Curriculum Vitae of

Zachary Ryne Noel

PharmD, BCCP

Assistant Professor

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Baltimore, MD 21201	

Education & Training

Academic Training

Doctorate of Philosophy, Health Professions Education	July 2023
University of Maryland, Baltimore Graduate School, Baltimore, MD	
Doctorate of Pharmacy (summa cum laude)	2010 – 2014
University of Kentucky College of Pharmacy, Lexington, KY	
Undergraduate Studies	
University of Kentucky College of Pharmacy, Lexington, KY	2007 – 2010

Professional Training

Post-Graduate Year 2 Cardiology Pharmacy Residency	2015 – 2016
University of Kentucky Chandler Medical Center, Lexington, KY	
Post-Graduate Year 1 Pharmacy Practice Residency	2014 – 2015
University of Kentucky Chandler Medical Center, Lexington, KY	

Certifications & Professional Development

Certifications

Basic Life Support Instructor	2019 – Present
American Heart Association	
Instructor ID: 09190819199	
Board Certified Cardiology Pharmacist (BCCP)	2018 – Present
Board of Pharmacy Specialties	
Credential Number: B10100032	
Advanced Cardiac Life Support Certification for Healthcare Providers	2014 – Present
American Heart Association	
Certification Number: SCIXSDHMSG7W	

Professional Experience

Academic & Professional Appointments

Residency Program Coordinator	2021 - Present
Post-Graduate Year 2 Cardiology Pharmacy Residency Program	2017 - 2020

University of Maryland School of Pharmacy, Baltimore, MD

Assistant Professor, Pharmacy Practice and Science	2016 – Present
University of Maryland School of Pharmacy, Baltimore, MD	

Practice Experience

Clinical Pharmacy Specialist, Primary Cardiology Service	2016 – Present
University of Maryland Medical Center, Baltimore, MD	
Clinical Pharmacist, Resident	2014 – 2016
University of Kentucky Medical Center, Lexington, KY	
Staff Pharmacist	2014 – 2016
Rite Aid Pharmacy, Lexington, KY	
Pharmacy Intern	2010 – 2013
Baptist Health, Lexington, KY	
Pharmacy Technician and Intern	2009 – 2014
Rite Aid Pharmacy, Lexington, KY	

Honors and Awards

Awards

Teacher of the Year, Class of 2023	2023
University of Maryland School of Pharmacy	
American College of Clinical Pharmacy, Cardiology Practice and Research Network Junior Investigator Award	2022
Maryland Society of Health-System Pharmacists Medication Safety Award	2022
Francis S. Balassone Lecturer	2020
University of Maryland School of Pharmacy	
AACP Teacher of the Year	2020
University of Maryland School of Pharmacy	
Jeffrey Ensor Leadership Award	2018
Maryland Society of Health-System Pharmacists	
Faculty Preceptor of the Year	2018
University of Maryland School of Pharmacy	
Spirit Award	2017
University of Maryland School of Pharmacy	
Impact Award	2016
University of Kentucky Chandler Medical Center	
Post-Graduate Year 1 Research Awardf	2015
University of Kentucky Chandler Medical Center	
James Rhodes Scholar Award	2014

University of Kentucky School of Pharmacy

Rho Chi Service Award   2013
University of Kentucky School of Pharmacy

Honorary Organizations
Rho Chi Academic Honor Society   2011 – 2014
University of Kentucky School of Pharmacy

Phi Lambda Sigma Pharmacy Leadership Society   2012 – 2014
University of Kentucky School of Pharmacy

Leadership & Service

National Involvement
American Association of Colleges of Pharmacy (AACP)   2021 - 2022
Member, Task Force on Professionalism and Social Media

American Association of Colleges of Pharmacy (AACP)   2021 – 2022
Delegate, University of Maryland School of Pharmacy

American College of Clinical Pharmacy (ACCP)
Secretary/Treasurer, Cardiology PRN   2019 – 2020
Chair, Cardiology PRN Student & Resident Committee   2017 - 2018
Member, Cardiology PRN Student & Resident Committee   2014 – 2016

American College of Cardiology (ACC)
Member, Cardiovascular Team   2015 – Present

American Society of Health-System Pharmacists (ASHP)
Member, New Practitioners Forum   2014 – 2016
Member, Community and e-Communications Advisory Group   2012 – 2013

University & Departmental Involvement
University of Maryland School of Pharmacy
Curriculum Redesign Task Force, Chair   2022 – Present
Therapeutics Task Force, Chair   2020 – 2022
Member, Curriculum Committee   2020 – 2022
President, Faculty Assembly   2019 – 2020
President-Elect, Faculty Assembly   2018 – 2019
Co-Chair, Cardiology Residency Program Advisory Committee   2017 – 2020
Member, Experiential Learning Committee   2016 – 2018
Member, Strategic Planning Education Committee   2016 – 2018
Member, Preceptor Development Committee   2016 – 2018

Community Service
Emmorton Recreation Sports Coach (soccer, basketball, basketball)   2020 – Present
Salvation Army Clinic   2014 – 2016
Ronald McDonald House Volunteer   2012 – 2014
God's Food Pantry Volunteer, Lexington, KY   2010 – 2012
Faith Pharmacy, Lexington, KY   2010 – 2011
Operation Christmas Child Local Organizer, Lexington, KY   2011 – 2013

Teaching Experience

University of Maryland School of Pharmacy
Course Manager

Course Title	Course Number	Students (No.)	Credit Hours	Years Taught
Essential Study Skills for PharmD Students	PHMY 535	PharmD (90)	1	2021 - Present
Applied Science and Therapeutics 3 and 5	PHAR 5003-05	PharmD (160)	6	2017 – Present
Current Concepts and Controversies in Cardiology (C4) Elective	PHMY 5016	PharmD (10)	2	2019 – 2020

Lecturer/Facilitator

Course Title & Lecture	Course Number	Students (No.)	Hours	Years Taught
Current Concepts and Controversies in Cardiology (C4) Elective	PHMY 5016	PharmD (10)	14	2019 – 2020
Pathophysiology and Therapeutics I: Antihypertensive Medications	MSPR 521	MD (150)	2	2019 – Present
Pathophysiology and Therapeutics I: Antiplatelet, Anticoagulant, and Fibrinolytic Therapies	MSPR 521	MD (150)	2	2018 – Present
Applied Science and Therapeutics 4 End Stage Renal Disease	PHAR 5004	PharmD (130)	2	2018 – Present
Applied Science and Therapeutics 5	PHAR 5005	PharmD (130)		
Advanced Cardiac Life Support			1	2017 – Present
Valvular Heart Disease			1	2017 – Present
Ventricular Arrhythmias			2	2017 – Present
Atrial Arrhythmias			2	2017 – Present

Preceptor

Course Title	Course Number	Students (No./Yr)	Years Taught
PGY2 Primary Cardiology Service	PCS I and II	PGY2 Cardiology Residents (2)	2016 – Present
Acute Care Cardiology Experience	APPE 451	PharmD (5)	2017 – Present

University of Kentucky School of Pharmacy
Lecturer/Facilitator

Course Title & Lecture	Course Number	Students (No.)	Hours	Years Taught
Pharmacotherapeutics II: Pulmonary Arterial Hypertension	PPS 957	PharmD (130)	1	2015
Pharmacotherapeutics II: Hyperlipidemia	PPS 957	PharmD (130)	2	2015
Patient Care Lab: Cardiovascular Physical Examination and Assessment	PPS 957	PharmD (160)	8	2015

Scholarship and Grants

Refereed Publications
Willeford A, Leiman V, **Noel ZR**. Impact of a Pharmacist-to-Dose Direct Oral Anticoagulant Protocol on Medication Errors at an Academic Medical Center. J Am Coll Clin Pharm. 2021. DOI: 10.1002/jac5.1503

Pincus KJ, Blackman AL, Suen SY, Devabhakthuni S, Gale SE, **Noel ZR**, Seung H, Sheth Pandi N. Statin gap in patients living with HIV: Assessing dose appropriateness. *HIV Medicine* 2021;00:1-7. DOI: 10.1111/hiv.13150

Noel ZR, Flannery AH. The Implications of Conduction Abnormalities on Pharmacotherapy Decision-making. Ann Pharmacother. 2020 Nov 13;1060028020973387.

Noel ZR, See VY, Flannery AH. Walk the Line-The Importance of Well-Informed Interpretation of QT Prolongation. Ann Pharmacother. 2021. Jan;55(1):123-126. doi: 10.1177/1060028020934718.

Reed BN, **Noel ZR**, Heil EL, Shipper AG, Gardner AK. Surveying the selection landscape: A systematic review of processes for selecting postgraduate year 1 pharmacy residents and key implications J Am Coll Clin Pharm. 2020. https://doi.org/10.1002/jac5.1334

Broscious R, Kukin A, **Noel ZR**, Devabhakthuni S, Seung H, Ramani H, Reed BN. Comparing Diuresis Patterns in Hospitalized Patients With Heart Failure With Reduced Versus Preserved Ejection Fraction: A Retrospective Analysis. J Cardiovasc Pharmacol Ther. 2020. doi: 10.1177/1074248420960930

Mouradjian MT, Plazak ME, Gale SE, **Noel ZR**, Watson K, Devabhakthuni S. Pharmacologic Management of Gout in Patients with Cardiovascular Disease and Heart Failure. Am J Cardiovasc Drugs. 2020. doi:10.1007/s40256-020-00400-6.

Plazak ME, Mouradjian MT, Watson K, Reed BN, **Noel ZR**, Devabhakthuni S, Gale, SE. An aspirin a day? Clinical utility of aspirin therapy for the primary prevention of cardiovascular disease. Expert Rev Cariovasc Ther. 2019 Aug;17(8):561-573. doi: 10.1080/14779072.2019.1642108

Noel ZR, Beavers CJ, Dunn SP, Schullo-Feulner AM, Caldas L, Dixon DL. Identifying Core Content for Electrocardiogram Instruction in Doctor of Pharmacy Curricula. American Journal of Pharmaceutical Education 2018; 82 (10).

Longyhore DS, Dixon DL, **Noel ZR**. A Modified Approach to Setting Curriculum Boundaries in Pharmacy School. American Journal of Pharmaceutical Education 2018; 82 (9) Article 7010.

Watson K, Broscious R, Devabhakthuni S, **Noel ZR**. Focused Update on Pharmacologic Management of Hypertensive Emergencies. Current Hypertension Reports (2018) 20:56.

Kukin A, **Noel ZR**, Watson K. Through the Decades: β-Blocker Use and Outcomes in Acute Coronary Syndromes. Cardiol Rev. 2018 May/Jun;26(3):157-166. doi: 10.1097/CRD.0000000000000197.

Noel Z. Safety concerns regarding selexipag in pulmonary arterial hypertension. Am J Health Syst Pharm. 2018 Apr 1;75(7):420. doi: 10.2146/ajhp170884.

Noel ZR, Kido K, Macaulay TE. Selexipag for the Treatment of Pulmonary Arterial Hypertension. Am J Health-Syst Pharm. 2017; 74:e360-6.

Noel ZR, Bastin ML, Montgomery AA, Flannery AH. Comparison of High-Dose Versus Standard Dose Oseltamivir in Critically Ill Patients with Influenza. J Intensive Care Med. March 2016. DOI 10.1177/0885066616638649.

Noel ZR, Beavers CJ. Proprotein Convertase Subtilisin/Kexin Type 9 Inhibitors: A Brief Overview. Am J Med. 2017 Feb;130(2):229.e1-229.e4. doi: 10.1016/j.amjmed.2016.09.021.

Cain J, **Noel Z**, Smith KM, Romanelli F. Four Rights of the Pharmacy Educational Consumer. Am J Pharm Educ. 2014 Aug 15;78(6):115. doi: 10.5688/ajpe786115.

Non-Refereed Publications and Blogs
Noel ZR. A Tough Pill to Swallow: Clinical Application of Prasugrel in Patients with ACS. ATRIUM Blog. October 2019.

Noel ZN. Three Things You Should Know Before Throwing in the Towel on Triple Therapy. ATRIUM Blog. June 2019.

Noel ZR. Apixaban Over Warfarin for Anticoagulation in Patients with Atrial Fibrillation and End Stage Renal Disease. ATRIUM Blog. January 2019

Devabhakthuni S, **Noel ZR**. No Anticoagulation in Patients with Atrial Fibrillation and End Stage Renal Disease. ATRIUM Blog. January 2019.

Noel ZR. Post-TAVR Antithrombotic Therapy: What To Do When No One Knows What To Do. ATRIUM Blog. December 2018.

Noel ZR. The Short End of the Stick: Practical Management of Cardiovascular Drug Shortages. ATRIUM Blog. October 2018.

Noel ZR. Dofetilide: A Diamond in the Rough for Atrial Fibrillation in Patients with Structural Heart Disease. ATRIUM Blog. March 2018.

Noel ZR, Reed BN. Dietary Supplements and Heart Health. ATRIUM Blog. November 2017.

Noel ZR. Anticoagulation Safety (Part 2 or 2): The Role of Anticoagulation Stewardship Pharmacist. ATRIUM Blog. September 2017.

Noel ZR. Anticoagulation Safety (Part 1 of 2): Common Drug Errors with NOACs… I Mean DOACs! ATRIUM Blog. June 2017

Noel ZR. Upstream P2Y12 Inhibitors and the CABG Quandary. ATRIUM Blog. April 2017

Noel ZR, Reed BN. Caveat Emptor: Dietary Supplements and Heart Health. Latest in Cardiology Expert Analysis. American College of Cardiology. April 2017.

Oliphant CS, Hale G, Berei T, **Noel ZR**, Cook JC, Scalese MJ. Idarucizumab and Andexanet Alfa. ACCP Experts in Training Newsletter - Cardiology PRN Focus. March 2016.

Book Chapters and Monographs
Noel ZR. Tisdale J. Cardiology Pharmacotherapy Board Prep Review: Arrhythmias. American College of Clinical Pharmacy. *2020 - Present*

Merry J, **Noel ZR**. Appropriate Post-Acute Anticoagulation Guidelines. Empirian Health Short Stay Prescribing Guidelines. 2019.

Noel ZR. Ventricular Arrhythmias. Pharmacotherapy First: A multimedia learning resource. American Pharmacists Association. 2018.

Smetana K, **Noel ZR**, Sidhartha RD. Chapter 19: Drugs Acting on the Cerebral and Peripheral Circulations. Side Effects of Drugs Annual. 40th Edition. 2018

Grants
Impact of Animated Video Counseling on Anticoagulation Comprehension and Retention
American College of Clinical Pharmacists (ACCP), Cardiology Practice and Research Network Seed
Grant. Primary Investigator

Presentations

Scientific/Research Presentations
Pincus K, Blackman AL, Devabhakthuni S, Gale SE, **Noel ZR**, Sheth P. *Statin Dose Appropriateness in Patients Living with HIV Compared to Uninfected Patients.* American College of Clinical Pharmacists Annual Meeting. Held virtually Oct 2020.

Kukin A, Gale SE, Reed BN, Devabhakthuni S, Watson K, **Noel ZR**. *Effect of Video-assisted Counseling versus Traditional Counseling on Patient Comprehension of Prescribed Direct Oral Anticoagulants.* American College of Clinical Pharmacists Annual Meeting. Held virtually Oct 2020.

Wasik A, **Noel Z.** *Changes in Diuretic Regimen and Impact on Readmission Rates Following Transcatheter Aortic Valve Replacement.* American College of Cardiology 67th Annual Scientific Session and Expo. Orlando, FL. Mar 2018

Pinkos K, Reed B, Devabhakthuni S, **Noel Z**. *Rates of Off-Label Dosing of Apixaban in End Stage Renal Disease: A retrospective analysis of a large health-system.* 75th ASHP Midyear Clinical Meeting. Orlando, FL. Dec 2017.

Schmersahl S, Reed B, Devabhakthuni S, **Noel Z**. *Evaluation of Impact of Upstream Clopidogrel on Time to Coronary Artery Bypass Grafting.* 75th ASHP Midyear Clinical Meeting. Orlando, FL. Dec 2017.

Mouradjian M, **Noel Z**. *Evaluation of Appropriateness of Bivalirudin Prescribing at an Academic Medical Center.* 75th ASHP Midyear Clinical Meeting. Orlando, FL. Dec 2017.

Noel Z, Bastin-Thompson M, Flannery A. *Comparison of High Dose Oseltamivir Versus Standard Dose Oseltamivir in Critically Ill Patients.* Poster. Society of Critical Care Medicine National Meeting, Orlando, FL, February 2016

Noel Z, Matson A, Goodin, A, Dobesh PP, Trujillo T, Ripley TL, Macaulay TE. *Relationship between Faculty Evaluation Scores and Qualifications on Participant Knowledge Retention Rates in Continuing Pharmacy Education Activities.* Poster. University Health Consortium National Meeting, New Orleans, LA, December 2015

Noel Z, Cook AM, Davis G. *Role of the pharmacy residency on-call program in management of direct thrombin inhibitor (DTI) use for heparin-induced thrombocytopenia (HIT).* Poster. American Society of Health-System Pharmacists National Meeting, Orlando, FL, December 2013.

Invited/Professional Presentations
"C" Your Way to It: Addressing Professional Competencies and Cognitive Load Using 4C/ID
American Association of Colleges of Pharmacy Annual Meeting, Aurora, CP July 2023

Too Much, Too Fast: Using Cognitive Load Theory to Inform Teaching and Learning
American Association of Colleges of Pharmacy Annual Meeting, Dallas, TX July 2022

Oversize Load: Using Cognitive Load Theory to the Readiness Process
Team-Based Learning Online Workshop sponsored by CognaLearn, May and August 2022

Voila! You Are Now Equipped with the Magical Presentation Secrets

American Society of Health-System Pharmacists Midyear Clinical Meeting, December 2021
*Due to COVID-19 this presentation was done virtually

DOAC Dilemmas: Direct Oral Anticoagulants for Atrial Fibrillation in the Oldest Old Adults and End Stage Renal Disease.
Joint Board Certification presentation at the American College of Clinical Pharmacy Annual Meeting and American Society of Health-System Pharmacists. October 2021 and December 2021
*Due to COVID-19 this presentation was done virtually

The Great Debate: Does Attendance Matter?
American College of Clinical Pharmacy Annual Meeting, October 2021
*Due to COVID-19 this presentation was done virtually

Team Work Makes the Dream Work: Using Team-Based Learning in PharmD Education
Teaching Excellent Day, University of Maryland School of Pharmacy, July 2021

Creating a High-Functioning Team Where Together Everyone Achieves More.
American Society of Health-Systems Pharmacists (ASHP) Midyear Clinical Meeting, December 2020.
*Due to COVID-19 this presentation was done virtually

Controversies Surrounding Antithrombotic Therapy Following Transcatheter Aortic Valve Replacement
American Society of Health-Systems Pharmacists (ASHP) Midyear Clinical Meeting, December 2020.
*Due to COVID-19 this presentation was done virtually

Mapping Out a Plan: Anticoagulation Considerations for Atrial Fibrillation Ablation.
American College of Cardiology, Maryland Chapter Cardiovascular Team. Pillars in Cardiology Presentation. Nov 2020.
*Due to COVID-19 this presentation was done virtually

Work Smarter Not Harder - Instructional Design and Project Management Principles for Course Managers
American Association of Colleges of Pharmacy (AACP) Annual Meeting, July 2020
*Due to COVID-19 this presentation was done virtually

The Pros and Pitfalls of Polling Platforms. Teaching Excellence Day. University of Maryland, Baltimore. June 2019.

#MondayMotivation: Getting the Most from Millennial Learners Starting Day 1. University of Maryland School of Pharmacy Academy of Preceptors. Baltimore, MD. 1.5 CE credits. May 2019

Ventricular Arrhythmias and Advanced Cardiac Life Support. American Society of Health-Systems Pharmacy Cardiology Board Certification Review Course. Webinar. June 2018

Whose Side Are You On? Warfarin vs DOACs for Stroke Prevention in Atrial Fibrillation and End Stage Renal Disease. 3rd Annual ATRIUM Spring Symposium. Baltimore, MD. April 2018

Role of Dietary Supplements in the Prevention and Treatment of Cardiovascular Disease. 35th Annual North Central Heart Cardiac Symposium. Siouix Falls, SD. November 2017

Statin Intolerance: Diagnosis and Management. VuMedi Live Webinar. May 2017

TSOACs, DOACs, and NOACs…OH MY! Drug Safety Considerations for Using Non-Vitamin K Antagonist Oral Anticoagulants. ATRIUM Annual Spring CE Symposium. Baltimore, MD. April 2017

Extended Dual Antiplatelet Therapy. Kentucky Society of Health-Systems Pharmacists Spring Meeting: Clinical Pearls Session. Lexington, KY. May 2016

Drug Therapy Update for the Treatment of Hyperlipidemia and Heart Failure. University of Kentucky College of Pharmacy Annual Law Review. Lexington, KY. April 2016

Abstract

Title: The Effects of Graded Versus Ungraded Individual Readiness Assurance Tests on Pharmacy Students' Assessment Performance and Achievement Goals in a Team-Based Learning Classroom

Zachary R. Noel, Doctor of Philosophy, 2023

Dissertation Co-Directed by:

Christina Cestone, PhD; Assistant Vice Provost, Faculty Affairs; Executive Director, Faculty Center for Teaching and Learning, Academic Affairs; Program Director and Associate Professor, Health Professions Education (HPE), Graduate School, University of Maryland, Baltimore

Karen Gordes, PhD, PT, DScPT; Chief Learning Officer, Associate Professor, PA Leadership Learning Academy (PALLA), Graduate School, University of Maryland, Baltimore

Abstract: Individual readiness assurance tests (iRATs) are frequently graded in team-based learning (TBL) classrooms, with the goal of incentivizing individual pre-class preparation. The purpose of this study was to determine whether shifting to an ungraded iRAT process affects student preparation and learning, as measured using assessment scores, and whether this is accompanied by a change in achievement goals. Using a crossover design in a required second-year Doctor of Pharmacy pharmacotherapy course, students were assigned to one of two iRAT grading sequences: graded/ungraded (G/UG) or ungraded/graded (UG/G). In the G condition iRATs were graded based on correctness and in the UG condition based on completion. Each period consisted of four iRATs and one examination. Students completed the Achievement Goal Questionnaire at the

conclusion of each period. A one-way repeated measures multivariate analysis of variance (MANOVA) was used to test within-subject differences of mean iRAT and examination scores across grading conditions. A separate one-way repeated measures MANOVA was used to analyze differences in achievement goal scores. A total of 91 doctor of pharmacy students were included in the study. There was a statistically significant main effect for iRAT grading condition on assessment scores, $F(2,88) = 3.851$, Wilks' $\Lambda = .992$, $p = .025$. Univariate testing using one-way analysis of variance with Bonferroni correction demonstrated a significant difference only in iRAT scores, with the mean score higher in the G condition (72.51% versus 67.99%; $p = .011$). Examination scores were similar in the G and UG conditions (81.07% versus 80.32%, $p = .397$). There was not a statistically significant difference in achievement goals based on iRAT grading condition, $F(4,85) = 1.109$, $\eta^2 = .050$, $p = .358$. In conclusion, a modest reduction in iRAT performance was observed when shifting from a graded to ungraded iRAT; however, this had no effect on examination performance. Achievement goals were unaffected by the change in iRAT grading condition.

The Effects of Graded Versus Ungraded Individual Readiness Assurance Tests on
Pharmacy Students' Assessment Performance and Achievement Goals
in a Team-Based Learning Classroom

by
Zachary R. Noel

Dissertation submitted to the Faculty of the Graduate School of the
University of Maryland, Baltimore in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
2023

Dedication

To my wife, Kristina, for showing an interest in my interests and for your unwavering support along this journey. Thank you for the sacrifices you made to support me, and for putting up with my (more than) occasional moodiness, stress, and fatigue. I love you and I could not have asked for a better teammate.

To my kids, Ryne (RJ) and Ruby. You two have provided the most real-world, authentic application "activity" on motivation and learning that I could have ever asked for! Thank you for teaching me.

To my students and their future patients, who provide meaning and value to health professions education and research.

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CHAPTER ONE: INTRODUCTION

Background

Team-based learning (TBL) is a structured form of collaborative learning that emphasizes peer-to-peer accountability, teamwork, and problem-solving through real-world application activities (Michaelsen et al., 1982; Sibley et al., 2014). TBL, which was formerly referred to as "team learning" in the early literature, was first implemented more than four decades ago as an active learning strategy for large, lecture-hall style classes with the intent of finding ways to replicate meaningful and real world challenges in the classroom (Michaelsen, 1992; Michaelsen et al., 1982; Sibley et al., 2014). Much of the early use of TBL was within business education, but it has since expanded to virtually all disciplines in higher education (Sibley et al., 2014).

Educators at Baylor College of Medicine first described their experience with TBL in medical education in the early 2000s, and it soon expanded to ten medical schools across the country (Haidet et al., 2002; Seidel & Richards, 2001; Thompson et al., 2007). Other health professions also began adopting TBL in the late 2000s, including pharmacy (Beatty et al., 2009; Conway et al., 2010; Letassy et al., 2008) and nursing (Clark et al., 2008). Currently, TBL has become one of the most common instructional strategies in health professions education around the world (Allen et al., 2013; Hong & Rajalingam, 2020). The rise in popularity of TBL can be attributed to a number of factors, including improved student learning outcomes (Fatmi et al., 2013; Koles et al., 2010; Zgheib et al., 2010), an emphasis on interpersonal skill development (e.g., communication, teamwork, providing feedback to peers), improvements in critical thinking skills (Silberman et al.,

2020), and the ability to facilitate large classes with only one facilitator (Alberti et al., 2021; Hrynchak & Batty, 2012; Reimschisel et al., 2017; Swanson et al., 2019).

Structurally, TBL flows through a sequence of learning activities that includes pre-class preparatory work (i.e., the readiness process), in-class assessments (i.e., individual and team readiness assurance tests), and in-class team application exercises. This is classically referred to as the TBL "cycle" and is repeated throughout a course or semester (Sibley et al., 2014, p. 37). Among the key elements that contribute to the success of TBL is an incentive structure to motivate students to come to class prepared (Sweet & Michaelsen, 2012).

In TBL, the readiness assurance process serves as a key motivator for students to come to class prepared (Michaelsen & Sweet, 2008; Sibley et al., 2014; Sweet & Michaelsen, 2012). The readiness assurance process consists of a graded individual (iRAT) and team readiness assurance test (tRAT), both of which are taken at the start of each in-class session. Each test consists of selected response questions that assess foundational concepts from the pre-class preparatory materials. The iRAT is designed to ensure individual accountability for completing pre-class learning of foundational content, whereas the tRAT is designed to promote team performance, relationship building, and peer-to-peer instruction (Michaelsen & Sweet, 2008; Sweet & Pelton-Sweet, 2008).

A graded iRAT process is cited as an essential element of TBL that "must be a substantial enough portion of the final grade so that students feel compelled to prepare but not so large that the iRAT turns into high-stakes testing" (Sibley et al., 2014, p. 143). Experts in TBL traditionally weight the iRAT approximately 10% of the final grade in

the course, and cite an average iRAT score of approximately 65-70% (Sibley et al., 2014; Sweet & Michaelsen, 2012). Although graded iRATs serve as an important motivator for students to learn foundational concepts from the pre-class preparatory materials, grades serve as an extrinsic motivator that may not be necessary for all students and in all contexts (Deci et al., 2001; Janzow & Eison, 1990; Pulfrey et al., 2013).

Grades are a well-established and effective way of motivating students to complete learning tasks. However, extrinsic motivators such as grades can also create undesirable effects, such as undermining intrinsic motivation and shifting students' goals from mastering materials and concepts to performance on an assessment (Deci et al., 1999, 2001; Pulfrey et al., 2013). Such goals are referred to as achievement goals, and in the context of education are focused on "students' intentions or reasons for engaging, choosing, and persisting at different learning activities" (Meece et al., 2006, p. 490). In essence, achievement goals explain the purpose for engaging in a particular learning task.

Understanding how grades influence students' achievement goals in the classroom is of growing interest, particularly within health professional programs (Bloodgood et al., 2009; Cain et al., 2021; Pulfrey et al., 2013; White & Fantone, 2010). Health professionals are expected to develop the skills necessary to be self-directed, lifelong learners upon graduating from their respective fields (Accreditation Council for Pharmacy Education, 2016; Commission of Collegiate Nursing Education, 2018; Liaison Committee on Medical Education Standards, 2022). In line with this, many health professional programs have made structural changes to their curricula that emphasize mastery of materials, such as competency-based milestones or pass/fail curricula (Bloodgood et al., 2009; Colbert-Getz et al., 2023; Reed et al., 2011; Spiess et al., 2022).

Similarly, instructional strategies and assessments are being re-envisioned to de-emphasize grades and prioritize mastery learning.

In consideration of the growing interest in de-emphasizing grades in health professions education, would an ungraded iRAT process compromise the integrity of the incentive structure that is so critical to TBL? Social interdependence theory may be able to help answer this question and provides the theoretical framework supporting this study. Social interdependence exists in an environment where the actions of one individual are affected by others' actions (Johnson & Johnson, 1989). In TBL, positive social interdependence is created through shared learning tasks, such as the tRAT, and increases not only team performance but also *individual* performance (Johnson & Johnson, 2009; Shimizu et al., 2022; Tomcho & Foels, 2012). In theory, the positive social interdependence created through shared learning tasks in TBL may produce enough individual accountability that shifting to an ungraded iRAT has minimal influence on health professional students' motivation to complete pre-class preparatory materials.

Statement of the Problem

The TBL literature cites that graded iRATs are a key element to incentivize and motivate students to complete pre-class preparatory work (Michaelsen & Sweet, 2008; Sibley et al., 2014; Sweet & Michaelsen, 2012). In many TBL classrooms, graded iRATs are a necessary and powerful motivator; however, the degree to which grades are necessary is highly dependent on the individual and the educational context. Students in health professional programs, including pharmacy students, are often higher achieving and are more likely to adopt mastery-approach goals (Gavaza et al., 2014; Oksana et al.,

2018). These factors make it more likely that health professions students strive to "learn for the sake of learning", rather than to achieve a particular grade. This raises the question of whether graded iRATs are necessary – or at least the *degree to which* they are necessary – in health professional programs using TBL.

Only three published studies have explored the effects of graded versus ungraded iRATs on assessment performance in TBL classrooms (Behling et al., 2017; Eudaley et al., 2022; Koh et al., 2019). Each of these studies was conducted in pharmacy (Eudaley et al., 2022) or medical education (Behling et al., 2017; Koh et al., 2019), but yielded discordant findings. Most importantly, none of the studies used an experimental design, limiting the ability to make causal inferences about how ungraded iRATs influence learning and assessment performance. The present study seeks to partially fill this evidence gap by using a prospective, experimental design so that causal inferences can be made. Also notable is that none of the studies analyzed how changing the grading structure of iRATs influences students' achievement goals. The present study will address this evidence gap by using a validated questionnaire to measure pharmacy students' achievement goals and determine how iRAT grading condition influences them.

Purpose of the Study

The purpose of this quantitative, crossover study is to directly evaluate the effects of iRAT grading condition (i.e., graded versus ungraded) on students' learning and achievement goals in a TBL course within a Doctor of Pharmacy program. The independent variable is iRAT grading condition. In the graded (G) iRAT condition, students were told that their iRAT scores for the study period were based on percent correct. In the ungraded (UG) iRAT condition, students were told that their iRAT scores

for the study period were based only on completion; however, students' actual raw scores in the UG iRAT condition were used for the analysis. The dependent variables include assessment performance, as measured using iRAT and examination scores, and achievement goals, as measured using achievement goal scores from the Achievement Goal Questionnaire (Elliot & McGregor, 2001).

Research Questions and Hypotheses

The research questions and hypotheses for this study are as follows:

Q1. Is there a difference in assessment performance in a Doctor of Pharmacy team-based learning classroom based on type of individual readiness assurance tests (graded versus ungraded)?

H1$_0$: There is no significant difference in assessment performance, as measured by individual readiness assurance test and examination scores, based on individual readiness assurance test type (graded versus ungraded) in a TBL classroom.

H1$_1$: There is a significant difference in assessment performance, as measured by individual readiness assurance test and examination scores, based on individual readiness assurance test type (graded versus ungraded) in a TBL classroom.

Q2. Is there a difference in PharmD students' achievement goals based on type of individual readiness assurance test (graded or ungraded) in a team-based learning class?

H2$_0$: There is no difference in pharmacy students' achievement goals, as measured by the Achievement Goal Questionnaire, based on type of

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individual readiness assurance test (graded versus ungraded) in a TBL

classroom.

H2₁: There is a difference in pharmacy students' achievement goals, as

measured by the Achievement Goal Questionnaire, based on type of

individual readiness assurance test (graded versus ungraded) in a TBL

classroom.

Significance of the Study

This study has important implications for health professional programs using

TBL. This study represents the first prospective experimental study directly comparing

the effects of graded versus ungraded iRATs on learning and achievement goal in a TBL

classroom. Although the generalizability of the results should be carefully considered in

the context of the study (e.g., within second-year students in a required Doctor of

Pharmacy program), the results may provide useful information for other health

professional programs considering the positives and negatives of variations in iRAT

grading structures. Given the widespread use of TBL within health professions education,

the findings are likely to be of interest across a broad range of health professions

education programs.

This study is also significant in that few studies in health professions education

have attempted to examine how a specific intervention influences students' achievement

goals. Interest in alternate grading structures in health professions education is growing,

and an increasing number of schools and colleges of medicine and pharmacy are

transitioning to pass/fail curricula for reasons such as student well-being and promotion

of mastery learning. (Bloodgood et al., 2009; Colbert-Getz et al., 2023; Reed et al., 2011;

Spiess et al., 2022; Spring et al., 2011; White & Fantone, 2010). Promoting mastery goals is a point of emphasis across the health professions, and identifying how alternative grading structures influence students' achievement goals is an important gap in health professions education literature. In fact, existing studies comparing graded versus ungraded iRATs have justified the significance of their study using the theoretical premise of promoting mastery-approach goals; however, none of them have used validated measurements to demonstrate actual changes in students' achievement goals. Interventional studies, such as this one, are important to determine whether the theoretical basis of these claims translates into actual differences in students' achievement goals.

> There is much to be learned from intervention studies that cannot be learned from correlational studies, observational studies, and laboratory experiments. It is only through intervention work that we can examine whether changes in practice inspired by theoretical insight can lead to actual benefits in the classroom. (Elliot et al., 2017, p. 53)

Summary

Despite the evidence base supporting TBL, and its burgeoning popularity, there are aspects of the original TBL design that may warrant re-examination for learning in today's health professions education programs. While much attention has been given to the incentive structure of TBL, very little attention has been given to how these incentives influence students' achievement goals and the downstream consequences of them, such as promoting less desirable achievement goals that may be incongruent with the goals and characteristics of a self-directed lifelong learner deemed important for health professionals.

TBL has traditionally relied on graded iRATs as an incentive for students to complete pre-class preparatory materials; however, an ungraded iRAT process and its influence on pre-class preparation and assessment performance is not well understood. Although grades are a dominant practice in classrooms, they have been shown to promote less desirable achievement goals. Health professions education programs are increasingly emphasizing the need to promote students' mastery goal orientation, and de-emphasize grades (Cain et al., 2021; Colbert-Getz et al., 2023; White & Fantone, 2010). This study is designed to evaluate the effects of graded versus ungraded iRATs on assessment performance. In addition, this study will evaluate whether changing to ungraded iRATs influences students' achievement goals.

CHAPTER TWO: LITERATURE REVIEW

Introduction

The purpose of this study is to evaluate the effects of individual readiness assurance test (iRAT) grading conditions (graded or ungraded) on assessment performance and achievement goals in Doctor of Pharmacy students. This chapter will begin with a review of team-based learning (TBL), including the structure and sequencing of learning activities, theoretical foundations, and its use in health professions education. A review of the literature on the effects of graded versus ungraded iRATs will also be provided.

Secondly, an overview of achievement goal theory and achievement goals will be provided. The effects of grades on achievement goals and promoting mastery-approach goals within health professional programs will be a point of emphasis. The chapter will conclude with an overview of the theoretical framework supporting the study.

Background and Literature Review

Team-Based Learning

TBL (formerly referred to as "team learning" in the early literature; Michaelsen, 1992; Michaelsen et al., 1982) was first implemented more than four decades ago as an active learning strategy for larger, lecture-hall style, class sizes with the intent of finding ways to replicate meaningful and real world challenges in the classroom (Michaelsen et al., 1982; Parmelee et al., 2012). Since this time, TBL has proliferated and expanded to become one of the most widely used instructional strategies in health professions educations, including medical, pharmacy, dental, nursing, and physician assistant programs (Allen et al., 2013; Hong & Rajalingam, 2020; Stewart et al., 2011).

Structure and Sequence of Learning Activities

TBL includes the following major elements: individual study (i.e., pre-class preparatory work, or the "readiness process"), individual and team readiness assurance tests (i.e., the "readiness assurance process"), and team application activities (Figure 1; Michaelsen & Sweet, 2008; Parmelee et al., 2012; Sweet & Michaelsen, 2012). In addition to the major phases of the TBL cycle, other supporting elements include immediate feedback, appeals process for readiness assurance questions, instructor-created teams of 5-7 students, and peer evaluation. The following sections will review each of the major elements within TBL.

Figure 1

Team-Based Learning Cycle
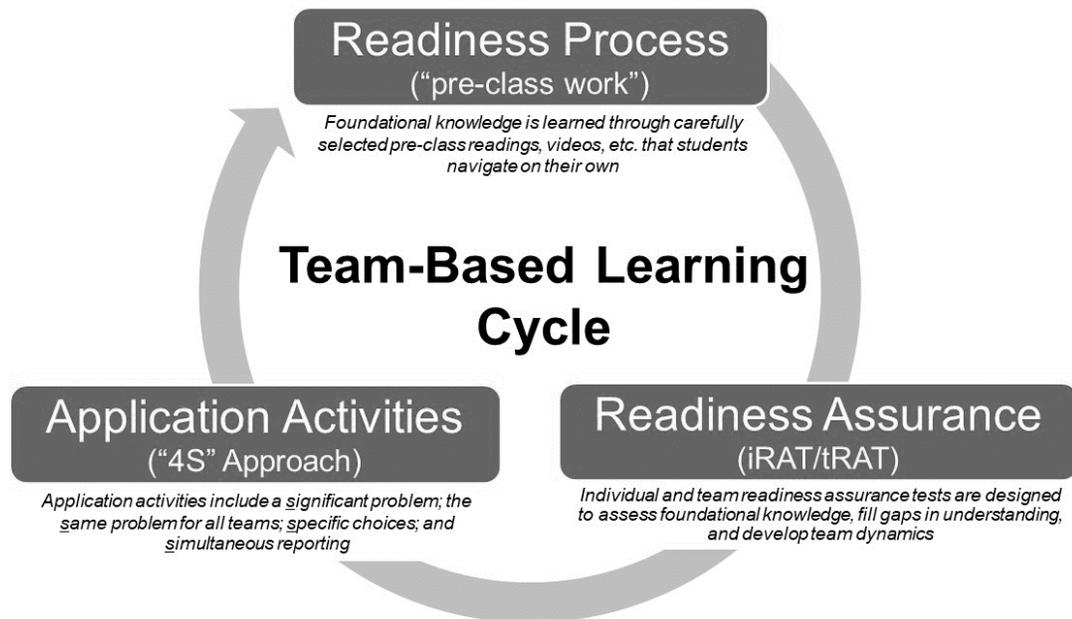
Readiness Process. The readiness process is the first phase of the TBL cycle (Michaelsen & Sweet, 2008). During the readiness process, students are responsible for independently learning foundational knowledge using instructor-selected materials. Instructors are charged with curating pre-class readiness materials, providing clear instructions and learning objectives to students, and ensuring alignment between the readiness materials and in-class application activities. The readiness materials generally consist of a variety of readings (e.g., textbook or journal article), outlines, figures, online videos (e.g., Khan Academy, YouTube), or pre-recorded lectures.

Readiness Assurance. The readiness assurance tests consist of a series of selected-response questions that are taken individually and then again as a team. The individual readiness assurance test (iRAT) is taken first, with the primary purpose to incentivize pre-class preparation during the readiness phase. Immediately following the iRAT, the team readiness assurance test (tRAT) is taken. Unlike the iRAT, during the tRAT teams receive immediate feedback following each question. The immediate feedback provided during the tRAT serves as a powerful reinforcement for student learning, peer accountability, and relationship building (Sweet & Pelton-Sweet, 2008). Lastly, following the iRAT and tRAT, the facilitator provides clarifying discussion, as needed, for commonly missed questions. Teams are also permitted to submit an appeal for questions that they may have missed if they can justify an alternative response.

From an information processing standpoint, the iRAT and tRAT encourage and enable knowledge reconsolidation, retrieval practice, and elaboration (Schmidt et al., 2019). Knowledge reconsolidation is the act of retrieving previously consolidated information from memory and then actively consolidating it again, such as when

information is retrieved from memory to answer questions on the iRAT (Schmidt et al., 2019). The reconsolidation process strengthens and stabilizes knowledge structures, producing more durable learning. Furthermore, intra-team discussion during the tRAT gives students an opportunity to elaborate on their response, which further helps to stabilize new knowledge.

Team Application Activities. Application activities are designed to challenge students to apply foundational knowledge learned during the readiness process and subsequently reinforced during the readiness assurance process (Michaelsen & Sweet, 2008). The structure of the activities is such that teams work on real-world, authentic problems. All teams complete the same activity, and all teams report their answers simultaneously. The instructor (facilitator) is responsible for leading inter-team discussion after all teams have reported their responses. Figure 2 provides an example of an application activity taken from a Doctor of Pharmacy course.

Figure 2

Example Application Activity

P.K. is a 48-year-old who presented to the hospital with sudden onset shortness of breath. P.K.'s past medical history is notable for hypertension, hyperlipidemia, chronic kidney disease, and HIV. A CT scan revealed an acute pulmonary embolism with no identifiable cause. Pertinent objective information is as follows:

Weight: 62 kg

Basic Metabolic Panel:

- Creatinine – 1.9 mg/dL (estimated Creatinine Clearance – 27 mL/min.)

Home Medications:

- Amlodipine 10 mg once daily
- Tenofovir alafenamide/emtricitabine/darunavir/cobicistat

Which of the following is(are) appropriate initial treatment options? (select all that apply)

A Rivaroxaban 15 mg twice daily for 21 days, then 20 mg once daily thereafter
B Enoxaparin 60 mg twice daily x 5 days followed by dabigatran 150 mg twice daily
C Apixaban 10 mg twice daily for 7 days, then 5 mg twice daily thereafter
D Enoxaparin 60 mg once daily x 5 days, overlapping with warfarin 2.5 mg daily (titrated to goal INR 2-3)

Additional Elements. Team formation and peer evaluation are critical to the

success of TBL (Cestone et al., 2008; Michaelsen & Sweet, 2008). Best practice is for

teams to be formed by instructors, not students. Each team should have 5-7 members, and

the teams should be permanent (i.e., the same throughout a course, semester, or even an

academic year). Students complete peer evaluations of their team members multiple times

throughout the semester, which serves as a mechanism for peer accountability to the

team's performance. Table 1 provides a review of the core elements within TBL (Haidet

et al., 2012; Sibley et al., 2014; Sweet & Michaelsen, 2012).

Table 1

Core Elements of Team-Based Learning

Core Element	Description
Team Formation	Permanent teams of 5-7 students are formed by the instructor (i.e., not student-formed) to ensure equal allocation of workload and input from a variety of viewpoints or perspectives
Readiness Assurance	Individuals complete a brief assessment, followed by a team assessment. The readiness assurance process is in place to ensure accountability for pre-class work.
Immediate Feedback	Answers to the readiness assurance are provided immediately following the team assessment.
Sequencing of In-Class Activities	Activities and communication occur within teams (intra-team) and then across teams (inter-team).
Four Ss	Activities represent a significant problem, offer specific choices, are the same across teams, and are reported simultaneously.
Incentive Structure	Individual and team readiness assurance tests are graded to incentive individuals to prepare and participate.
Peer Review	Peers provide feedback to their teammates.

Educational Theory Supporting Team-Based Learning

Like other forms of active learning, TBL is rooted in constructivism (Burgess et

al., 2018; Hrynchak & Batty, 2012). Constructivism states that knowledge is actively

constructed by the learner and discovered through problem-solving and social

interactions (Schunk, 2020; Wadsworth, 1996). In constructivism, teachers serve as

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facilitators, rather than lecturers, and seek to expose inconsistencies in learners'

understanding. For example, in TBL learners solve problems and create solutions during

the team application activities, while the instructor facilitates discussion and draws out

points of confusion. The application activities within TBL are designed to represent real-

world scenarios that are authentic to the profession (Hrynchak & Batty, 2012).

It is worth noting that few articles explicate TBL through the lens of an

educational theory. Original publications and historical perspectives on TBL state that

TBL was designed with the intent of creating an "active learning strategy" and designing

effective group activities (Haidet et al., 2002; Hunt et al., 2003; Koles et al., 2010;

Michaelsen & Sweet, 2008; Seidel & Richards, 2001; Sibley et al., 2014; Sweet &

Michaelsen, 2012). In early studies, direct comparisons are made to problem-based

learning, which is a widely used active learning strategy also rooted in constructivism. In

essence, the ties to constructivism in seminal publications are indirect and implied.

In recent years, a few studies have highlighted the connection between TBL and

constructivism. Hrynchak and Batty (2012) published a review of the educational theory

supporting TBL, which emphasized the connection between constructivist learning

theories and TBL. In a separate publication by Dolmans et al. (2015), the similarities and

differences between TBL and problem-based learning are highlighted. One of the key

similarities noted is that each is a "…learner-centered instructional [approach] based on

constructivist learning theory" (p. 356). Although no supporting references are provided

for either of the articles by Hrynchak and Batty (2012) or Dolmans et al. (2015), a

theoretical explanation is based on the premise that students work closely with a group of

their peers to complete authentic, real-world problems that are relevant to the profession.

More recently, research by Burgess et al. (2018) explained the educational theory underlying TBL. This study was a qualitative analysis of first year medical students' experience of using both TBL and problem-based learning. Fourteen students participated in focus group sessions and the themes that emerged from the data were consistent with the major premises of constructivist theory: guided learning, problem solving, collaborative learning, and critical reflection.

Albert Bandura's (1986) Social Learning Theory also has important connections to TBL, particularly as it relates to self-efficacy. Within Social Learning Theory, Bandura used the framework of reciprocal determinism to explain human learning and behavior. Reciprocal determinism posits that a person's behavior both influences, and is influenced by, environmental and personal variables (Bandura, 1986). Environmental factors include physical or social contexts in which a behavior takes place. Personal variables include elements such as cognition and self-efficacy.

Self-efficacy is an individual's perceived ability to perform a particular task at an expected level and can be enhanced through social interactions and/or social persuasions (Bandura, 1986). The social interactions afforded through TBL have been shown to influence self-efficacy. A study by Loftin and West (2017) used Bandura's Social Learning Theory to illustrate how self-efficacy can be influenced by social interactions within TBL. In this study, investigators gave physician assistant students a pre-post survey using a validated, general self-efficacy survey. The pre-post survey was administered to a group of students before and after completion of an end-of-life module. In one cohort, the module was completed using TBL. In another cohort, the module was completed entirely asynchronously on the internet. The students in the TBL group

reported greater confidence in learning about end-of-life care, finding solutions to problems, and using critical thinking skills compared to the online only group.

Readiness Assurance Testing and Grades

The individual readiness assurance test (iRAT) serves to hold students accountable for completing individual pre-class work, as well as to isolate gaps in foundational understanding before advancing to application activities. On the contrary, the team readiness assurance test (tRAT) is in place to clarify gaps in understanding and promote team performance (Michaelsen & Sweet, 2008; Sweet & Pelton-Sweet, 2008). It is commonly believed by experts in TBL that the readiness assurance process must be graded to adequately incentivize individual student preparation, individual team contribution, and overall team performance (Michaelsen & Sweet, 2008). To evaluate the validity of these claims, a review of the team-based learning literature was performed to identify articles addressing graded versus ungraded readiness assurance tests. Three articles evaluating the effects of graded versus ungraded readiness assurance tests were identified within the health professions education literature (Behling et al., 2017; Eudaley et al., 2022; Koh et al., 2019). A review of the references in each of the identified articles did not yield additional articles of relevance, nor did an expanded literature search outside the context of health professions education.

Behling et al. (2017) conducted a retrospective cohort study to identify whether including TBL exercises (inclusive of the iRAT, tRAT, and team application activities) into the course grade correlated with final examination performance in a first year medical school curriculum. Three cohorts were included, and each cohort was analyzed across two courses: microbiology and infectious diseases. Cohort 1 (*N*=64 students)

consisted of ungraded TBL activities in microbiology, but the activities were graded in the infectious disease course. Cohorts 2 (N=72) and 3 (N=80) consisted of graded TBL activities in both courses, with the readiness process contributing anywhere from 6-12% towards the final grade in the course. In cohort 1, student performance on the iRAT and tRAT were consistently lower in the (ungraded) microbiology TBL sessions as compared to the graded cohorts (p <0.001). Of note, exact percentages were not provided in the study, but based on the bar graphs presented the absolute percent difference in scores was ~25%. Interestingly, when cohort 1 entered the infectious disease course, which required a shift from ungraded to graded TBL activities, the performance in the iRAT and tRAT improved to at or above the performance of cohorts 2 and 3. This suggests that students' performance on the in-class activity was indeed influenced by whether the TBL activities were for a grade. However, the authors found that the iRAT scores did not correlate with final examination performance, suggesting that graded readiness assurance activities did not influence long-term academic performance. The authors noted that there were more failures in the ungraded cohort compared to the graded cohort, but this difference was not described as statistically different (13% vs 8%; no p-value provided).

There are several important limitations of the above study. First, in the ungraded cohort the readiness process (including both the iRAT and tRAT) and application activities were weighted *zero* percentage to the final grade in the course. This is distinctly different from having the readiness process contribute to grades in the course based on completion, which provides at least *some* incentive for coming to class and engaging in classroom activities. Second, the cohorts were compared across different students in different academic years. Although the authors state the course instructors, materials, and

examinations were consistent across the three cohorts, variations (however minor) are inevitable and cannot be controlled for in a retrospective study. One strength of the study was that cohort 1 served as their own control in the ungraded microbiology course compared to the graded infectious disease course. Lastly, the ungraded cohort consisted of an ungraded iRAT *and* tRAT. It is unclear how the results would have differed if the iRAT served as a single independent variable in the study.

Most recently, a study by Eudaley et al. (2022) evaluated the impact of a graded versus ungraded readiness assurance process in an elective ambulatory care pharmacy course. This was also a retrospective cohort study comparing a historical, graded cohort (*N*=47) to an ungraded cohort (*N*=36). Unlike the Behling et al. (2017) study, the ungraded assessments contributed to 2.5% of the final grade in the course, but only in the form of participation points. Content was kept the same across the years; however, due to the COVID 19 pandemic, the synchronous TBL sessions in the 2021 (ungraded cohort) were facilitated using video web conferencing. Student RAT and examination performances were analyzed between the two cohorts. In addition, the ungraded cohort was provided with a survey evaluating time spent preparing for class, as well as relevant items on accountability from the TBL Student Assessment Instrument. The authors found no significant difference in iRAT scores between the graded and ungraded cohorts (76% vs 74%, $p = .301$), nor was there a difference in the overall examination grade in the course (82% vs 80%, $p = 0.146$). The results of the survey suggested that students in the ungraded cohort still felt a sense of accountability to their peers and prepared each week for class.

There are a few important caveats of this study. First, this was an elective pharmacy course. It is not unreasonable to assume that most of the students were higher achieving and more likely to have mastery goals. This could have resulted in selection bias, in which the students in the study were less likely to be influenced by grades. Second, although the demographics between the graded and ungraded cohorts were similar, the retrospective nature of the study prevents rigorous control of potential confounders, such as the transition to online learning. This is particularly true given the relatively small sample size in the study. Lastly, although the authors stated that the content was kept the same year-over-year, the TBL sessions changed from live, in-person delivery in the graded cohort to synchronous web conferencing in the ungraded cohort. This change in delivery (however unavoidable it may have been) could have influenced test and examination integrity, student engagement, and student learning.

A third study, performed by Koh et al. (2019), was a quasi-experimental study that retrospectively looked at the effects of changing from a graded to an ungraded readiness assurance process in an undergraduate medical school curriculum ($N = 220$). The authors analyzed surrogate markers for pre-class preparation (e.g., class material download frequency), average iRAT performance, and examination scores for three cohorts, each over two academic years. Compared to the graded cohort, the number of downloads of the pre-class material in the ungraded cohort dropped by 26-58% (depending on the class year). Furthermore, there was a significant drop in iRAT scores in the ungraded cohorts ($M = 75.35$) compared to the graded cohorts ($M = 81.17$, $p<.001$). This drop in iRAT scores was found to correlate with examination performance at the end of the first year (75.35% in the graded cohort v 72.93% in the ungraded cohort, $p=0.005$),

suggesting that the shift from a graded to ungraded RAT process did indeed influence academic performance. These effects were observed during the first, but not the second, professional year.

There were several notable limitations to this study. Similar to the study by Behling et al. (2017), the RAT process contributed zero points towards the final grade in the undergraduate curriculum. It is plausible that this overly de-incentivized the RAT process compared to a RAT process that was graded based on participation points. Second, although the findings pointed towards a correlation between ungraded iRATs and poorer examination performance, the difference in examination scores in the graded and ungraded cohorts was less than 2.5 percentage points. Such a small difference in assessment performance must be weighed against the potential downsides that extend beyond grades (e.g., added stress and student anxiety). Third, although downloads were fewer in the ungraded cohort, it should be noted that this is a surrogate marker and does not provide information on how students are consuming the information or actively processing it. Lastly, the findings demonstrate correlation between grading condition and assessment scores, but a causal inference cannot be made due to the non-experimental design of the study.

Achievement Goals

Achievement goals can be defined as "the purpose for engaging in competence-relevant behavior" (Elliot et al., 2017, p. 44) and serve an important role in explaining *why* students engage in learning tasks. The central tenet of achievement goals is *competence*, which is defined based on the standard used in performance evaluation (Elliot & McGregor, 2001). Furthermore, standards can be defined as being either

normative or intrapersonal, where normative standards are defined based on the performance in comparison to others and intrapersonal standards are defined by the individual (Elliot & McGregor, 2001). To illustrate this, suppose there are two pharmacy students studying for an upcoming final examination covering cardiovascular pharmacotherapeutics. Student A happens to have a strong family history of cardiovascular disease and has a keen interest in learning about the topic so that she can offer help and guidance to her family. On the other hand, Student B has a 3.0 grade point average in pharmacy school and is on the cusp of losing an academic scholarship if she does not get an "A" on the final examination.

The standard to define competence for Student A is intrapersonal – she wants to learn as much as she can to best help her family. Student B, however, is driven by a normative standard – achieving a particular score or grade for fear of losing her scholarship. These standards can be defined as mastery (Student A) and performance (Student B) goals. Both mastery and performance goals are associated with desirable, or undesirable, student characteristics and predict certain behaviors and academic outcomes. The relationship between academic outcomes and achievement goal will be reviewed in the subsequent sections. Before addressing mastery and performance goals in more detail, consideration must also be given to another dimension of competence: valence.

Valence can be defined as the direction of an individual's competence (McGregor & Elliot, 2002). In our prior example, Student A is presumably *positively* directed towards the learning task. She is focused on succeeding, not failing. On the other hand, Student B is likely to have a negative valence towards the learning task because she is

driven by fear of failure, and the consequences that would come with losing her academic scholarship.

Taken altogether, the way that students define competence, and the direction that it takes, creates a 2x2 achievement goal framework (Elliot & McGregor, 2001). Table 2 provides the crosstabs of these two dimensions, which make up four distinct achievement goals: 1) mastery-approach, 2) mastery-avoidance, 3) performance-approach, and 4) performance-avoidance.

Table 2

2x2 Achievement Goal Framework

		How competence is defined…	
		Mastery	**Performance**
Valence (direction) of competence…	**Positive**	Mastery-approach *"Learning for the sake of learning"* Need for success; self-determination; work-mastery	Performance-approach *"Learning to perform well on an exam"* Competitiveness; fear of failure; improved examination performance
	Negative	Mastery-avoidance *"Learning to avoid misunderstanding"* Fear of failure; perfectionism; worry; disorganization	Performance-avoidance *"Learning to avoid performing poorly"* Fear of failure; poorer examination performance; surface processing; disorganization

Prior to discussing each of the achievement goals in more detail, it should be noted that the focus of this review is on individuals' achievement goals as it pertains to a specific task or situation. This is in contrast to dispositional orientations, which describes one's general tendency or predisposition to evaluate competence across situations (Fryer & Elliot, 2007). Achievement goals are task-specific and dynamic, compared to dispositional orientations which are more stable. The following sections will discuss the

characteristics and qualities for task-specific achievement goals and their relationship to learning outcomes and behaviors.

Mastery-Approach. Mastery-approach goal are associated with positive characteristics and adaptive behaviors. Prior studies have demonstrated that mastery-approach goals are associated with increased student engagement in the classroom, persistence, positive emotions, and deep-processing learning strategies (Elliot & McGregor, 2001; Elliot & Murayama, 2008; Harackiewicz et al., 1997; McGregor & Elliot, 2002; Urdan & Kaplan, 2020). Using the previous analogy of students in a cardiovascular pharmacotherapy course, Student A demonstrated a mastery-approach goal because she is driven by an intrapersonal standard (i.e., to learn as much as she can to help her family members, many of whom have cardiovascular disease) that is positively directed (i.e., she is striving towards success, rather than avoidance of failure).

Mastery-Avoidance. Unlike mastery-approach goals, mastery-avoidance is associated with several *maladaptive* behaviors. The prototypical example of mastery-avoidance is the perfectionist that strives to avoid making mistakes, or an individual focused on not losing existing knowledge or skills (Elliot et al., 2017; Elliot & McGregor, 2001). Such goals are driven out of fear of failure and are associated with worry, disorganization, and less self-determination (Elliot & McGregor, 2001). An example of this is a pharmacy student who learns how to perform a new skill, such as sterile compounding or taking a patient's blood pressure, and is driven to maintain this skill out of fear of losing their skills over time. Of note, trichotomous models of achievement goals do not include mastery-avoidance as a relevant construct (Midgley et al., 2000).

Performance-Approach. In contrast to mastery goals, performance goals define competence based on a normative standard. Within learning environments, competence relative to others serves as the normative standard, which is often defined by grades. Performance-approach goals are associated with competitiveness, persistence, higher assessment performance, and less help-seeking behaviors (Elliot et al., 2017; Elliot & McGregor, 2001; Urdan & Kaplan, 2020). An example of this is a high-performing pharmacy student striving to get a 4.0 grade point average to achieve the top rank in their pharmacy class. The standard they are using is external (i.e., achieving a certain grade) and positively directed toward success.

Performance-Avoidance. Like mastery-avoidance goals, performance-avoidance goals are driven by fear of failure. Unlike mastery-avoidance goals though, performance-avoidance goals have a normative standard. Performance-avoidance is associated with negative emotions, worry, disorganization, and surface processing strategies (Elliot et al., 2017; Elliot & McGregor, 2001; Urdan & Kaplan, 2020). Using the previous analogy of students in a cardiovascular pharmacotherapy course, Student B demonstrated a performance-avoidance goal because she was driven by an external standard (i.e., to achieve a certain grade) that was negatively directed (i.e., to avoid failure and losing her scholarship).

Achievement Goals in Health Professions Education

This section will review achievement goals specifically within the context of health professions education. Given the significant heterogeneity of how achievement goals are measured and defined, only articles using the trichotomous framework (mastery-approach, performance-approach, and performance-avoidance) or 2x2

framework for measuring achievement goals were included (e.g., AGQ by Elliot &

McGregor, 2002; AGQ-R by Elliot & Murayama, 2008; PALS by Midgley et al., 2000).

Articles using a dichotomous framework (e.g., motivated strategies for learning

questionnaire by Pintrich et al., 1993) were excluded.

Early Studies on Achievement Goals in HPE. Early studies on achievement

goals in health professions education built upon the Archer's seminal research (1994).

Archer created an instrument to measure mastery and performance orientations in first

year university students in Australia. Archer also included the construct of academic

alienation, which was used to define those who had no desire to develop competence.

Archer's instrument was validated in a cohort of medicine, nursing, and pharmacy

education students (Perrot et al., 2001).

Some of the earliest research on goal orientation in the health professions was

performed in pharmacy education (Hastings et al., 2001; Perrot et al., 2001). One study

used the instrument developed by Archer (1994) to measure changes in goal orientation

in 80 pharmacy students enrolled in the first professional year of pharmacy school

(Hastings et al., 2001). Students completed the survey during the start of the Fall

semester and again at the end of the academic year. The authors found a significant

decrease in mastery orientation from the Fall ($M = 4.00$, $SD = .43$) to Spring semesters

($M = 3.77$; $SD = .52$; $p < 0.006$) and an increase in academic alienation from the start ($M = 2.77$, $SD = .59$) to end of the academic year ($M = 3.13$, $SD = 0.77$, $p<.001$). A follow-

up analysis of the same students demonstrated a consistent year-over-year decline in

mastery goal orientation from the start of the four-year professional program ($M = 4.00$,

$SD = 0.43$) to the end ($M = 3.67$, $SD = 0.28$, $p<.001$) (Hastings et al., 2005). Similarly,

performance goal orientation declined from the start ($M = 3.74$, $SD = .79$) to the end of the professional program ($M = 3.52$, $SD = 0.28$, $p = .0257$).

This study demonstrates an important concept and trend that is highly relevant to the present study: achievement goals are dynamic and change with time, interventions, and experiences. This opens the door for educators to create intervention studies targeted at influencing students' achievement goals. For example, Gardner (2006) conducted an intervention study in which nursing students were taught characteristics of mastery goals over a 3-week period. The authors found that mastery goals tended to be higher following the intervention. This suggests not only the malleability of goals, but the short time frame in which they can be influenced.

Achievement Goals and Academic Outcomes in HPE. Educators and administrators have a keen interest in predicting students' academic achievement and adaptive behaviors. Multiple studies have correlated achievement goals to academic achievement in health professional students across a variety of cultures (Alrakaf et al., 2014; Barkur et al., 2013; Hall et al., 2015; Kool et al., 2016; Li et al., 2021). Alrakaf et al. (2014) conducted a study of 380 first- and third-year students in a 4-year bachelor of pharmacy degree completed the AGQ. The results of the AGQ correlated with academic performance in two required courses within the curriculum. Among first-year students, performance-approach and performance-avoidance positively ($r=.14$, $p=.04$) and negatively ($r=-0.14$, $p=0.03$) correlated with academic performance. Among third-year students, mastery-avoidance goals negatively correlated with academic performance ($r=-0.31$, $p<.001$). Also noteworthy is that mastery-approach goals were significantly lower

in the third-year students (*M*=5.6, *SD*=1.0) compared to the first-year students (*M*=5.9, SD=1.2, *p*=.01).

Hall et al. (2015) used the AGQ to look at the relationship between achievement goals with academic performance in a masters of pharmacy program in the United Kingdom. Three-hundred nineteen students completed the questionnaire, and the mean achievement goal scores were correlated with academic achievement. Mastery-avoidance was found to have a significant negative correlation with academic performance (*r*=-0.35, *p*=.002). Mastery-approach goals also tended to decrease throughout the professional years, whereas avoidance goals tended to increase (Hall et al., 2015).

Studies in other health professions education programs have shown similar trends in achievement goals over time and in association with academic performance (Li et al., 2021; March & Robinson, 2015; Naismith & Lajoie, 2018). Among 151 nursing students, performance-avoidance goals were found to be negatively associated with performance on high-stakes examinations ($\beta = 5.2$, *SE* = 2.6, $p = 0.05$; March & Robinson, 2015). Among medical students, performance-avoidance goals positively predicted attention to feedback on assignments, whereas performance-approach goals negatively predicted attention to feedback (Naismith & Lajoie, 2018). Another study by Li et al. (2021) evaluated achievement goals in over 3,500 Chinese medical students and found that mastery goals positively correlated with academic performance ($\beta = 0.199$, $p < .01$), as did performance-approach goals ($\beta = 0.267$, $p < .01$). Each of these studies is limited by the self-reported nature of measuring achievement goals, and the generalizability across health professions and education context cannot necessarily be assumed.

The Effects of Grades on Achievement Goals. Preparing students to be "lifelong learners" within their profession requires graduates to be self-determined and to see the value in learning. Such qualities are characteristic of *mastery-approach* goals (Elliot & McGregor, 2001; Harackiewicz et al., 1997; McGregor & Elliot, 2002). Traditional grading methods rely on an external, normative standards and promote performance goals (Ames, 1992; Elliot & Murayama, 2008; Meece et al., 2006; Pulfrey et al., 2011, 2013). Although performance-approach goals are associated with positive academic performance, they are not necessarily associated with sustained effort and self-determined learning. Many health professions programs have transitioned from traditional letter grades to pass/fail curricula, in part, to promote mastery goals among students (Bloodgood et al., 2009; Reed et al., 2011; Spiess et al., 2022; Spring et al., 2011; White & Fantone, 2010). Promoting mastery goal orientations is cited as a reason for shifting from graded to ungraded iRATs in TBL, but there have been no studies comparing whether this shift in grading truly affects achievement goals.

Grades have been shown to undermine intrinsic motivation and play a mediating role in students adopting performance-avoidance goals (Deci et al., 2001; Pulfrey et al., 2011, 2013). Performance-avoidance goals are inherently antithetical to mastery-approach goals and are associated with less self-determination, fear of failure, surface processing, and poorer examination performance (McGregor & Elliot, 2002). Considering this, the potential downsides of overemphasizing individual grades in TBL classrooms must be weighed against the benefits. For example, in TBL, students are expected to navigate the pre-class preparatory materials and learn foundational knowledge before coming to class, at which time they complete the readiness assurance

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tests and application activities. In an environment where grades are the primary individual incentive for pre-class preparation – such as with graded iRATs – students may be more likely to adopt performance goals rather than mastery goals. In an environment where iRAT grades are *de-emphasized*, students may be more likely to complete pre-class preparation for the sake of learning and their own growth.

Theoretical Framework

For educators using TBL, the primary concern with changing from graded to ungraded individual readiness assurance tests (iRATs) is that individual preparation is no longer incentivized. This mindset, however, neglects other notable incentives within TBL, particularly peer accountability and that positive social interdependence that is created through shared learning tasks. Social interdependence theory provides the premise for why shifting to ungraded iRATs may not necessarily equate to an unsatisfactory level of pre-class preparation in all contexts.

Social Interdependence Theory

Social interdependence exists in an environment where the actions of one individual are affected by others' actions (Johnson & Johnson, 1989, 2009). Social interdependence explains, in part, the widespread success of cooperative learning strategies, including TBL (Johnson, 1970, p. 197; Tomcho & Foels, 2012). Cooperative learning is a socially mediated form of learning in which students work (and learn) together towards a common goal (Johnson, 1971; Schunk, 2020). The social environment in cooperative learning strategies, such as TBL, produces different motivational perspectives when compared to individual learning (Slavin, 1996). For example, within

TBL, team members are successful when the group is successful, which creates an interpersonal reward system and positive social interdependence.

The premise of social interdependence is that the goals of the people in the situation determine how they interact, and the people's interactions determine the outcomes of the situation (Johnson & Johnson, 1989). Social interdependence can be further characterized as positive or negative. Positive social interdependence exists when the actions of an individual promotes the achievement of a joint goal, and negative social interdependence exists when the actions of an individual obstruct the achievement of the joint goal (Johnson & Johnson, 2009). Studies have demonstrated that having positive goal interdependence results in higher achievement and greater productivity (Johnson & Johnson, 1989, 2005). The reasons for this are, at least in part, due to responsibility forces. Responsibility forces are the result of positive social interdependence and create a sense of "ought to" within individuals (Johnson & Johnson, 2009). For example, in TBL, positive social interdependence within teams contributes to individuals' feelings that they ought to complete the pre-class preparatory work so that they are prepared for class and contribute meaningfully to the team's performance on the tRAT.

Applying social interdependence theory to TBL, shared tasks such as the tRAT and team application activities encourage the achievement of team goals (Shimizu et al., 2022). A common strategy to encourage team communication and goal formation is to begin the semester by creating a team "contract", in which teams mutually agree upon shared goals and rules (Farland & Beck, 2019; Sibley et al., 2014; Sweet & Michaelsen, 2012). Often, teams create goals that are related to their performance on various shared learning tasks, such as the tRAT. According to social interdependence, in this scenario a

team's motivation to achieve their goals is likely to produce positive social interdependence and not only increase team performance, but also individual preparation and performance (Johnson, 1970; Johnson & Johnson, 2009).

The effects of positive social interdependence on individual preparation provides the theoretical framework supporting this study. Because of positive social interdependence, and the collateral effects on individual accountability, it is plausible that students' motivation to complete pre-class preparation work is less reliant on graded iRATs.

Summary

Graded iRATs serve as a key motivator for students to complete pre-class preparatory materials in TBL; however, the degree to which a graded iRAT process is necessary in various contexts, such as health professions education, is unclear. The current literature shows mixed findings on how ungraded iRATs influence assessment performance. Two studies have demonstrated a modest reduction in iRAT scores when they were ungraded, but no consistent or strong correlation with lower examination scores (Behling et al., 2017; Koh et al., 2019). Importantly, two of the three studies removed the RAT process from the grading structure altogether, as opposed to having them formatively count towards grades (e.g., earning a grade for participation). This has important implications on students' motivation to attend class, and the learning benefits that stem from in-class activities beyond just the readiness process. Furthermore, and perhaps most importantly, the ungraded interventions involved *both* the iRAT and tRAT, rather than isolating the effects of the iRAT alone.

It is prudent to consider the impact of graded readiness assurance tests beyond assessment performance. A central focus of the present study is on how changes in the grading structure for iRATs influence students' achievement goals. Research has demonstrated that grades not only promote performance goals but also *undermine* mastery-approach goals. This shift is in direct opposition with the goals and outcomes of health professional programs, which seek to develop self-determined learners that value continuous professional development and growth. An area of focus among health professions education programs is developing learners that possess the skills, knowledge, and attitude to be self-directed, lifelong learners. These qualities are characteristic of mastery-approach goals. Indeed, the articles by Behling et al. (2017), Koh et al. (2019), and Eudaley et al. (2022) allude to the need to promote mastery achievement goals as a key reason for studying the effects of ungraded iRATs. Despite the theoretical arguments, none of the studies analyzed actual changes in achievement goals.

Furthermore, TBL produces positive social interdependence within teams. Positive social interdependence is associated with not just improved team performance, but also improved individual performance. In consideration of the positive social interdependence and implication on individual accountability, the need to motivate students through a graded iRAT process becomes less clear.

CHAPTER THREE: METHODS

Introduction

The purpose of this quantitative crossover study was to evaluate the effects of graded versus ungraded iRATs on assessment performance and achievement goals in a required Doctor of Pharmacy course that uses team-based learning (TBL). This chapter will provide a detailed review of the research design, research questions and hypotheses, participants and educational context, data collection and instrumentation, procedures, and data analysis.

Research Design

Learning cannot be directly measured, and thus must be defined by what people do, say, or write (Schunk, 2020). In higher education, learning is most often inferred based on assessments. Assessment performance can be measured qualitatively (e.g., through written feedback) and/or quantitatively (e.g., numeric grade). Within TBL, the most common way to assess learning on readiness assurance tests is through quantitative methods. Each readiness assurance test question is administered as a selected-response question and learners receive points for correct answers. Similarly, just as learning is measured indirectly so are achievement goals. Achievement goals are most often measured using quantitative questionnaires using Likert scales. Therefore, quantitative data on assessment performance and achievement goals were used for this study.

Changes in assessment performance and achievement goals were measured in response to a given intervention (i.e., whether students' iRAT scores were graded or ungraded). Because the study sought to establish a causal effect between an intervention and the outcomes of interest, an experimental approach was most appropriate.

Several experimental designs could be used to test the hypotheses. For this study, a prospective crossover design was used such that subjects participated in both grading conditions. This allowed for measurements of the dependent variables (assessment performance and achievement goals) in both conditions, with subjects serving as their own control. A crossover design was chosen for its unique ability to control for between-subject confounders, which are otherwise present when conducting parallel or cohort studies (Jones & Kenward, 2014). In a crossover study, since individuals receive both treatments, they can serve as their own control. Another notable advantage to crossover designs is that they maintain a similar type I and type II error risk as parallel studies, while relying on a lower sample size (Jones & Kenward, 2014; Wellek & Blettner, 2012). This lower sample size allows for a robust analysis within a single academic course, as opposed to performing measurements over multiple years. It is worth noting that several studies involving TBL in health professions education have used a crossover design, partly because of the advantages just described (Bleske et al., 2016; Carbrey et al., 2015; Gopalan et al., 2013; Kim & Kim, 2021; Koles et al., 2005; Thomas & Bowen, 2011).

The crossover design also addressed ethical concerns related to intervention deprivation and the impact it could have on student grades. For example, if a parallel study were conducted, students in the ungraded iRAT condition would have a potentially unfair advantage compared to those in the graded iRAT condition. The crossover design mitigates this issue because students participate in both conditions in equal proportions, ensuring equitable grading across the course.

Research Questions and Hypotheses

The research questions and hypotheses for this study are as follows:

Q1. Is there a difference in assessment performance in a Doctor of Pharmacy team-based learning classroom based on type of individual readiness assurance tests (graded versus ungraded)?

H1$_0$: There is no significant difference in assessment performance, as measured by individual readiness assurance test and examination scores, based on individual readiness assurance test type (graded versus ungraded) in a TBL classroom.

H1$_1$: There is a significant difference in assessment performance, as measured by individual readiness assurance test and examination scores, based on individual readiness assurance test type (graded versus ungraded) in a TBL classroom.

Q2. Is there a difference in PharmD students' achievement goals based on type of individual readiness assurance test (graded or ungraded) in a team-based learning class?

H2$_0$: There is no difference in pharmacy students' achievement goals, as measured by the Achievement Goal Questionnaire, based on type of individual readiness assurance test (graded versus ungraded) in a TBL classroom.

H2$_1$: There is a difference in pharmacy students' achievement goals, as measured by the Achievement Goal Questionnaire, based on type of individual readiness assurance test (graded versus ungraded) in a TBL classroom.

Participants and Sampling

Participants were recruited from second-year students in the Doctor of Pharmacy program at the University of Maryland School of Pharmacy. Convenience sampling of all students in the Applied Science and Therapeutics 5 (AST 5): Cardiovascular and

Cerebrovascular Disease course during the Fall 2022 semester was used. Convenience

sampling was chosen given issues with practicality and feasibility of randomly recruiting

across multiple Doctor of Pharmacy courses or across multiple health professions

(Creswell & Guetterman, 2019). A preliminary power analysis was performed using

G*Statistic (Erdfelder et al., 1996). To detect a medium effect size (Cohen's $f = .25$)

using 80% power and alpha of 0.05, a minimum of 33 students was needed in each group

(Cohen, 1988). There were 91 students in the course, which was enough to meet the

prespecified sample size. All students in the course were eligible to participate if they

signed and acknowledged the consent form. As an incentive to participate, students were

eligible to receive 5 extra credit points on their final examination if they consented and

completed all elements of the study. (It should be noted that the extra credit points were

removed from the statistical analysis.)

Prior to discussing the study procedures, it is prudent to provide an overview of

the PharmD curriculum, as well as AST 5, to understand the educational context of the

study. Thus, the following section will provide a brief overview of the PharmD

curriculum, with a focus on the Applied Science and Therapeutics course series. Then, a

more detailed overview of AST 5 is provided.

Educational Context

Doctor of Pharmacy Curriculum

The University of Maryland PharmD program is an accredited, 4-year terminal

degree program. During the curriculum, students must complete a series of didactic and

experiential courses (Appendix A). Didactic courses take place over the first three years

of the program. Students take, on average, approximately 17 didactic credit hours per Fall

and Spring semester of their first three years. The fourth professional year is devoted to experiential learning.

The Applied Science and Therapeutics (AST) course series is a required course series spanning three semesters within the PharmD curriculum, starting in the Spring of the first professional year and ending in the Spring of the second professional year (highlighted in red with Appendix A). The course series consists of eight separate courses (abbreviated as "AST 1", "AST 2", and so forth) that range from 2-4 credit hours each. Courses span 4-8 weeks in duration and cover anatomy and physiology, pharmacology, and pharmacotherapeutics of various organ systems or diseases. Each course within the series has its own course manager(s) and instructors, and in general the instructional strategy used is highly variable. Of note, TBL is also used in AST 3, and therefore students enter AST 5 having had prior exposure to TBL.

Applied Science and Therapeutics 5 and Team-Based Learning Procedures

Applied Science and Therapeutics 5: Cardiovascular and Cerebrovascular Disease is a four-credit hour course positioned in the second eight weeks of the Fall semester ("Fall B") in the second professional year. Team-based learning has been the guiding instructional strategy in AST 5 since 2020. The course is divided into nine modules, each covering anatomy and physiology, pharmacology, and pharmacotherapeutics of various cardiovascular or cerebrovascular diseases. There are a total of five instructors, each of whom has used TBL for at least two years. Instructors are responsible for creating their own learning objectives, readiness materials, readiness assurance test questions, application questions, and examination questions for their assigned module. All pre-class materials are reviewed by the course manager to ensure the readiness materials stay

within the specified contact hours, that the readiness assurance test questions are assessing foundational knowledge (rather than application of knowledge) and align with the module's learning objectives, and that the application exercises represent authentic scenarios with specific choices for teams to select from. Examination questions also undergo a standardized review process. After instructors draft their examination items, the course manager reviews them for common item flaws. Revisions are made and then the exam is sent out for a final review by all instructors in the course.

Each module in the course follows the standard three phase "cycle" of TBL depicted previously in Figure 1. The pre-class materials for the modules include a multimedia selection of pre-recorded lectures, online videos, and readings. Students are expected to complete the materials before each live, in-person TBL session. Each TBL session is 2.5-hours and consists of the individual and team readiness assurance tests (iRAT and tRAT), clarifying discussion, and team application exercises. All in-class sessions use InteDashboard™ to facilitate the iRAT, tRAT, clarifying discussion, and application activities. InteDashboard™ is a web-based platform specifically designed for courses using TBL. All students in the course are given access to InteDashboard™ and all instructors receive training on how to use InteDashboard™.

Consistent with TBL best practices, teams are formed by the course manager and consist of 5-6 team members per team (16 total teams in the class). Within the health professions, there is no generally accepted method for creating teams based on particular student characteristics (e.g., grade point average, personality traits, etc.; Farland et al., 2019); therefore, teams are randomly generated through a learning management system.

During the course, team members complete a peer evaluation at two different time points: one at the midway point in the course (i.e., after module 4) and one at the conclusion of the course. The peer review process uses a combination of qualitative and quantitative feedback. The Michaelsen method, in which students are given a set number of points (e.g., 50 points) and are asked to distribute them across their team members, serves as the primary quantitative component (Cestone et al., 2008). Then, students provide written feedback for each of their team members. Students are graded based on both the score provided by their team members and the quality of the feedback they provided. Following each peer evaluation, students can see their scores and feedback from team members.

Data Collection

Data on assessment performance was collected from October through December ("Fall B" semester) of 2022. Data were stored using InteDashboard™, Exam Soft™, and the learning management system (LMS). InteDashboard™ is a web-based software designed specifically for TBL classrooms, and all students in the course are provided a subscription by the University of Maryland School of Pharmacy. Individual readiness assurance tests were completed using InteDashboard™. Examinations were completed using Exam Soft™, which is a secure assessment software used for summative assessments at the University of Maryland School of Pharmacy. The assessment scores were transferred from InteDashboard™ and Exam Soft™ to the LMS for storage and grade calculations.

Demographic information and data on achievement goals were collected using two separate questionnaires administered through Qualtrics (Qualtrics, Provo, UT).

Student names were collected to match participants' survey responses for performing the within-subject analysis. Age, gender, grade point average (GPA), and English as a second language were collected as baseline variables to test for imbalance between groups. The first survey also contained the consent process, which students were required to acknowledge and sign before participating (Appendix D).

The Achievement Goal Questionnaire (AGQ; Elliot & McGregor, 2001) was used to measure achievement goals. All questionnaire items were adapted from the original AGQ. Permission was obtained from the original study authors, Elliot & McGregor, to use the AGQ for our study (see Appendix C for an electronic copy of the communication).

The AGQ consists of 12 questionnaire items, which are divided across four achievement goals. Table 3 contains a list of the achievement goals, their designated item codes, and the questionnaire items associated with them. Consistent with the original AGQ by Elliot & McGregor (2001), a 7-point Likert scale ranging from 1 ("not true at all of me") to 7 ("very true of me") was used. Each item in the instrument was scored based on the Likert scale response (e.g., Likert response of 1 is equal to a score of 1). The lowest score is 1 and the highest is 7. For each achievement goal, a sum score is calculated. Sum scores for each achievement goal are then averaged to provide an overall mean.

Table 3

Achievement Goal Questionnaire Items and Codes

Achievement Goal	Item Code	Questionnaire Items
Performance-Approach (P-AP)	PAP1	*"It is important for me to do better than other students."*
	PAP2	*"It is important for me to do well compared to others."*
	PAP3	*"My goal in this class is to get a better grade than most of the other students."*
Performance-Avoidance (P-AV)	PAV1	*"I just want to avoid doing poorly in this class."*
	PAV2	*"My goal in this class is to avoid performing poorly."*
	PAV3	*"My fear of performing poorly in this class is often what motivates me."*
Mastery-Approach (M-AP)	MAP1	*"I want to learn as much as possible from this class"*
	MAP2	*"It is important for me to understand the content of this course as thoroughly as possible."*
	MAP3	*"I desire to completely master the material presented in this class"*
Mastery-Avoidance (M-AV)	MAV1	*"I worry that I may not learn all that I possibly could in this class"*
	MAV2	*"Sometimes I'm afraid that I may not understand the content of this class as thoroughly as I'd like"*
	MAV3	*"I am often concerned that I may not learn all that there is to learn in this class"*

The AGQ (Elliot & McGregor, 2001) was initially validated in undergraduate college students. Based on the exploratory factor analysis, the four factors (achievement goals) accounted for 81.5% of the total variance in the study. Each of the four factors had an eigenvalue >1. Taken altogether, the results validated the premise that there are four separable achievement goal constructs. Following the initial studies, the AGQ was revised (AGQ-R; Elliot & Murayama, 2008) to address weakness of the original questionnaire. Though the original questionnaire items were retained, the wording was updated to enhance rigor and reliability. In addition, the Likert scale was changed to a 5-point scale (1 = strongly disagree; 5 = strongly agree). Confirmatory factor analysis

confirmed high levels of internal consistency across the four achievement goals (> 0.80) in a similar undergraduate college population as the original study by Elliot and McGregor (2001).

Since the time of the original studies, the AGQ (Elliot & McGregor, 2001) and AGQ-R (Elliot & Murayama, 2008) have been used and validated across a range of cultures and training levels (Apostolou, 2013; Cook et al., 2017; Elliot & Murayama, 2008; Raccanello & Brondino, 2016; Rosas, 2015). Most relevant to the present research is an international validation study in pharmacy students performed by Alrakaf et al. (2014). In this study, researchers compared the psychometrics of the original AGQ (Elliot & McGregor, 2001) and AGQ-R (Elliot & Murayama, 2008) among international pharmacy students from Australia, the United Kingdom, and a combined cohort of New Zealand and the United States (US). Surprisingly, they found that in each of the pharmacy cohorts the original AGQ (Elliot & McGregor, 2001) demonstrated a superior fit to the AGQ-R (Elliot & Murayama, 2008).

An important limitation to note from the study by Alrakaf et al. (2014) is the difference in pharmacy education internationally versus within the US. Within the US, all schools and colleges of pharmacy are Doctorate programs, whereas internationally it remains a 4-year Bachelor of Pharmacy degree. Despite these differences, the study investigators combined the US and New Zealand schools into a single cohort during confirmatory factor analysis. It's possible that combining these into a single cohort may have conflated the findings. To gain additional insight and determine if a separate US-only analysis was performed, an inquiry was sent to the study investigators. The investigators noted that because the "[confirmatory factor analysis] fitted adequately

without modification strongly suggests that the [United States] and [New Zealand] data most probably had similar underlying factor structure" (Appendix B; L. Smith & G. Rose, personal communication, February 24, 2022). This suggests that similar findings would have been found if the New Zealand and United States cohorts were analyzed separately. Taken altogether, the original AGQ (Elliot & McGregor, 2001) appears to demonstrate a superior fit compared to the AGQ-R (Elliot & Murayama, 2008) in studies involving pharmacy students.

Procedures

The subsequent sections outline the procedures for how the study was conducted. Approval was obtained through the University of Maryland Baltimore's institutional review board prior to conducting the study.

Study Sequencing and Grading Conditions

Students were randomly assigned to teams of 5-6 members during the Fall semester of AST 3 in 2022, and these same teams were used during AST 5. Student teams were allocated to one of two grading sequences during AST 5 (Table 4 and Figure 3). Students in TBL teams 1-8 were assigned to a graded (G) iRAT condition during period 1, followed by an ungraded (UG) iRAT condition during period 2 (denoted as the "G/UG" group henceforward). Students in TBL teams 9-16 were assigned to an ungraded (UG) iRAT condition during period 1, followed by a graded (G) iRAT condition during period 2 (denoted as the "UG/G" group henceforward). Of note, students were assigned to an intervention sequence regardless of their decision to participate in the study; however, only data for students who completed consent were included in the analysis.
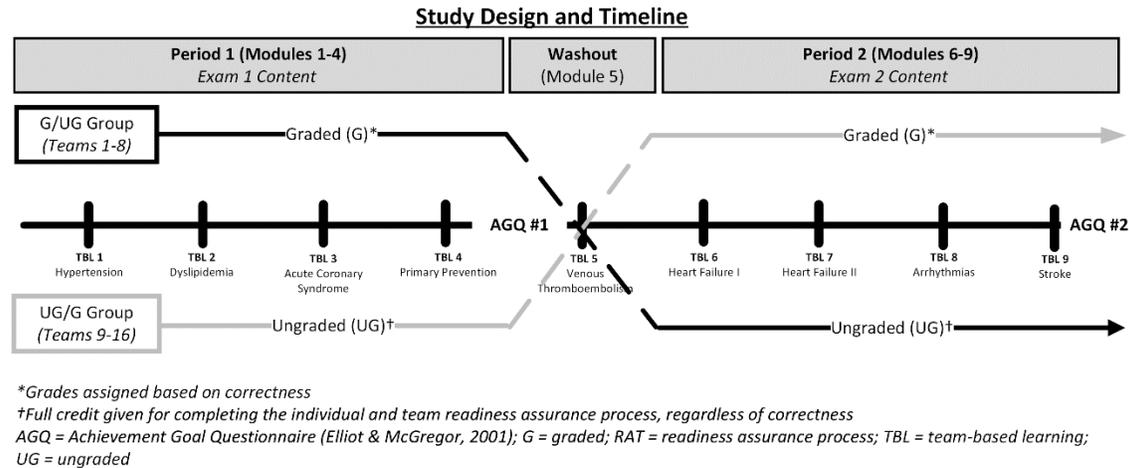
Table 4

Intervention Sequencing Based on Team Number

Intervention Sequence	Period 1 (Modules 1-4)	Washout (Module 5)	Period 2 (Modules 6-9)
Graded/Ungraded (G/UG) Group: Teams 1-8	Graded iRATs	Ungraded iRATs	Ungraded iRATs
Ungraded/Graded (UG/G) Group: Team 9-16	Ungraded iRATs	Ungraded iRATs	Graded iRATs

Figure 3

Study Sequencing and Timeline

Study Design and Timeline

*Grades assigned based on correctness
†Full credit given for completing the individual and team readiness assurance process, regardless of correctness
AGQ = Achievement Goal Questionnaire (Elliot & McGregor, 2001); G = graded; RAT = readiness assurance process; TBL = team-based learning; UG = ungraded

Each period was distributed over four modules in the course, as indicated in Table 5. Modules were similar in size and structure across the two periods and followed a traditional TBL "cycle". Period 1 included modules 1-4 and period 2 included modules 6-9. Module 5 served as a blanking, or washout, period and thus was not included in the analysis.

Table 5

Applied Science and Therapeutics 5 Modules

Period	Module # and Topic	Instructor	Date Range
	1 – Hypertension	A	10/18/22 – 10/21/22
	2 – Dyslipidemia	B	10/22/22 – 10/25/22
1	3 – Acute Coronary Syndrome	B	10/26/22 – 11/1/22
	4 – Primary Prevention	C	11/2/22 – 11/4/22
	EXAM 1	A, B, C	11/8/22
Washout	5 – Venous Thromboembolism	D	11/9/22 – 11/11/22
	6 – Chronic Heart Failure I	A	11/12/22 – 11/18/22
	7 – Chronic Heart Failure II	A	11/19/22 – 11/22/22
2	8 – Arrhythmias	D	11/23/22 – 11/29/22
	9 – Stroke	E	11/30/22 – 12/2/22
	EXAM 2	A, D, E	12/9/22

Student Acknowledgement of Intervention Sequencing

To ensure that students were psychologically aware of their assigned grading condition during each period, students were given multiple notifications throughout the semester. A brief introductory video to the course explained the variable grading structure of the iRATs. In addition, all students were required to acknowledge their team's assigned iRAT grading condition prior to advancing through the modules in each study period. Adaptive release features were used in the learning management system such that without acknowledgement of their individual iRAT grading condition, none of the modules in the course would be accessible. The acknowledgement and adaptive release features were required to be completed at the start of period 1 (i.e., before beginning module 1) and period 2 (i.e., before beginning module 6).

Administering Achievement Goal Questionnaires

At the conclusion of period 1, all students received an email link to the first survey, which contained the informed consent, demographic questions, and AGQ (Elliot & McGregor, 2001). Students were also notified using the learning management system.

Students wishing to participate were required to complete the survey before taking their first examination. During period 2, the second survey was distributed following module 9 and was required to be completed before examination 2.

A copy of the survey can be found in Appendix D. The original wording of questionnaire items in the AGQ (Table 3) was modified to include a qualifier intended to help frame the statement for students in the course (e.g., "It is important for me to do better than other students *in AST 5*"). To reduce order effect, all questionnaire items for the AGQ were presented randomly, with only one question per page.

Creating and Administering Graded Assessments

Readiness Assurance Tests

Each readiness assurance test in the course consisted of five single-best answer selected-response questions assessing foundational knowledge from the pre-class readiness process. Each iRAT question was assigned 1-point (5 total points per iRAT). The iRATs contributed a total of 7.5% towards the final grade in the course. Those in the graded condition received a score based on the number of questions answered correctly. Those in the ungraded condition received full credit for completing the iRAT, regardless of how many questions were answered correctly. Students with unexcused absences received a "0", regardless of grading condition. The instructor assigned to each module was responsible for creating the readiness assurance test questions. All questions were submitted to the course manager and reviewed for item flaws and checked for alignment with the module outcomes.

Students were given 6-minutes to complete the iRAT in InteDashboard™. Raw scores were stored for analysis, regardless of whether students were in the graded or

ungraded condition. Although students were aware of the assigned iRAT grade condition, they were not provided their scores or answers to the questions until after they completed the tRAT.

Following the iRAT, students immediately transitioned into the tRAT. Teams had 10 minutes to complete the tRAT and received immediate feedback after each question. Team readiness assurance tests were graded for correctness, rather than completion, throughout the course. In other words, only the iRAT grading structure varied from period-to-period.

To ensure exam integrity, two instructors were present during the iRAT to proctor. All questions were displayed one at a time (as opposed to all questions on one page) and all answer options were randomized. Students were asked to shut their computer upon completing the iRAT. Only one student was permitted to have their computer open during the tRAT to prevent other students from using their computers to look up the answers. Of note, students with an excused absence for a TBL session did not complete a make-up iRAT. Instead, their iRAT grade in the course was determined by the number of iRATs that they were present for. Students without an excused absence received a zero on the assessment.

Examinations

The two examinations were composed of selected-response questions, either as a single-best answer or select all that apply. Instructors were responsible for creating their own examination questions. Examination questions were distributed evenly across the course based on the volume of content, with an approximately equal share distributed into

each module. Instructors were provided with a guide on best practices for examination writing.

The course manager completed a review of all examination items. This included a review for item flaws (e.g., inaccurate information, typographical errors, etc.) and alignment with module and course objectives. Corrections were made following this initial revision, and then the examination was subsequently sent out for review by all instructors in the course. Prior to final approval, the course manager completed a preview version of the test in Exam Soft™. Each examination item was equally weighted worth 1-point. Following the examination, the course manager and instructors reviewed the item analysis for each question. Problem questions were reviewed, and adjustments made as needed.

To preserve the integrity of the examinations, examinations were proctored each time. In addition, students are required to take their examinations in Exam Soft™, which prevents access to the internet or other applications. Exam question sequence and answer choices were electronically randomized.

Data Analysis

At the conclusion of the semester, demographic information, assessment scores, and questionnaire data were downloaded from the learning management system (LMS) and Qualtrics (Qualtrics, Provo, UT) and imported into SPPS Statistics for Windows (version 29). All data analysis was performed using SPPS Statistics for Windows, version 29 (IBM Corp., Armonk, N.Y., USA). After the grades and survey data were compiled and matched to each respective student, each participant was assigned a study number and de-identified. Descriptive statistics were used to compare baseline demographic

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information variables (e.g., work history, gender, age, grade point average). Chi-square test was used to analyze baseline differences in categorical variables (e.g., gender, English as a second language) and student's *t*-test was used for baseline differences in continuous variables (e.g., age, GPA).

Multivariate analysis of variance requires two or more continuous dependent variables. Examination and iRAT scores were the continuous dependent variables for analyzing changes in assessment performance. The four achievement goal scores served as the continuous dependent variables for analyzing changes in achievement goals. Grading condition served as the categorical independent variable. Univariate outliers were analyzed using boxplots and Q-Q plots. Multivariate outliers were measured using Mahalanobis distance. The assumption of normality was tested using the Shapiro-Wilk test. Linearity between each group of dependent variables was measured using scatterplot matrices. Homogeneity of variance-covariance matrices were tested using Box's M test of equality of covariance with follow-up testing using Levene's test. Lastly, correlation testing was used to test that there was no multicollinearity.

To detect a medium effect size (Cohen's f = .25) with 80% power and alpha equal to .05, an estimated sample size of 33 students in each group is needed. For comparison, a total of 198 students would be needed in each group to detect a small effect (Cohen's f = .10). A total of 14 students in each group would be needed to detect a large effect (Cohen's f = .40). A medium effect size was chosen based on what was feasible from the anticipated size of the convenience sample.

Data Screening

Data screening was performed for each group's dependent variables (iRAT scores, examination scores, and achievement goal scores). A total of eight students' iRATs had one missing value because of excused absences, which accounted for only 1% of all administered iRATs in the course. Missing iRAT scores due to excused absences were accounted for as part of the mean iRAT score (i.e., mean scores were calculated using the total number of iRATs that the student was present for). Examination performance was available for all students. Review of box and whiskers plots demonstrated five outliers across all assessments in the course, which accounted for <2.5% of the data points. Given the low number of outliers, the data points were kept for the primary analysis. Similarly, <5% of the achievement goal scores were outliers. These data points were maintained in the primary analysis.

Survey data was available for all students, except for one student who did not complete the second survey. This data was removed from the analysis on achievement goals.

Assessment Performance

Raw iRAT and examination scores were converted to percentage scores. The iRAT scores were averaged over the four modules in each study period. For students with excused absences, scores were averaged based on the number of iRATs for which they were present. Because assessment performance was assessed using two separate dependent variables (i.e., iRAT scores and examination scores), repeated measures multivariate analysis of variance of within-subject differences was used to test for an effect of the grading condition on assessment performance (Jones & Kenward, 2014). To

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test individual variables, univariate testing using one-way analysis of variance with Bonferroni correction was performed. Analysis of variance was also used to measure period and carryover effects. Period effects were analyzed using differences in assessment scores within each group and for each study period. Carryover effects were analyzed using between-subject differences in effects based on study period and treatment (Jones & Kenward, 2014).

The data were analyzed visually using Q-Q plots, histograms, and boxplots (Appendix E). Within-subject differences in iRAT scores and examination scores for each group followed an approximately normal distribution. Using the Shapiro-Wilk test, the within-subject differences in iRAT and examination performance did not violate the assumption of normality for either of the groups. Using Mahalanobis distance, no significant multivariate outliers were identified.

The Box's M test value was 7.158, indicating equal variance-covariance matrices across the dependent variables ($F(10, 37483) = .681, p = .743$). Correlation tests demonstrated no multicollinearity between mean differences in iRAT scores and exam scores ($r = .026$).

Achievement Goals

Likert responses were scored on a scale from 1-7. The sum of scores for the three questions in each achievement goals were averaged to determine a mean achievement goal score. Within-subject differences in mean achievement goal scores between periods 1 and 2 were used for inferential analysis. It should be noted that the ideal approach to analyzing Likert response data is controversial; however, it is generally accepted that, for large sample sizes (i.e., greater than 10-20 observations per group), parametric tests are

appropriate even if the data is non-normally distributed (Derrick & White, 2017; Sullivan & Artino, 2013). This approach does run the risk of detecting a statistically significant difference when one does not exist (type I error), but with large sample sizes the risks are similar to that of non-parametric alternatives (Derrick & White, 2017). It should be noted that transformation of the data (e.g., logarithmic transformation) would have been inappropriate given the dependent variables are ordinal, rather than continuous.

Change in achievement goals was analyzed using within-subject differences in each of the four achievement goal scores from the Achievement Goal Questionnaire (Elliot & McGregor, 2001). Repeated measures multivariate analysis of variance test was used to analyze within-subject differences. Analysis of variance was also used to measure period and carryover effects. Period effects were analyzed using differences in achievement goal scores within each group and for each study period. Carryover effects were analyzed using between-subject differences in effects based on study period and treatment (Jones & Kenward, 2014).

Data tables and plots were used for assumption testing (Appendix F). In summary, the mean within-subject differences in achievement goals demonstrated a non-normal distribution. This is expected given the scores are based on a 7-point ordinal scale. Using the Shapiro-Wilk test, the data for mastery-approach (MaP) did not meet the assumption of normality for the G/UG ($W = .890$; $p < .001$) and UG/G ($W = .849$; $p < .001$) groups. Similarly, the performance-approach data (PaP) for the UG/G group did not meet the assumption of normality ($W = .921$; $p = .006$). Box's M test did, however, indicate homogeneity of variance-covariance matrices, $F(36,25623) = 1.044$, $p = .396$. Correlation tests demonstrated no multicollinearity between achievement goals ($r = .20$). Analysis of

variance offers robust protection against violations in normality; therefore, since other assumptions were not violated, multivariate analysis of variance was used for the primary analysis.

Summary

In summary, this study is a prospective crossover study comparing the effects of graded versus ungraded iRATs on assessment performance and achievement goals. The study was conducted in a required four credit hour second-year pharmacotherapy course within a Doctor of Pharmacy curriculum. The course took place during the Fall "B" semester of 2022. Students were randomly assigned to 16 TBL teams at the start of the course. Eight teams participated in a graded iRAT process during period 1, while the other eight teams participated in an ungraded iRAT process. At the approximate midpoint in the semester, the teams crossed over to the other grading condition for period 2. Each study period included four iRATs, one examination, and one administration of the AGQ (Elliot & McGregor, 2001). Best practices for TBL were followed.

Assessment performance was determined using iRAT and examination scores. The iRAT consisted of a series of selected response questions covering foundational concepts from the pre-class preparatory materials. InteDashboard™ was used to collect readiness assurance test data. Examination data was collected using Exam Soft™. All assessment questions underwent a quality assurance review to correct item flaws and ensure alignment with course and module objectives.

Achievement goals were measured using the AGQ (Elliot & McGregor, 2001). Students completed the AGQ at the conclusion of each study period. Students were eligible to receive 5 extra points, added to their final examination in the course, for

completing both AGQs. Extra credit was removed from the analysis prior to conducting statistical testing on assessment performance.

Multivariate analysis of variance tests (MANOVA) was performed to test each of the research questions. Tests for period and carryover effects were performed. If a statistically significant main effect for iRAT grading condition was detected, univariate testing using one-way analysis of variance with Bonferroni correction was used.

CHAPTER FOUR: RESULTS

Introduction

In this crossover study, Doctor of Pharmacy (PharmD) students in their second professional year were assigned to two grading sequences for individual readiness assurance tests (iRATs) during a team-based learning (TBL) course. Students in the graded condition (G) had iRAT scores determined by *correctness*. Students in the ungraded condition (UG) had iRAT scores based on *completion*. The primary outcomes of the study were within-subject differences in 1) assessment scores, as measured by iRAT and examination scores, and 2) achievement goal scores. This section will review the descriptive statistics and primary findings for each of the research questions on assessment performance and achievement goals.

Descriptive Statistics

All students in the course signed and acknowledged the consent form (N=91). Forty-seven students were in the G/UG grading sequence and 44 students in the UG/G grading sequence. The mean age of participants was 25.42 years ($SD = 3.98$), and the average grade point average (GPA) was 2.89 ($SD = .47$). Overall, 65.9% of participants were female and 28.6% spoke English as a second language. Bivariate comparisons between groups demonstrated similar baseline characteristics including age, GPA, gender, and English as a second language (Table 6). There were no statistically significant differences noted between groups.

Table 6

Univariate and Bivariate Baseline Characteristics of Participants

	Overall	Group 1 (G/UG) $n = 47$	Group 2 (UG/G) $n = 44$	p
Age, years, *M (SD)*	25.42 (3.98)	25.43 (4.00)	25.41 (3.99)	.764
GPA, *M (SD)*	2.89 (.47)	2.84 (.43)	2.95 (.51)	.373
Gender				.655
Female, *n* (%)	60 (65.9)	32 (68.1)	28 (63.6)	
Male, *n* (%)	31 (34.1)	15 (31.9)	16 (36.4)	
English as a second language, *n* (%)	26 (28.6)	11 (23.4)	15 (34.1)	.259

Note. There were no statistically significant differences in baseline characteristics between groups. GPA = grade point average; *M* = mean; *n* = number of participants; *SD* = standard deviation

Findings

Assessment Performance

Tables 7 and 8 outline the performance statistics for iRATs and examinations, respectively. There were 5 questions per iRAT in each study period (20 questions total per period). The mean iRAT scores were 3.49 out of 5 (69.72%) and 3.54 out of 5 (70.77%) for study period 1 and 2, respectively. The mean examination scores were 46.86 out of 60 (80.79%) and 47.53 out of 60 (80.56%) for examinations 1 and 2, respectively. The assessment score reliability (KR20) value indicated that the exams had satisfactory-to-good internal consistency.

Table 7

Individual Readiness Assurance Test Statistics

	Period 1 (Modules 1-4)	Period 2 (Modules 6-9)
Total iRAT Questions	20	20
Total Question per iRAT	5	5
Questions Withdrawn	0	0
iRAT Performance (per iRAT)		
M, raw (*SD*)	3.49 (.60)	3.54 (.77)
M, % (*SD*)	69.72 (12.04))	70.77 (15.54)

Note. M = mean; iRAT = individual readiness assurance test; *SD* = standard deviation

Table 8

Examination Statistics

	Examination 1	Examination 2
Total Original Questions	60	60
Questions Withdrawn[a]	2	1
Final Number of Questions	58	59
Examination Performance		
M, raw (*SD*)	46.86 (5.21)	47.53 (5.13)
M, % (*SD*)	80.79 (11.11)	80.56 (10.79)
Assessment Score Reliability (KR20) Factor	0.74	0.72

Note. M = mean; *iRAT* = individual readiness assurance test; *SD* = standard deviation; KR20 = Kudor-Richardson 20.
[a]Questions withdrawn contained items flaws, had a high degree of difficulty (<60% correct), and low discrimination (*d* < .15).

The omnibus test demonstrated a statistically significant main effect of the iRAT grading condition on assessment performance, $F(2,88) = 3.851$, Wilks' $\Lambda = .992$, $\eta^2 =.080$, $p = .025$ (Table 9). There were no significant within-subject differences based on treatment period, $F(2,88) = .288$, $\eta^2 =.008$, $p = .750$. Furthermore, between-subject differences based on intervention sequence were also similar, $F(2,88) = 340$, $\eta^2 =.008$, $p = .713$. These findings indicate that that there were no significant period or carryover effects, respectively, and that the observed treatment effect was due to differences in

grading condition and not external factors. Based on these findings, the null hypothesis that there is no difference in assessment performance based on iRAT grading condition was rejected.

Table 9

Multivariate Analysis of Within-Subject Differences in Assessment Scores

	Wilks' Λ	F	Hypothesis df	Error df	p	η^2
Between-Subject						
Carryover Effect	.992	.340	2.000	88	.713	.008
Within Subjects						
Period Effect	.993	.288	2.000	88	.750	.007
iRAT Condition Effect	.920	3.851	2.000	88	.025	.080

Note: df = degrees of freedom; iRAT = individual readiness assurance test

Univariate testing using one-way analysis of variance with Bonferroni adjustment demonstrated a significant effect of the iRAT grading condition on iRAT scores ($F(1,89)$ = 6.813, p = .011, η^2 =.071) but not on examination scores ($F(1,89)$ = .723, p = .397, η^2 =.008) (Table 10). Within-subject iRAT scores were 4.53% (SD = 17.09) higher during the graded iRAT condition than the ungraded condition. Figures 4 and 5 depict the difference in iRAT scores and examination scores, respectively, for each group during periods 1 and 2.

Table 10

Analysis of Variance of Within-Subject Differences in Assessment Scores

Assessment	Sequence	Period 1		Period 2		Within-Subject Differences (G – UG)		F (1,89)	η^2	p
		M	SD	M	SD	M	SD			
iRAT	G/UG	71.95	10.89	68.62	13.95	3.33	15.12	6.813	.071	.011
	UG/G	67.35	12.87	73.07	16.92	5.72	17.92			
Exam	G/UG	79.82	9.24	80.31	9.01	.49	9.21	.723	.008	.397
	UG/G	81.82	8.70	80.82	8.45	1.00	7.29			

Note. G = graded; UG = ungraded

Figure 4

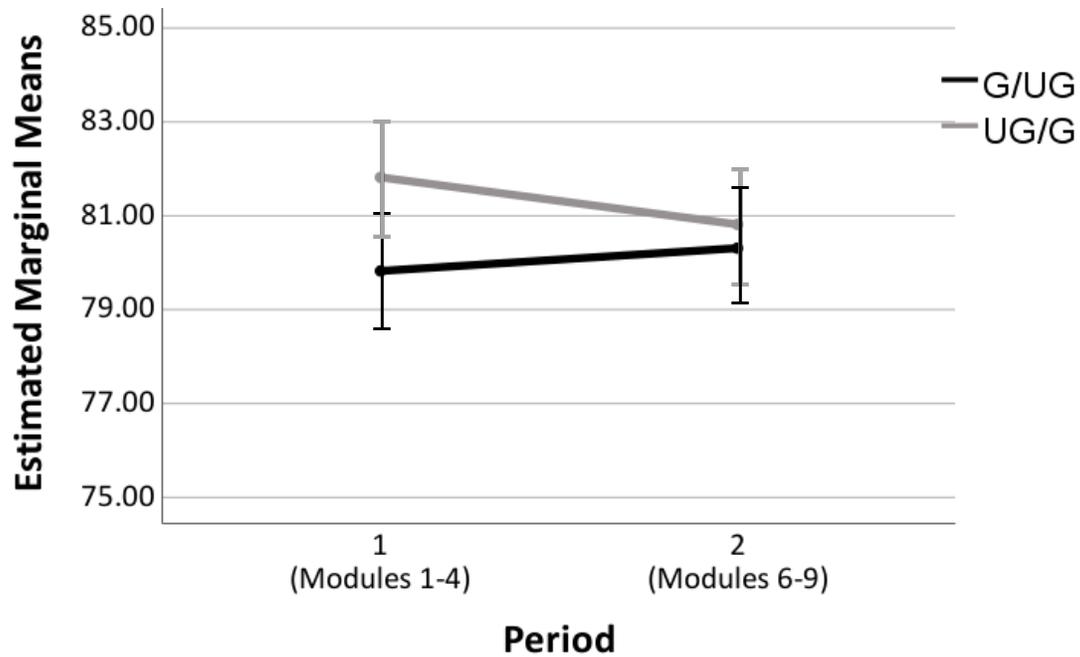*Mean Individual Readiness Assurance Test Scores by Period and Group*
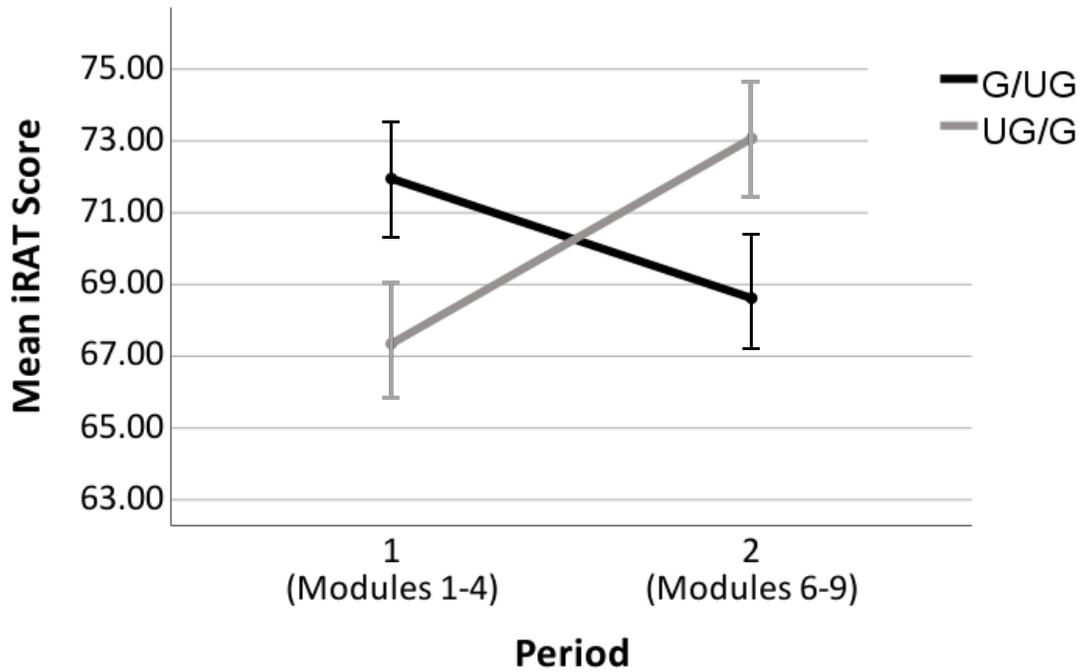
Note. Mean iRAT scores based on study period and group sequence are shown here.

There was a statistically significant effect of iRAT grading condition on iRAT

performance ($p = .011$). No period or carryover effects were observed. Error bars

represent standard error. iRAT = individual readiness assurance test; G = graded; UG =

ungraded.

Figure 5

Mean Examination Scores by Period and Group

Note. Mean examination scores based on study period and group sequence are shown here. There was no statistically significant effect of iRAT grading condition on examination performance. No period or carryover effects were observed. Error bars represent standard error. iRAT = individual readiness assurance test; G=graded; UG=ungraded.

Achievement Goals

Mean and median achievement goal scores by group can be found in Table 11. Participants' achievement goal scores tended to be highest on mastery-approach and lowest on performance-approach, regardless of period or group.

Table 11

Achievement Goal Scores by Group and Period

Achievement Goals by Group	Period 1		Period 2	
	M (SD)	*Mdn*	*M (SD)*	*Mdn*
Performance-Approach (PAp)				
G/UG	4.70 (1.39)	5	4.16 (1.25)	4.33
UG/G	4.98 (1.57)	5	4.67 (1.59)	5
Performance-Avoidance (PAv)				
G/UG	5.79 (1.23)	6	5.67 (1.04)	5.67
UG/G	5.54 (1.30)	6	5.26 (1.59)	5.67
Mastery-Approach (MAp)				
G/UG	6.16 (.75)	6	5.92 (.91)	6
UG/G	6.27 (.74)	6.33	6.33 (.63)	6.33
Mastery-Avoidance (MAv)				
G/UG	5.26 (1.34)	5.33	4.98 (1.04)	5
UG/G	5.10 (1.34)	5.33	4.83 (1.52)	5

Note. Mean and median are provided for completeness. Inferential statistics were performed using within-subject differences in mean achievement goal scores. G = graded; UG = ungraded; *M* = mean; *Mdn* = median; *SD* = standard deviation

The omnibus test demonstrated no significant effect of the iRAT grading condition on achievement goal scores, $F(4,85) = 1.109$, Wilks' $\Lambda = .940$, $p = .358$, $\eta^2 = .050$ (Table 12). There was no significant carryover effect present, ($F(4,85) = 1.979$, Wilks' $\Lambda = .915$, $p = .105$, $\eta^2 = .085$). Based on these findings, the null hypothesis that achievement goals are unchanged based on iRAT grading condition was not rejected. There was, however, a statistically significant period effect ($F(4,85) = 4.401$, Wilks' $\Lambda = .828$, $p = .003$, $\eta^2 = .172$), indicating that achievement goal scores may have differed in each period due to external factors and not iRAT grading condition.

Table 12

Multivariate Analysis of Within-Subject Differences in Achievement Goal Scores Based on iRAT Grading Condition

	Wilks' Λ	F	Hypothesis df	Error df	p	η^2
Between-Subject						
Carryover Effect	.915	1.979	4	85	.105	.085
Within Subjects						
Period Effect	.828	5.001	4	85	.003	.172
iRAT Condition Effect	.950	1.109	4	85	.358	.050

Note. df = degrees of freedom; iRAT = individual readiness assurance test

Figures 6-9 show each of the achievement goal scores by iRAT grading condition across study periods. Univariate testing using one-way analysis of variance with Bonferroni correction was performed to determine which achievement goal scores had a significant period effect. A statistically significant period effect was present for performance-approach ($F(1,85) = 11.777$, $p < .001$, $\eta^2 = .118$) and mastery-avoidance ($F(1,85) = 5.001$, $p = .028$, $\eta^2 = .054$). Additional analysis was not performed since there was no treatment effect (i.e., no effect of iRAT grading condition on achievement goal scores).

Figure 6

Mastery-Approach Scores by iRAT Grading Condition
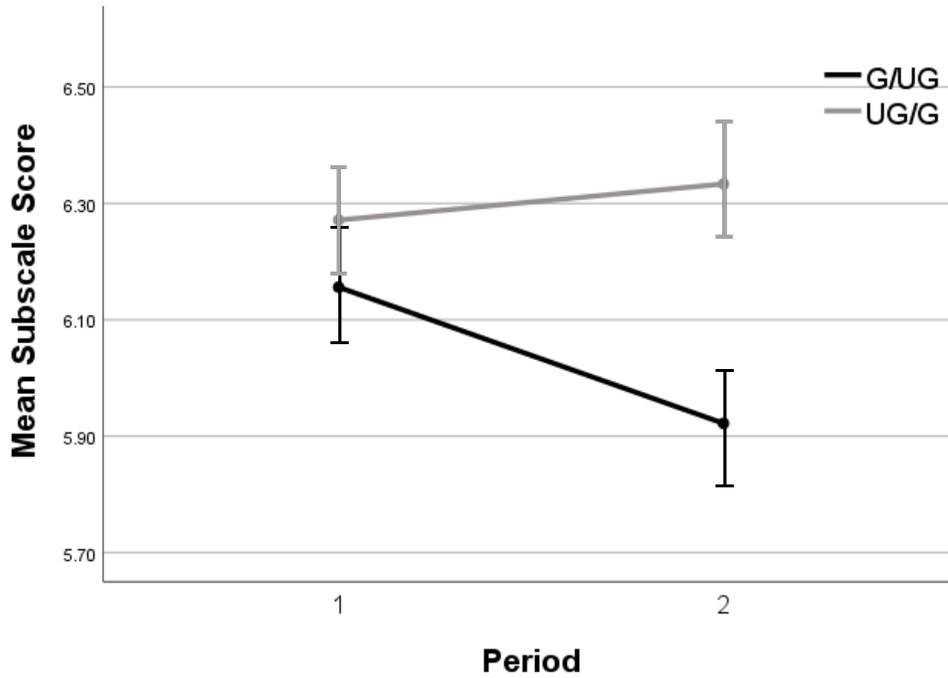
Note. Mean mastery-approach scores based on study period and group sequence are shown here. There was no statistically significant effect of iRAT grading condition on mastery-approach scores. No period or carryover effects were observed. Error bars represent standard error. iRAT = individual readiness assurance test; G=graded; UG=ungraded.
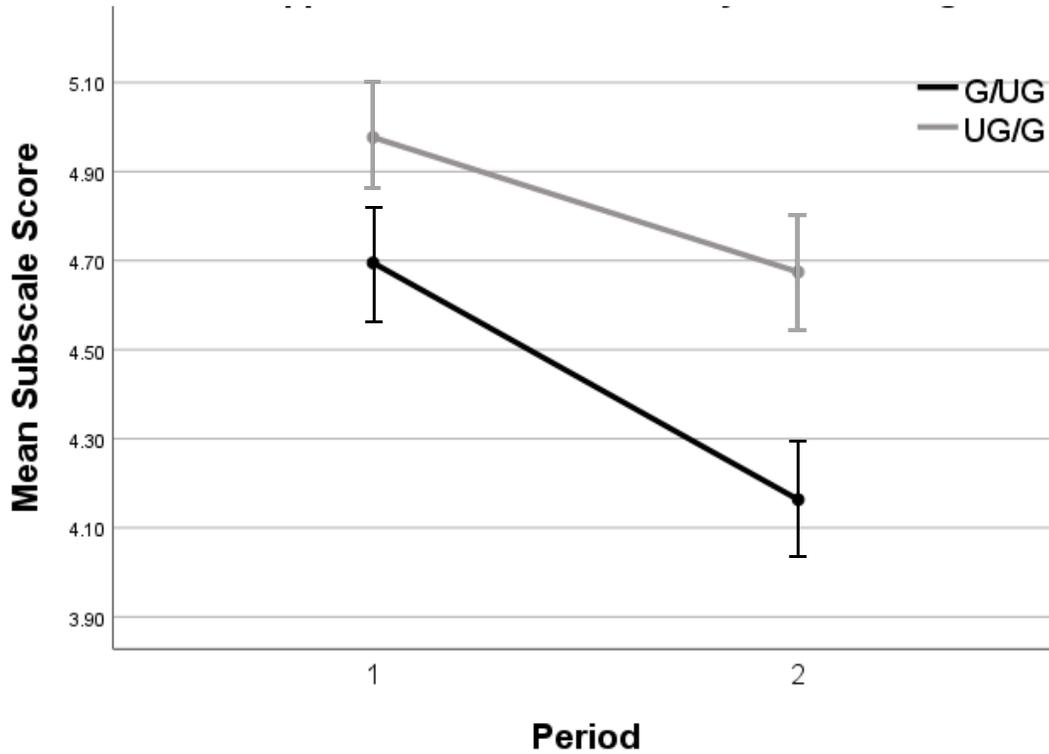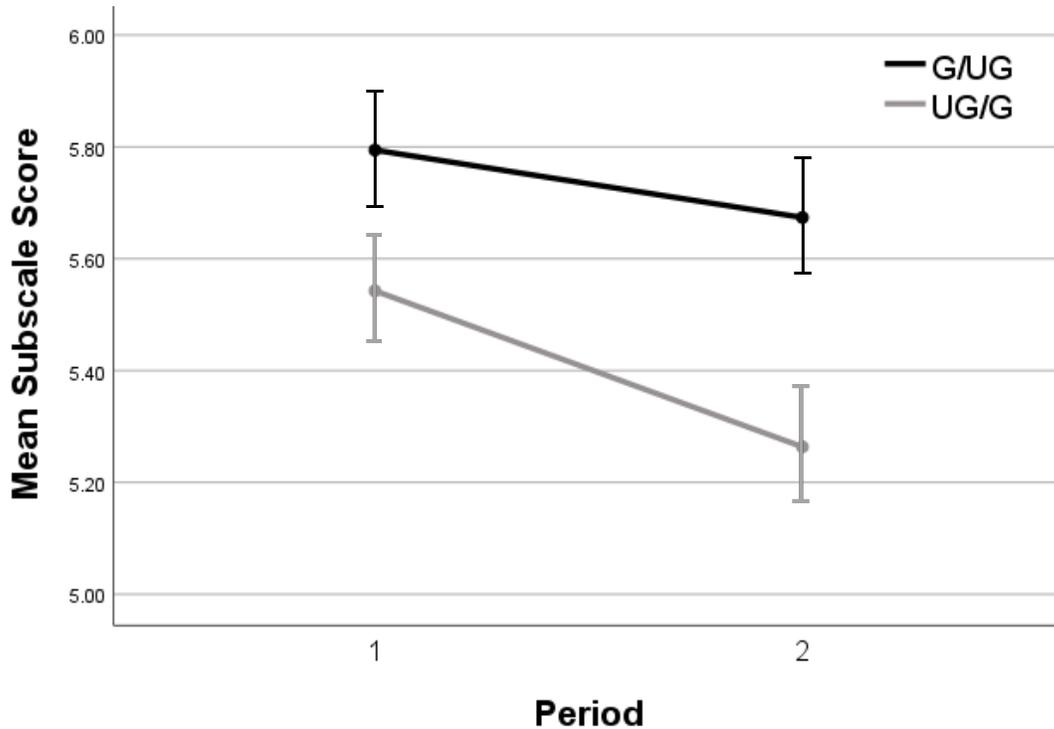
Figure 7

Mastery-Avoidance Scores by iRAT Grading Condition
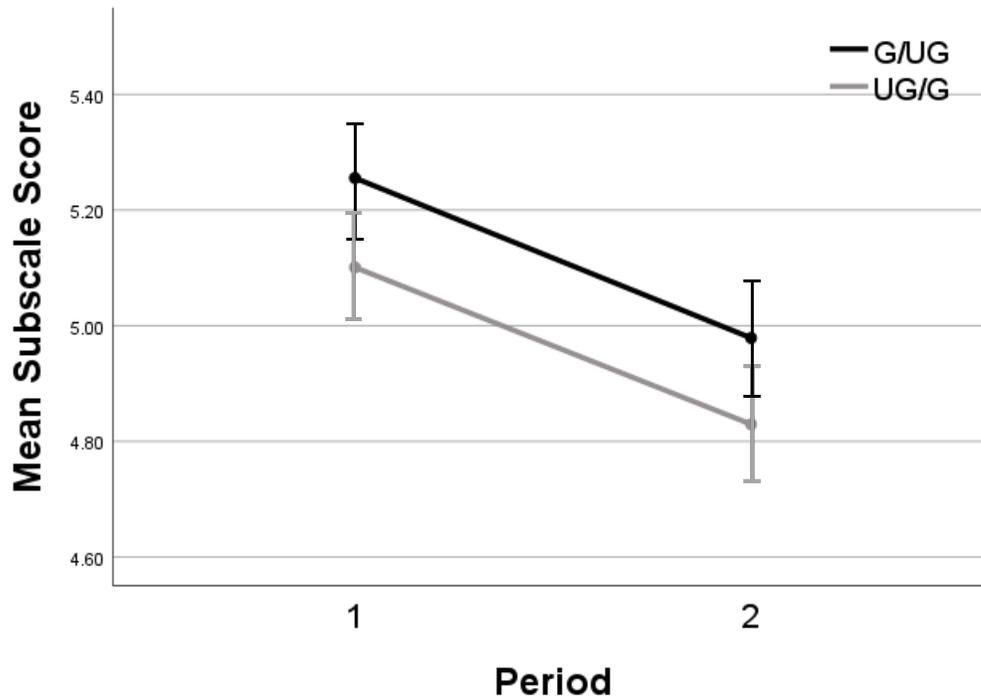
Note. Mean mastery-avoidance scores based on study period and group sequence are shown here. There was no statistically significant effect of iRAT grading condition on mastery-avoidance scores. A statistically significant period effect was observed (p = .028). No significant carryover effect was observed. Error bars represent standard error. iRAT = individual readiness assurance test; G=graded; UG=ungraded.

Figure 8

Performance-Approach Scores by iRAT Grading Condition

Note. Mean performance-approach scores based on study period and group sequence are shown here. There was no statistically significant effect of iRAT grading condition on performance-approach scores. A statistically significant period effect was observed ($p <$ .001). No significant carryover effect was observed. Error bars represent standard error. iRAT = individual readiness assurance test; G=graded; UG=ungraded. Error bars represent standard error.

Figure 9

Performance-Avoidance Scores by iRAT Grading Condition

Note. Mean performance-avoidance scores based on study period and group sequence are shown here. There was no statistically significant effect of iRAT grading condition on performance-avoidance scores. No statistically significant period or carryover effects were observed. Error bars represent standard error. iRAT = individual readiness assurance test; G=graded; UG=ungraded. Error bars represent standard error.

Summary

In summary, 47 students participated in the G/UG group and 44 students in the UG/G group. Baseline characteristics were similar between the two groups. The omnibus test for assessment performance demonstrated a statistically significant difference based on iRAT grading condition. Univariate testing with one-way analysis of variance and Bonferroni correction demonstrated that students in G condition had an average iRAT

score 4.53% higher than the UG condition (*SD* = 17.09, *p* = .011). Examination performance, however, was similar in the G and UG conditions. There were no statistically significant interactions for period or carryover effects.

The omnibus test for achievement goals did not demonstrate a statistically significant difference based on iRAT grading condition. There was, however, a statistically significant period effect, indicating that factors other than iRAT grading condition influenced students' achievement goals. No significant carryover effects were detected.

CHAPTER FIVE: DISCUSSION

Introduction

In this prospective, quantitative crossover study of second-year Doctor of Pharmacy students in a team-based learning (TBL) course, assessment scores were statistically significantly different when iRATs were graded compared to when they were ungraded. Specifically, iRAT scores were lower in the ungraded iRAT condition; however, examination scores were not statistically significantly different. Furthermore, achievement goals did not differ based on iRAT grading condition. This chapter will discuss these findings in the context of the existing literature and theory. Then, implications and limitations of the study and recommendations for future research are discussed.

Interpretation of Findings

The results of this study demonstrated that differences in iRAT performance exist based on whether the iRAT is graded versus ungraded; however, the change in iRAT grading condition had no bearing on examination scores. Students in the graded (G) iRAT condition had an average iRAT score of 72.51% compared to 67.99% in the ungraded (UG) iRAT condition (M within-subject difference = 4.53%, SD = 17.09, p = .011). Examination performance was similar in the G and UG conditions (81.07% vs 80.32%, p = .397).

Literature on TBL has historically emphasized the importance of a graded iRAT process, primarily to ensure individual accountability for completing pre-class readiness materials (Haidet et al., 2012; Parmelee et al., 2012; Sibley et al., 2014; Sweet & Michaelsen, 2012). Prior studies have demonstrated mixed effects of graded versus

ungraded iRATs on assessment performance. In a retrospective study by Behling et al. (2017), a much larger reduction in iRAT scores was observed among a cohort of first year medical students when iRATs and tRATs were ungraded. When compared to cohorts that participated in graded iRATs and tRATs, the mean iRAT score dropped from approximately 75% to 50% ($p < .001$) in the ungraded cohorts. Furthermore, tRAT scores were significantly lower in the ungraded cohort ($p < .001$). A key difference in the study by Behling et al. and the present one is that both the iRAT *and* tRAT were ungraded in the Behling study, as opposed to just the iRAT. Graded tRATs contribute to positive social interdependence within teams, which fuels not only team performance but also incentivizes individual pre-class preparation. Thus, it is plausible that the smaller magnitude of difference in the present study is the result of maintaining a graded tRAT.

A second study by Koh et al. (2019) also demonstrated a difference in iRAT scores among medical students when the iRAT was ungraded, but the effects were more modest than the study by Behling et al. (2017). Students in TBL courses that used ungraded iRATs scored approximately 4% lower than the graded cohorts (75% vs 79%; $p < .001$), a finding quite similar to the present study. Examination scores in the studies by Behling et al. (2017) and Koh et al. (2019) were inconsistently affected by changes in iRAT grading condition. In the present study, there was no observed effect of iRAT grading condition on examination performance. The likely reason for this is that, while students were less incentivized to learn pre-class preparatory materials, they were still incentivized to prepare for higher stakes summative assessments.

In contrast, a study in an elective pharmacy course found no difference in iRAT, tRAT, and examination scores when the RAT process was ungraded (Eudaley et al.,

2022); however, there are several aspects of the study that limit the generalizability and reliability of the findings. First, the study included students in an elective ambulatory care course. Such a course is likely to be selective for higher performing students. Unlike the study by Eudaley et al. (2022), the present study was conducted in a required PharmD course and included both higher and lower performing students. Lastly, the retrospective design of the study by Eudaley et al. (2022) could not control for significant differences in instructional delivery that occurred because of the COVID 19 pandemic. In contrast, the present study's prospective within-subjects design provided robust control over potential confounders (e.g., differences in students and instruction from one class year to the next).

Acknowledging the nuances of how educational context influences outcomes is critical, and attempting to generalize this study's findings to other TBL classrooms should be done cautiously. The students included in this study were second-year pharmacy students. Extrapolating the results to other health professions programs, or even to other class years within pharmacy education, may produce entirely different outcomes depending on the circumstances. As an example, consider whether these findings could be extrapolated to first-year pharmacy students. Pharmacy students in their first professional year have much less exposure to the practice of pharmacy and have a relatively undeveloped sense of professional identity. As a result, first-year pharmacy students may be less capable of relating what they are doing in the classroom to what they will be doing as a future pharmacist. This subtle difference may be enough to produce a much more pronounced effect on assessment scores when iRATs are ungraded. Similar differences in student motivation exist in contexts outside of health professions

education, too (e.g., undergraduate education). In short, the results of this study should not be blindly applied to other TBL courses.

It is also important to interpret the findings within the context of other incentives used within the course. For example, students in the ungraded iRAT condition still had *some* incentive to be present for class because their scores were based on completion. In addition, in this study the tRAT was still graded to ensure that team performance was adequately incentivized. Combining both an ungraded iRAT *and* tRAT may result in a more significant effect on pre-class preparation and team performance, as seen by Behling et al. (2017).

Changes in grading structure are believed to influence task-specific achievement goals; however, this study did not support such notions. Within-subject differences in achievement goals were not statistically significantly different based on iRAT grading condition. The stability in achievement goals is somewhat unsurprising. Prior studies have demonstrated stability in achievement goals across a similar learning task within a course or semester (Fryer & Elliot, 2007; Senko & Harackiewicz, 2005). Within health professions education, a study by Kool et al. (2016) demonstrated fluctuations in achievement goals, but the differences were observed semester-over-semester and year-over-year. In the present study, changes in achievement goals were measured within a single, 8-week course, and assessments of achievement goals were separated by only four weeks. Furthermore, despite manipulating the iRAT grading condition, all other aspects of grading in the course relied on traditional grading measures. For example, examinations still accounted for 60% of the total grade in the course. It is plausible that subtle changes in the iRAT grading structure were not significant enough to produce

changes in task-specific achievement goals. It remains uncertain how more substantive changes (e.g., changing to pass/fail course) would have influenced students' achievement goals. It is also possible that changes in grading structure alone are not enough, and that it needs to be coupled with an intervention to teach students about the malleability of achievement goals and the benefits of adopting mastery goals (Elliot et al., 2017; Gardner, 2006).

It is worth noting that a significant period effect was observed with mastery-avoidance and performance-approach goals. This is important because it suggests students' achievement goals fluctuated over time for reasons *other than* changes in iRAT grading condition. Students' workload and academic performance in other ongoing Doctor of Pharmacy courses may explain this. One hypothesis is that assessments in *other courses* may have influenced students' responses on the AGQ in each study period. For example, at the start of period 1 students were completing mid-semester examinations in several other second-year courses. In comparison to the ungraded iRAT group, students in the graded iRAT group likely felt a greater sense of stress and pressure to perform while also preparing for examinations in other courses. Anecdotally, multiple students commented on this as part of the evaluations at the conclusion of the course.

Implications for Practice

Incentivizing pre-class preparation through a graded readiness assurance process is a fundamental part of TBL (Sibley et al., 2014; Sweet & Pelton-Sweet, 2008). The findings from this study are concordant with this and demonstrate that there is indeed a change in iRAT performance when the iRAT is ungraded, even among higher achieving cohorts such as pharmacy students. For TBL educators, perhaps the most significant

implication of this study is to consider *the degree to which* changes in iRAT grading structure influence students' motivation for completing pre-class preparatory work. In essence, educators should view the motivational effects that might stem from changes in iRAT grading structure on a spectrum, rather than as a dichotomy.

For some health professions educators, the modest difference in iRAT scores without a significant difference in summative examination scores may be enough to encourage the use of ungraded iRATs in their course or curriculum. Such decisions should be carefully considered within the educational context and needs of the course. For example, in health professions education, elective courses tend to select for students that are intrinsically motivated to learn about a particular subject. Such courses may be well-suited to rely less on graded iRATs and more on the other incentive structures within TBL. On the contrary, having ungraded iRATs early on in a professional curriculum (e.g., during the first professional year) may be less desirable because students often have an unclear sense of expectations, little foreknowledge and experience within their field of study, and an under-developed sense of professional identify. A more extreme example is in the context of undergraduate education. Removing the graded iRAT from an undergraduate course is likely to produce much more significant and noticeable changes in pre-class preparation. As educators, it is prudent to carefully assess the educational context, student characteristics, and factors affecting motivation in the classroom.

Studies that have evaluated the effects of graded versus ungraded iRATs have cited the need to promote mastery learning and more desirable achievement goals (Behling et al., 2017; Eudaley et al., 2022; Koh et al., 2019). Although well-intentioned,

the results of this study do not support such a notion. It is likely that a change in iRAT grading structure alone is not enough to produce meaningful change in students' achievement goals. Promoting more desirable achievement goals likely requires broader consideration within a curriculum, and how the overall structure supports, or undermines, the development of mastery-approach goals. One example of this is changing from a traditional letter-grade system to a pass/fail curriculum (Colbert-Getz et al., 2023). Nonetheless, health professional programs should use caution in citing changes in students' achievement goals as the primary reason for shifting to ungraded iRATs.

Implications for Theory

It was hypothesized that social interdependence would provide the necessary incentive for students to complete pre-class preparatory work, regardless of whether the iRAT is graded or ungraded. Positive social interdependence created through shared learning tasks such as the tRAT and team application activities should not only improve team performance, but also incentivize individuals to complete pre-class preparatory material (Johnson & Johnson, 2009; Tomcho & Foels, 2012). This study did not directly test social interdependence theory, but hypotheses about how social interdependence influenced the findings can be made.

One hypothesis is to reject the notion that social interdependence alone is enough to incentivize students to complete pre-class preparatory work. As previously alluded to though, motivation should be viewed on a spectrum and not as an all-or-none principle. An alternative hypothesis is that positive social interdependence explains why there was only a modest reduction in iRAT scores. Had positive social interdependence not been a factor, the differences in iRAT scores between the graded and ungraded groups may have

been much larger. This latter hypothesis may partially explain why coupling ungraded tRATs with ungraded iRATs can result in an exaggerated effect on iRAT scores, as observed in the study by Behling et al. (2017).

Limitations of the Study

It is plausible that my role as a course manager and instructor in the course influenced students' willingness to participate in the study, as well as their responses to the questionnaire items. To mitigate undue influence, recruitment emails, links to the surveys, and notifications were sent by a research member who was not affiliated with the Doctor of Pharmacy curriculum. I also deliberately refrained from conversations with students about the purpose of the study. In addition, all the materials and assessment questions in the course underwent a review process involving at least one other instructor that was not a member of the research team.

Differences in assessment scores were used as a surrogate to measure pre-class preparation and knowledge acquisition. The assessments were carefully created, and performance statistics for the examinations indicated good internal reliability and consistency. Unlike the performance statistics on the examinations, the performance statistics on the iRAT were of limited utility because each iRAT contained only five questions. Increasing the number of questions per iRAT would have potentially increased the reliability of the findings. Nonetheless, the average iRAT performance within each study period was consistent with what is expected in TBL courses (i.e., approximately 65-70%).

It is unclear whether student satisficing contributed to the observed differences in iRAT scores. For example, students in the ungraded iRAT condition may have spent

similar time and effort on pre-class readiness materials but simply put forth less effort

completing the iRAT because their scores were based merely on completion. Although

not part of this study, data collected from InteDashboard™ showed that students spent

~20% less time completing the iRAT when they were in the ungraded condition. It is

unclear whether this is due to satisficing or because students were less prepared.

The Achievement Goal Questionnaire (AGQ; Elliot & McGregor, 2001) is based

on self-reported perceptions, and may not always be an accurate reflection of actual

achievement goals. Despite this limitation, the AGQ has robust research supporting it and

has been validated within pharmacy education (Alrakaf et al., 2014). Nonetheless, some

students may select responses that they perceive as more desirable, rather than what they

feel is true of themselves. On the contrary, other students may have put forth minimal

effort simply to receive the extra credit points. This study also did not consider students'

achievement goals as dispositional orientations, and a baseline measurement of students'

achievement goal orientation was not collected. Including baseline achievement goal

orientation as a covariate may have allowed for greater precision with the statistical

analysis.

Numerous external factors may have influenced achievement goal scores. As an

example, examination performance has been shown to influence achievement goals

(Senko & Harackiewicz, 2005). For this reason, students were required to complete the

AGQ *before* taking each examination in the course; however, students in the second-year

Doctor of Pharmacy curriculum are taking five other courses worth 11 additional credit

hours throughout the semester. Their performance in competing courses undoubtedly

influences their achievement goals and offer a plausible explanation for the observed period effects with performance-approach and mastery-avoidance goals.

Another limitation is the relatively short timeframe in which the study took place. Each study period was approximately 4 weeks in duration, and only included four TBL modules per study period. It is possible that extending the study over the course of a semester or academic year would yield different findings, particularly in students' achievement goals.

Recommendations for Future Research

In consideration of the findings from this study, there are many additional questions for future research. For example, how would the findings differ in other student populations? Extending this study to other contexts, such students earlier in a professional program, would provide a more comprehensive perspective of how ungraded iRATs influence assessment performance and learning in TBL classrooms. Furthermore, there remain questions about the quality and quantity of pre-class preparation when the iRAT is ungraded. Qualitative methods to discover how an ungraded iRAT process influences pre-class preparation would provide a more wholistic perspective, beyond just assessment performance.

Although the crossover design of the study allowed for rigorous control over confounders, it did not allow for longer term observation of academic performance. Observing the effects of ungraded iRATs over the span of multiple courses or semesters, particularly within health professional programs that incorporate TBL throughout a curriculum, would provide a more complete picture of how students' academic performance is affected.

Intervention studies on achievement goals remain understudied, particularly in health professions education. Future studies on how broad sweeping changes in grading structure (e.g., pass/fail course or curriculum) influence achievement goals are needed. In addition, studies that couple changes in grading structure with an intervention designed to teach students the importance of achievement goals may be more likely to produce positive changes in students' achievement goals.

APPENDICES

Appendix A: PharmD Curriculum Overview

	Year 1 Fall	Year 1 Spring	Year 1-2 Summer	Year 2 Fall	Year 2 Spring	Year 2-3 Summer	Year 3 Fall	Year 3 Spring	Year 3-4 Summer	Year 4 Fall	Year 4 Spring
Didactic Courses	PHAR505: Abilities Lab 1 (2)	PHAR518: Abilities Lab 2 (2)		PHAR538: Abilities Lab 3 (1.5)	PHAR548: Abilities Lab 4 (2)		PHAR557: Abilities Lab 5 (1.5)	PHAR5019: Abilities Lab 6 (2)			
	PHAR5000: General Patient Management (3)	PHAR5001: AST1: Respiratory/ GI/Nutrition (3)		PHAR5003: AST3: Autoimmune/ Joints/Bones (2)	PHAR5006: AST6: Endocrine/ Women's Health/GU (3)		PHAR569: Pharmacotherapy 1 (2)	PHAR570: Pharmacotherapy 2 (2)			
	PHAR503: Genomics & Proteomics (3)	PHAR5002: AST2: Hematology/ Pain/Oncology (3)		PHAR5004: AST4: Renal/Hepatic Disorders (2)	PHAR5021: AST7: Psyc/ Toxicology (3)		PHAR5013: Self-Care & Nonprescription 1 (2)	PHAR5014: Self-Care & Nonprescription 2 (2)			
	PHAR506: Principles of Drug Action (3)	PHAR525: Immunology (2)		PHAR5005: AST5: Cardio/ Cerebrovascular (4)	PHAR5022: AST8:Substance Abuse & Neuro (3)		PHAR5011: Pharmacy Practice Mgmt & Leadership (3)	PHAR580: Pharmacy Law (2)			
	PHAR510: Biochemistry (3)	PHAR533: Medicinal Chemistry 1 (2)			PHAR5010: Health Policy & Systems (2)		PHAR5012: Pharmacoepi and Pharmacoecon (2)	PHAR5015: Public Health Pharmacy (2)			
	PHAR504: Physical & Pharmaceutical Chem (3)	PHAR539: Medicinal Chemistry 2 (2)		PHAR5016: Infectious Disease Therapeutics 1 (3)	PHAR5017: Infectious Disease Therapeutics 2 (3)		PHAR535: Pharmaceutics (3)				
	PHAR5023: Professional Foundations of Pharmacy 1 (1)	PHAR5024: Professional Foundations of Pharmacy 2 (1)		PHAR556: Pharmacokinetics (2)				Electives (7)			
		PHAR5009: Medical Evidence (2)					Electives (4)				PHAR5018: PharmD Capstone (2)
Experiential Courses			IPPE 100 One week (40 hour) rotation (1)			IPPE 300 (4) 4 weeks IPPE 307 (3) 3 weeks (40 hours per week) summer or winter break		IPPE 300 (4) 4 weeks IPPE 307 (3) 3 weeks (40 hours per week) summer or winter break	Required Advanced Community, Health-System, Acute Care/ General Medicine, Ambulatory Care, and Population Health, four elective rotations and the Pharmacy Practice Pinnacle (1440 hours) (36)		
Credit Hours	18	17	1	14.5	16	6	17.5	17	38 (146 overall)		

Content Key

Abilities Lab 1-6
ABL1 Dispensing (incl. IV dosage forms),vital signs, patient counseling, drug information and medical documentation
ABL2 Dispensing (incl. complex IV admixture), lung and foot exams
ABL3 Hospital dispensing (unit dose, physician order review, IV infusion devices, sterile compounding) , medication errors, adverse drug events, Medication history/reconciliation, discharge counseling
ABL4 Community dispensing, mental status exams and motor function evaluations, diagnostic devices, injections
ABL5 Compounding and drug information
ABL6 Medication therapy management (MTM), patient assessment skills, calculations, medical terminology, documentation of interventions, PCOA

Applied Science and Therapeutics 1-8
AST1   Respiratory, Gastrointestinal and Nutrition
AST2   Hematology, Pain and Oncology
AST3   Autoimmune, Bone and Joint
AST4   Renal and Hepatic Disorders
AST5   Cardiovascular and Cerebrovascular Disorders
AST6   Endocrine, Women's Health and Genitourinary Disorders
AST7   Psychiatric and Toxicology
AST8   Substance Abuse & Neurology

Appendix B: Communication with Smith & Rose

Dear Zac,

Thank you very much for your interest in our research. To answer your first question about why we combined the US and NZ samples, it's some time ago now since conducting this research and many more projects have since passed under the bridge so to speak, so my memory is hazy. I suspect, looking at the sample sizes, the US and NZ samples were not quite large enough on their own to enable a robust CFA. I'm amazed, now reading the paper again after some passage of time, that we weren't asked by the journal reviewers to justify the combining of the two samples! I will need to talk to our statistics expert, Dr Grenville Rose, to confirm my thoughts and I'll get back to you as soon as I can.

With respect to your second question about whether or not a separate (unpublished) analysis was performed comparing the AGQ and AGQ-R in an isolated US cohort, I'm not aware of any unpublished research, but as stated in our publication, the original validation studies of both the AGQ and AGQ-R used US single-discipline psychology students (see page 340: "For example, one well-known instrument is the Achievement Goals Questionnaire (AGQ),6,27 reported by Elliot and McGregor (6). This instrument was developed and validated in higher education settings in the US, using a cohort of psychology students" and "Based on these concerns, a Revised Achievement Goal Questionnaire (AGQ-R) (26) was developed by Elliot and Murayama, which was administered to undergraduate psychology students enrolled in US universities").

Regarding Dr Alrakaf, he returned to Saudi Arabia to work as a Hospital Pharmacy Director. I'm not aware of him continuing to conduct educational research.

Your dissertation study sounds fascinating, Zac, and I wish you all the best with it. I will get back to you as soon as I can about the combining of samples.

Kind regards,
Lorraine

Lorraine Smith, Professor
Sydney Pharmacy School
Faculty of Medicine and Health
University of Sydney

From: Noel, Zachary
Sent: Thursday, 24 March 2022 1:24 AM
To: Lorraine Smith
Cc: Cestone, Christina
Subject: RE: AGQ-R Validation Study

Hi Dr. Smith,

My name is Zac and I'm a current student in the Health Professions PhD program at the University of Maryland, Baltimore in the US (Dr. Christina Cestone, my program director, is cc'ed). The reason for my email is to inquire about a validation study in pharmacy students involving the AGQ and AGQ-R that you and your colleagues performed. Would you be willing to provide clarification regarding a question I have? I've outlined the question below, but I'll preface it by saying that if you think it would be easier to meet briefly (virtually, of course) I'd be happy to set something up during a time that works for you. Also, I attempted to find updated contact information of Dr. Alrakaf but came up empty-handed. If you feel it's more appropriate for me to touch base with Dr. Alrakaf feel free to point me in their direction.

Inquiry: Part of my dissertation proposal aims to assess changes in achievement goal orientation with changes in graded structure. Obviously, a critical step is ensuring that I'm using a validated instrument in the population of interest, which for me is PharmD students here in the US. I noticed that in the validation study you all performed that the New Zealand and US students were lumped into a single cohort, rather than separating them into separate cohorts. Given the differences in US and international pharmacy education (e.g., PharmD students in the US are several years older and likely have a different set of undergraduate experiences to shape their motivational tendencies) I can't help but wonder whether the findings for US students would be similar or different had the counties been looked at separately. Throughout your research, do you know if a separate (unpublished) analysis was performed comparing the AGQ and AGQ-R in an isolated US cohort?

My apologies for the longwinded email. Thank you in advance for considering my inquiry and any input you can offer.

Zachary R. Noel, PharmD, BCCP
Assistant Professor

Appendix C: Permission to Use the Achievement Goal Questionnaire

Yes, you have my permission.

Andrew

From: Noel, Zachary
Sent: Friday, February 18, 2022 8:14 AM
To: Elliot, Andrew
Cc: Cestone, Christina
Subject: [EXT] RE: Permission to Use AGQ-R

Dr. Elliot,

In the way of a brief introduction, my name is Zac and I'm an assistant professor at the University of Maryland School of Pharmacy and current student in the Health Professions Education PhD program at the University of Maryland, Baltimore. The reason for my email is to request permission to use the Achievement Goal Questionnaire-Revised as part of my dissertation research project within the PhD program. The focus of my research is on measuring changes in pharmacy students' goal orientation with graded vs ungraded assessments in a team-based learning classroom. Your research has provided much of the theoretical framework I'll be using and I'd be honored to extend the research into the health professions domain! Of course, I plan to cite your 2008 paper with Dr. Murayama (among other publications).

As a disclaimer, there will most likely be slight modifications to the questionnaire items so that they are contextually relevant. I've listed an example of what this might look like below.

- *Original: My aim is to completely master the material presented in this class.*
- *Modification: My aim is to completely master the material presented <u>during the readiness process</u>.*

May I have permission to use the AGQ-R in this capacity? I'm happy to share additional information about the research or answer any questions you may have. Thank you for considering.

P.S. I've cc'ed Dr. Christina Cestone, who is an educational psychologist as well as my advisor, dissertation committee chair, and program director for the HPE PhD program.

Zachary R. Noel, PharmD, BCCP

Appendix D: Survey with Achievement Goal Questionnaire

Please provide the following information:

○ First Name _____

○ Last Name _____

○ Email _____

○ Age (years) _____

What is your cumulative pharmacy school grade point average (GPA)?
(If grades from AST 3 and 4 are not yet included in your cumulative GPA calculation, please provide your GPA at the start of the Fall semester)

	2	2	2	2	3	3	3	3	4
GPA									

Which gender do you most closely identify with?

○ Male

○ Female

○ Non-binary / third gender

○ Prefer not to say

Is English your native language?

○ Yes

○ No

End of Block: Instructions #2

It is important for me to do better than other students in AST 5.

○ Not at all true of me

○ Untrue of me

○ Somewhat untrue of me

○ Neutral

○ Somewhat true of me

○ True of me

○ Very true of me

Page Break

It is important for me to do well compared to others in AST 5.

○ Not at all true of me

○ Untrue of me

○ Somewhat untrue of me

○ Neutral

○ Somewhat true of me

○ True of me

○ Very true of me

Page Break

My goal in AST 5 is to get a better grade than most of the other students.

- ○ Not at all true of me
- ○ Untrue of me
- ○ Somewhat untrue of me
- ○ Neutral
- ○ Somewhat true of me
- ○ True of me
- ○ Very true of me

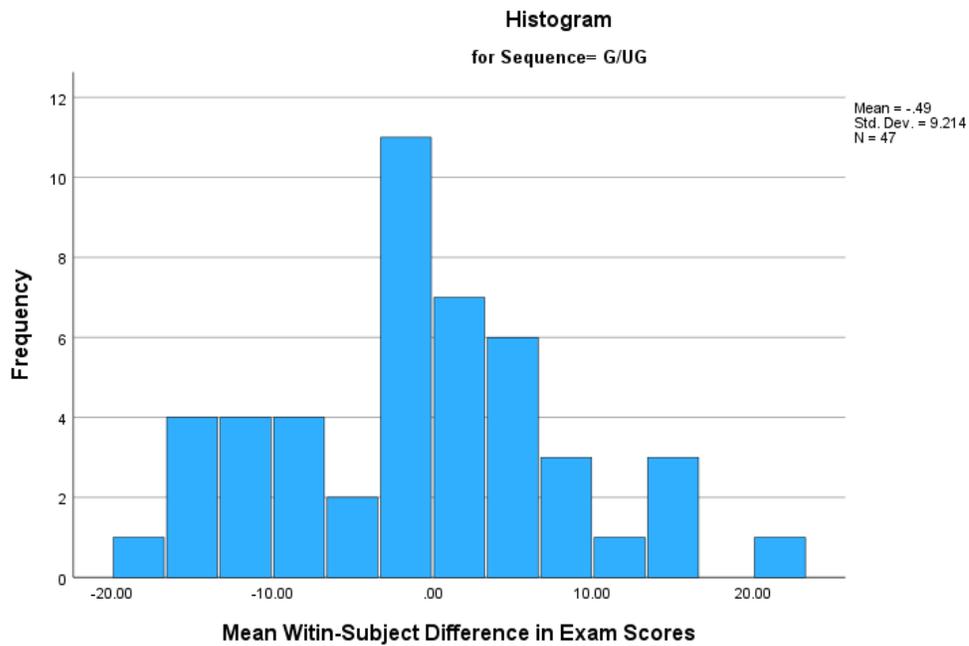I worry that I may not learn all that I possibly could in AST 5.

- ○ Not at all true of me
- ○ Untrue of me
- ○ Somewhat untrue of me
- ○ Neutral
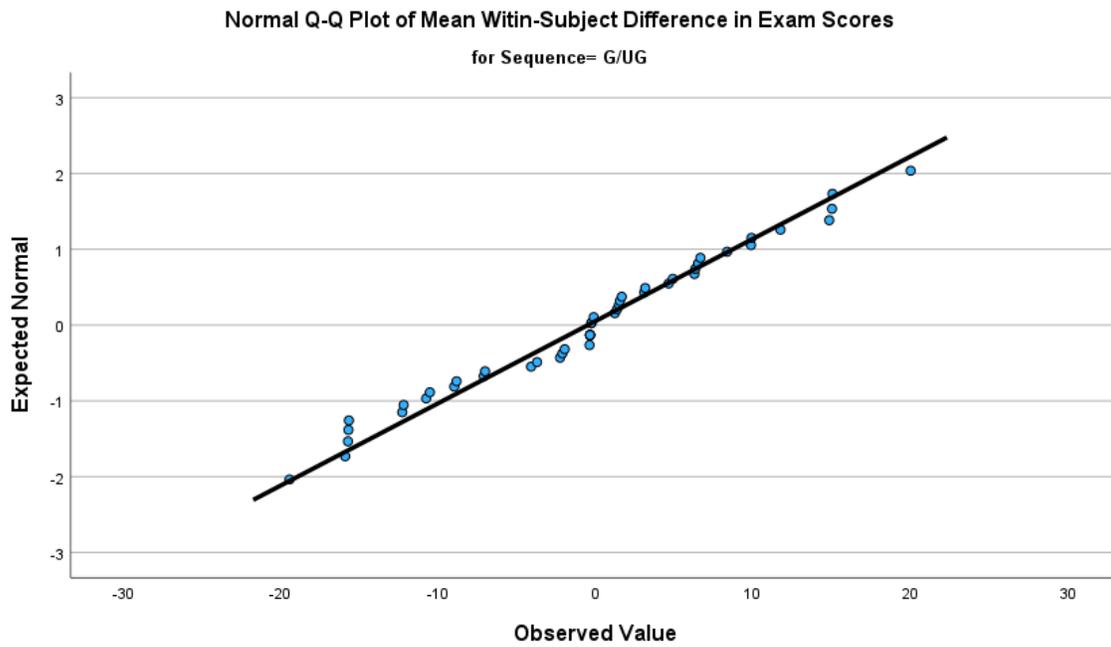- ○ Somewhat true of me
- ○ True of me
- ○ Very true of me

Page Break

Sometimes I'm afraid that I may not understand the content of AST 5 as thoroughly as I'd like.

- ○ Not at all true of me
- ○ Untrue of me
- ○ Somewhat untrue of me
- ○ Neutral
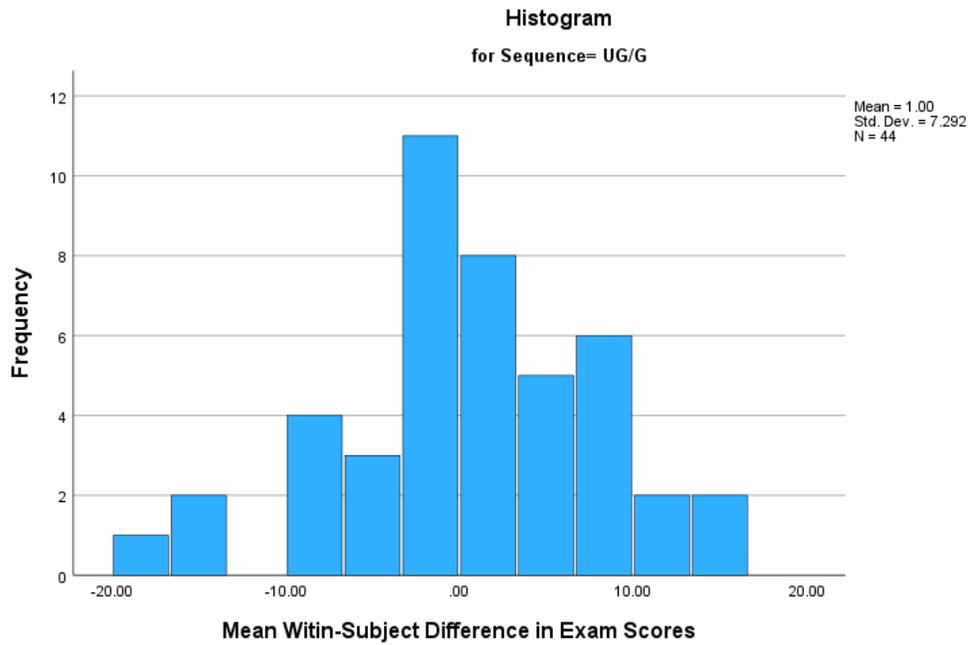- ○ Somewhat true of me
- ○ True of me
- ○ Very true of me

I am often concerned that I may not understand the content of AST 5 as thoroughly as I'd like.

- ○ Not at all true of me
- ○ Untrue of me
- ○ Somewhat untrue of me
- ○ Neutral
- ○ Somewhat true of me
- ○ True of me
- ○ Very true of me

I want to learn as much as possible from AST 5.

- ○ Not at all true of me
- ○ Untrue of me
- ○ Somewhat untrue of me
- ○ Neutral
- ○ Somewhat true of me
- ○ True of me
- ○ Very true of me

It is important for me to understand the content of AST 5 as thoroughly as possible.

- ○ Not at all true of me

- ○ Untrue of me

- ○ Somewhat untrue of me

- ○ Neutral

- ○ Somewhat true of me

- ○ True of me

- ○ Very true of me

Page Break

I desire to completely master the material presented in AST 5.

- ○ Not at all true of me

- ○ Untrue of me

- ○ Somewhat untrue of me

- ○ Neutral

- ○ Somewhat true of me

- ○ True of me

- ○ Very true of me

Page Break

I just want to avoid doing poorly in AST 5.

○ Not at all true of me

○ Untrue of me

○ Somewhat untrue of me

○ Neutral

○ Somewhat true of me

○ True of me

○ Very true of me

My goal in AST 5 is to avoid performing poorly.

○ Not at all true of me

○ Untrue of me

○ Somewhat untrue of me

○ Neutral

○ Somewhat true of me

○ True of me

○ Very true of me

My fear of performing poorly in AST 5 is often what motivates me.

○ Not at all true of me

○ Untrue of me

○ Somewhat untrue of me

○ Neutral

○ Somewhat true of me

○ True of me

○ Very true of me

Appendix E: Assumption Testing for Assessment Scores

Tests for Normality of Within-Subject Differences in Assessment Performance

Within-Subject Outcome	Group	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	*p*	Statistic	df	*p*
Mean Difference for Exams	G/UG	.122	47	.079	.977	47	.472
	UG/G	.099	44	.200	.977	44	.511
Mean Difference for iRATs	G/UG	.097	47	.200	.978	47	.498
	UG/G	.133	44	.049	.981	44	.661

Note. G = graded; UG = ungraded

Histogram

for Sequence= G/UG

Mean = -.49
Std. Dev. = 9.214
N = 47

Mean Witin-Subject Difference in Exam Scores

Histogram

for Sequence= UG/G

Mean = 1.00
Std. Dev. = 7.292
N = 44

Frequency

Mean Witin-Subject Difference in Exam Scores

Normal Q-Q Plot of Mean Witin-Subject Difference in Exam Scores

for Sequence= G/UG

Expected Normal

Observed Value

Normal Q-Q Plot of Mean Witin-Subject Difference in Exam Scores
for Sequence= UG/G

Histogram

for Sequence= G/UG

Mean = 3.33
Std. Dev. = 15.12
N = 47

Mean Within-Subject Difference in iRAT Scores

Histogram

for Sequence= UG/G

Mean = -5.72
Std. Dev. = 17.923
N = 44

Mean Within-Subject Difference in iRAT Scores

94

Normal Q-Q Plot of Mean Within-Subject Difference in iRAT Scores
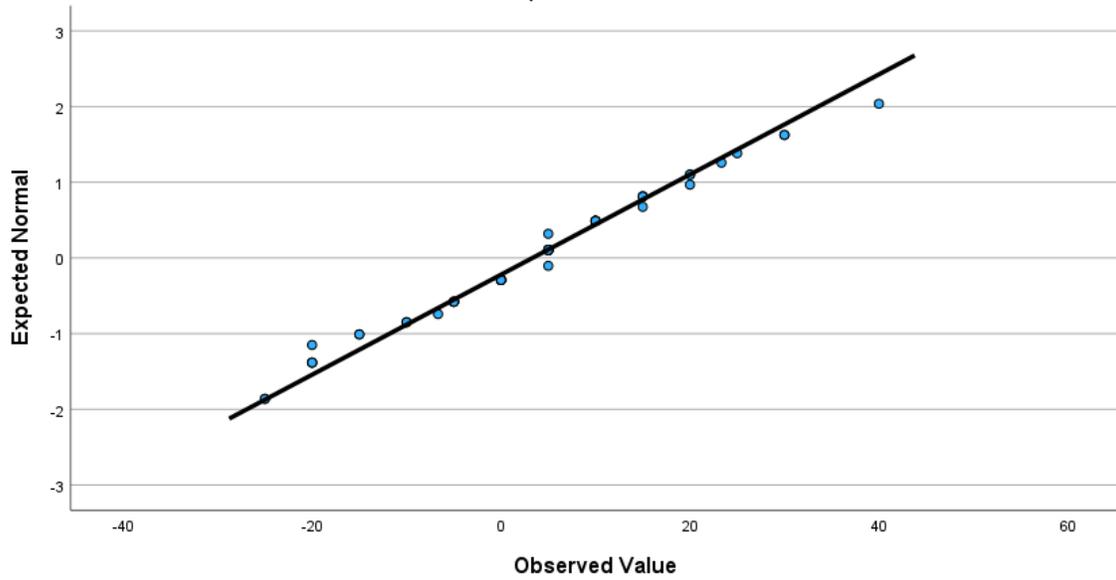
for Sequence= G/UG

Normal Q-Q Plot of Mean Within-Subject Difference in iRAT Scores

for Sequence= UG/G
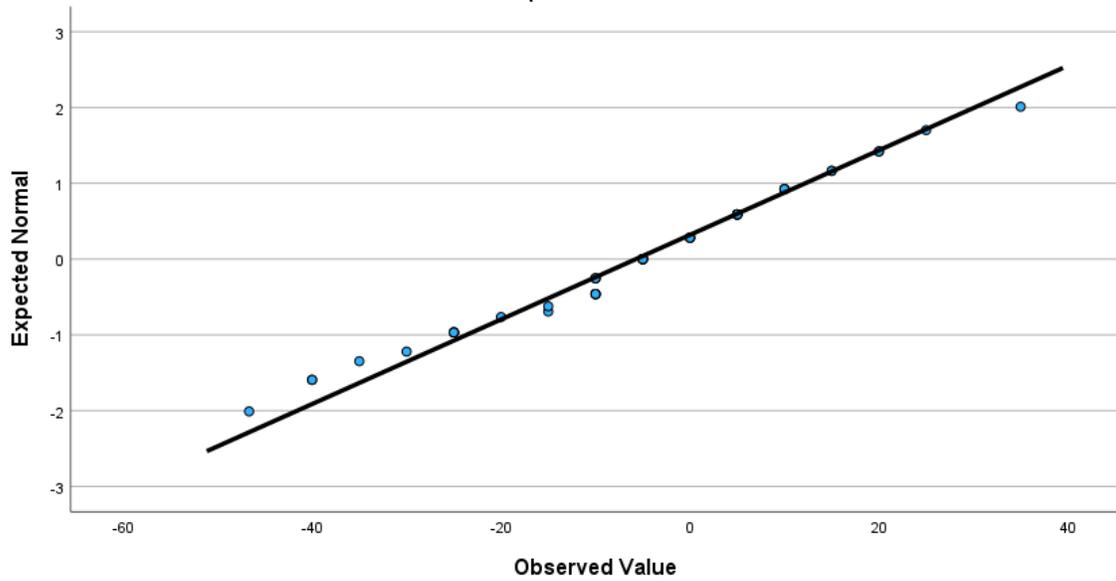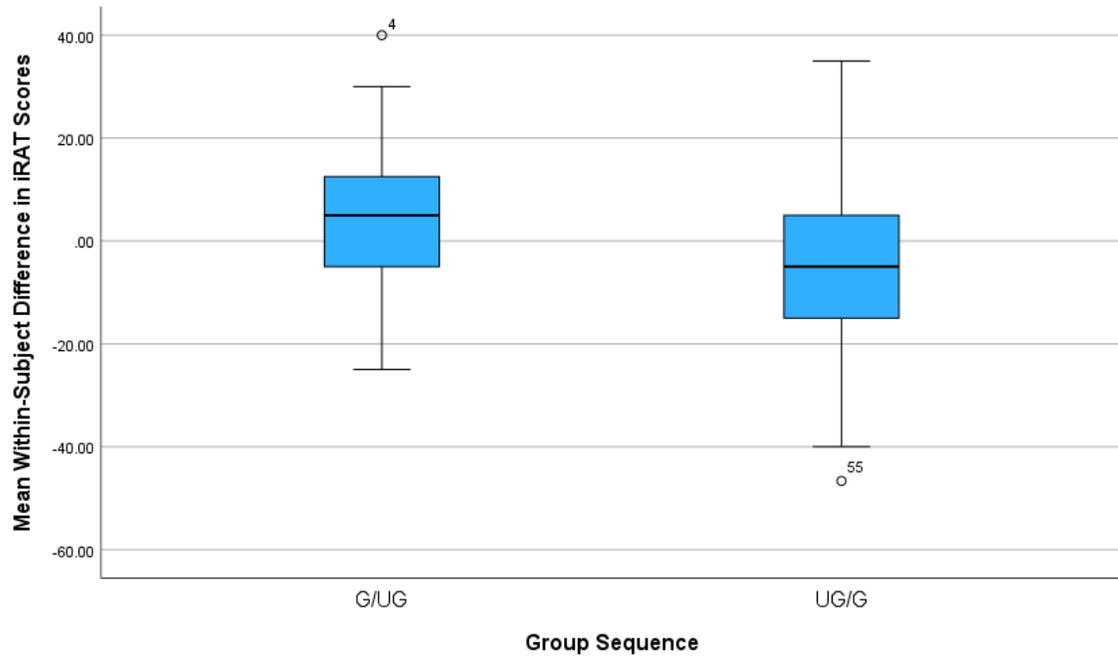
Levene's Test of Equality of Error Variances[a]

		Levene Statistic	df1	df2	Sig.
iRA1_4_PERC	Based on Mean	1.017	1	89	.316
	Based on Median	.681	1	89	.411
	Based on Median and with adjusted df	.681	1	83.726	.412
	Based on trimmed mean	1.073	1	89	.303
iRA6_9_PERC	Based on Mean	.848	1	89	.360
	Based on Median	1.178	1	89	.281
	Based on Median and with adjusted df	1.178	1	85.373	.281
	Based on trimmed mean	.940	1	89	.335
Exam1_PERCENT	Based on Mean	.067	1	89	.796
	Based on Median	.054	1	89	.816
	Based on Median and with adjusted df	.054	1	85.994	.816
	Based on trimmed mean	.066	1	89	.798
Exam2_PERCENT	Based on Mean	.144	1	89	.706
	Based on Median	.160	1	89	.690
	Based on Median and with adjusted df	.160	1	88.541	.690
	Based on trimmed mean	.168	1	89	.683

Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

a. Design: Intercept + Sequence
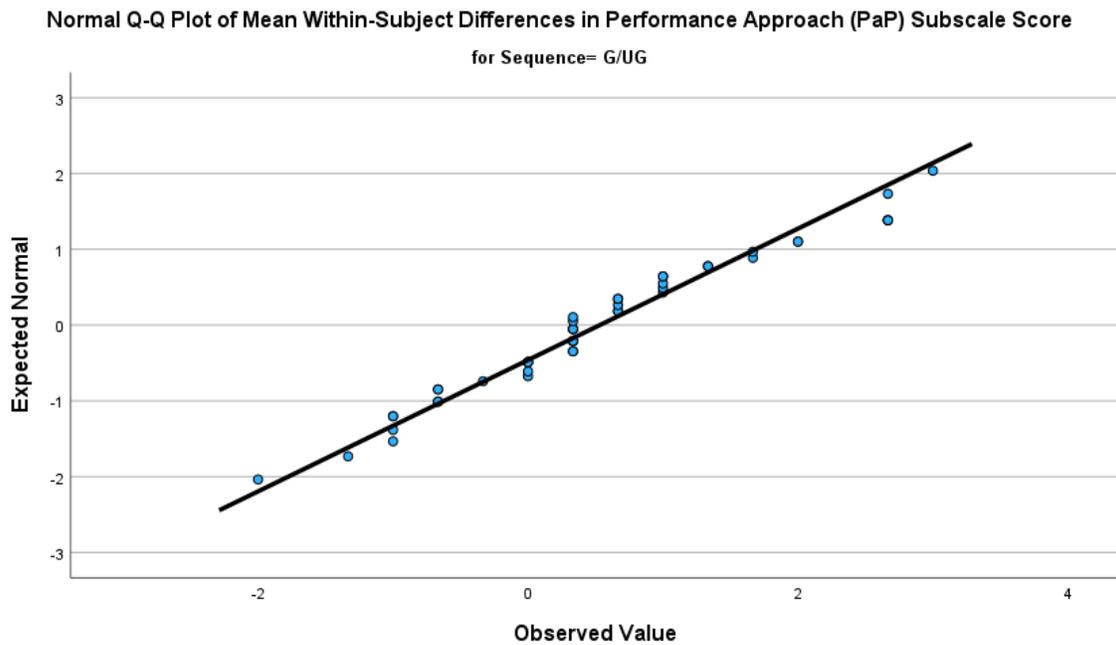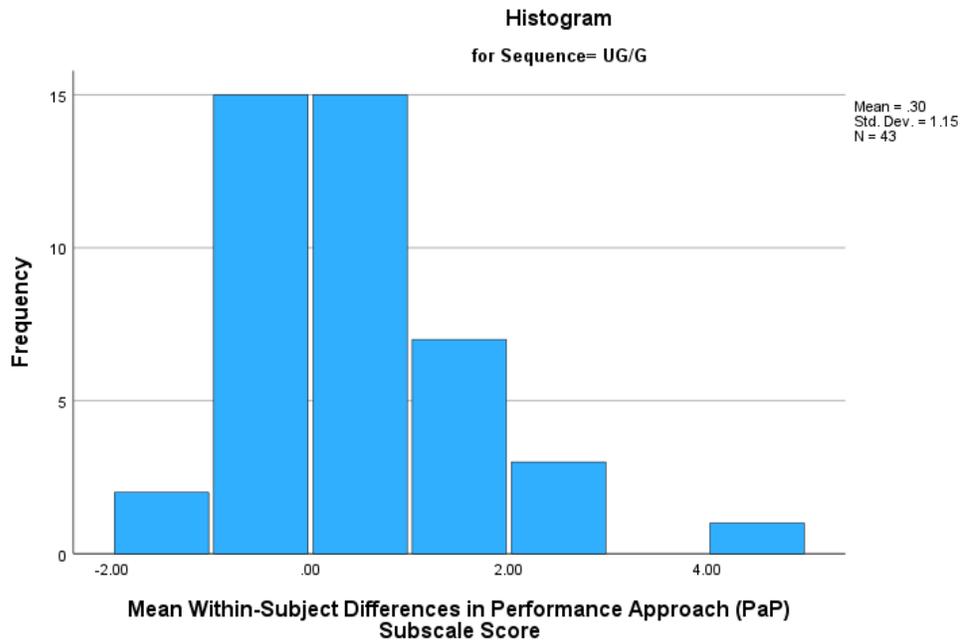   Within Subjects Design: Period

Appendix F: Assumption Testing for Achievement Goals

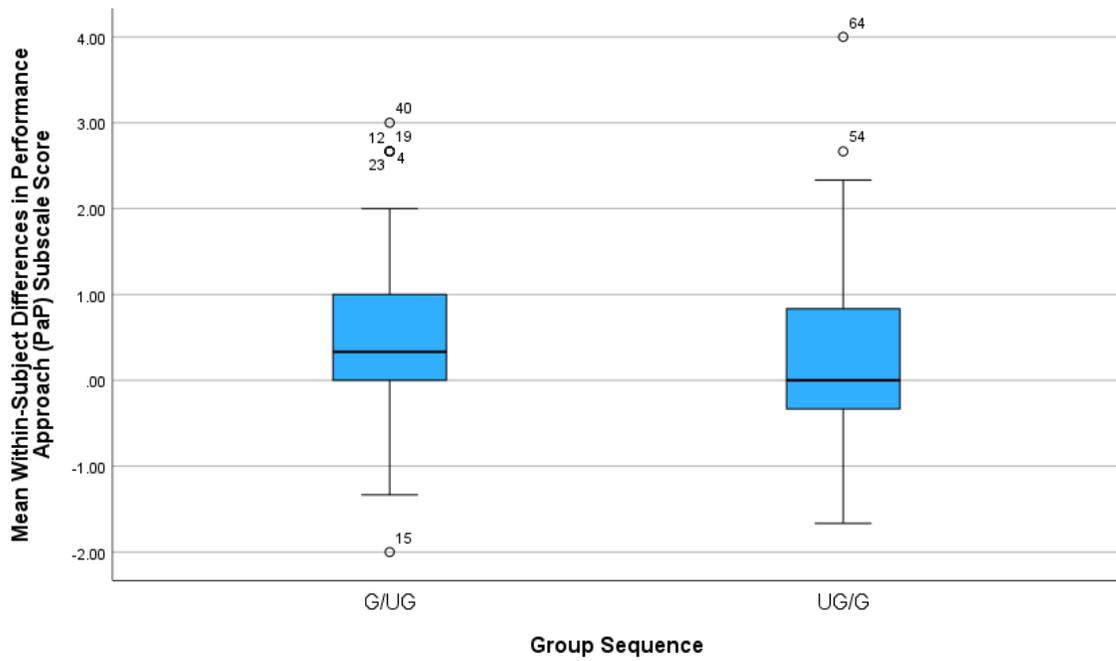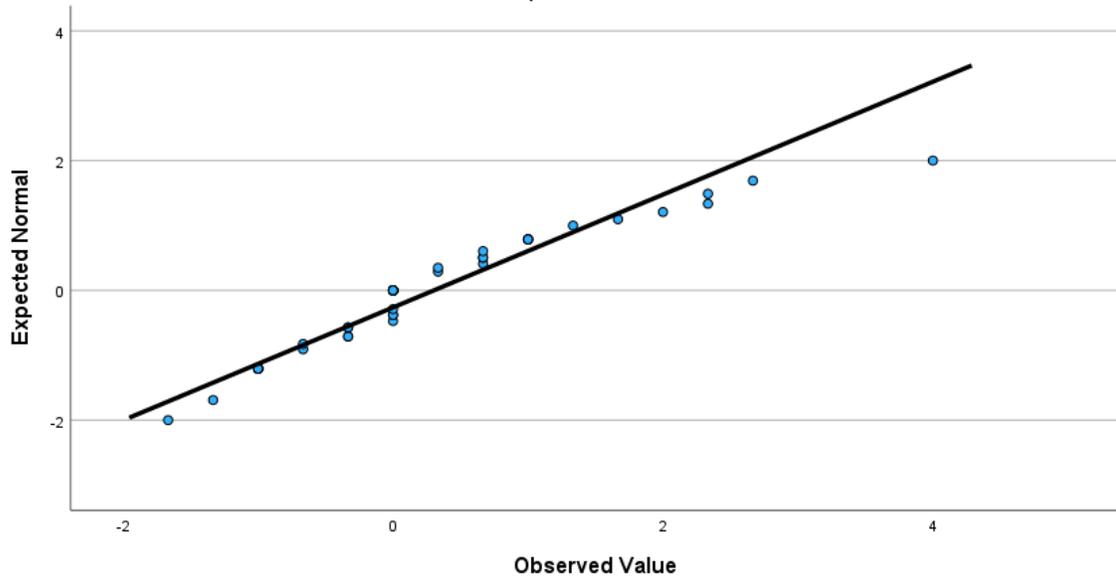*Tests for Normality of Within-Subject Differences in Achievement Goals Subscale Scores*

Mean Within-Subject Difference Subscale Scale	Group Sequence	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Performance-Approach (PaP)	G/UG	.122	47	.080	.965	47	.165
	UG/G	.208	43	<.001	.921	43	.006
Mastery-Avoidance (MaV)	G/UG	.137	47	.027	.959	47	.095
	UG/G	.133	43	.055	.965	43	.204
Mastery-Approach (MaP)	G/UG	.208	47	<.001	.890	47	<.001
	UG/G	.234	43	<.001	.849	43	<.001
Performance-Avoidance (PaV)	G/UG	.118	47	.098	.956	47	.078
	UG/G	.135	43	.048	.961	43	.149

Note: [a]Lilliefors Significance Correction; *G* = graded; *UG* = ungraded

Histogram

for Sequence= UG/G

Mean = .30
Std. Dev. = 1.15
N = 43

Mean Within-Subject Differences in Performance Approach (PaP)
Subscale Score

Normal Q-Q Plot of Mean Within-Subject Differences in Performance Approach (PaP) Subscale Score
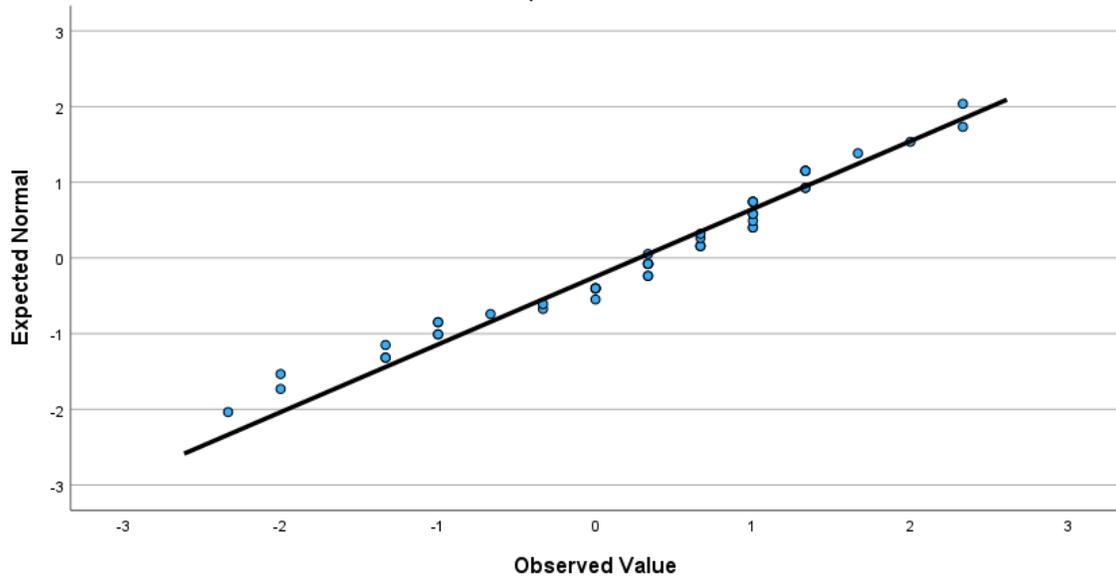
for Sequence= G/UG

Normal Q-Q Plot of Mean Within-Subject Differences in Performance Approach (PaP) Subscale Score for Sequence= UG/G

Histogram

for Sequence= G/UG
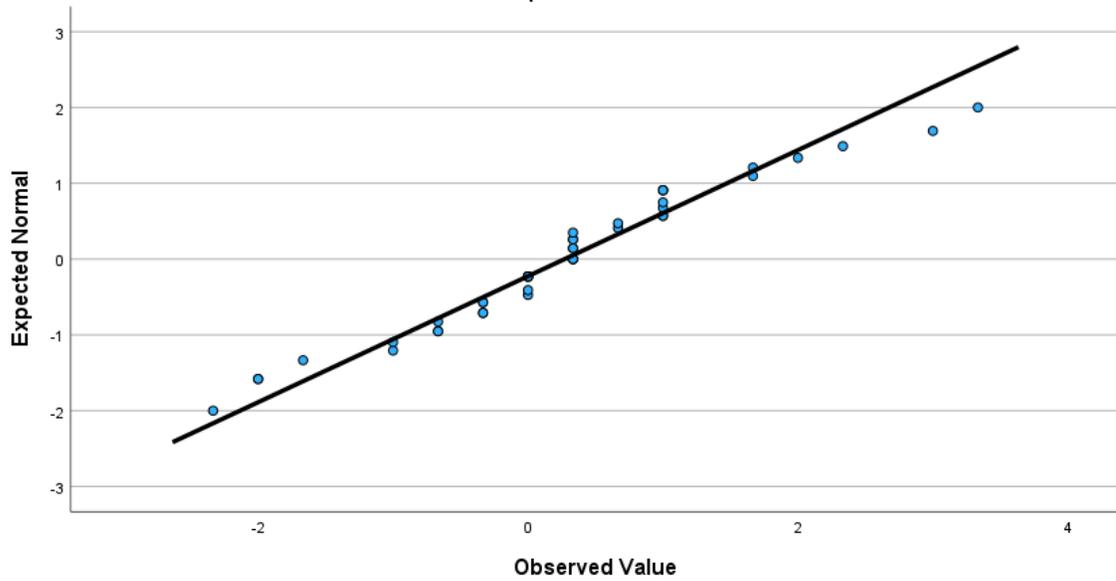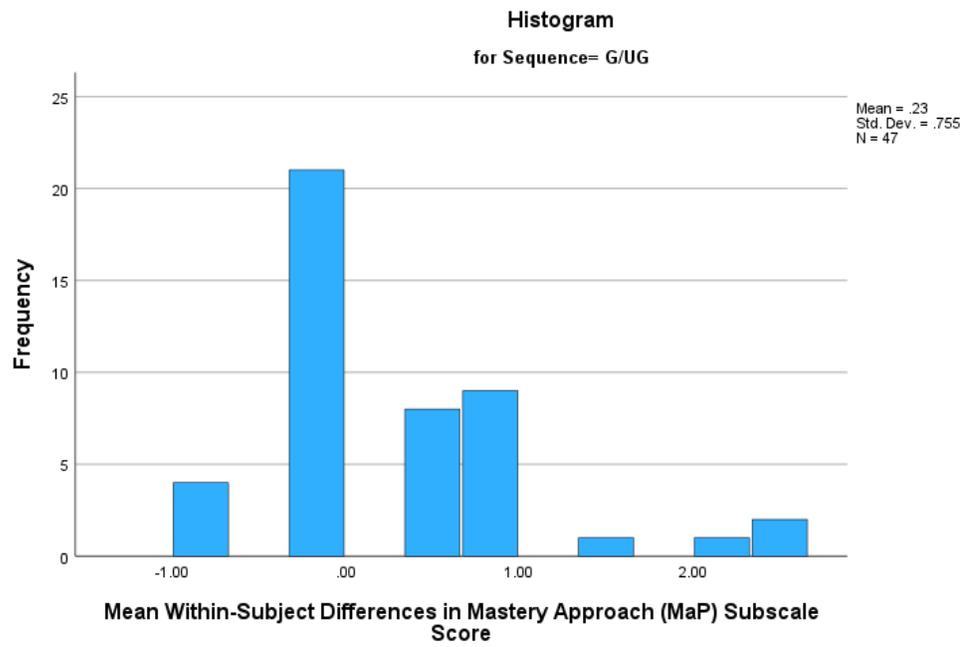
Mean = .28
Std. Dev. = 1.117
N = 47

Frequency

Mean Within-Subject Differences in Mastery Avoidance (MaV) Subscale Score

Histogram

for Sequence= UG/G

Mean = .27
Std. Dev. = 1.202
N = 43

Frequency

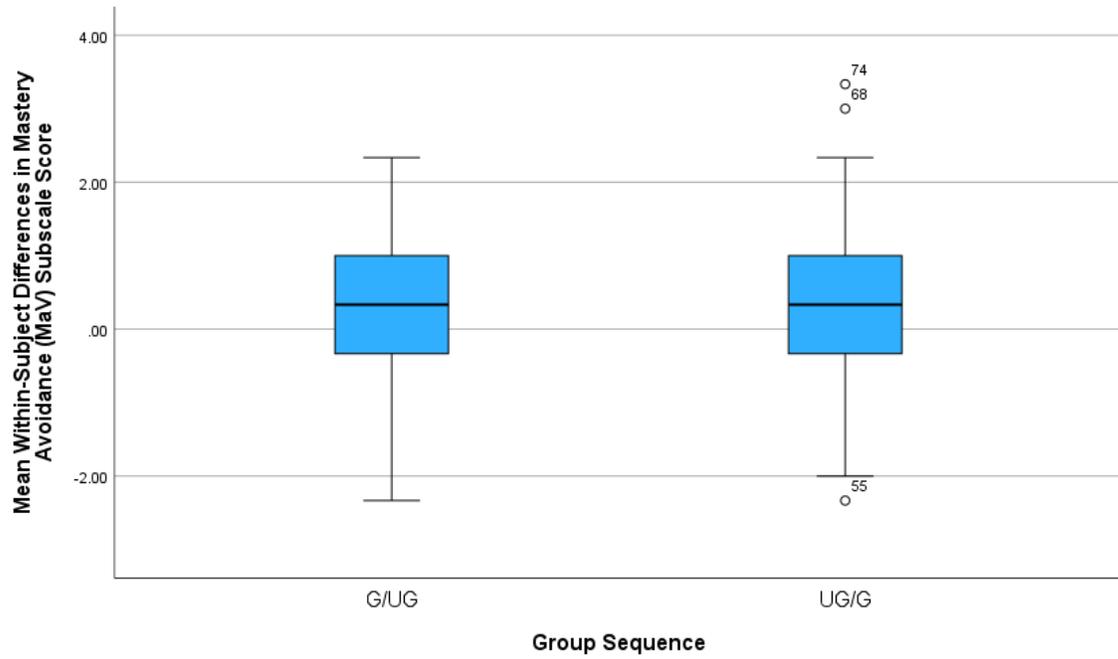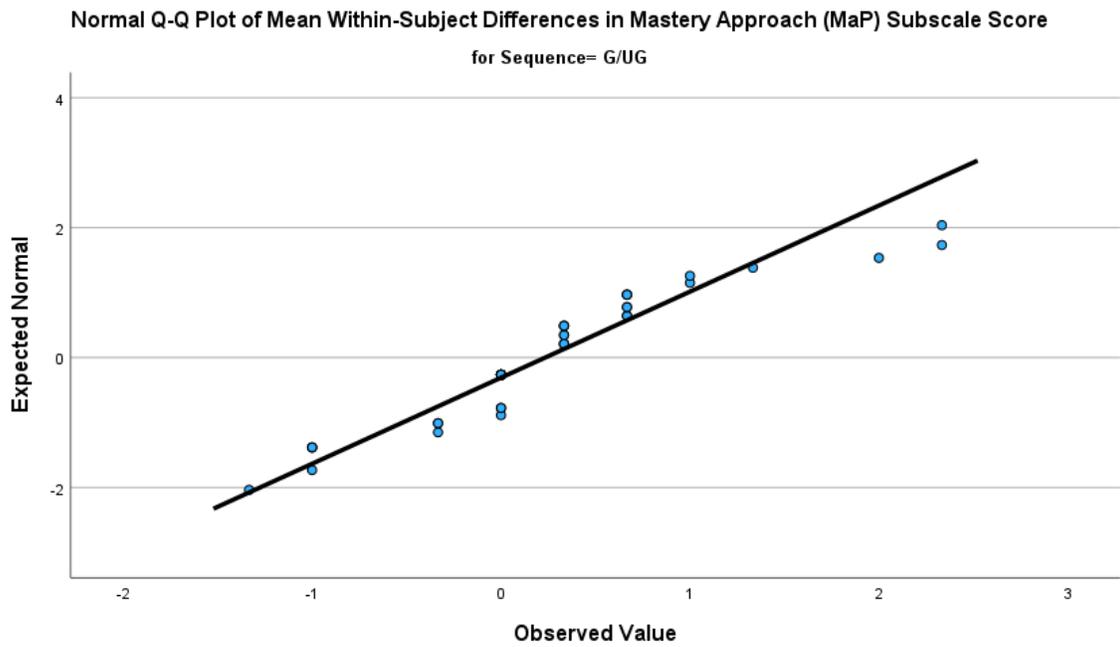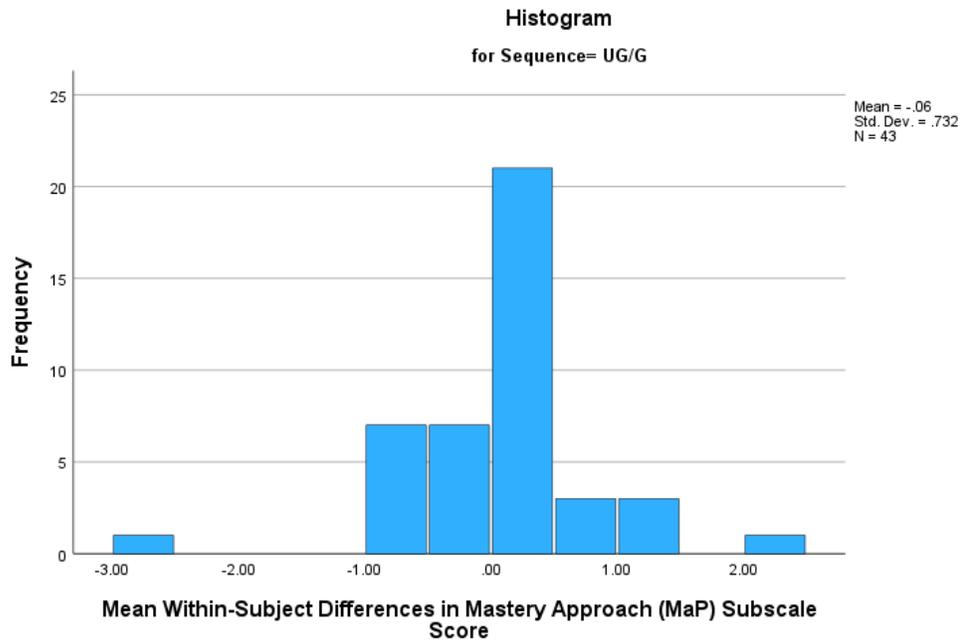Mean Within-Subject Differences in Mastery Avoidance (MaV) Subscale Score

Normal Q-Q Plot of Mean Within-Subject Differences in Mastery Avoidance (MaV) Subscale Score

for Sequence= G/UG

Normal Q-Q Plot of Mean Within-Subject Differences in Mastery Avoidance (MaV) Subscale Score

for Sequence= UG/G

Group Sequence

Histogram

for Sequence= G/UG

Mean = .23
Std. Dev. = .755
N = 47

Mean Within-Subject Differences in Mastery Approach (MaP) Subscale
Score

Histogram

for Sequence= UG/G

Mean = -.06
Std. Dev. = .732
N = 43

Mean Within-Subject Differences in Mastery Approach (MaP) Subscale Score

Normal Q-Q Plot of Mean Within-Subject Differences in Mastery Approach (MaP) Subscale Score
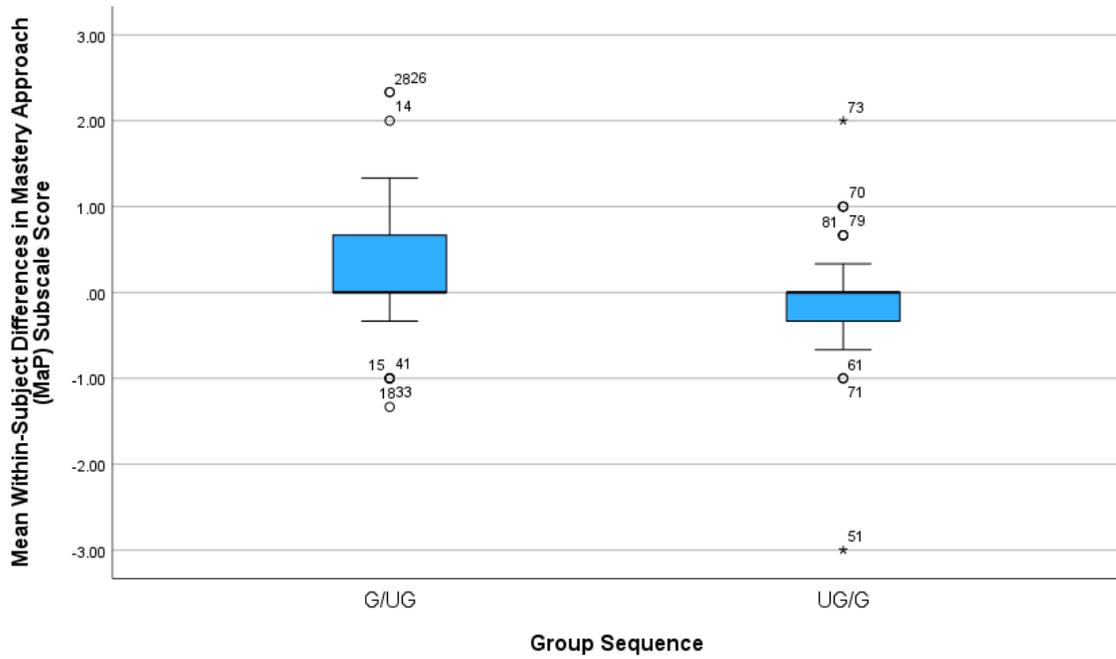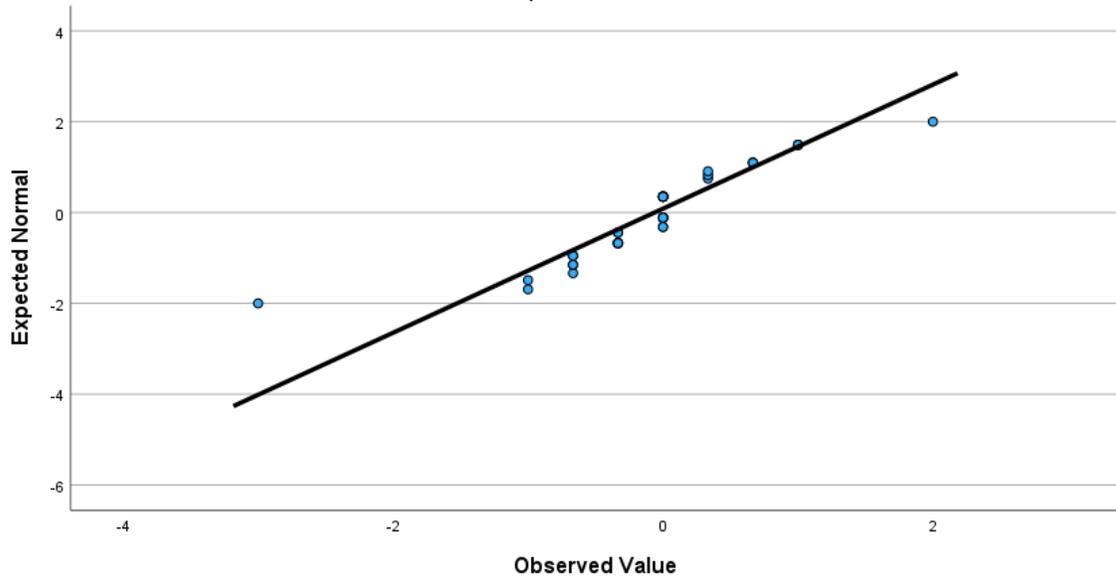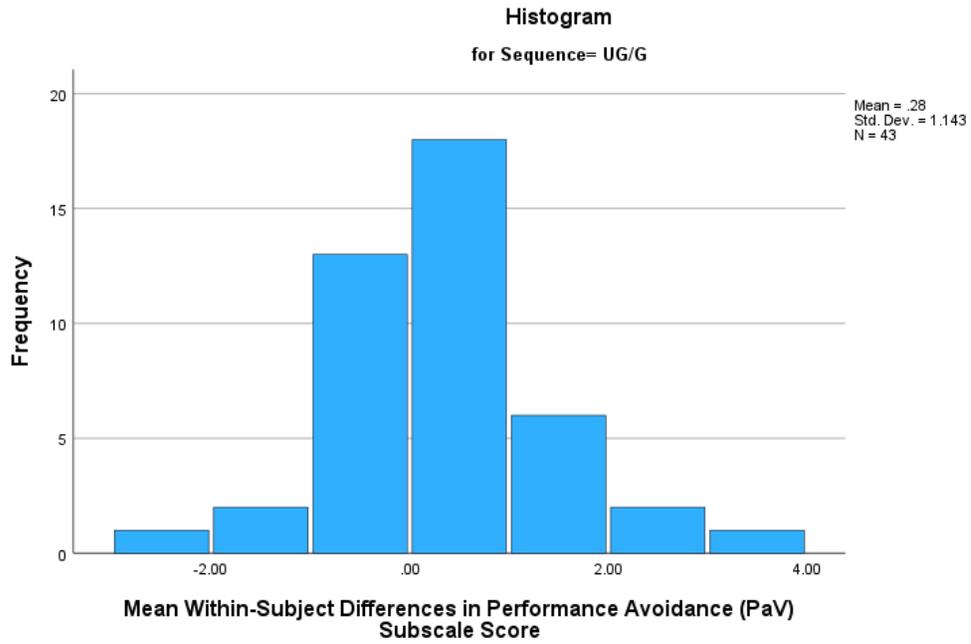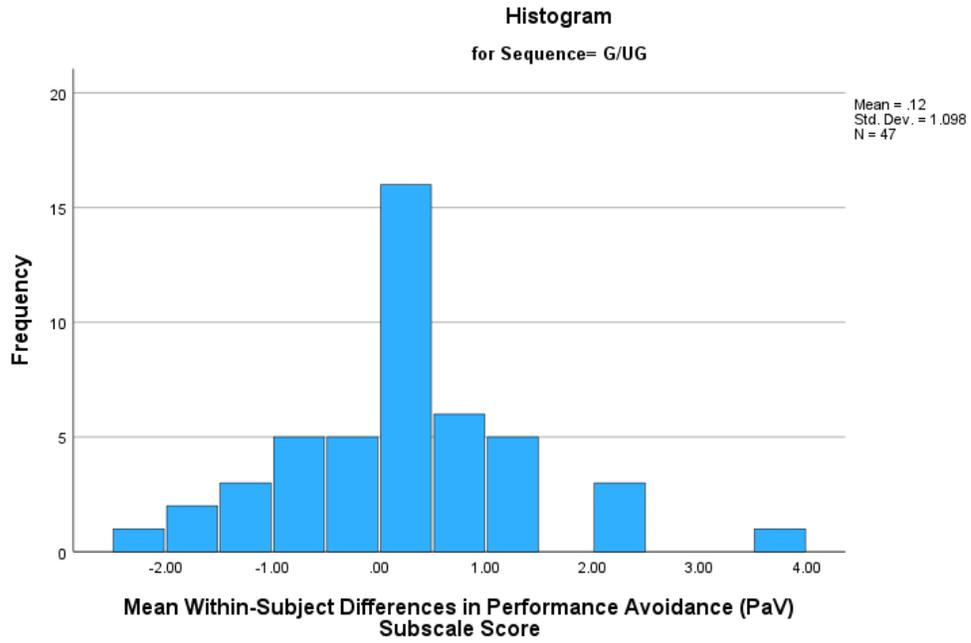
for Sequence= G/UG

Normal Q-Q Plot of Mean Within-Subject Differences in Mastery Approach (MaP) Subscale Score
for Sequence= UG/G

Histogram

for Sequence= G/UG

Mean = .12
Std. Dev. = 1.098
N = 47

Frequency

Mean Within-Subject Differences in Performance Avoidance (PaV)
Subscale Score

Histogram

for Sequence= UG/G

Mean = .28
Std. Dev. = 1.143
N = 43

Frequency

Mean Within-Subject Differences in Performance Avoidance (PaV)
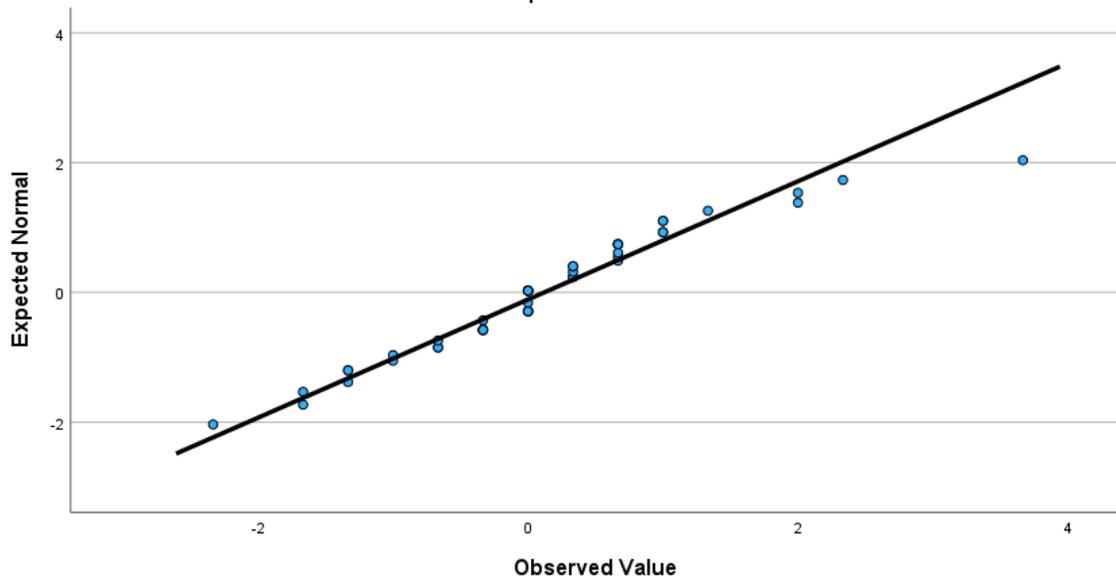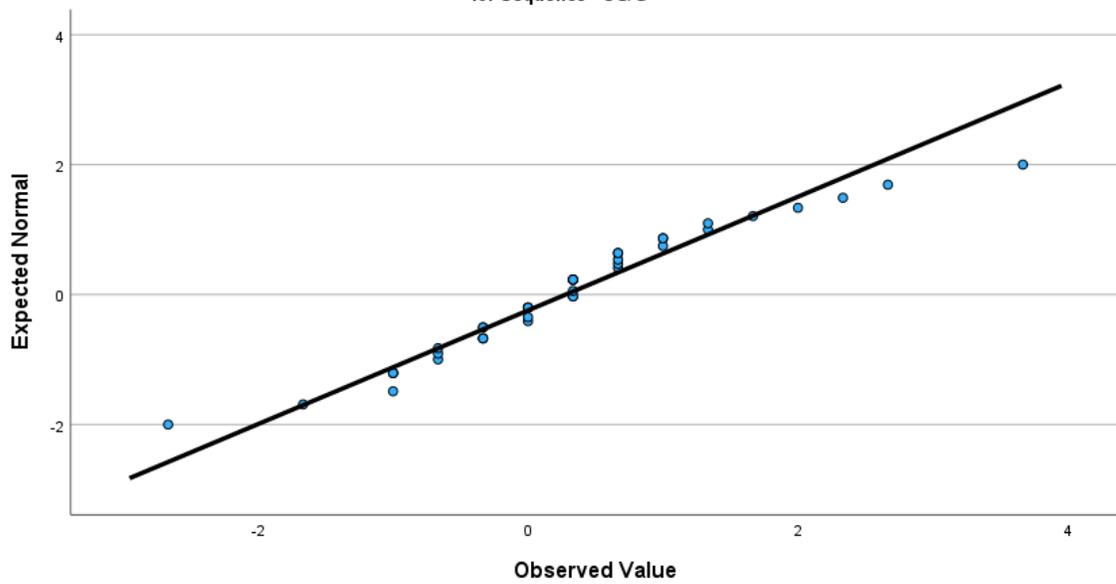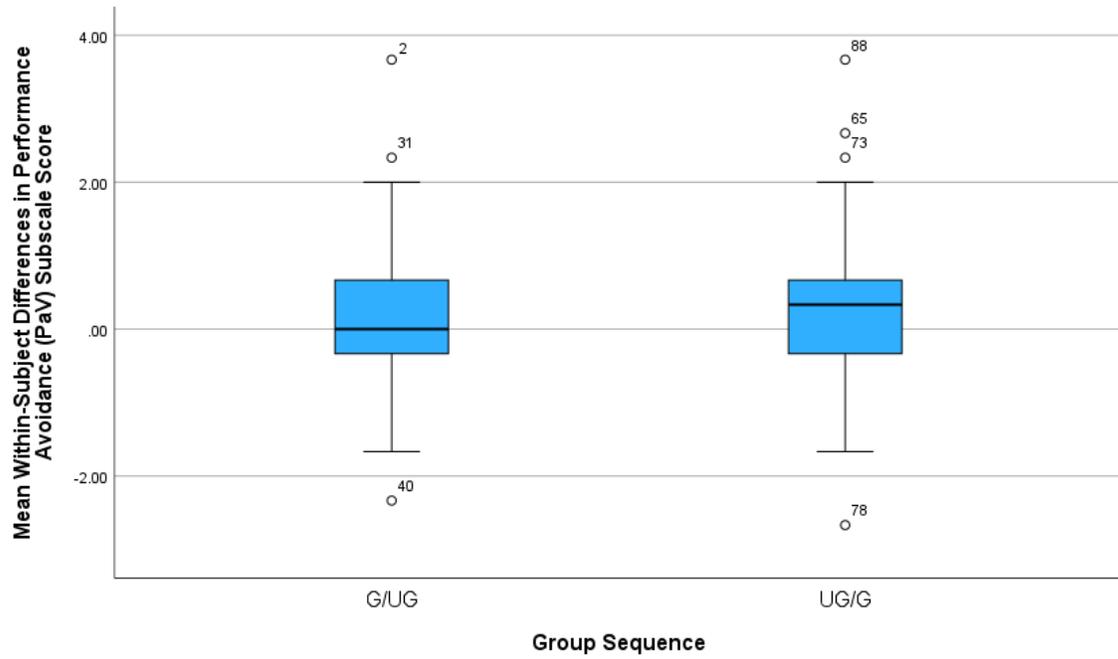Subscale Score

Normal Q-Q Plot of Mean Within-Subject Differences in Performance Avoidance (PaV) Subscale Score

for Sequence= G/UG

Normal Q-Q Plot of Mean Within-Subject Differences in Performance Avoidance (PaV) Subscale Score

for Sequence= UG/G

GLOSSARY OF TERMS

Achievement Goal Theory: a conceptualization of motivation that identifies two types of achievement goals, mastery oriented (sometimes referred to as learning centered or task- oriented) and performance oriented (sometimes referred to as ego-oriented), and that relates these to differences in individuals' perceived ability for the task and their achievement behavior (American Psychology Association, n.d.)

Achievement-Motivation: "the striving to be competent in effortful activities" (Schunk, 2020)

Carryover Effect: an observed treatment or experiment effect that is the result of a preceding treatment or condition (Jones & Kenward, 2014)

Competence: feeling effective and that one can perform a given task; defined in terms of the referent or standard used in performance evaluations; relative to an absolute, intrapersonal, or normative standard (Elliot & McGregor, 2001)

Goal Orientation (or Achievement Goal Orientation): the broad purpose or reason for engaging in a competence-relevant task (Midgley et al., 2001)

Mastery Goals: a goal to develop an ability, or to learn for the sake of learning (Midgley et al., 2001)

Performance Goals: a goal to demonstrate ability, or to avoid the demonstration of lack of an ability (Midgley et al., 2001)

Period Effect: differences in observed effect that are the result of external factors rather than the treatment or condition itself (Jones & Kenward, 2014)

Readiness Assurance Test (RAT): An assessment administered at the start of in-class team-based learning sessions; the readiness assurance test process encompasses both individual (iRAT) and team (tRAT) readiness assurance tests

Team-Based Learning (TBL): an evidence based collaborative learning strategy designed around units of instruction that are taught in a three-step cycle: preparation, in-class readiness assurance testing, and application-focused exercise (Michaelsen et al., 2004)

Treatment Effect: the observed effect resulting from a treatment or experimental condition (Jones & Kenward, 2014)

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