15</td>
</tr>
<tr>
<td>Exam Performance (All)</td>
<td>85.149 ± 8.211</td>
<td>102</td>
<td>84.919 ± 4.535</td>
<td>15</td>
</tr>
</tbody>
</table>

*Suggests p<0.05

**TABLE S3.** Alternate model without interactions. Results of multiple linear regression with Overall Attitudinal Score as target.

<table>
<thead>
<tr>
<th>Adjusted R²</th>
<th>(Constant)</th>
<th>Unstandardized B</th>
<th>Coefficients Std. Error</th>
<th>Standardized Coefficients Beta</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.107</td>
<td>21.222</td>
<td>3.645</td>
<td></td>
<td>5.822</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Reasoning (LCTSR)</td>
<td>-0.055</td>
<td>0.061</td>
<td>-0.078</td>
<td>-0.899</td>
<td>0.371</td>
<td></td>
</tr>
<tr>
<td>TQ-I</td>
<td>0.964</td>
<td>0.479</td>
<td>0.172</td>
<td>2.012</td>
<td>0.046*</td>
<td></td>
</tr>
<tr>
<td>Year in School</td>
<td>-0.281</td>
<td>0.307</td>
<td>-0.081</td>
<td>-0.916</td>
<td>0.362</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>-0.290</td>
<td>0.541</td>
<td>-0.049</td>
<td>-0.536</td>
<td>0.593</td>
<td></td>
</tr>
<tr>
<td>Social Anxiety</td>
<td>-2.332</td>
<td>0.755</td>
<td>-0.357</td>
<td>-3.086</td>
<td>0.002*</td>
<td></td>
</tr>
<tr>
<td>Extroversion</td>
<td>-0.107</td>
<td>0.353</td>
<td>-0.034</td>
<td>-0.302</td>
<td>0.763</td>
<td></td>
</tr>
</tbody>
</table>

*Suggests p<0.05