SELF-GENERATED UTILITY VALUE INTERVENTION EFFECTS ON MOTIVATION AND ACHIEVEMENT IN UNDERGRADUATE STATISTICS

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ABSTRACT

This study tested a self-generated utility value intervention aimed at increasing undergraduate statistics students' motivation and achievement. The intervention was based on Situated Expectancy-Value Theory (Eccles & Wigfield, 2020) and encouraged students to make relevant connections between statistics learning content and their lives, primarily emphasising the content's usefulness to the student, or utility value. In testing a self-generated utility value intervention within the domain of undergraduate statistics, the study extended research previously conducted in high school and undergraduate sciences (psychology and biology) and replicated Hulleman et al. (2017) which tested the role of frequency of students' connections between the learning content and their lives in their motivation and achievement. In addition to transferring a self-generated utility value intervention to the domain of statistics, the study's main contribution was made by investigating the role of connection quality—the quality of utility value connections undergraduate statistics students made between the learning content and their lives in their motivation and achievement. The study used collected data from a blindly randomised longitudinal field experiment conducted with undergraduate business school students from a research-intensive university located in the north-eastern USA. The students were of two differing sections of the same 15-week introductory statistics course. The self-generated utility value intervention consisted of prompts, twice during the semester, which instructed students to write 2-3 paragraphs in response to. Data collected was comprised of students' gender, first-generation status, initial/final achievement assessments, pre/post self-reports on motivation (expectancy, cost, intrinsic value, utility value) and connection frequency, and researcher scaled ratings coding on

student intervention responses for connection quality. Part I Results from this study suggest that the intervention significantly increased students' achievement (d = .42)—an approximately 7-percentage point difference between intervention and control group conditions. Furthermore, the intervention was found to be especially effective at increasing at-risk, low initial achievement, students' motivation (expectancy, d = .54) and achievement (d = .87)—an approximately 14.5-percentage point difference between group conditions. Study results also suggest that the intervention's impact on at-risk students' achievement was mediated via motivation increases—through students' expectancy for success, though, not through students' utility value. The Part I results were confirmatory of Hulleman et al.'s (2017) findings—the intervention effected students' achievement, but the pathway of indirect effects traversed through students' expectancy, not their utility value which Hulleman et al. (2017) and this study both hypothesised it would do instead. Part II Results attempted to explain the intervention's pathways of effects through expectancy to achievement by creating new measures, connection quality measures. Connection quality measures were constructed to capture students' utility value more effectively than the self-reported utility value survey measure. This study's Part II Results suggest that the intervention was found, again, to significantly increase students' achievement (d = 1.46), but the indirect intervention effects traversed a pathway to affecting students' achievement, not through their expectancy, but through their utility value (as captured via the newly minted connection quality measures), to their motivation (cost and interest), and then to their achievement. The new connection quality measures, exploratorily, were found to capture students' utility value more effectively than the self-reported utility value survey measure, enabling

the self-generated utility value intervention's effects on students' achievement and motivation to be further explained.

Keywords: *motivation, undergraduate statistics, situated expectancy-value theory, self-generated utility value intervention, connection quality and frequency*

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CHAPTER 1. INTRODUCTION

Statistics, deemed by many to be one of the most salient of undergraduate subjects (Brown & Kass, 2009; Jordan & Haines, 2006), fosters statistical thinking skills by students which enable them to make intelligent decisions on matters of daily life. Considering they are the citizens and future leaders of our information age, the importance of efficiently developing their statistical thinking skills becomes readily apparent. Pfannkuch (1999) and Chance (2002), as well as this study, define statistical thinking as encompassing statistical literacy (understanding and interpreting statistical information), statistical reasoning (ability to use statistical tools and concepts within a course), and being able to apply those tools and concepts outside of the course in an individual's daily life. Although students' development of statistical thinking skills is important, research has found students face numerous challenges while learning to develop said skills. One of the challenges some students face can be low motivation for learning statistics (Garfield & Ben-Zvi, 2004; Ncube & Moroke, 2015; Vaessen et al., 2017).

Low motivation for learning statistics can stem from students having math anxiety, low self-efficacy, and/or due to perceiving statistics as meaningless and irrelevant (Ncube & Moroke, 2015). Theories of motivation provide a means to assess the effectiveness of an intervention intended to promote students' motivation. Interventions promoting students' motivation for learning statistics, and the theory which frames their development, are, therefore, vital elements in bettering students' statistical thinking skills.

One prominent theory of motivation used as a framework to develop interventions is Situated Expectancy-Value Theory (SEVT; Eccles & Wigfield, 2020). This study adopted SEVT as it embraces a holistic approach to motivation by intertwining motivational theories such as Self-Efficacy Theory (Bandura, 1997), Attribution Theory (Weiner, 1985), Self-Worth Theory (Covington, 1992), and Self-Determination Theory (Deci & Ryan, 1985).

The SEVT framework has been used to develop interventions to promote student motivation and achievement most often within the domains of undergraduate sciences (psychology, Hulleman et al., 2010; Canning & Harackiewicz, 2015; Hulleman et al., 2017; biology, Harackiewicz et al., 2016; Canning et al. 2018; Perez et al., 2019; physics, Rosenzweig et al., 2020). SEVT has also been used to promote the same within the domains of high school science (Hulleman & Harackiewicz, 2009) and mathematics (Brisson et al., 2017), community college mathematics (Kosovich et al., 2019), and undergraduate statistics (Acee & Weinstein, 2010). The type of SEVT developed intervention deployed most often to promote student motivation and achievement were *self-generated* utility value interventions.

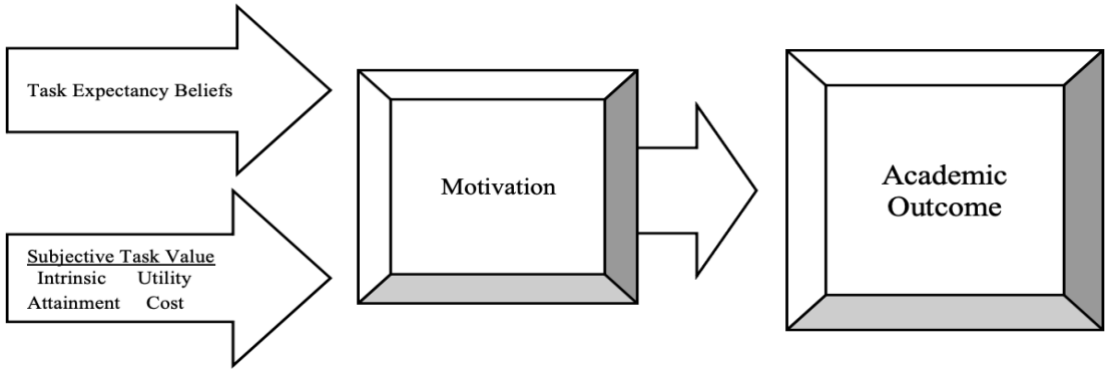
Studies which deployed a self-generated utility value intervention to promote motivation and achievement have found both to increase for high school and undergraduate students. Self-generated utility value interventions have a confirmed history of success within the domain of undergraduate sciences (psychology and biology), and although a single utility value intervention had been extended to the domain of statistics, a *self-generated* utility value intervention had not been. This lack of extension to statistics was especially salient as undergraduate mathematics courses have a

history of high DFW rates (students dropping the course or earning a D/F in the course; Koch & Drake, 2018) as opposed to courses such as psychology and biology—for which the self-generated intervention had been found to be successful for. This study's goals included extending upon the self-generated utility value intervention line of research by applying the motivation and achievement increasing intervention within the high DFW rate domain of undergraduate statistics. Would undergraduate statistics students' motivation and achievement be increased via the self-generated utility value intervention? Another study goal was to replicate Hulleman et al.'s (2017) testing of the role of frequency of undergraduate students' connections between learning content and their lives in their motivation and achievement. Would the frequency of connection construct/measure highlight a pathway navigated by the self-generated utility value intervention's effects? Additionally, this study included within its goals as its main contribution to create and investigate the role of connection quality as a construct with multi-faceted measures. The multi-faceted measures created captured the quality of utility value connections undergraduate statistics students made between learning content and their lives in affecting their motivation and achievement. Would the connection quality construct/measures highlight a pathway navigated by the self-generated utility value intervention's effects? The overarching goal of this study was to advance research on approaches to motivate undergraduate students to achieve in the challenging content area of statistics. Findings garnered via this study enabled the fulfilment of said goals.

CHAPTER 2. SITUATED-EXPECTANCY VALUE THEORY

SEVT originated from Expectancy-Value Theory (EVT). EVT was developed by psychologist John Atkinson (1957, 1964) and describes individuals' motivation for a task as being based on their expectancy (perceived likelihood of achievement), value (perceived positive and negative task achievement incentives—the inverse of likelihood of achievement), and motive (perceived achievement need) for the task. Unlike most modern expectancy-value models, a primary assumption of EVT models was that achievement outcomes were a product function of motivation constructs, expectancy and value (with motive and other constructs also included at times). As such, most early-EVT models assumed a relation between individuals' expectation to achieve and their achievement, with the strength of relation contingent upon individuals' value—greater value, greater strength of relation between expectation to achieve and achievement. Over time EVT has been expanded, redefined, and applied to several fields (i.e., business, communication, health), including the field of education. Eccles et al. (1983) and Eccles (1984) who expanded and re-defined the theory to be applied to the field of education modelled academic outcomes (i.e., achievement) as an additive function consisting of motivation constructs expectancy and value, but with value further defined as four

Figure 1.
SEVT Motivation for an Academic Outcome



distinct value-constructs. Eccles et al. (1983) contextual application of EVT was dubbed Eccles Expectancy-Value Theory (EEVT) and was later re-named Situated Expectancy-Value Theory (SEVT) by Eccles & Wigfield (2020). As such, in this proposal, SEVT mentions encompass work under both the EEVT and SEVT labels.

SEVT describes students' motivation for an academic outcome (i.e., performance-achievement, choice, engagement, etc.) as being based on students' task expectancy and their net subjective task value (derived from four benefit and cost perceptions for a task) as seen in Figure 1. Task expectancy refers to the student's performance beliefs or confidence in their achievement for an educational domain task(s). SEVT posits, students who are confident in their performance for a domain task(s) will achieve or perform with greater results than students who are not as confident. Subjective task value refers to students' four subjective perceptions: intrinsic value, attainment value, utility value, and cost.

The subjective perception of intrinsic value, or interest, attends to the pure joy the student perceives for completing an educational domain task(s). SEVT posits, students who perceive to have greater interest for a domain task(s) are more likely to reengage with the task(s) which furthers their likelihood of greater performance-achievement for the domain task(s). The attainment value subjective perception describes students' perceived importance for completing an educational domain task(s) well. This perceived importance is derived from how the student self identifies. For example, a student who identifies as a "math person" will perceive greater importance for completing mathematical tasks well, as opposed to a student who does not identify as such, because earning good marks on a mathematical task is important to the student who identifies as a

"math person". SEVT posits, students who perceive to have greater importance for completing a domain task(s) well tend to perform better or attain greater achievement outcomes than those who do not. Utility value, as a subjective perception, is defined as students' perceived usefulness for completing an educational domain task(s) towards their short or long-term goals. SEVT posits, students who perceive greater utility value (usefulness) for a domain task(s) produce connections of importance which induce greater extrinsic motivation from students to engage with a domain task(s), therefore increasing their likelihood of greater performance-achievement for a domain task(s). Cost, the fourth of the four subjective perceptions, constitutes students' perceived losses for completing a domain task and is commonly associated with students' perceived opportunity cost (task trade-offs), psychological cost (anxiety), and/or effort cost (effort needed) for completing an educational domain task(s). SEVT posits, students who perceive less cost for a domain task(s) more readily engage with domain task(s), therefore increasing their likelihood of greater performance-achievement for a domain task(s). A summary of definitions for SEVT academic outcome motivation terms are shown within Table 1.

Table 1.
SEVT Academic Outcome Motivation Term Definitions

Term	Definition
Expectancy	A students' performance beliefs or confidence for completing a domain task(s) well.
Intrinsic Value	A students' perceived joy/interest for completing a domain task(s).
Attainment Value	A students' perceived importance for completing a domain task(s) well.
Utility Value	A students' perceived usefulness for completing a domain task(s).
Cost	A students' perceived losses for completing a domain task(s).

SEVT Correlational Research: Motivation Constructs and Achievement—Validation

Expectancy has been found to significantly correlate positively with students' achievement for elementary mathematics in Korea (Bong et al., 2012), middle school language arts in Korea (Bong et al., 2012), middle school/junior high school mathematics in Korea (Bong et al., 2012; Jiang et al., 2018) and the USA (Gilbert et al., 2014; Meece et al., 1990), undergraduate statistics in Australia (Hood et al., 2012), and undergraduate engineering (Platt, 1988), biology (Perez et al., 2019) and chemistry (Perez et al., 2014) in the USA. Thus, as the students self-reported greater performance beliefs, or confidence, for an educational domain task(s), their achievement was greater for the domain task(s) as well, validating the motivation construct of expectancy.

All four subjective perceptions of task value have been found to significantly correlate with students' achievement as well. Intrinsic value, attainment value, and utility value have been found to correlate positively, while cost has been found to correlate negatively. Intrinsic value, attainment value, and utility value correlations with achievement found were within the domains of undergraduate mathematics and science in the USA (Cole et al., 2008). Cost correlations with achievement found were within the domains of junior high school mathematics in Korea (Jiang et al., 2018), and undergraduate mathematics (Flake at al., 2015) and biology (Perez et al., 2019) in the USA. Thus, in respect to an educational domain task(s), students self-reporting greater perceived interest, usefulness, importance for successfully completing, and self-reporting less perceived opportunity, psychological, and/or effort cost attained greater

achievement—validating the motivation constructs of intrinsic value, attainment value, utility value, and cost.

The studies above found motivation constructs (expectancy, cost, intrinsic value, attainment value, and utility value) to significantly correlate with student achievement, but only found said correlations for, at most, three of the five constructs within a single respective study. In one of the only studies to measure all five motivation constructs, Trautwein et al. (2012) found each to significantly correlate with German high school students' achievement in mathematics and English. Correlations were positive for each of the five constructs of motivation sans cost which correlated negatively. Summary findings of all SEVT correlational research reviewed on students' motivation (expectancy, cost, intrinsic value, attainment value, utility value) and achievement can be found on the following page within Table 2.

SEVT Rebrand

An area of the theory which has been accentuated as of late concerns students' expectancy and situated task value person centred sources of influences—students' situatedness. Simply put, students' situatedness, or social positionality, refers to their environmental and demographical moderating variables. Accentuation of students' situatedness within the theory led Eccles & Wigfield (2020) to re-brand/rename the theory from EEVT to that of SEVT.

Through rebranding, SEVT highlights the social setting, and the idea of student situated difference to emphasise, in ways EEVT hadn't previously, that varying social settings, demographics, and domain task(s) may affect students' expectancy and situated task value (Eccles & Wigfield, 2020). Empirically capturing students' situated

Table 2.

Correlational Research on Students' Motivation and Achievement

Study	Motivation Correlating w/Achievement, p-value		Motivation Measured (Student Reported)	Achievement Measured	Sample Size
Bong et al., 2012	Expectancy	$p < .001$	Mid-semester, ratings (1-5) on 4-questions, Bandura Survey.	Mid-semester class grade.	227
Bong et al., 2012	Expectancy	$p < .001$	Mid-semester, ratings (1-5) on 4-questions, Bandura Survey.	End of semester mid-term exam.	507
Jiang et al., 2018	Cost Expectancy	$p < .05$ $p < .01$	Week-1 and Week-7, ratings (1-7) on 6-expectancy and 12-cost questions, Motivation Strategies for Learning Questionnaire (MSLQ) and Jiang Survey.	Mid-term exam, Week-9.	211
Gilbert et al., 2014	Expectancy	$p < .001$	Before SAT-10 administered, ratings (1-5) on 3-questions, Patterns of Adaptive Learning Scale (PALS).	End of year state-assessed standardised test (Stanford Achievement Test, SAT-10)	979
Meece et al., 1990	Expectancy	$p < .05$	Before SAT-10 administered, ratings (1-7) on 3-questions, Student Attitudes Questionnaire (SAQ).	End of year class grade, year-1 and 2.	250
Hood et al., 2012	Expectancy	$p < .05$	1st day of semester course, ratings (1-7) on 3-questions, Hood Survey.	End of semester course grade.	149
Platt, 1988	Expectancy	$p < .05$	1st day of semester course, ratings (0-4) on 2-questions, Platt Survey.	Semester GPA.	208
Perez et al., 2014	Expectancy	$p < .05$	Before Exam I and after Exam III, ratings (1-6) on 5-questions, Success and Abilities Beliefs Scale.	Course grade after Exam I and before Final.	363
Perez et al., 2019	Cost Expectancy	$p < .02$ $p < .001$	Before Exam I and after Exam III, ratings (1-6) on 4-expectancy and 14-cost questions, Success and Abilities Beliefs Scale and Perez Survey.	End of semester course grade.	234
Cole et al., 2008	Utility Intrinsic Attainment	$p < .001$ $p < .01$ $p < .001$	After CollegeBASE Exam, ratings (0-6) on 3-utility, 2-interest, and 5-attainment questions, Motivation Strategies for Learning Questionnaire (MSLQ) and Student Opinion Survey.	CollegeBASE Exam taken after general education requirements completed.	1005
Flake et al., 2015	Cost Expectancy	$p < .01$ $p < .01$	Week-5 and Week-15, ratings (1-9) on 4-expectancy and 19-cost questions, Flake Surveys.	End of semester course grade.	95
Trautwein et al., 2012	Utility Intrinsic Attainment Cost Expectancy	$p < .001$ $p < .001$ $p < .001$ $p < .001$ $p < .001$	Before TIMSS Exam administered, ratings (1-4) on 4-expectancy, 2-utility, 5-intrinsic, 3-attainment, and 2-cost questions, Self-Description Questionnaire III (SDQ-III) and Expectancy-Value Theory (EVT) Survey.	Third International Mathematics and Science Study (TIMSS) Exam.	2,508

differences and the roles they play in students' expectancy and situated task value can help design more effective interventions to promote equitable academic outcomes. Majority of EEVT correlational studies have addressed students' contextual characteristics, while many EEVT experimental studies have not—instead concentrating on EEVT's original focus. In short, SEVT, in name, is more encompassing of the original theory's intent—aptly re-named to denote the saliency of situated differences in students' expectancy and situated task value for a domain task(s) which EEVT experimental studies have not been attending to—typically discounting them.

CHAPTER 3. SEVT EXPERIMENTAL RESEARCH

SEVT experimental studies focus on manipulating a motivation construct to increase students' motivation and academic outcomes but focus amongst the constructs has not been equal. A large majority of SEVT interventions focus on manipulating students' utility value to increase their motivation and academic outcomes. Expectancy and intrinsic value manipulations account for the largest share of the minority (Harackiewicz & Priniski, 2018-review). Relatively few have focused interventions on manipulating cost. As of 2020, attainment value had yet to be the primary focus of a published experimental study (Wigfield & Eccles, 2020), although one study (Johnson and Sinatra, 2013) did use an attainment value intervention to affect students' motivation and achievement in a comparison study between interventions.

Relatively little research has gauged the effects of SEVT on students' motivation and achievement through interventions (Hulleman et al., 2017). Acknowledging this empirical need along with the study's overarching goal, this study deployed a SEVT based intervention to students within the high DFW rate domain of undergraduate statistics and assessed its effects on their motivation and achievement. For the study to accomplish this endeavour successfully, applicable SEVT based intervention research gauging the effects on students' motivation and achievement, which used students as the pathway, was reviewed. Upon completion of the review, determinations were made which moulded the deployment of the SEVT based intervention and the type of data which was collected for this study. The four determinations made were 1) the motivational construct to attempt manipulation with via an intervention, 2) the type of

intervention to deploy to students, 3) the motivation constructs to measure alongside achievement, and 4) which moderators to consider.

SEVT Construct Manipulation: Effects on Motivation and Achievement

Intervention research published attempting to effect students' motivation and achievement via the manipulation of an SEVT construct is shown within Table 3. Almost all of the interventions focused on manipulating students' utility value (Acee & Weinstein, 2010; Brisson et al., 2017; Canning & Harackiewicz, 2015; Canning et al., 2018; Harackiewicz et al., 2016; Hulleman & Harackiewicz, 2009; Hulleman et al., 2010; Hulleman et al., 2017; Johnson & Sinatra, 2013, Intervention 1; Kosovich et al., 2019; Rosenzweig et al., 2020, Intervention 1). Three exceptions to the trend were noted though. Exceptions included attempts to manipulate attainment value (Johnson and Sinatra, 2013, Intervention 2) and cost (Rosenzweig et al., 2020, Intervention 2; Perez et al., 2019).

Attesting to the demonstrated efficacy of utility value interventions, the intervention deployed for this study focused on manipulating students' utility value to affect students' motivation and achievement within undergraduate statistics. This study is the first of its kind to introduce an effective *self-generated* utility value intervention to the domain undergraduate statistics. As challenges for the domain included garnering one of the highest DFW rates historically and to be that of low motivation, due to students perceiving statistics as meaningless and irrelevant, the manipulation of students' utility value (meaningfulness, relevancy, usefulness) for statistics was theoretically befitting for rectification endeavours.

Table 3.

Experimental Research Attempting to Effect Students' Motivation and Achievement

Study	Level & Domain	SEVT Intervention(s)	Motivation Constructs	M & A Effected	Findings
Hulleman & Harackiewicz, 2009	HS Science	SG (Utility)	Utility (initial), Intrinsic, Expectancy (initial)	M A	Intervention effected students' intrinsic value and achievement, when moderated by their initial expectancy.
Hulleman et al., 2010	UG Psychology	SG (Utility)	Utility, Intrinsic	M	Intervention effected students' utility value and intrinsic value, when moderated by their initial achievement. Greater student utility value was associated with greater student achievement.
Acee & Weinstein, 2010	UG Statistics	DC (Utility, Attainment, and Intrinsic)	Utility, Intrinsic, Attainment, Expectancy	M	Intervention effected students' utility-attainment-intrinsic values.
Johnson & Sinatra, 2013	UG Lab	SG (Utility) SG (Attainment)	Utility, Attainment	M A	Both interventions were found to affect their intended student motivation construct, utility value or attainment value, qualitatively. Both effected students' achievement. SG (Utility) had significantly greater change in students' achievement compared to alternate SG.
Canning & Harackiewicz, 2015, Study 1	UG Psychology	SG (Utility) DC (Utility)	Utility, Intrinsic, Expectancy (initial)	M A	Both interventions effected students' utility value when moderated by their expectancy. SG had a weak effect on students' intrinsic value in comparison to DC when moderated by their expectancy. SG effected students' achievement in comparison to DC and effected students' achievement more in comparison to DC when moderated by their expectancy. SG effected students' achievement in comparison to control when moderated by their expectancy.
Canning & Harackiewicz, 2015, Study 2	UG Psychology	SG (Utility) DC (Utility) SG + DC (Utility)	Utility, Intrinsic, Expectancy (initial)	M A	SG effected students' utility value and intrinsic value. SG + DC effected students' utility value, intrinsic value, and achievement, when moderated by their initial expectancy.
Harackiewicz et al., 2016	UG Biology	SG (Utility)	Utility, Intrinsic (initial), Expectancy (initial)	M A	Intervention found to effect students' utility value, qualitatively. Intervention effected students' achievement and effected additionally when moderated by prior GPA or URM/FG status.
Brisson et al., 2017	HS Mathematics	SG + DC (Utility) AT + DC (Utility)	Utility, Expectancy	M A	Both interventions effected students' utility value. AT + DC effected students' expectancy and achievement.
Hulleman et al., 2017	UG Psychology	SG (Utility)	Utility, Intrinsic, Cost, Expectancy	M A	Intervention effected students' expectancy and achievement. Intervention effects on students' achievement mediated by intervention effects on students' expectancy. Intervention effected students' achievement more when moderated by their initial achievement.
Canning et al. 2018	UG Biology	SG (Utility)	Utility, Intrinsic (initial)	M A	Intervention found to effect students' utility value, qualitatively. Intervention effected students' achievement.
Kosovich et al., 2019	CC Mathematics	SG + DC + AT (Utility)	Utility, Intrinsic, Attainment, Cost, Expectancy	M A	Intervention effected students' utility value and achievement.
Perez et al. 2019	UG Biology	LS (Cost) DC (Cost) LS (Cost) + DC (Cost)	Utility, Intrinsic, Cost, Expectancy		All three interventions did not affect students' motivation or achievement.
Rosenzweig et al., 2020	UG Physics	AT (Utility) AT (Cost)	Utility, Cost, Expectancy	M A	Both interventions effected students' expectancy and achievement. Both interventions effected students' expectancy, cost, and achievement when moderated by students' initial achievement.

Note. Level is coded: UG = Undergraduate, CC = Community College, HS = High School. Intervention is coded: DC = Direct Communication, SG = Self-generated, AT = Associated, LS = Learning Strategies. M = Effects on motivation found. A = Effects on achievement found. URM = Under-represented minority. FG = First-generation college student.

Utility Value Intervention Types

Of the utility value intervention research published, attempting to effect students' motivation and achievement (12-studies), differing types of utility value interventions deployed to students were noted. The differing intervention types, and quantity of each, consisted of 3-directly communicated utility value interventions, 8-self-generated utility value interventions, 1-associated utility value intervention, and 4-utility value interventions combining two or three of the types previously listed. Directly communicated utility value interventions inform students about the relevancy of a domain task(s) as it connects to their lives (Acee & Weinstein, 2010). Self-generated utility value interventions employ relevance essays prompting students to generate their own relevancy of a domain task(s) as it connects to their lives (Hulleman & Harackiewicz, 2009). Associated utility value interventions employ former students' quotations on a domain task's relevance prompting students to associate the quotations with their own relevancy of a domain task(s) as it connects to their lives (Brisson et al., 2017). Two of the four utility value intervention combinations included self-generated and directly communicated utility value (Canning & Harackiewicz, 2015; Brisson et al., 2017), a third combination was three-pronged as it also included associated utility value (Kosovich et al., 2019), and the fourth only included associated and directly communicated utility value (Brisson et al., 2017). Study methods, intervention deployments, and data collection details for all utility value intervention studies have been consolidated and can be found within Table 5**.** The question was, do the interventions effect students' motivation and achievement differently; do the interventions have varying efficacies?

Directly Communicated Utility Value Intervention Research. Acee & Weinstein (2010) deployed a directly communicated utility-attainment-intrinsic value intervention to effect students' motivation and achievement within the domain of undergraduate statistics. The intervention consisted of messages communicated to students dispersed between problems within a single online assignment, completed during class. The motivational messages directly communicated the importance of statistics in everyday life (to increase attainment value), academics and professional settings (to increase utility value), and how it's purely fun to learn (to increase intrinsic value). An example (synopsis) of each can be found within Table 4. Although the intervention did affect the students' intrinsic-attainment-utility value motivation measure ($p < .01$, $d = .36$) it was unsuccessful in affecting students' achievement.

Another directly communicated utility value intervention study exists (Rozek et al., 2017), but the intervention used early high school students' parents as the pathway for the intervention—not the students. The two-generation, parent and child, intervention consisted of brochures, and a website, mailed/offered to the parents, touting the utility value of STEM courses. The authors hypothesised that the materials provided to parents would affect parents' utility value for STEM courses and communication between

Table 4.
Synopsis of Examples: Messages Directly Communicated to Effect Students' Motivation

Motivation	Synopsis of Example
Intrinsic Value	Message 6 of 7 (244 words) directly communicated challenging, interesting, and enjoyable aspects of statistics. Directly communicated how associating negativity with statistics learning can decrease enjoyment.
Attainment Value	Message 2 of 7 (453 words) directly communicated reasons it may be personally important to learn statistics, perform well on assessments, and master its associated skills.
Utility Value	Message 5 of 7 (136 words) directly communicated the usefulness of developing statistical knowledge and skills by showing how statistics are used in various careers.

parents and their early high school children about STEM courses' utility value. They additionally hypothesised that affects to parents' utility value and communication with their children would affect students' utility value, and then students' achievement—five years after the initial investigation. Results indicated that the intervention did affect low initial GPA students' utility value ($p < .05$, $d = .33$) and students' achievement (ACT scores, $p < .05$, $d = .19$). The two-generation intervention study serves as evidence highlighting another pathway, for students in their early high school years, to affect students' motivation and achievement via a utility value intervention.

In sum, directly communicated utility value interventions deployed to students to affect their motivation and achievement have not yielded a successful study to date—students' achievement has yet to be affected alongside students' motivation. Furthermore, directly communicated, deployed to student, utility value interventions were not only ineffective, but they were ineffective for the very domain this study was to be carried out within—undergraduate statistics.

Self-Generated Utility Value Intervention Research. Hulleman and Harackiewicz (2009) investigated whether a self-generated utility value intervention deployed a couple days before each class exam (See **Appendix A** and **Appendix B** for an example) effected high school science students' intrinsic value and achievement. The self-generated utility value intervention was deployed a couple days before each class exam and consisted of students responding to prompts with 1-paragraph essays on how the material they were learning was connected/relevant to their daily lives. Although students' achievement is an important outcome to promote, intervention effects on students' motivation (interest) were sought by the authors as well, as students' interest

Table 5.
Study Methods: Utility Value Intervention Deployments and Data Collection Details

Study	n	Intervention Deployment	Motivation Measured	Achievement Measured
Hulleman & Harackiewicz, 2009	262	SG (x4).: Before each exam.	Beginning of semester (pre) and end of semester (post), ratings (1-7) on 2-expectancy (initial only), 3-intrinsic, and 3-utility (initial only) questions, Harackiewicz Questionnaire. .	End of semester course grade.
Hulleman et al., 2010	318	SG (x2): Week-10 and Week-12.	Beginning of semester (pre) and end of semester (post), ratings (1-7) on 5-intrinsic and 3-utility questions, Harackiewicz Questionnaire.	Mid-term exam (initial) and end of semester course grade.
Acee & Weinstein, 2010	82	DC (x1): Week-6 during an online class assignment.	Pre and post the Week-6 online class assignment, and a delayed post Week-8, ratings (1-7) on 7-expectancy, 2-intrinsic, 2-utility, and 2-attainment questions, Motivation Strategies for Learning Questionnaire (MSLQ) and Perceived Academic Confidence Scale.	Week-3 course exam (initial) and Week-12, course exam.
Johnson & Sinatra, 2013	160	SG (x1): Laboratory task.	Pre and post the laboratory task, ratings (1-7) on 6-utility and 6-attainment questions, Johnson adapted Motivation Strategies for Learning Questionnaire (MSLQ).	Laboratory task test (x2, pre and post the laboratory task).
Canning & Harackiewicz, 2015, Study 1	88	SG (x1) and DC (x1): During single class session.	Pre and post bookends to class session, ratings (1-7) on 3-expectancy (initial only), 4-intrinsic, and 5-utility questions, Harackiewicz Questionnaire.	Session test (x2, pre and post following motivation measurements.
Canning & Harackiewicz, 2015, Study 2	113	SG (x1), DC (x1), and SG + DC (x1): During single class session.	Pre and post bookends to class session, ratings (1-7) on 3-expectancy (initial only), 4-intrinsic, and 5-utility questions, Harackiewicz Questionnaire.	Session test (x2, pre and post following motivation measurements.
Harackiewicz et al., 2016	1,040	SG (x4): 3-weeks before each exam.	Week-2 (pre) and after final exam (post), ratings (1-7) on 5-expectancy, 5-intrinsic, and 4-utility questions, Harackiewicz Questionnaire.	Prior GPA (initial) and end of semester course grade.
Brisson et al., 2017	1,916	AT + DC (x1) and SG + DC (x1): During single class session.	Beginning of semester (pre), 6-weeks after intervention (post), and 5-months after intervention (delayed post), ratings (1-4) on 5-expectancy and 12-utility questions, Baumert Questionnaire and Gaspard Questionnaire.	State of Baden-Wu¨rttemberg standardised Grade-9 test (initial) and 3-minute speed test (post, 5-months after intervention).
Hulleman et al., 2017	357	SG (x2): Following the 1st and 2nd exams.	Week-2 (pre) and Week-14 (post), ratings (1-8) on 4-expectancy, 9-intrinsic, 6-cost, and 6-utility questions, Kosovich Questionnaire and Harackiewicz Questionnaire.	First course exam (initial) and end of semester course grade.
Canning et al. (2018)	577	SG (x4): 3-weeks before each exam.	Week-2 (pre) and after final exam (post), ratings (1-7) on 5-intrinsic questions, Kosovich Questionnaire.	Prior GPA (initial) and end of semester course grade.
Kosovich et al., 2019	177	AT + SG + DC (x1): During single class session, Week-3/4.	Week-2/3 (pre) and Week-14/15 (post), ratings (1- 5) on 3-expectancy, 3-intrinsic, 4-cost, 3-attainment, and 2-utility questions, Kosovich Questionnaire and Harackiewicz Questionnaire.	Course pass rates.
Rosenzweig et al., 2020	148	AT (x2): 3-weeks before 2nd exam and 6-weeks before 3rd exam.	After intervention and end of semester, ratings (1-7) on 5-expectancy, 15-cost, and 2-utility questions, Eccles Questionnaire and Flake Questionnaire.	First course exam (initial) and end of semester course grade.

Note. Intervention is coded: DC = Direct Communication, SG = Self-Generated, AT = Associated.

better predicts student retention for a domain compared to students' achievement (Harackiewicz et al., 2002). Greater student interest leads to greater student retention for a domain.

Results indicated that the intervention was successful in effecting at-risk students' interest ($p = .05$, $d = .18$) and achievement ($p < .03$, $d = .30$). The authors defined a student to be at-risk if they had initial low expectations for success (low confidence) due to research (Eccles et al, 1983; Updegraff et al., 1996) finding low student expectancies led to lower student achievement, interest, and persistence for a domain task(s). Students who had initial low expectations for success (low confidence) benefited from the intervention's effects on students' interest and achievement—effectively closing the achievement gap between initial low/high expectancy psychology students.

Hulleman et al. (2010) investigated whether a self-generated utility value intervention effected undergraduate psychology students' intrinsic value (interest), utility value, and achievement. Utility value had not previously been measured for change within a self-generated utility value intervention study attempting to effect motivation and achievement. The intervention was like Hulleman and Harackiewicz's (2009) but was deployed twice during the semester (Week-10 and Week-12) and consisted of students responding to prompts with 1-page essays on how the material they were learning was connected/relevant to their daily lives. The authors hypothesised that the relevance generating intervention would increase at-risk (low-initial achievement) students' utility value for the material they were learning, which would also be associated with the intervention's effects on students' interest and achievement. At-risk students were previously identified as low-initial expectancy, but both low-initial expectancy,

prior GPA, and low-initial achievement are used to identify at-risk students. Study method and environment typically dictate which measure is the viable option for a particular study—with initial achievement measured often as the factor captures at-risk students most effectively (Harackiewicz et al, 2016).

Results indicated that the intervention was successful in effecting at-risk students' utility value ($p < .01$, $d = .23$) and intrinsic value ($p < .05$, $d = .20$). Additionally, utility value increases were associated with higher student intrinsic value (standardised ß = .61, $p < .01$) and achievement (standardised ß = .33, $p < .01$). Thus, the authors deemed the self-generated utility value intervention to be successful at promoting at-risk students' interest and achievement through the intervention's effects on students' utility value. Effectively, the self-generated utility value intervention closed the achievement gap between initial low/high achievement psychology students.

The two studies complement one another in demonstrating a self-generated utility value intervention can be effective at promoting at-risk students' intrinsic value and achievement and can do so within differing levels of a domain (high school and undergraduate, sciences). The Hulleman et al. (2010) finding of effected utility value as the responsible party for the promoting of at-risk students' intrinsic value and achievement seems intuitive, but its role would need to be confirmed through future research—research found below.

Studies since Hulleman et al. (2010) have deployed self-generated utility value interventions as well, with slight differences, though, to the quantity and length of intervention sessions. Johnson and Sinatra (2013) and Canning and Harackiewicz's (2015) intervention deployments consisted of short single class session's bookended with

their pre/post measures. Harackiewicz et al. (2016) and Canning et al.'s (2018) deployments were more akin to Hulleman and Harackiewicz (2009) where the intervention consisted of multiple sessions across a semester course with much more length between pre/post measures. Each session, across the studies, consisted of students responding to prompts with short essays on how the material they were learning was connected/relevant to their daily lives. Regardless of the slight differences amongst study's quantity of intervention sessions and their lengths, each found self-generated utility value interventions to effect students' utility value, albeit qualitatively aside from Canning and Harackiewicz (2015), $p = .03$, $d = .19$. Although intrinsic value effects were found within Hulleman & Harackiewicz (2009) and in Hulleman et al. (2010), only one of the four deployments, measured the motivation construct. When measured, though, it too was confirmed to be affected due to a self-generated utility value intervention (Canning & Harackiewicz, 2015, $p = .02$, $d = .20$). The four self-generated utility value intervention deployments confirmed significant student achievement effects (Johnson & Sinatra, 2013, $p = .01$, $d = 1.10$; Canning et al. 2018, $p < .01$, $d = .26$) and significant at-risk student achievement effects, as well (Canning & Harackiewicz, 2015, $p = .01$, $d = .59$; Harackiewicz et al., 2016, $p < .001$, $d = .55$). Amongst the four self-generated utility value intervention deployments, domain level replication transpired for undergraduate sciences in finding students' utility value, intrinsic value, and achievement to be affected.

Researchers further distinguished the effectiveness of deploying a self-generated utility value intervention to effect student motivation and achievement by comparing it to other interventions as well. Within Johnson and Sinatra (2013), a self-generated utility value intervention was compared to a self-generated attainment value intervention.

Findings show each effected students' achievement (utility value intervention, p = .01, *d* = 1.10; attainment value intervention, p = .03, *d* = .49), but when compared to one another directly, significant student achievement differences were present for the self-generated utility value intervention (p = .01, *d* = .56). Within Canning and Harackiewicz (2015), a self-generated utility value intervention was compared to a directly communicated utility value intervention. Results show the directly communicated utility value intervention effected neither students' utility value, intrinsic value, or achievement. On the other hand, the self-generated utility value intervention effected students' utility value (p = .03, *d* = .19), intrinsic value (p = .02, *d* = .20), and at-risk students' achievement (p = .01, *d* = .59). Furthermore, when the two interventions were compared specifically to one another, significant at-risk student achievement differences were present for the self-generated utility value intervention (p = .03, *d* = .41)—*signifying the importance of at-risk students putting the utility value of a domain task(s) in their own words (self-generated) for it to significantly affect their achievement*.

Directly communicated utility value may not be entirely ineffective, though, as Canning and Harackiewicz (2015) also found that a combination of interventions creating a self-generated plus directly communicated utility value intervention can affect at-risk students' utility value (p < .03, *d* = .21), intrinsic value (p < .02, *d* = .23), and achievement (p < .02, *d* = .21) better than deploying a standalone self-generated utility value intervention. Across the six self-generated utility value intervention studies (Johnson and Sinatra, 2013; Canning and Harackiewicz's, 2015; Harackiewicz et al., 2016; Canning et al. 2018; Hulleman & Harackiewicz, 2009; Hulleman et al., 2010) student utility value, intrinsic value, and achievement were effected each time they were

measured—self-generated utility value interventions have been confirmed to be successful within the domain of sciences, at both the high school and undergraduate levels, and to be better at effecting undergraduate students' motivation and achievement when compared to alternative interventions.

Associated Utility Value Intervention Research. Brisson et al. (2017) compared how two differing interventions effected high school mathematics students' utility value, expectancy, and achievement. Expectancy had not previously been measured for change within a SEVT study attempting to effect motivation and achievement—prior studies had only measured students' initial expectancy, if at all. The two interventions compared were that of a self-generated utility value plus directly communicated utility value intervention and an associated utility value plus directly communicated utility value intervention. The associated utility value intervention, within its intervention combination, consisted of students reading and responding to other classmates' quotations on a domain task's relevance. Students responded by associating the quotations, via ranking, with their own relevancy of a domain task(s) as it connected to their lives.

Results comparing the interventions found each to effect students' utility value (SG + DC, $p = .01$, $d = .14$; AT + DC, $p < .001$, $d = .30$), but only the intervention combination including associated utility value significantly affected students' expectancy ($p < .02$, $d = .10$) and achievement ($p < .01$, $d = .18$) as well. Although this study doesn't directly compare an associated utility value intervention with a self-generated utility value intervention, this finding does provide preliminary evidence showing that an associated utility value plus directly communicated utility value intervention may be

more effective than a self-generated utility value plus directly communicated utility value intervention, at least for the domain level of high school mathematics. Regardless, even preliminary findings showing an associated utility value intervention combination to be more effective than a type of combination including a utility value intervention which has a well-established history of success, is impressive, and should demand more attention from educational researchers.

Like Brisson et al. (2017), Kosovich et al. (2019) combined utility value interventions (associated utility value and directly communicated) into one, but they also combined a self-generated utility value intervention creating an associated plus directly communicated plus self-generated utility value intervention. Results from the combined three-pronged utility value intervention found community college mathematics students' utility value ($p = .01$, $d = .38$) and achievement ($p = .04$, $d = .39$) to be affected. Interestingly, Kosovich et al. (2019) is the first and only published motivation and achievement experiment which employed measures to collect all five main motivational constructs of SEVT (utility value, intrinsic value, attainment value, cost, expectancy).

A single standalone associated utility value intervention was deployed within the domain of undergraduate physics (Rosenzweig et al., 2020). They measured to detect effects to students' utility value, cost, expectancy, and achievement, but only students' expectancy ($p = .04$, $d = .15$) and achievement ($p < .01$, $d = .24$) were affected via the associated utility value intervention. When considering moderation by initial achievement, though, the intervention effected at-risk students' expectancy ($p = .01$, $d = .15$), cost ($p = .01$, $d = .20$), and achievement ($p < .001$, $d = .81$). Although the associated utility value intervention has found promising preliminary effects when combined with

others, and even as a standalone, replication within a domain or a level of education has yet to occur for the associated utility value intervention or any of its combination of interventions which include associated utility value.

Utility Value Intervention: Directly Communicated, Self-Generated, or Associated?

First and foremost, a directly communicated, deployed to student, utility value intervention was instantly ruled out as none had effectively affected students' motivation and achievement to date. With directly communicated utility value interventions ruled out, the question which remained was, which, between self-generated and associated, had been the most effective utility value intervention? Neither had been extended to the high DFW rate domain of undergraduate statistics—or any level of statistics. Each of the interventions compared to a control were found to significantly increase student motivation and achievement.

Differences found between the two interventions included, only the self-generated utility value intervention effected undergraduate students' motivation and achievement in comparison to another utility value intervention (directly communicated) and confirmed the finding with a follow up study. Although an associated utility value intervention hadn't been directly compared to a self-generated utility value intervention, an associated utility value plus directly communicated utility value intervention was compared to a self-generated utility value plus directly communicated utility value intervention, and the intervention combination including associated utility value was found to be more effective than the intervention combination including self-generated utility value at promoting high school students' achievement, but lacked a follow up study. Comparisons between the standalone self-generated and associated, utility value interventions, within

any domain or level of education have yet to occur. Domain and/or domain-level confirmatory studies for the associated utility value intervention, or its combinations, have not been carried out. Confirmatory studies have been carried out for the self-generated utility value intervention within a specific domain (undergraduate sciences) and across levels of a domain (high school and undergraduate, sciences).

In considering the compilation of studies in their entirety, associated utility value interventions showed promise, while self-generated utility value interventions had a confirmed history of success. As such, the study herein deployed a self-generated utility value intervention to affect students' motivation and achievement within the high DFW rate domain of undergraduate statistics.

Extending Self-Generated Utility Value Intervention Research to Undergraduate Statistics

Once a self-generated utility value intervention was planned to be extended to the domain of undergraduate statistics, a review of the intervention's most explanatory deployment commenced. That deployment, Hulleman et al. (2017), built upon their previous 2009 and 2010 studies by replicating them while investigating a possible mechanism for the self-generated utility value intervention's success in effecting students' utility value, intrinsic value, and achievement. The authors theorised that the utility value intervention, being a relevance intervention, effected students' utility value, and later their intrinsic value (interest) and achievement, due to increasing the connections made by students between the course's material and their lives. Thus, the authors operationalised the construct *connection frequency* to measure the frequencies in which students connected the material to their lives either during lecture, while reading

the textbook, or as they studied for an exam. The authors also measured motivation constructs expectancy and cost—which, in 2017, had not been investigated in previous self-generated utility value intervention studies attempting to enhance students' motivation and achievement.

Results indicated that the self-generated utility value intervention was, again, successful in increasing at-risk students' achievement ($p < .01$, $d = .82$), but their motivation was affected differently than had been observed in previous investigations. Previous investigations found the intervention to effect students utility value and interest, but expectancy was not previously tested. With expectancy included in the investigation it was found to be affected by the intervention instead of utility value and interest for at-risk students ($p < .05$, $d = .22$). Students' expectancy was also found to mediate the intervention's effect on at-risk students' achievement ($\omega = .15$, 95% CI [0.019, 0.322]), instead of utility value as had also been found in previous investigations. Again, students' expectancy had not been previously analysed as a potential pathway for the intervention's effects— necessitating a confirmatory study which is addressed by this study.

Considering Hulleman et al. (2017) findings, this self-generated utility value intervention study measured students' connection frequencies to further validate the construct. Gender, first-generation (FG), and initial achievement were further scrutinised as moderators of the intervention's effect on students' motivation and achievement within this study as well—as at-risk students particularly benefited from self-generated utility value interventions within Hulleman et al. (2009, 2010, 2017), Canning and Harackiewicz (2015), and Harackiewicz et al. (2016). This study also provided a secondary, if not confirmatory, study regarding students' expectancy for the

undergraduate level, as motivation was measured through not only utility value and interest but through expectancy and cost as well. Summed, this study replicated Hulleman et al. (2017) within a high DFW rate domain, but also addressed pathway limitations noted by Hulleman et al. (2017).

Potential Pathways for Intervention Effects: Connection Frequency and Connection Quality

Hulleman et al. (2017) noted as a limitation that their *connection frequency* measure, newly minted for their study, needed further validation—this study addressed by providing the needed validation. Another limitation noted by the authors was their connection frequency measure lacked operationalisation which captured the quality of the connections students were making—this study addressed this limitation as well. This study addressed via researcher ratings scale coding of students' intervention responses—their short relevance essay prompt responses. Coding student intervention responses for their quality of connections enabled a deeper dive into the intervention's effects on students' motivation and achievement—as it was suspected that connections of higher quality, as opposed to lower, would elicit greater intervention effects on students' motivation and achievement. In coding the intervention responses for connection quality (CQ) , the measures CQ *statistical literacy usefulness,* CQ *statistical thinking usefulness,* CQ *accuracy,* CQ *effort,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity* were newly minted. The new measures captured the quality of connections undergraduate statistics students made between the learning content and their lives.

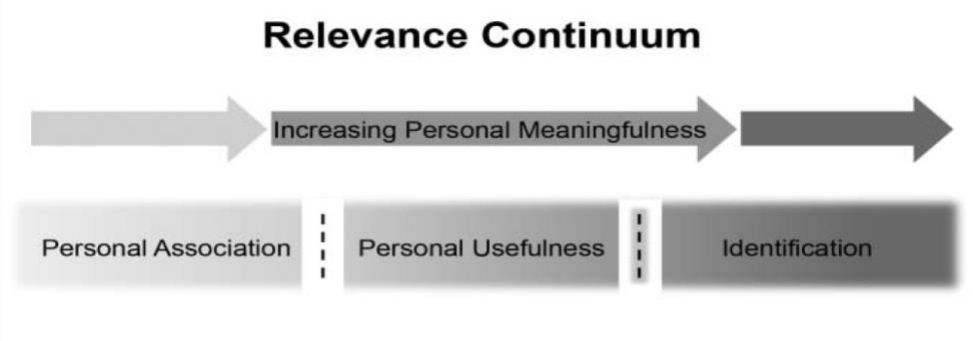
Connection Quality. Although students' frequency of utility value connections from learning content to their lives is important, it is more important to understand the

quality of the utility value connections students are making from learning content to their lives. There are, at least, a couple reasons for this. One, higher quality utility value connections are expected to benefit students more than lower quality utility value connections. As such, measuring students' higher frequency of utility value connections may not be meaningful if the utility value connections are of lower quality. Two, although this study's intervention targeted students' utility value (a type of relevance), the intervention prompted students to self-generate connections of this type of relevance. Self-generating relevant connections can sometimes result in students generating connections of differing types of relevance, that of lower or higher quality relevance.

Knowing the type of relevance connection, or quality of relevance connection, generated by students via the intervention, then, accomplishes a few additional items. We can determine if the intervention is working appropriately—are students generating the relevance connections the intervention was aiming to generate? If not, we could, then, knowingly adjust and test the intervention until precision was achieved in some respect—adjusting for precision or for a differing population of student. We could, also, determine if differing types (lower/higher quality) of relevance connections use differing pathways to effect students' motivation and achievement.

As this study's intervention aimed to promote student generated utility value connections, a type of relevance connection, an approach to measure the aim of the intervention was to measure the differing types of relevance students generate. With that said, the connection quality measures created were defined to capture the quality of the relevance connections students made. Furthermore, relevance was defined as Priniski et al. (2018, p.12) proposed, "relevance: a personally meaningful connection to the

Figure 2.
Priniski et al.'s (2018) Relevance Continuum of Personal Meaningfulness



individual". Priniski et al.'s (2018) definition continues, "relevance is personal" and "relevance is meaningful" and conceptualises a relevance continuum of personal meaningfulness (see Figure 2).

The continuum denotes the levels of quality relevance from personal association as relevance, to personal usefulness as relevance (utility value), to identification as relevance, but each can be lower/higher levels of personal meaningfulness—personal value. As such, *connection quality* measures were defined on ratings scales, guided, in part, by Priniski's definition of relevance, which captured the type of statistics usefulness and contextualised personalness of connections students made within their intervention prompt responses.

Analysis was two-fold. First this study replicated the analytical process undergone by Hulleman et al. (2017) to serve as a confirmatory study. Second, this study added as its main contribution to the literature via the analysation of the new connection quality measures alongside the Hulleman et al. (2017) replicated study variables. Exploratory analysis including the new measures provided findings on how the quantity and quality of the connections undergraduate statistics students made were important to their motivation and achievement. Deployment of the intervention to undergraduate statistics extended the line of research on self-generated utility value interventions domain wise, as well.

In extending the line of research on self-generated utility value interventions to the high DFW rate domain of undergraduate statistics, an agenda for the domain level was produced for the intervention (see **Appendix C**). This study will be the first of its kind, domain wise, and is labelled in Row 1 of Table Appendix C as the PRCS study (Prompting Relevant Connections in Statistics study). As the agenda foretells, a confirmatory study of the PRCS's findings is next in line and will be dubbed PRCS II. In replicating Hulleman et al. (2017), intervention effects were not measured for students' attainment value for the PRCS and won't be for the PRCS II either but will be included thereafter—as seen within Row 2 of Table Appendix C (Motivation Constructs). Doing so will make it, presumably the PRCS III, the first of its kind to investigate self-generated utility value intervention effects on students' achievement and all five main motivational constructs of SEVT (utility value, interest, attainment value, cost, expectancy) within any domain or level of education. Continuance of the agenda foretells the investigating of self-generated utility value interventions in comparison to other interventions such as directly communicated utility value interventions and associated utility value interventions before moving on to differing combinations of interventions. All forthcoming studies, following the PRCS II, would currently be *first-of-their-kinds* within any domains or levels of education, but first, the self-generated utility value intervention research line needed to be extended to the domain of statistics, specifically the domain level of undergraduate statistics—and the PRCS study fulfilled this need.

CHAPTER 4. PRCS STUDY

The Prompting Relevant Connections in Statistics (PRCS) study was carried out as a blindly randomised longitudinal field experiment. The PRCS deployed a domain adapted (undergraduate statistics) self-generated utility value intervention (Hulleman et al., 2009, 2010, 2017) constructed to encourage students to make utility value connections between statistics learning content and their lives. The self-generated utility value intervention consisted of prompts, twice during the semester, which instructed students to write 2-3 paragraphs in response to. Through the increasing of quality utility value connections, prompted via the self-generated utility value intervention, students were hypothesised to foster greater utility value for statistics, and the learning thereof, which, in turn, would mediate increases to students' interest and achievement within undergraduate statistics. In carrying out the PRCS study, the following research questions were investigated:

1. Does a self-generated utility value intervention effect undergraduate statistics students' achievement?
2. Does a self-generated utility value intervention effect undergraduate students' interest for statistics?
3. Does achievement at-risk categorisation, gender, and/or first-generation moderate self-generated utility value intervention effects on undergraduate statistics students' interest or achievement?
4. Does a self-generated utility value intervention effect undergraduate statistics students' achievement or interest when factors of initial achievement, gender,

first-generation, and initial and change values of expectancy, cost, interest, utility value, and connection frequency are considered?

5. Does a self-generated utility value intervention effect undergraduate statistics students' expectancy, cost, utility value, and frequency of connections?
6. Are self-generated utility value intervention effects on undergraduate statistics students' interest and achievement mediated via intervention effects to students' expectancy, cost, utility value, and/or frequency of connection measures?
7. Are self-generated utility value intervention effects on undergraduate statistics students found to be different when the newly minted measures of connection quality are analysed alongside the Hulleman et al. (2017) replicated variables?

Hypothesis

The study's main hypothesis was that (1) undergraduate statistics students within the intervention condition would earn greater achievement scores and self-report higher interest than that of control conditioned students. Additional hypotheses involved achievement at-risk and more-at-risk statistics students. At-risk statistics students were defined as students who earned low scores on their initial assessment. It was hypothesised that (2) undergraduate statistics at-risk students within the intervention condition would earn greater achievement scores and self-report higher interest than that of control conditioned at-risk students. Hulleman et al. (2017) determined undergraduate male students who score poorly on an initial/pre assessment to be more-at-risk. This study did as well, and it was hypothesised that (3) undergraduate statistics more-at-risk students within the intervention condition would earn greater achievement scores and self-report higher interest than that of control conditioned more-at-risk students. Additionally, it was

hypothesised that (4) the intervention would positively affect undergraduate statistics students' self-reporting of utility value in comparison to control conditioned students and that (5) the effects to students' utility value would be found to mediate the effects of the intervention on undergraduate statistics students' interest and achievement as well. The final hypothesis regarding the intervention effects on undergraduate statistics students concerned the measures of connection quality. It was hypothesised that (6) the analysis including the new measures would find that undergraduate statistics students who made higher quality utility value connections would earn greater achievement scores and self-report higher interest and utility value than that of students who made lower quality utility value connections or none at all.

Hypotheses 1 - 3 were all based upon the premise that any category of undergraduate statistics student would thrive due to their condition (intervention versus control). Hypotheses 4 and 5 were based upon the self-generated utility value intervention's constructed purpose—which had been verified by Hulleman et al. (2009, 2010) within the domains of high school science and undergraduate psychology but was not within Hulleman et al. (2017) when additional motivation constructs were included in the study. Hypothesis 6 was based upon the general suspicion that utility value connections of higher quality, as opposed to lower or none, would elicit greater student effects**.**

Method

Sample

The blindly randomised longitudinal field experiment consisted of 89 business school undergraduate students (freshman to senior), encompassing two differing sections

of the same 15-week introductory statistics course, taught by the same educator, from a research-intensive university located in the north-eastern USA. The educator had taught the undergraduate statistics course in question for more than five years at the time of the study. That educator was I. Although I was the educator, risk was tended to extensively and remediated. Additional details regarding its remediation are listed herein (see ***Procedure***).

64 of the 89 undergraduate statistics students (72%) completed each of the study measures (surveys and assessments) and the consent form and were, thus, research participant eligible. All 89 students, within the two sections of the statistics course, were awarded the same proportion of the extra credit points made available. Extra credit awarded was calculated on the proportion of students, per section, who consented to be research participant eligible. This method was employed to ensure students who consented were awarded extra credit while retaining their anonymity with the educator. The sample was 52% male, 100% non-statistics majors, and 48% freshman (26% sophomore, 22% junior, and 4% senior). The study took place during the Spring 2021 semester—data collection occurred weeks 10 through 15. The educator and research team members involved with the IRB approved study were current with their IRB (CITI) training.

Of note, one of the two sections was taught as a hybrid, 50/50 on in-person/online-zoom environment of instruction, while the other section's environment of instruction was 100% online-zoom—synchronous instruction was always received by undergraduate statistics students, in all environments. The environment of instruction, for the hybrid section, was subject to change, though, due to the state of COVID-19 at the

time of the study. As such, the hybrid course endured two semester environment adjustments (once during the PRCS study) rendering it too a 100% online environment of instruction course due to necessary COVID-19 precautions deployed (two weeks at a time, each time). Regardless of the differing environments and environmental adjustments, undergraduate statistics student differences were not detected between environments of instruction (see **Appendix F**).

Extant Course Materials and Class Structure. Course coverage included an introduction to the fundamentals of data description and analysis. Weeks 11 through 15 focused on probability, population and sampling distributions, and estimation of parameters. Three, hour and ten-minute, lectures were given each week. Typical class structure afforded 5-10 minutes on daily announcements and warm-up problems, 40-45 minutes on the days' lesson and concept examples, and 15-25 minutes for collaborative-group work on a concept activity or project.

Self-Generated Utility Value Intervention Design

Undergraduate statistics students initially completed self-reports on motivation (expectancy, cost, interest, utility value) and connection frequency measures, followed by an administered achievement assessment (all Time 1 measures). Upon completion of the Time 1 measures, the self-generated utility value intervention was deployed via e-mail amongst the students—randomly assigning each a condition (intervention or control). The intervention was of two parts (prompts), with start and end dates for each spaced two-weeks apart. Once Intervention Prompt II ended, students, again, completed self-reports on motivation (expectancy, cost, interest, utility value) and connection frequency measures, followed by an administered achievement assessment (all Time 2 measures).

Intervention Prompt I (complete version, see **Appendix D and E**).

Self-Generated Utility Value I: STATISTICS REFLECTION #1 (FOL Assessment). I would like you to write 1 to 2 paragraphs (75-125 words) about how the statistics material that you have been studying in STAT 1102 relates to your life. I am not asking you to summarise the material, just to elaborate on its relevance to your life. So far, you have covered and completed the following statistics units in your class.

Control I: STATISTICS REFLECTION #1 (FOL Assessment). Below is a list of the units we have covered and completed in STAT 1102 so far. For each topic, summarise what you know in about 1 or 2 sentences. I am not asking you to elaborate on the material, just to summarise the information that you can recall.

Intervention Prompt I Units. 1. Descriptive Statistics, 2. Inferential Statistics, 3. Fundamental Elements of Statistics, 4. Types of Data, 5. Collection of Data, 6. Methods for Describing Qualitative and Quantitative Data, 7. Numerical Measures of Central Tendency, 8. Numerical Measures of Variability, 9. Using the Mean and Standard Deviation to Describe Data, 10. Numerical Measures of Relative Standing, 11. Methods for Detecting Outliers

Intervention Prompt II (complete version, see **Appendix F and G**).

Self-Generated Utility Value II: STATISTICS REFLECTION #2 (FOL Assessment). Below are the statistics units we covered in STAT 1102 this semester. Complete parts **a.** and **b.**: **a.** Choose a topic from below that is personally useful and meaningful to you. In 1 to 2 paragraphs (75 to 125 words), describe how learning about this topic is useful to your life right now. **B.** Choose a topic below that is personally useful and meaningful to you (it may be the same topic as chosen for **a.**). In 1 to 2

paragraphs (75 to 125 words), describe how learning about this topic will be beneficial to you in the future (i.e., education, career, daily life)—150 to 250 words combined between **a.** and **b.**

Control II: STATISTICS REFLECTION #2 (FOL Assessment). Below are the statistics units we covered in STAT 1102 this semester. Choose **ONE** specific topic below. In 1 to 2 paragraphs (75 to 125 words), **summarise** the details of the chosen topic as best you can.

Intervention Prompt II Units. 1. Descriptive & Inferential Statistics, 2. Fundamental Elements of Statistics, 3. Types of Data and its Collection, 4. Methods for Describing QL and QN Data, 5. Numerical Measures of Central Tendency, 6. Numerical Measures of Variability, 7. Data Description: Mean/Standard Deviation, 7. Numerical Measures of Relative Standing, 8. Methods for Detecting Outliers, 9. Probability (Unions, Intersections, Compliments, and Conditionals), 10. Additive & Multiplicative Rules, Independence, and Mutual Exclusivity, 11. Bayes's Rule, 12. Types of Random Variables, 13. Probability Distributions for Discrete and Continuous Random Variables

Measures

The independent experimental variable was *condition*, utility value intervention (UVI) or control. Moderator variables were Time 1 *achievement, first-generation,* and *gender*. Other Time 1 variables were that of motivation (*expectancy, cost, interest, utility value*) and *connection frequency.* Time 2 motivation (*expectancy, cost, interest, utility value*) and *connection frequency* were change values, respective of their Time 1 measurement, used as predictors and response variables—dependent on the model which was being analysed. Connection Quality-I and II (CQ-I and CQ-II) measures, CQ-I and II

statistical literacy usefulness, CQ-I and II *statistical thinking usefulness,* CQ-I and II *correctness,* CQ-I and II *effort,* CQ-I and II *personal life,* CQ-I and II *professional/business life,* and CQ-I and II *periodicity,* were used as predictors and response variables—dependent on the model which was being analysed as well. Time 2 *achievement* served as a dependent variable. All data was collected from students during regular class time, sans connection quality which involved researcher coding of students' intervention prompt responses after the semester had concluded.

The self-reported Time 1 and 2 motivation (*expectancy, cost, intrinsic value , utility value*) and *connection frequenc*y data was collected via the Motivation, Interest, and Connection Frequency (MICF) survey (see **Appendix H**). The MICF survey was adapted from the Self-Report Measures of Motivation, Interest, and Connection Frequency survey employed within Hulleman et al. (2017). The MICF survey (CLUV Assessment) contained 28 self-evaluative questions/items. Self-report Likert-type scale response ratings for motivation, task expectancy for success and subjective task value constructs (cost, interest, utility value), ranged from 1-low through 8-high, while ratings for connection frequency ranged from 1-low through 6-high.

Expectancy was comprised of four questions/items (i.e., "I am confident that I will be successful in this class.", α = .90 and .88). Cost was comprised of six questions/items (i.e., "This class requires too much time.", α = .78 and .85). Interest was comprised of nine questions/items (i.e., "My experience in this course has made me want to take more statistics courses.", α = .93 and .93). Utility value was comprised of six questions/items (i.e., "The material in this class is personally relevant to me.", α = .93 and .93). Connection frequency was comprised of three questions/items (i.e., "During a

regular class period or lecture, how often do you connect the class material to your life?"). The MICF survey, like Hulleman et al. (2017), did not collect data on students' attainment value. Intervention and survey designations of CLUV (Collaborative Learning's Utility Value) and FOL (Feel of Learning) Assessment were in reference to a broader set of assessment categories not discussed further within this study. The situated variable of *gender* and *first-generation student* were collected as the 29th and 30th questions/items on the post-MICF survey.

Time 1 and 2 *achievement* data was measured, along a standard 0 to 100 scale, via the courses typical chapter and unit quizzes. Unit quizzes comprised of two chapters apiece. Chapter quizzes were check in points between Unit quizzes. Time 1 *achievement* data consisted of the course's first chapter quiz. Time 2 *achievement* data consisted of the course's final unit quiz. Although quiz grades were curved within the course, all achievement data used during analysis was raw (uncurved). Point biserial correlations, p-values, and other info regarding the quizzes can be provided by the author as needed.

Connection quality data consisted of students' two intervention prompt responses. Connection quality data was researcher coded on ratings scales, as seen in Table 6, comprising of seven new 1 - 3 ratings scaled measures, measured twice, CQ *statistical literacy usefulness,* CQ *statistical thinking usefulness,* CQ *accuracy,* CQ *effort,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity*. Table 6, as seen, is an incarnation of the finalised ratings scale used. The finalised ratings scale used by researcher coders is presented within Part II of the results. Each intervention prompt response was scaled ratings coded seven times, once for each of the CQ variables. Ratings scales for each measure were defined based on a thematic analysis performed on

Table TBD.

Connection Quality Measures and Coding Category Descriptions

Measure	Code	Coding Category Descriptions
Connection Utility Elaboration		
Statistical Literacy Usefulness	1	No connection of a statistical concept claimed/perceived
	2	Connection claimed/perceived a statistical concept to be useful
	3	Connection claimed/perceived a statistical concept to be useful and described how it's useful.
	Note	Categorising as "3" requires a student made claim to describe how they used the statistical concept.
Statistical Thinking Usefulness	1	No connection of a statistical tool/technique claimed/perceived
	2	Connection claimed/perceived a statistical tool/technique to be useful
	3	Connection claimed/perceived a statistical tool/technique to be useful, 3 = connection claimed/perceived a statistical tool/technique to be useful and described how it's useful.
	Note	Categorising as "3" requires a student made claim to describe how they used the statistical tool/technique.
Effort	1	No connection claimed/perceived—no effort to rate
	2	Connection(s) claimed/perceived word count totalled less than threshold, the median word count
	3	Connection(s) claimed/perceived word count totalled at least the threshold, the median word count.
	Note	Researcher coders will confirm word counts (all words) and discuss significant differences amongst differing thresholds before establishing "2" and "3" threshold categorisations based on the median word count.
Accuracy	1	No connection claimed/perceived—no accuracy to rate
	2	Connection claimed/perceived inaccurately, or more than half are inaccurate if multiple exist
	3	Connection claimed/perceived accurately, or at least half are accurate if multiple exist.
	Note	Categorising as a "2" requires a student made claim, or more than half of a students' claims, to be inaccurate due to applying statistical concept/tool/technique inaccurately, which stems from a lack of understanding the statistical concept/tool/technique.
Connection Utility Contextualisation		
Personal Life	1	No personal life connection claimed/perceived
	2	Connection claimed/perceived to be applied to one's personal life
	3	Connection claimed/perceived to be applied to one's personal life and described specific personal life instances where it was applied.
	Note	Categorising as "3" requires a student made claim to specify a personal life instance of application.
Professional/Business Life	1	No professional/business life connection claimed/perceived
	2	Connection claimed/perceived to be applied to one's professional/business life
	3	Connection claimed/perceived to be applied to one's professional/business life and described specific professional/business life instances where it was applied.
	Note	Categorising as "3" requires a student made claim to specify a personal life instance of application.
Periodicity	1	No connection claimed/perceived—no periodicity to rate
	2	Connection(s) claimed/perceived sporadic use of statistics, or no more than once per week
	3	Connection(s) claimed/perceived multiple times per week to daily use of statistics.
	Note	When students make a vague claim such as, "I do this often", the response will be categorised as 'sporadic use', a "2", due to a lack of periodicity specificity.

the connection quality data. The scaled ratings coded a students' quality of connections of statistics utility value (usefulness) to an undergraduate business school students' life (contextualised personalness). Exploring the seven new measures together helped determine the type of quality utility value connections the self-generated utility value intervention promoted, what type of quality connection(s) affect students' motivation and achievement, and what makes a utility value connection to be of higher quality. As such, *connection quality* measures were defined on scaled ratings, guided, in part, by Priniski's definition of relevance, which captured the type of statistics usefulness and contextualised personalness of connections students made within their intervention prompt responses.

The scaled ratings coded a students' connections of statistics utility value (usefulness) and contextualised personalness due to the intent of the intervention to manipulate students' utility value for statistics. Manipulation of students' utility value can be seen within Intervention Prompt I: Self-Generated Utility Value I when it prompts students to write about how statistics relates and is relevant to their lives (useful and contextualised personalness). Manipulation of students' utility value can be seen within Intervention Prompt II: Self-Generated Utility Value II when it prompts students to write about a statistics topic that is useful and meaningful to them in their life right now and on a statistics topic that is useful and meaningful to them due to future benefits they will provide students with.

As Parts I and II of the intervention prompted students to explain how statistics was useful and meaningful to them, connections which were seen within the thematic analysis were students who made connections finding statistics useful in the sense that

they can usefully apply statistical tools in their lives or whether students found statistics useful in the sense that it was useful to understand through relation, to be statistically literate. A connection thereby constituted a student exemplifying how statistics' usefulness, as either the application of and/or the relational understanding of, was associated with an aspect of their life.

Another attribute found within the useful connections made by business students, via the thematic analysis performed, was the contextualised personalness of the connection, the personal meaningfulness of the connection. Contextualised personalness of connections were found to be based on how personally meaningful the connection was to students by either their contextualising of statistics' usefulness in a personal professional/business sense and/or in a personal non-professional/business sense. As business school students were expected to connect statistics to their business endeavours of today or tomorrow, it was expected to be found to be a more personally meaningful type of connection, due to the student identifying the usefulness and meaningfulness of statistics in the context of a business professional of today or tomorrow—instead of identifying the usefulness and meaningfulness of statistics in the context of a non-professional/business, everyday life. In a sense, *connection quality* could be thought of as a connections' useful understanding or application of statistics (utility value) associated with interest reasoning (non-professional/business, everyday life) or attainment value reasoning (professional/business life), but findings within the results will tell which of the two are found to be of a higher quality utility value connection.

Procedure

Consents were initially solicited from undergraduate statistics students early-week 10 but were accepted until the study closed week 15. A returned signed consent by a student enabled them to be research participant eligible. Research participant eligible students' assessed achievement and self-reported survey data was included in the study's analysis. Mid-week 10, undergraduate statistics students completed the MICF survey, thus collecting students Time 1 (T1) Motivation (*expectancy, cost, interest, utility value*) and *connection frequency* data. Late-week 10, the T1 *achievement* measure was administered. Early-week 11, students from both sections of the course were randomised amongst conditions (UVI or control) via the e-mail which contained their Intervention Prompt I (Statistics Reflection #1). Submission of Intervention Prompt I was due early week 12. The appropriately conditioned Intervention Prompt II (Statistics Reflection #2) was e-mailed to student's mid-week 13 and submissions were due mid-week 14. Late-week 14, T2 Motivation (*expectancy, cost, interest, utility value*) and *connection frequency* data was collected via the post-MICF survey. The post-MICF survey also included the demographical student data points of first-generation and gender. Early-week 15, students were administered the T2 *achievement* measure. The PRCS study procedural timeline is also shown within Table 7.

An ethical point of consideration, *conflict of interest,* was noted as I was both the researcher and educator, but the concern and impact of the conflict were sufficiently minimised, due to how consents were solicited/recorded. Participants were recruited to consent, via a posted course announcement within the institutions Canvas or Black Board site. Students, who were willing to consent, were instructed to contact a research team

Table 7.
PRCS Study Timeline

	Mon	Wed	Fri
Week 10	Consents Requested	MICF (pre)	T1 Achievement
Week 11	Randomisation Stat. Reflection #1		
Week 12	Stat. Reflection #1 (due)		
Week 13		Stat. Reflection #2	
Week 14		Stat. Reflection #2 (due)	MICF (post)
Week 15	T2 Achievement		

member that was not I, the educator. The research member provided willing participants the consent forms, if needed, and secured the signed consent forms. The research team member did not disclose to me, the educator, who was willing to participate until after the semester had concluded and grades had been submitted. Participation was voluntary and uncompensated. Students who choose to participate were accepted but were also made acutely aware that their decision to participate or not would have no impact on their grade—as the interventions, surveys, and assessments were made part of the "normal" course. Only those who consented had their data analysed for the study. I, the educator, was privy only to the proportion of students per section who consented (before grades were submitted) and awarded the same proportional amount of the extra credit points, which had been made available, to all students within the section. Thus, students who consented, or not, were ensured their anonymity with me, the educator.

Analytical Strategy

The PRCS study's primary research question was whether the self-generated utility value intervention would affect undergraduate students' achievement and interest

within the high DFW rate domain of statistics. The associated main hypothesis was that the intervention would positively affect undergraduate students' achievement and interest for statistics. First, *environment* was analysed due to conditions randomised amongst students drawn from two classes, one Hybrid and one Online (both synchronous learning), to ensure significant differences did not exist between the learning environments for response variables or T1/T2 covariates. Thereafter regression techniques were applied to response variables T2 *achievement* and Interest$_{res}$ functioned on experimental *condition* (UVI or control) as the primary analyses before including moderators and covariates using hierarchical multiple regression (see Model Summary Tables 8 and 9).

Table 8.
Part I: T2 achievement Hierarchical Models 1-5 Summarised

Model 1:	T2 *achievement* regressed on condition
Model 2:	T2 *achievement* regressed on *condition* moderated by T1 *achievement*
Model 3:	T2 *achievement* regressed on *condition* moderated by T1 *achievement* and *gender*
Model 4:	T2 *achievement* regressed on *condition* moderated by T1 *achievement* and *gender*, plus T1 Motivation and *connection frequency* variables
Model 5:	T2 *achievement* regressed on *condition* moderated by T1 *achievement* and *gender*, plus T1/T2 Motivation and *connection frequency* variables

Table 9.
Part I: Interest$_{res}$ Hierarchical Models 6-10 Summarised

Model 6:	Interest$_{res}$ regressed on *condition*
Model 7:	Interest$_{res}$ regressed on *condition* moderated by T1 *achievement*
Model 8:	Interest$_{res}$ regressed on *condition* moderated by T1 *achievement* and *gender*
Model 9:	Interest$_{res}$ regressed on *condition* moderated by T1 *achievement* and *gender*, plus T1 Motivation and *connection frequency* variables
Model 10:	Interest$_{res}$ regressed on *condition* moderated by T1 *achievement* and *gender*, plus T1/T2 Motivation and *connection frequency* variables

Note. *res = residual change value.*

Amongst the hierarchical regressions performed, achievement at-risk undergraduate statistics students were analysed to determine if the self-generated utility value intervention differentially effected their achievement and interest. In analysing achievement at-risk students, the interaction between condition and initial achievement was considered—parsing further, gender and first-generation interactions with condition and initial achievement were also considered. Additional analyses involved determining whether intervention effects on students' achievement and interest were mediated by intervention effects on their motivation (expectancy, interest, cost, utility value) and/or connection frequency (see Model Summary Table 10).

The analyses described above were **Part I** of the two-folded analytical process carried out for the PRCS study and addressed research questions 1-6 and hypotheses 1-5. **Part II** analyses addressed research question 7 and hypothesis 6, and involved determining whether intervention effects on students' motivation, frequency of connections, and achievement differed once connection quality measures, CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life*, CQ

Table 10.
Part I: Motivation Residual and Connection Frequency$_{res}$ Models 11-14 Summarised

Model 11:	Connection Frequency$_{res}$ regressed on *condition* moderated by T1 a*chievement,* plus *gender*, T1 Motivation, and T1/T2 *connection frequency* variables
Model 12:	Expectancy$_{res}$ regressed on *condition* moderated by T1 a*chievement,* plus *gender*, T1 Motivation, and T1/T2 *connection frequency* variables
Model 13:	Utility Value$_{res}$ regressed on *condition* moderated by T1 a*chievement,* plus *gender*, T1 Motivation, and T1/T2 *connection frequency* variables
Model 14:	Cost$_{res}$ regressed on *condition* moderated by T1 a*chievement*, plus *gender*, T1 Motivation, and T1/T2 *connection frequency* variables

Note. *res = residual change value.*

professional/business life, and CQ *periodicity*, were analysed alongside the Hulleman et al. (2017) replicated study variables (see Model Summary Table 11 in **Part II: Analytical Strategy Extended.)**

Part I: Confirmatory Analytical Strategy. Descriptive statistics for study variables per experimental condition were calculated. Significant T1 covariate differences, between student experimental conditions, if existed, were found via F-test/t-test comparisons. The same was conducted for T2 covariate experimental condition comparisons. In rounding out the preliminary analysis, major variable correlations, scale measures, and reliabilities were found.

In addressing the primary research question of whether a self-generated utility value intervention could affect undergraduate students' achievement and interest for statistics, Models 1 and 6 only included the experimental *condition* variable as a predictor for T2 *achievement* and Interest_{res}— unless a significant difference between experimental conditions was found for any of the T1 covariates necessitating their initial inclusion. In examining the intervention's differential effectiveness specific to achievement at-risk undergraduate statistics students, Models 2 and 7 were constructed from Models 1 and 6 by including the predictor variable T1 *achievement* (initial assessment) and its interaction with the Model 1 and 6 predictor variable *condition.* At-risk undergraduate statistics students were defined as students who earn low scores on their T1 *achievement*. Hulleman et al. (2017) determined undergraduate male students, who earn poor initial/pre assessment scores, to be more-at-risk. With that in mind, Models 3 and 7 built upon Models 2 and 7 by including *gender* and its interactions with *condition* and T1

achievement to analyse undergraduate statistics students more-at-risk as well. A first-generation factor and its interactions were also considered.

Regardless of whether Models 1 and 6 included T1 covariates or not, Models 4, 5, 9, and 10 included T1 or T1 and T2 Motivation (*expectancy, cost, interest, utility value*) and *connection frequency* covariates in predicting T2 *achievement* and Interest$_{res}$ to determine whether significant *condition* effects found through the hierarchy of regressions remained and whether the covariates served as effect pathways to students' achievement and interest. Models 11-14 which included *condition*, T1 *achievement*, their interaction, *gender*, T1 motivation, and T1/T2 *connection frequency* covariates, as predictors for Expectancy$_{res}$, Cost$_{res}$, Utility Value$_{res}$ and Connection Frequency$_{res}$, analysed whether a self-generated utility value intervention could affect undergraduate statistics students' motivation (*expectancy, cost*, utility value) and connection frequency. Effects were sought to determine if any Model 5 and/or 10 discovered effect pathways mediated intervention effects found for students' achievement and interest. Models 11-14 also analysed whether students' connection frequency served as a mechanism for any pathways found to be mediating intervention effects on students' achievement and interest.

With the purpose of easing comparisons between Hulleman et. all (2017) and the PRCS study, analyses were carried out in like to the former—with standardised metric interpretations. T2 regression predictions were calculated based on T1 *achievement* scores one standard deviation above and below the continuous predictor variable. Predictions were estimated via regression equations reliant on standardised predictors resulting in standardised dependent predictions. Expectancy$_{res}$, cost$_{res}$, utility value$_{res}$, and

connection frequency$_{res}$ are residual changes to their respective T1 measure-controlled value. A summary of the proposed models analysed for **Part I** were seen within Tables 8, 9, and 10. **Part I** concludes with an effects path analysis. For all models in **Part I** and **Part II,** multiple testing p-value adjustments were made before attesting to findings of significance. Model details are expanded upon following the study's criteria on findings of significance due to conducting multiple tests.

Adjustment methods employed included Holm-Bonferroni (known also as Sequential Bonferroni), Benjamini–Hochberg, and Bonferroni. Adjusted p-values, per the three methods, are shown in companion tables and attest to the robustness of the findings reported. Companion tables list unadjusted regression model predictor p-values and their adjusted p-values, per each of the respective adjustment methods. The PRCS study denoted significant findings as those found by the Benjamini–Hochberg method controlled at a false discovery rate (FDR) of less than 10% (FDR < .10). Weak findings found in the **Part I** analysis by the Benjamini–Hochberg method controlled at .1 < FDR < .15 were also noted. Weak findings found in the **Part II** analysis by the Benjamini–Hochberg method controlled at .1 < FDR < .2, due to its analysis being exploratory, were also noted. Positive effects found, significant or weak, via the FDR controlled Benjamini–Hochberg method are reported herein with their unadjusted regression predictor p-values.

Model 1. T2 *achievement* was regressed on experimental *condition.* Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects students' achievement within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 2. T2 *achievement* was regressed on experimental *condition*, T1 *achievement*, and its interaction. Analysing this model was beneficial as it provided findings on whether a self-generated utility value intervention affects achievement differentially for at-risk students within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 3. T2 *achievement* was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions. Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects achievement differentially for, Hulleman et al. (2017) defined, more-at-risk students within the high DFW domain of undergraduate statistics as hypothesised.

Model 4. T2 *achievement* was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions along with T1 Motivation and *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects undergraduate statistics students', at risk or not, achievement differently when their initial connection frequency and motivation are considered, as they were hypothesised not to do so.

Model 5. T2 *achievement* was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions along with T1 and T2 Motivation and *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Analysing this model was beneficial as it

replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects at-risk undergraduate statistics students' achievement differently, as hypothesised, when their connection frequency and motivation change values are considered. The model was also analysed to provide findings on whether connection frequency and/or motivation serve as a pathway to effecting students' achievement, as connection frequency and/or utility value were hypothesised to do so.

Change variables were employed in Models 5-14 to analyse if motivation (expectancy, interest, cost, utility value) and *connection frequency* change was occurring, if the change noted was significant to predicting T2 *achievement* or Interest$_{res}$, and whether the significant change(s) were due to UVI effects. If the UVI was found to significantly affect motivation and/or *connection frequency* change(s), and motivation and/or *connection frequency* changes, in turn, were found to be significant in predicting T2 *achievement,* then potential mediation of UVI effects on T2 *achievement* or Interest$_{res}$ may have occurred, at least partially. Instance as such were tested for and reported on.

Model 6. Interest$_{res}$ was regressed on experimental *condition*. Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects students' interest within the high DFW rate domain of undergraduate statistics as hypothesised. Interest$_{res}$, interest residual change value, was the difference of two values, T2 *interest* (observed) and the slope found when T2 *interest* was regressed on T1 *interest.*

Model 7. Interest$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and its interaction Analysing this model was beneficial as it provided findings on whether

a self-generated utility value intervention affects interest differentially for at-risk students within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 8. Interest$_{res}$ was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions. Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects interest differentially for, Hulleman et al. (2017) defined, more-at-risk students within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 9. Interest$_{res}$ was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions along with T1 Motivation and *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects at-risk undergraduate statistics students' interest differently when their initial connection frequency and motivation are considered, as they were hypothesised not to do so.

Model 10. Interest$_{res}$ was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions along with T1 and T2 Motivation and *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest* (T1 only), and *utility value.* Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention affects at-risk undergraduate statistics students' interest differently, as hypothesised, when their connection frequency and motivation change values are considered. The model was also analysed to provide findings on whether connection

frequency and/or motivation serve as a pathway to effecting students' interest, as connection frequency and/or utility value were hypothesised to do so.

Model 11. Connection Frequency$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, along with gender and T1 Motivation and *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention effects at-risk, or not, undergraduate statistics students' frequency of connections, as hypothesised, when their initial frequency of connections and motivation were considered. The model was also analysed to provide findings on whether connection frequency serves as a pathway for the UVI to affect students' achievement and/or motivation as hypothesised. Residual change values used throughout Models 11-14 for Expectancy$_{res}$, Cost$_{res}$, Utility Value$_{res}$, and Connection Frequency$_{res}$ is the difference of the two values exemplified previously within Model 6 for Interest$_{res}$.

Model 12. Expectancy$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, along with gender, T1 Motivation, and T1 and T2 *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value.* Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention effects at-risk, or not, undergraduate statistics students' expectancy when their frequency of connections change value and initial motivation are considered, as it was not hypothesised to do so. The model was also analysed to provide findings on whether expectancy serves as a pathway for the UVI to affect students' achievement and/or

motivation, and whether students' frequency of connections serves as a pathway mechanism for expectancy, which both were not hypothesised to.

Model 13. Utility Value$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, along with *gender*, T1 Motivation, and T1 and T2 *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value.* Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention effects at-risk, or not, undergraduate statistics students' utility value, as hypothesised, when their frequency of connections change value and initial motivation were considered. The model was also analysed to provide findings on whether utility value serves as a pathway for the UVI to affect students' achievement and/or motivation, and whether students' frequency of connections serves as a pathway mechanism for utility value, as both were hypothesised to.

Model 14. Cost$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, along with gender, T1 Motivation, and T1 and T2 *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value.* Analysing this model was beneficial as it replicated Hulleman et al. (2017) to provide findings on whether a self-generated utility value intervention effects at-risk, or not, undergraduate statistics students' cost when their frequency of connections change value and initial motivation are considered, as it was not hypothesised to do so. The model was also analysed to provide findings on whether cost serves as a pathway for the UVI to affect students' achievement and/or motivation, and whether students' frequency

of connections serves as a pathway mechanism for cost, which both were not hypothesised to.

Part II: Analytical Strategy Extended. Hulleman et al. (2017) noted, as a limitation, that their connection frequency measure lacked operationalisation which captured the quality of the utility value connections students were making—this study has attempted to rectify the limitation via scaled ratings coding of the students' intervention responses—their two short relevance essay prompt responses. Scaled ratings coding of the intervention responses comprised of seven new connection quality measures, CQ responses. Scaled ratings coding of *statistical literacy*, CQ *statistical thinking*, CQ *effort*, CQ *accuracy*, CQ *personal life*, CQ *professional/business life*, and CQ *periodicity*, are measured as a set for each intervention response. **Part II** analyses addressed research question 7 and hypothesis, 6, by re-analysing Models 5 and 10, as Models 15 and 16, and Models 11-14, as Models 17-20 from **Part I**, but with the connection quality measures included alongside the previously measured model variables (see Table 11). **Part II** also analysed additional models, 21-25, which provided findings on CQ measures to help determine the quality of utility value connection the self-generated utility value intervention promoted which, in turn, affected students' motivation and achievement (see Table 11). **Part II** concludes with an effects path analysis, as well, specific to the inclusion of the connection quality measures.

Model 15. T2 *achievement* was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions, T1 and T2 Motivation and *connection frequency*, and Connection Quality-I and II predictors. Motivation predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Connection quality predictors

Table 11.

Part II: CQ Extended Models 15-25 Summarised

Model 15:	T2 *achievement* regressed on *condition* moderated by T1 *achievement* and *gender*, plus T1/T2 Motivation and *connection frequency*, and Connection Quality (CQ-I/CQ-II *statistical literacy*, CQ-I/CQ-II *statistical thinking*, CQ-I/CQ-II *effort* CQ-I/CQ-II *accuracy*, CQ-I/CQ-II *personal life*, CQ-I/CQ-II *professional/business life*, and CQ-I/CQ-II *periodicity*) variables
Model 16:	Interest$_{res}$ regressed on *condition* moderated by T1 *achievement* and *gender*, plus T1/T2* Motivation and *connection frequency*, and Connection Quality (CQ-I/CQ-II *statistical literacy*, CQ-I/CQ-II *statistical thinking*, CQ-I/CQ-II *effort* CQ-I/CQ-II *accuracy*, CQ-I/CQ-II *personal life*, CQ-I/CQ-II *professional/business life*, and CQ-I/CQ-II *periodicity*) variables
Model 17:	Connection Frequency$_{res}$ regressed on *condition* moderated by T1 a*chievement*, plus *gender*, T1 Motivation and *connection frequency*, and Connection Quality (CQ-I/CQ-II *statistical literacy*, CQ-I/CQ-II *statistical thinking*, CQ-I/CQ-II *effort* CQ-I/CQ-II *accuracy*, CQ-I/CQ-II *personal life*, CQ-I/CQ-II *professional/business life*, and CQ-I/CQ-II *periodicity*) variables
Model 18:	Expectancy$_{res}$ regressed on *condition* moderated by T1 a*chievement*, plus *gender*, T1 Motivation, T1/T2 *connection frequency*, and Connection Quality (CQ-I/CQ-II *statistical literacy*, CQ-I/CQ-II *statistical thinking*, CQ-I/CQ-II *effort* CQ-I/CQ-II *accuracy*, CQ-I/CQ-II *personal life*, CQ-I/CQ-II *professional/business life*, and CQ-I/CQ-II *periodicity*) variables
Model 19:	Utility Value$_{res}$ regressed on *condition* moderated by T1 a*chievement*, plus *gender*, T1 Motivation, T1/T2 *connection frequency*, and Connection Quality (CQ-I/CQ-II *statistical literacy*, CQ-I/CQ-II *statistical thinking*, CQ-I/CQ-II *effort* CQ-I/CQ-II *accuracy*, CQ-I/CQ-II *personal life*, CQ-I/CQ-II *professional/business life*, and CQ-I/CQ-II *periodicity*) variables
Model 20:	Cost$_{res}$ regressed on *condition* moderated by T1 a*chievement*, plus *gender*, T1 Motivation, T1/T2 *connection frequency*, and Connection Quality (CQ-I/CQ-II *statistical literacy*, CQ-I/CQ-II *statistical thinking*, CQ-I/CQ-II *effort* CQ-I/CQ-II *accuracy*, CQ-I/CQ-II *personal life*, CQ-I/CQ-II *professional/business life*, and CQ-I/CQ-II *periodicity*) variables
Model 21 - 25:	Connection Quality variable*** regressed on *condition* moderated by T1 a*chievement*, plus *gender*, T1 Motivation, and T1/T2 *connection frequency variables*

Note. *res* = residual change value. *T2 *interest* not included. **T2 *connection frequency* not included.***Connection Quality variables found to affect motivation or achievement positively were used in the models.

consisted of CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity.* Analysing this model was beneficial as it provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' achievement differently, as hypothesised, when connection quality predictors were considered. The model also provided findings to help determine whether quality of connections, frequency of connections, and motivation serve as pathways to affecting students' achievement, when connection quality predictors were considered, as utility value, connection frequency, and connection quality measures were hypothesised to.

Model 16. interest$_{res}$ was regressed on experimental *condition*, T1 *achievement*, *gender*, and their 3-way and 2-way interactions, T1 and T2 Motivation (sans T2 *interest)* and *connection frequency*, and Connection Quality-I and II predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Connection quality predictors consisted of CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity.* Analysing this model was beneficial as it provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' interest differently, as hypothesised, when connection quality predictors were considered. The model also provided findings to help determine whether quality of connections, frequency of connections, and motivation serve as pathways to affecting students' interest, when connection quality predictors were considered, as utility value, connection frequency, and/or connection quality measures were hypothesised to.

Model 17. Connection Frequency$_{res}$ was regressed on experimental *condition*, T1 *achievement,* and their 2-way interaction, T1 Motivation and *connection frequency,* and Connection Quality-I and II predictors. Motivations predictors consisted of *expectancy*, *cost, interest,* and *utility value*. Connection quality predictors consisted of CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity.* Analysing this model was beneficial as it provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' frequency of connections differently, as hypothesised, when connection quality predictors were considered. The model also provided findings to help determine whether frequency of connections, when connection quality predictors were considered, serves as a pathway for the intervention's effects on students' achievement or motivation and whether, exploratorily, quality of connection predictors serve as pathway mechanisms, as connection frequency and connection quality predictors were hypothesised to.

Model 18. Expectancy$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, T1 Motivation and T1/T2 *connection frequency,* and Connection Quality-I and II predictors. Motivations predictors consisted of *expectancy*, *cost, interest,* and *utility value*. Connection quality predictors consisted of CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity.* Analysing this model was beneficial as it provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' expectancy for success differently, as hypothesised, when connection quality predictors

were considered. The model also provided findings to help determine whether expectancy, when connection quality predictors were considered, serves as a pathway for the intervention's effects on students' achievement or motivation, which it was not hypothesised to, and whether frequency of connections or, exploratorily, quality of connection predictors serve as pathway mechanisms, which they were not hypothesised to via expectancy.

Model 19. Utility Value$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, T1 Motivation and *connection frequency*, and Connection Quality-I and II predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value*. Connection quality predictors consisted of CQ *statistical literacy*, CQ *statistical thinking*, CQ *effort*, CQ *accuracy*, CQ *personal life*, CQ *professional/business life*, and CQ *periodicity*. Analysing this model was beneficial as it provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' utility value differently, as hypothesised, when connection quality predictors were considered. The model also provided findings to help determine whether utility value, when connection quality predictors were considered, serves as a pathway for the intervention's effects on students' achievement or motivation and whether frequency of connections or, exploratorily, quality of connection predictors serve as pathway mechanisms, as utility value, connection frequency, and connection quality predictors were hypothesised to.

Model 20. Cost$_{res}$ was regressed on experimental *condition*, T1 *achievement*, and their 2-way interaction, T1 Motivation and T1/T2 *connection frequency*, and Connection Quality-I and II predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*,

and *utility value*. Connection quality predictors consisted of CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity.* Analysing this model was beneficial as it provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' cost differently, as hypothesised, when connection quality predictors were considered. The model also provided findings to help determine whether cost, when connection quality predictors were considered, serves as a pathway for the intervention's effects on students' achievement or motivation, which it was not hypothesised to, and whether frequency of connections or, exploratorily, quality of connection predictors serve as pathway mechanisms, which they were not hypothesised to via cost.

Models 21-25. Connection quality predictors found to affect students' achievement or motivation positively within Models 15-20 were each regressed on experimental *condition*, T1 *achievement,* and their 2-way interaction, along with *gender*, T1 Motivation, and T1 and T2 *connection frequency* predictors. Motivations predictors consisted of *expectancy*, *cost*, *interest*, and *utility value.* Analysing these models were beneficial as they provided exploratory findings which helped determine whether a self-generated utility value intervention affected at-risk, or not, undergraduate statistics students' connection quality, in respect to the variable being regressed. These findings also helped determine the quality of connection the self-generated utility value intervention Part's I and II individually promoted. The models were also analysed to provide findings on whether connection quality, in respect to the variable being

regressed, serves as a pathway for the UVI to affect students' achievement or motivation, and whether students' frequency of connections serve as a pathway mechanism.

CHAPTER 5. RESULTS

Part I: Confirmatory Analysis (Replication of Hulleman et al., 2017)

Initially this study analysed *environment* to ensure significant differences did not exist between hybrid and online classes in the sample. Differences were not detected between hybrid and online learning environments for response variables or T1/T2 covariates ($F < 1.82$ and $p > .05$, see Appendix I). Additionally, a first-generation (FG) factor, planned to be included in the regression analyses, was scrutinised and removed from consideration due to too few of said type of student within the sample. Furthermore, when students' FG status was analysed, significant differences did not exist between FG and non-FG students for response variables or T1/T2 covariates ($F < 1.82$ and $p > .05$, see Appendix J). Thereafter analyses consisted of descriptive statistics for T1/T2 study outcome and covariate variables, correlations for major variables, hierarchical model regressions for study outcome variables achievement and interest, and model regressions for motivation (expectancy, cost, utility value) and connection frequency variables, before concluding with path analyses for study outcome variables achievement and interest. Hierarchical model regressions for achievement span Models 1-5. Hierarchical model regressions for interest span Models 6-10. Model regressions for connection frequency (Model 11), expectancy (Model 12), utility value (Model 13), and cost (Model 14) span Models 11-14.

Descriptive statistics calculations for response variables and T1/T2 covariates comprised of sample means and sample standard deviations, totals and per experimental condition (see Table 12). Visually, UVI conditioned students initially (T1) self-reported higher frequency of connections and motivation (expectancy, interest, cost, utility value)

Table 12.
Descriptive Statistics by Condition for Motivation, Connection Frequency, and Achievement Variables

	Control		Intervention		Total	
Variable	M	SD	M	SD	M	SD
T1 Expectancy	5.56	1.19	6.12	1.43	5.84	1.34
T1 Utility Value	4.58	1.39	5.12	1.62	4.85	1.52
T1 Cost	4.72	1.05	5.24	1.14	4.98	1.12
T1 Connect Freq.	2.86	0.92	3.18	1.18	3.02	1.06
T1 Interest	4.06	1.32	4.74	1.65	4.40	1.52
T1 Achievement	43.47	13.61	42.41	13.84	42.94	13.63
T2 Expectancy	5.36	1.27	6.25	1.34	5.81	1.37
T2 Utility Value	4.58	1.41	4.84	1.49	4.71	1.44
T2 Cost	4.16	1.34	4.75	1.30	4.46	1.35
T2 Connect Freq.	2.67	1.32	3.38	1.18	3.02	1.29
T2 Interest	4.02	1.55	4.65	1.63	4.33	1.61
T2 Achievement	64.69	18.91	71.68	14.21	68.19	16.96

Note: $N = 64$ for all variables. Significant differences were not detected on T1 variables across conditions (all F's < 1.82, all p's > .05).

for statistics than control conditioned students, while control conditioned students earned higher initial achievement scores. Noted visually as well, though, UVI conditioned students' motivation (expectancy) and connection frequency increased from T1 to T2, while control conditioned students motivation (expectancy, interest, cost, utility value) and connection frequency decreased from T1 to T2. Confirming the T1 between condition differences weren't significant to necessitate their initial inclusion in analyses, F-test/t-tests were conducted on the T1 response variables and covariates between conditions. Differences were not detected between experimental and control conditions for T1 response variables or covariates (F's < 1.82 and p's > .05). This finding also confirmed successful randomisation had occurred. As for semesters end (T2), UVI conditioned students not only self-reported higher frequency of connections and motivation (expectancy, interest, cost, utility value) for statistics than control conditioned students, but earned higher achievement scores as well.

Condition comparisons for T2 response variables and covariates, for this study, found UVI conditioned students to self-report higher motivation (interest, expectancy, cost, utility value), frequency of connections, and earn higher achievement with small and medium effect sizes (T2 *interest*, d = .39; T2 *expectancy*, d = .65; T2 *cost*, d = .44; T2 *utility value*, d = .18; T2 *connection frequency*, d = .55; T2 *achievement*, d = .41). These findings corroborate Hulleman et al.'s (2017) findings with the exception of cost and connection frequency. Hulleman et al. (2017) did not find differences between conditions for students' post cost and connection frequency. T2 response variables and covariate experimental condition comparisons were then followed by major variable correlations, scale measures, and reliabilities (see Table 13).

Table 13.
Descriptive Statistics for Major Variables

Variable	1	2	3	4	5	6	7	8	9	10	11	12
1. T1 Expectancy												
2. T1 Utility Value	0.60											
3. T1 Cost	0.49	0.42										
4. T1 Conn. Freq.	0.24	0.44	0.06									
5. T1 Interest	0.62	0.79	0.51	0.46								
6. T1 Achievement	0.19	0.03	0.27	-0.07	0.14							
7. T2 Expectancy	0.80	0.47	0.53	0.24	0.52	0.23						
8. T2 Utility Value	0.35	0.67	0.31	0.58	0.56	0.05	0.45					
9. T2 Cost	0.30	0.28	0.56	0.11	0.48	0.27	0.40	0.30				
10. T2 Conn. Freq.	0.26	0.33	0.15	0.61	0.35	0.11	0.37	0.67	0.12			
11. T2 Interest	0.47	0.65	0.51	0.52	0.78	0.18	0.54	0.79	0.43	0.60		
12. T2 Achievement	0.34	0.05	0.38	0.04	0.19	0.58	0.55	0.12	0.51	0.09	0.27	
13. Gender	-0.11	-0.05	-0.02	0.01	0.11	0.04	-0.10	0.11	-0.24	0.15	0.15	-0.18
Observed min.	1.75	1.17	2.83	1.00	1.44	1.18	2.00	1.00	1.00	1.00	1.11	8.15
Observed max.	8.00	7.17	7.33	6.00	7.78	57.46	8.00	7.67	7.83	6.00	7.56	100.00
Mean	5.84	4.85	4.98	3.02	4.40	42.94	5.81	4.71	4.46	3.02	4.33	68.19
Standard Deviation	1.34	1.52	1.12	1.06	1.52	13.63	1.37	1.44	1.35	1.29	1.61	16.96
α	0.90	0.93	0.78	0.83	0.93	-	0.88	0.93	0.85	0.92	0.93	-

Note. N = 64. Gender is a dummy-coded variable: 0 = female, 1 = male. Correlations greater than |.19| are significant at $p < .10$. Correlations greater than |.24| are significant at $p < .05$. Correlations greater than |.33| are significant at $p < .01$.

Correlations of particular interest were those involving the connection frequency measure Hulleman et al. (2017) introduced. This study further explored whether connection frequency relates to undergraduates students' motivation (expectancy, cost, utility value) and outcome variables (interest, achievement). Positive correlations of note were found. A positive correlation was found between students' T1 *connection frequency* and T2 *utility value* ($r = .58$, $p < .05$). A positive correlation was found between students' T1 *connection frequency* and T2 *expectancy* ($r = .24$, $p = .05$). Both of the findings corroborates Hulleman et al.'s (2017) findings that students' initial connection frequency relates to their post motivation. A positive correlation was found between students' T2 *connection frequency* and T2 *interest* ($r = .60$, $p < .01$). A positive correlation was found between students' T2 *connection frequency* and T2 *achievement* ($r = .09$, $p > .1$). Both of the findings corroborates Hulleman et al.'s (2017) findings that students' post connection frequency relates to the study outcome of post interest, but not post achievement. In sum, the connection frequency measure is significantly related to student' motivation and study outcome variables.

Other significant correlations the study noted, foreshadowing the resultants found herein, were such as T1 *cost* and T1 *achievement* ($r = .27$, $p < .05$). Initial *cost* played a larger role in students' initial performance than all other motivation variables. T1/T2 *cost* and expectancy played a larger role in students' final performance (T2 achievement) than all other motivation variables—all correlations $r > .33$, $p < .01$. In regard to students' initial interest, initial *utility value* played a larger role than all other motivation variables ($r = .79$, $p < .01$). T2 *interest* correlated strongest with T2 *connection frequency* and T1/T2 *utility value*—all correlations $r > .59$, $p < .01$. In regard to students' T2 *connection*

frequency, T2 expectancy and utility value had the strongest relations—all correlations $r > .36$, $p < .01$. Concerning correlations noted, or lack thereof, was for T1/T2 utility value and T1/T2 achievement. Utility value is the least related motivation variable with achievement—all correlations $r < .13$, $p > .1$.

Following the analysis of the major variable correlations, study outcome variables (T2 *achievement*, Models 1-5, Table 14; $Interest_{res}$, Models 6-10, Table 15) were analysed via hierarchical regression—beginning with students' achievement. Multiple testing adjustment method companion tables to Tables 14 and 15 can be found in the Appendices (see Appendix K for Table 14 companion table, and Appendix L for Table 15 companion table). Again, study findings denoted as significant were those found by the Benjamini–Hochberg method, controlling for the false discovery rate (FDR) amongst multiple tests.

Hierarchical Regression Analysis of T2 achievement

The five blocks of predictors which were used to build onto each prior hierarchy of T2 *achievement* model analysed were:

Block 1 = *condition*

Block 2 = T1 *achievement* and *condition*-T1 *achievement* interaction

Block 3 = *gender*, T1 *achievement-gender* interaction, *condition-gender* interaction, and *condition*-T1 *achievement-gender* interaction

Block 4 = T1 Motivation (*expectancy, cost, utility value, interest*) and *connection frequency*

Block 5 = T2 Motivation (*expectancy, cost, utility value, interest*) and *connection frequency*

Table 14.

GLS Regression Results for T2 Achievement

	Model 1				Model 2				Model 3				Model 4				Model 5			
	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2
Condition	**0.42****	0.20	0.04	0.05	**0.45*****	0.11	0.00	0.21	**0.54****	0.24	0.03	0.07	-0.04	0.23	0.87	0.00	0.31	0.32	0.34	0.00
T1 Achievement					**0.84*****	0.13	0.00	0.42	**0.87*****	0.29	0.00	0.12	**0.69*****	0.23	0.00	0.13	**0.62*****	0.21	0.00	0.15
Condition * T1 Achievement					**-0.42****	0.17	0.02	0.08	-0.51	0.32	0.12	0.03	**-0.61****	0.26	0.02	0.08	*-0.43**	0.23	0.07	0.05
Gender									-0.09	0.26	0.73	0.00	**-0.62*****	0.23	0.01	0.11	0.19	0.24	0.45	0.00
Condition * Gender									-0.42	0.40	0.30	0.00	0.11	0.36	0.77	0.00	-0.27	0.33	0.43	0.00
T1 Achievement * Gender									-0.06	0.32	0.85	0.00	0.12	0.26	0.65	0.00	-0.14	0.24	0.56	0.00
Condition * Gender * T1 Achievement									0.57	0.47	0.23	0.01	0.65	0.43	0.13	0.02	**0.88****	0.37	0.02	0.09
T1 Interest													-0.02	0.15	0.91	0.00	-0.27	0.20	0.20	0.02
T1 Expectancy													**0.32*****	0.11	0.00	0.13	0.08	0.16	0.59	0.00
T1 Utility Value													**-0.39*****	0.14	0.01	0.11	-0.22	0.16	0.18	0.02
T1 Cost													**0.35*****	0.10	0.00	0.19	-0.05	0.10	0.64	0.00
T1 Connection Freq.'s													0.12	0.09	0.21	0.01	**0.23****	0.11	0.04	0.07
T2 Expectancy																	**0.45*****	0.15	0.00	0.14
T2 Utility Value																	-0.11	0.18	0.54	0.00
T2 Cost																	**0.33*****	0.11	0.00	0.15
T2 Connection Freq.'s																	-0.22*	0.13	0.09	0.04
T2 Interest																	0.25	0.20	0.21	0.01
R^2				0.09**				0.60***				0.61***				0.78***				0.80***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardized regression coefficient. SE_β = standard error of the standardized regression coefficient. $\eta_a^2 = \varepsilon_p^2$ = indices denoting the approximate partial variance explained by an individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .10. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .15.

Model 1: T2 *achievement* Regressed on Predictors from Block 1. This study found a significant *condition* effect on students' T2 *achievement* (ß = .42, p = .04, η_a^2 = .05). UVI conditioned students earned higher T2 *achievement* (M_{UVI} = 71.68, *d* = .42) than control conditioned students (M_{Cntl} = 64.69). This finding corroborates Hulleman et al.'s (2017) findings. A self-generated utility value intervention can positively affect students' achievement within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 2: T2 *achievement* Regressed on Predictors from Blocks 1-2. This study found a significant interaction effect (*condition* by T1 *achievement*) on students' T2 *achievement* (ß = -.42, p = .02, η_a^2 = .08). The interaction was due to UVI conditioned at-risk students earning higher T2 *achievement* than control conditioned at-risk students (*d* = .87, see Figure 3)—an approximately 14.5-percentage point grade difference between groups. This finding corroborates Hulleman et al.'s (2017) findings. A self-generated utility value intervention can positively affect achievement differentially for at-risk students within the high DFW rate domain of undergraduate statistics as hypothesised.

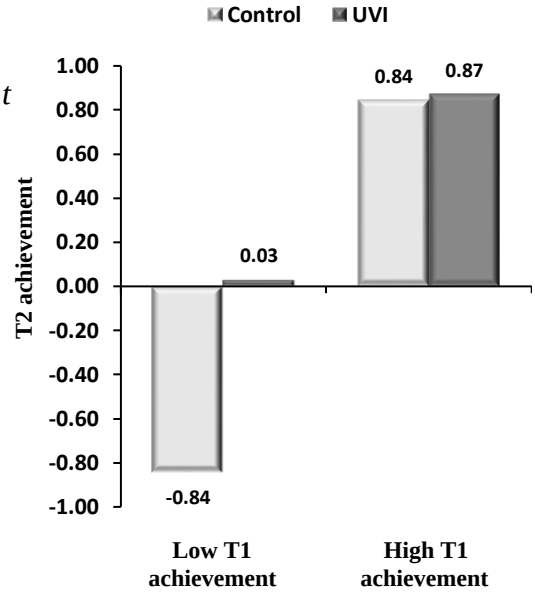


Figure 3. T2 *achievement* interaction between *condition* and T1 *achievement*. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 *achievement* mean, predictions of T2 *achievement* per *condition*. Regression equation predictions were standardised resulting in standardised mean differences per condition and Low/High T1 *achievement*. (i.e., T2 *achievement* prediction for control students with Low T1 *achievement* was -.84, while .03 was predicted for UVI students with Low T1 *achievement*). The contrasting predictions for Low T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = .87.

Model 3: T2 *achievement* Regressed on Predictors from Blocks 1-3. This study did not find that accounting for student's *gender*, without considering students' motivation and frequency of connections, to have a moderating effect on their T2 *achievement*. This finding differed from Hulleman et al. (2017) which did find gender to moderate effects on students' post achievement without considering their motivation and frequency of connections. Regardless, a significant *condition* effect on students' T2 *achievement* found in prior models was present and not significantly altered (ß = .54, $p < .03$, $\eta_a^2 = .07$). This finding indicated UVI conditioned students earned higher T2 *achievement* ($d = .54$) than control conditioned students—an approximately 9-percentage point grade difference between conditions. Although self-generated utility value intervention differential condition effects on T2 achievement were hypothesised to be found for Hulleman et al. (2017) defined more-at-risk undergraduate students, when not considering for their motivation and frequency of connections, they were not.

Model 4: T2 *achievement* Regressed on Predictors from Blocks 1-4. This study found significant initial motivation effects on students' T2 *achievement* (T1 *utility value*, ß = -.39, $p < .01$, $\eta_a^2 = .11$; T1 *cost*, ß = .35, $p < .01$, $\eta_a^2 = .19$). Regardless of T1 Motivation and *connection frequency* variable additions, though, a significant interaction effect (*condition* by T1 *achievement*) on students' T2 *achievement* found in prior models was present and not significantly altered (ß = -.61, $p = .02$, $\eta_a^2 = .08$). The interaction was due to UVI conditioned at-risk students earning higher T2 *achievement* than control conditioned at-risk students ($d = .57$, see Figure 4)—an approximately 9.5-percentage point grade difference between groups. This finding corroborates Hulleman et al.'s (2017) findings. In sum, students who initially had a higher expectancy for success in statistics,

less utility value for statistics, and associated less costs with learning statistics, earned higher T2 *achievement*, but UVI conditioned at-risk students still earned significantly higher T2 *achievement* (*d* = .57) than control conditioned at-risk students. As hypothesised, a self-generated utility value intervention can positively affect achievement differentially for at-risk students within the high DFW rate domain of undergraduate statistics and the effects are not significantly altered when their initial connection frequency and motivation are considered.

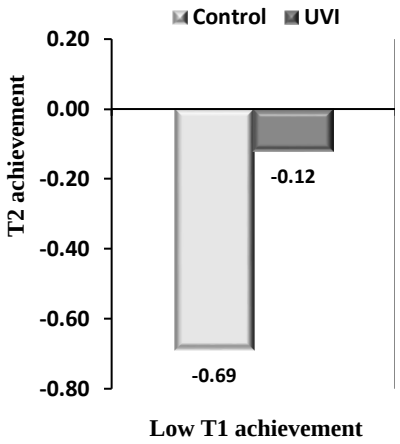


Figure 4. T2 *achievement* interaction between *condition* and Low T1 *achievement*. N = 64. Low T1 *achievement*, based on estimates of one standard deviation below T1 *achievement* mean, predictions of T2 *achievement* per *condition*. The contrasting predictions resulted in an adjusted standardised mean difference of *d* = .57.

Model 5: T2 *achievement* Regressed on Predictors from Blocks 1-5. This study found significant change value motivation effects on students' T2 *achievement* (*expectancy,* ß = .45, $p < .01$, $\eta_a^2 = .14$; *cost,* ß = .33, $p < .01$, $\eta_a^2 = .15$). These findings indicated students' *expectancy* and *cost* to be potential pathways for UVI indirect effects on students' T2 *achievement*. This study's finding of expectancy as a potential pathway corroborates Hulleman et al.'s (2017) findings. This study's finding of cost as a potential pathway differs from Hulleman et al.'s (2017) findings which did not find it to be a potential pathway. Although students' motivation was hypothesised to provide potential pathways for UVI indirect effects on students T2 achievement through students' utility value and connection frequency, expectancy and cost were instead the potential pathways found through students' motivation.

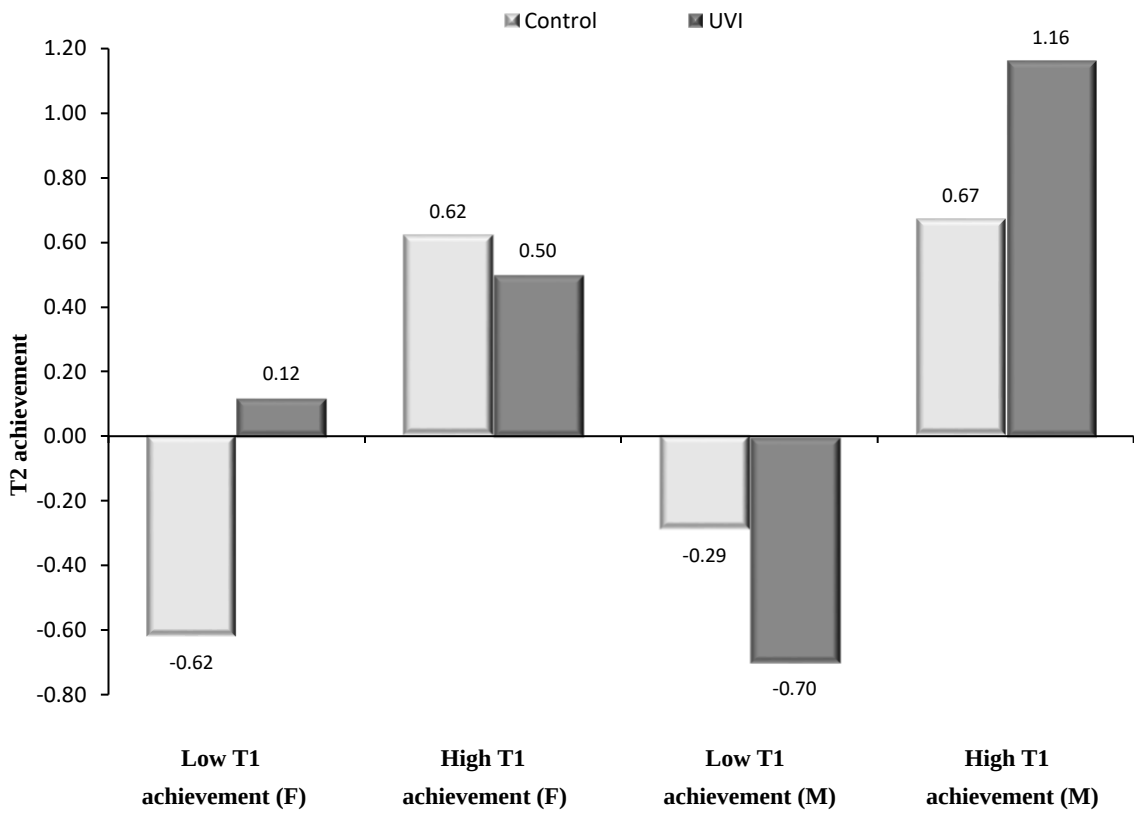


Figure 5. T2 *achievement* interaction between *condition*, T1 *achievement*, and *gender*, PI. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 *achievement* mean, predictions of T2 *achievement* per *condition* and *gender*. The contrasting predictions of note resulted in adjusted standardised mean differences of $d_{fem.T1\text{-}L}$ = .74 and $d_{mal.T1\text{-}H}$ = .49.

Along with the significant *expectancy* and *cost* change value effects found, this study also found a significant interaction effect (*condition* by T1 *achievement* by *gender*) on students' T2 *achievement* (ß = .88, p = .02, η_a^2 = .09). The interaction was due in large part to UVI conditioned at-risk female students and initial high achieving male students earning higher T2 *achievement* than their control conditioned counterparts. UVI conditioned at-risk female students earned higher T2 *achievement* than control conditioned at-risk female students (*d* = .74, see Figure 5)— more than a 12-percentage point grade difference between groups. UVI conditioned high achieving male students earned higher T2 *achievement* than control conditioned high achieving male students (*d* = .49, see Figure 5)— more than an 8-percentage point grade difference between

groups. These findings differed from Hulleman et al. (2017) which found at-risk male students (more-at-risk) to earn higher post achievement than control conditioned at-risk male students.

In summary, students whose expectancy for statistics success increased and associated costs with learning statistics decreased, earned higher T2 *achievement* than those whose didn't, but UVI conditioned at-risk female students, who were impacted most by the self-generated utility value intervention, still earned significantly higher T2 *achievement* (*d* = .74) than control conditioned at-risk female students. As hypothesised, a self-generated utility value intervention can positively affect achievement differentially for students within the high DFW rate domain of undergraduate statistics when their change values for connection frequency and motivation are considered.

A preliminary path analysis for UVI effects on students' T2 *achievement* and for potential pathways for UVI indirect effects on students' T2 *achievement* can be seen in Figure 6. The preliminary path depicts the significant *condition* by T1 *achievement* interaction found in Model 2 for predicting T2 *achievement* (ß = -.42, p = .02, η_a^2 = .08). Recall, the interaction was due to UVI conditioned at-risk students earning higher T2 achievement (*d* = .87) than control conditioned at-risk students (see Figure 3). Depicted, as well, are Model 5 change values for *cost* (ß = .33, p < .01, η_a^2 = .15) and *expectancy* (ß = .45, p < .01, η_a^2 = .14) which were found to be significant in affecting students' T2 *achievement*—providing potential pathways for the UVI to indirectly affect students' T2 *achievement.* Following the preliminary path analysis for study outcome variable achievement, study outcome variable interest (Models 6-10, Table 15) was analysed via hierarchical regression.

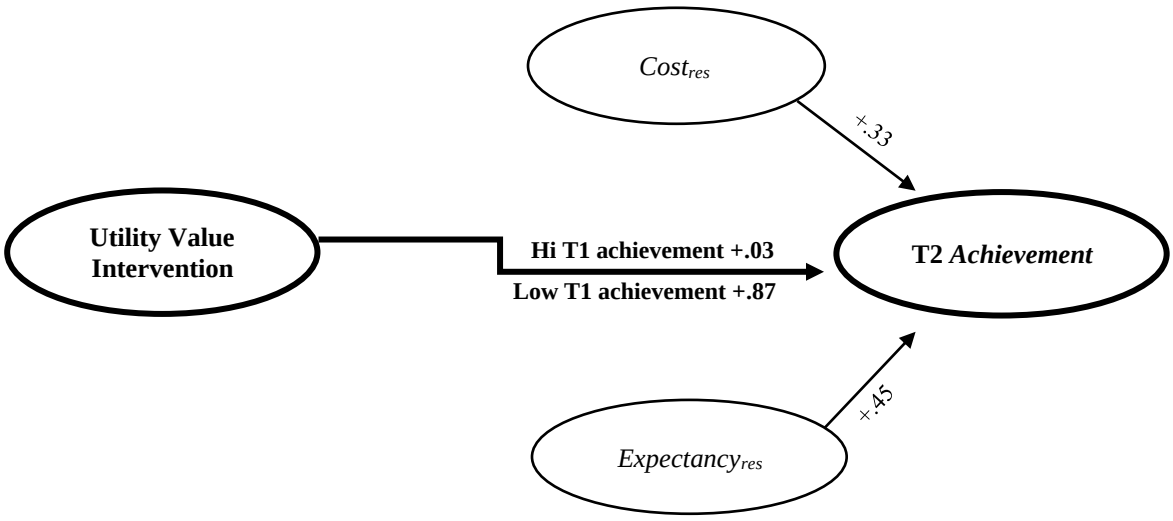


Figure 6. Condition effects on T2 *achievement* preliminary path model. N = 64. Values denoted are standardised regression coefficients. Solid line paths are that of significant effects. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 *achievement* mean, predictions of T2 *achievement* condition contrasts. Contrasting UVI prediction of note: Low T1 *achievement* students resulted in an adjusted standardised mean difference of d = .87 for T2 *achievement*. UVI at-risk students (Low T1 *achievement*) earned better scores (almost a full standard deviation higher) on T2 *achievement* than that of control condition at-risk students.

Hierarchical Regression Analysis of Interest$_{res}$

The additional block of predictors which were used to build onto each prior hierarchy of Interest$_{res}$ model analysed (see below) were the same blocks used on T2 *achievement* except for Block 5 which did not include T2 *interest.*

Block 1 = *condition*

Block 2 = T1 *achievement* and *condition*-T1 *achievement* interaction

Block 3 = *gender*, T1 *achievement-gender* interaction, *condition-gender* interaction, and *condition*-T1 *achievement-gender* interaction

Block 4 = T1 Motivation (*expectancy, cost, utility value, interest*) and *connection frequency*

Block 5 = T2 Motivation (*expectancy, cost, utility value*) and *connection frequency*

Table 15.

GLS Regression Results for T2 Interest$_{res}$

	Model 6				Model 7				Model 8				Model 9				Model 10			
	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2
Condition	*0.39**	0.21	0.06	0.04	*0.41**	0.211	0.06	0.04	0.51	0.35	0.16	0.02	-0.05	0.24	0.82	0.00	-0.23	0.19	0.24	0.01
T1 Achievement					0.239	0.166	0.16	0.02	0.44	0.39	0.26	0.01	-0.03	0.24	0.91	0.00	0.14	0.16	0.41	0.00
Condition * T1 Achievement					-0.09	0.234	0.69	0.00	-0.38	0.43	0.38	0.00	0.00	0.27	0.99	0.00	-0.05	0.18	0.79	0.00
Gender									0.42	0.36	0.25	0.01	0.13	0.24	0.58	0.00	-0.28	0.18	0.13	0.03
Condition * Gender									0.02	0.53	0.97	0.00	0.06	0.33	0.85	0.00	0.39	0.24	0.11	0.03
T1 Achievement * Gender									-0.22	0.43	0.60	0.00	0.16	0.27	0.57	0.00	-0.14	0.19	0.46	0.00
Condition * Gender * T1 Achievement									0.50	0.63	0.43	0.00	0.27	0.41	0.51	0.00	0.09	0.28	0.76	0.00
T1 Interest													**0.49*** **	0.15	0.00	0.16	**0.66*** **	0.12	0.00	0.38
T1 Expectancy													-0.05	0.11	0.64	0.00	-0.17	0.12	0.16	0.02
T1 Utility Value													0.08	0.13	0.54	0.00	**-0.29** *	0.12	0.02	0.09
T1 Cost													**0.20** *	0.10	0.05	0.06	0.13*	0.08	0.10	0.04
T1 Connection Freq.'s													**0.29*** **	0.09	0.00	0.14	-0.05	0.08	0.58	0.00
T2 Expectancy																	0.18	0.11	0.11	0.03
T2 Utility Value																	**0.56*** **	0.11	0.00	0.34
T2 Cost																	-0.10	0.08	0.22	0.01
T2 Connection Freq.'s																	0.10	0.09	0.27	0.01
R^2				0.10*				0.14*				0.19				0.72***				0.87***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardized regression coefficient. SE_β = standard error of the standardized regression coefficient. $\eta_a^2 = \varepsilon_p^2$ = indices denoting the approximate partial variance explained by an individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .10. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .15.

Model 6: Interest$_{res}$ Regressed on Predictors from Block 1. This study found a weak *condition* effect on students' Interest$_{res}$ (ß = .39, p = .06, η_a^2 = .04). Albeit weakly, UVI conditioned students self-reported higher increases for interest (M_{UVI} = 0.25, *d* = .39) than control conditioned students (M_{Cntl} = -0.38). This finding weakly corroborates Hulleman et al.'s (2017) findings. A self-generated utility value intervention can positively affect students' interest within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 7: Interest$_{res}$ Regressed on Predictors from Blocks 1-2. This study did not find that accounting for student's T1 achievement to have a moderating effect on their Interest$_{res}$. This finding differed from Hulleman et al. (2017) which did find initial achievement to moderate effects on students' interest. Regardless, a weak *condition* effect on students' T2 *achievement* found in prior models was present and not significantly altered (ß = .41, p = .06, η_a^2 = .04). This finding indicated UVI conditioned students self-reported higher increases for interest (*d* = .41) than control conditioned students. Although self-generated utility value intervention differential condition effects on interest were hypothesised to be found for at-risk undergraduate students, they were not.

Model 8: Interest$_{res}$ Regressed on Predictors from Blocks 1-3. This study did not find that accounting for student's gender to have a moderating effect on their Interest$_{res}$. This finding corroborates Hulleman et al.'s (2017) findings. Different from Hulleman et al.'s (2017) findings, though, accounting for student's *gender* rendered the model nonsignificant on all accounts—model and each individual variable. Although self-generated utility value intervention differential condition effects on interest were

hypothesised to be found for Hulleman et al. (2017) defined more-at-risk undergraduate students, they were not.

Model 9: Interest$_{res}$ Regressed on Predictors from Blocks 1-4. This study found significant initial motivation and frequency of connection effects on students' Interest$_{res}$ (T1 *cost*, ß = .20, p < .05, η_a^2 = .06; T1 *connection frequency*, ß = .29, p < .01, η_a^2 = .14). This study did not find the weak condition effect on students' Interest$_{res}$ found in prior models to be unaltered though—as the effects found for Interest$_{res}$ in prior models were reduced to nonsignificant once T1 Motivation and *connection frequency* variables were considered. This finding differed from Hulleman et al. (2017) which did find condition effects on students' Interest$_{res}$ found in prior models to be unaltered once T1 Motivation and *connection frequency* variables were considered. In sum, students who initially connected the statistics material more with their lives and associated less costs with learning statistics self-reported higher interest increases than students that did not. Although self-generated utility value intervention condition effects on Interest$_{res}$ were hypothesised to be found unaltered once T1 Motivation and *connection frequency* variables were considered, they were not.

Model 10: Interest$_{res}$ Regressed on Predictors from Blocks 1-5 sans T2 *interest*. This study found a significant change value motivation effect on students' Interest$_{res}$ (*utility value*, ß = .55, p < .01, η_a^2 = .34). This finding indicated students' *utility value* to be potential pathway for UVI indirect effects on students' Interest$_{res}$. This finding corroborates Hulleman et al.'s (2017) findings. Motivation can provide a potential pathway for UVI indirect effects on students' Interest$_{res}$ through students' utility value within the high DFW rate domain of undergraduate statistics as hypothesised.

This study did not find the weak condition effect on students' Interest$_{res}$ found in prior models to be unaltered though—as the effects found for Interest$_{res}$ in prior models were reduced to nonsignificant once Motivation and *connection frequency* change values were considered. This finding corroborates Hulleman et al.'s (2017) findings. In summary, students whose utility value for statistics increased self-reported higher interest increases than those whose didn't. As hypothesised, a self-generated utility value intervention can differentially effect students within the high DFW rate domain of undergraduate statistics when their change values for connection frequency and motivation are considered—although not beneficially as *condition* effects on Interest$_{res}$ were reduced from weak to nonsignificant.

A preliminary path analysis for UVI effects on students' Interest$_{res}$ and for potential pathways for UVI indirect effects on students' Interest$_{res}$ can be seen in Figure 7. The preliminary path depicts the weak *condition* effect found in Model 7 for predicting Interest$_{res}$ (ß = .41, p = .06, η_a^2 = .04). Recall, the weak condition effect was due to UVI conditioned students self-reporting higher interest increases (d = .41) than control conditioned students but was then reduced to nonsignificant once students' motivation and connection frequency were considered. Depicted, as well, is the Model 10 change value effect for *utility value* (ß = .56, p < .01, η_a^2 = .34) which was found to be significant in predicting Interest$_{res}$—providing a potential pathway for the UVI to indirectly affect students' Interest$_{res}$. Following the preliminary path analysis for study outcome variable Interest$_{res}$, motivation and connection frequency model regressions were analysed (Models 11-14, Table 16). The multiple testing adjustment method companion table to Table 16 can be found in Appendix M.

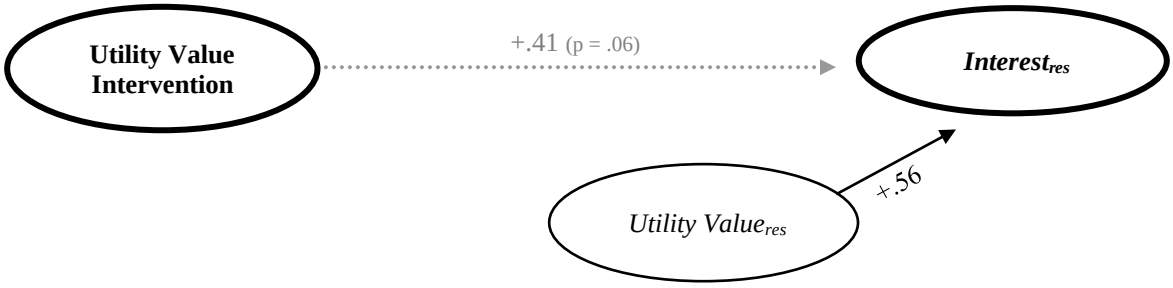


Figure 7. Condition effects on Interest$_{res}$ preliminary path model. N = 64. Values denoted are standardised regression coefficients. Solid line paths are that of significant effects. Dotted line paths are that of weak effects, reduced to nonsignificant when students' motivation and connection frequency were considered. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure.

Regression Analysis of Motivation Residuals and Connection Frequency$_{res}$

A single block of predictors were used for Expectancy$_{res}$ (Model 12), Utility Value$_{res}$ (Model 13), and Cost$_{res}$ (Model 14) models analysed (see below). The same block of predictors were used on the analysed Connection Frequency$_{res}$ model (Model 11) sans T2 *connection frequency.*

Block 6 = *condition,* T1 *achievement, condition*-T1 *achievement* interaction, *gender,* T1 Motivation (*expectancy, cost, utility value, interest*) and T1/T2 *connection frequency*

Model 11: Connection Frequency$_{res}$ Regressed on Predictors from Block 6 sans T2 *connection frequency.* This study found a weak *condition* effect on students' Connection Frequency$_{res}$ (ß = .59, p = .05, η_a^2 = .05). Albeit weakly, UVI conditioned students self-reported higher increases for connection frequency than control conditioned students (*d* = .59). This finding indicated students' *connection frequency* to be a potential pathway and/or a pathway mechanism for UVI indirect effects on students' T2 *achievement* and/or motivation. This finding differs from Hulleman et al.'s (2017) which did not find *condition* effects on students' frequency of connections. A self-generated

Table 16.

GLS Regression Results for Motivation Variable Residuals and Connection Frequency$_{res}$

	11 Connection Frequency$_{res}$				12 Expectancy$_{res}$				13 Utility Value$_{res}$				14 Cost$_{res}$			
	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2
Condition	*0.59**	0.30	0.05	0.05	0.21	0.15	0.16	0.02	-0.25	0.15	0.11	0.03	-0.12	0.24	0.62	0.00
T1 Achievement	0.11	0.14	0.41	0.00	*0.20**	0.10	0.06	0.05	0.03	0.10	0.79	0.00	0.14	0.14	0.32	0.00
Condition * T1 Achievement	0.03	0.20	0.90	0.00	**-0.33****	0.14	0.03	0.07	-0.01	0.15	0.95	0.00	-0.08	0.20	0.69	0.00
Gender	**0.44****	0.20	0.03	0.07	0.01	0.16	0.97	0.00	0.10	0.15	0.53	0.00	**-0.82*****	0.22	0.00	0.20
T1 Interest	-0.22	0.18	0.23	0.01	-0.05	0.13	0.70	0.00	-0.06	0.14	0.65	0.00	**0.71*****	0.18	0.00	0.21
T1 Expectancy	0.10	0.13	0.43	0.00	**0.73*****	0.10	0.00	0.51	-0.14	0.10	0.15	0.02	-0.17	0.13	0.20	0.01
T1 Utility Value	0.12	0.15	0.44	0.00	-0.07	0.12	0.56	0.00	**0.57*****	0.13	0.00	0.27	-0.35**	0.16	0.04	0.06
T1 Cost	0.04	0.12	0.71	0.00	**0.20****	0.09	0.03	0.07	0.09	0.08	0.30	0.00	**0.42*****	0.12	0.00	0.17
T1 Connection Freq.'s	**).61*****	0.11	0.00	0.35	-0.03	0.10	0.80	0.00	0.05	0.10	0.65	0.00	-0.09	0.14	0.50	0.00
T2 Connection Freq.'s	--	--	--		*0.17**	0.10	0.08	0.04	**0.55*****	0.10	0.00	0.37	0.09	0.14	0.51	0.00
R^2				0.56***				0.76***				0.75***				0.54***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardized regression coefficient. SE_β = standard error of the standardized regression coefficient. η_a^2 = ε_p^2 = indices denoting th approximat partial variance explained by a individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .15.

utility value intervention can positively affect, weakly, students' frequency of connections within the high DFW rate domain of undergraduate statistics as hypothesised.

Model 12: Expectancy$_{res}$ Regressed on Predictors from Block 6. This study found a significant initial motivation effect (T1 *cost*, ß = .20, $p < .03$, $\eta_a^2 = .07$) and a weak change value connection frequency effect (ß = .17, $p < .08$, $\eta_a^2 = .04$) on students' Expectancy$_{res}$. This finding indicated students' *connection frequency* to be a potential pathway mechanism for an expectancy pathway for UVI indirect effects on students' T2 *achievement* and/or Interest$_{res}$. These findings differ from Hulleman et al.'s (2017) which did not find initial motivation or change value connection frequency effects on students' expectancy. Although students' frequency of connections was hypothesised to be a potential pathway mechanism for a potential pathway found through students' motivation for UVI indirect effects on students' T2 *achievement* and/or Interest$_{res}$, the potential mechanised pathway was not hypothesised to be expectancy.

Along with the *cost* and change value connection frequency effects found, this study also found a significant interaction effect (*condition* by T1 *achievement)* on students' Expectancy$_{res}$ (ß = -.33, $p < .03$, $\eta_a^2 = .07$).

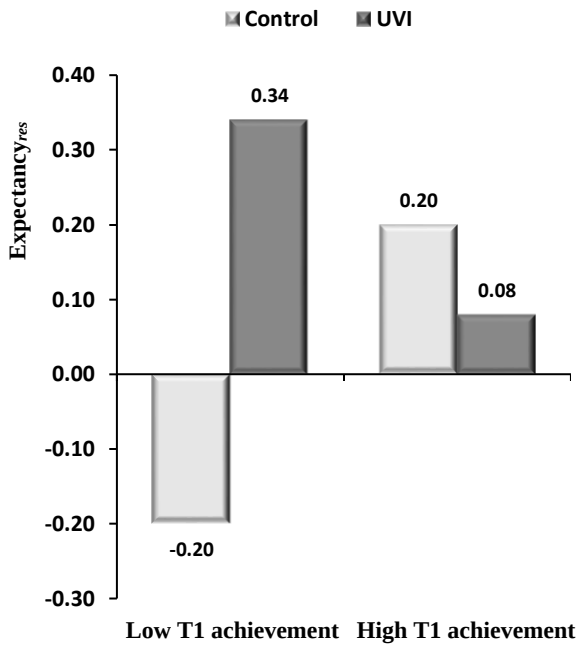


Figure 8. Expectancy$_{res}$ interaction between *condition* and T1 *achievement*, PI. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 achievement mean, predictions of Expectancy$_{res}$ per *condition*. The contrasting predictions for Low T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = .54.

The interaction was due to UVI conditioned at-risk students self-reporting higher increases for expectancy than control conditioned at-risk students (d = .54, see Figure 8). This finding indicated students' *expectancy* to be a potential pathway for UVI indirect effects on students' T2 *achievement* and/or motivation. This finding corroborates Hulleman et al.'s (2017) findings. Of special note, this study's at-risk UVI conditioned students not only self-reported higher increases for expectancy than that of at-risk control conditioned students but, in fact, reported higher increases for expectancy compared to control conditioned students in total (at-risk and not).

In summary, students who initially associated less costs with learning and whose frequency of connections increased, self-reported higher Expectancy$_{res}$ than those whose didn't, but UVI condition at-risk students still self-reported significantly higher Expectancy$_{res}$ than, not only, control conditioned at-risk students (d = .54), but control conditioned students as a whole. Although not hypothesised, a self-generated utility value intervention can positively affect at-risk students' expectancy within the high DFW rate domain of undergraduate statistics..

Model 13: Utility Value$_{res}$ Regressed on Predictors from Block 6. This study found a significant change value connection frequency effect (ß = .55, $p < .01$, $\eta_a^2 = .37$) on students' Utility Value$_{res}$. This finding indicated students' *connection frequency* to be a potential pathway mechanism for a utility value pathway for UVI indirect effects on students' T2 *achievement* and/or Interest$_{res}$. This finding corroborates Hulleman et al.'s (2017) findings. Frequency of connections can be a potential pathway mechanism for a utility value pathway for UVI indirect effects on students' T2 *achievement* and/or Interest$_{res}$, as hypothesised.

Although change value connection frequency effects were found, this study did not find *condition* effects on students' Utility Value$_{res}$. This finding corroborates Hulleman et al.'s (2017) findings. In sum, students whose frequency of connections increased, self-reported higher Utility Value$_{res}$ than those whose didn't. Although a self-generated utility value intervention was hypothesised to positively affect students' utility value within the high DFW rate domain of undergraduate statistics, no such affect was found.

Model 14: Cost$_{res}$ Regressed on Predictors from Block 6. This study found significant initial motivation effects (T1 *utility value,* ß = -.35, $p < .04$, $\eta_a^2 = .06$; T1 *interest,* ß = .71, $p < .01$, $\eta_a^2 = .21$) on students' Cost$_{res}$. This study's finding of initial utility value effects on students' cost differs from Hulleman et al.'s (2017) findings which did not find the effects. This study's finding of initial interest effects on students' cost corroborates Hulleman et al.'s (2017) findings.

This study did not find *condition* effects on students' Cost$_{res}$. This finding corroborates Hulleman et al.'s (2017) findings. In sum, students whose initial interest in statistics was higher, and had a lower perception of statistics' utility value, self-reported higher decreases for Cost$_{res}$ than those that did not. Cost$_{res}$ was not hypothesised to be affected via condition, to be a pathway for UVI condition indirect effects on students' T2 *achievement* and/or Interest$_{res}$, or to be affected via a pathway mechanism of connection frequency—and no findings as such were found either. With preliminary path analyses completed for T2 *achievement* (Models 1-5) and Interest$_{res}$ (Models 6-10), findings from Models 11-14 will complete each of the path analyses which follow.

Path Analysis

With preliminary path analyses completed for T2 *achievement* and Interest$_{res}$, findings from Models 11-14 complete each of the paths by denoting students' motivation (expectancy, utility value, cost) and/or connection frequency found to be affected due to the UVI and whether the change value for connection frequency was found to be significant in predicting students' motivation (expectancy, utility value, cost). Student motivation (expectancy, utility value, cost) found to be affected due to the UVI provide potential paths for the UVI to indirectly effect T2 *achievement* and Interest$_{res}$. Change values for connection frequency found to be significant in predicting students' motivation (expectancy, utility value, cost) provide potential mechanised paths through students' motivation for the UVI to effect T2 *achievement* and Interest$_{res}$. Connection Frequency found to be affected due to the UVI would provide a potential path for the UVI to effect T2 *achievement* and Interest$_{res}$ and/or would provide a potential mechanised path for the UVI to effect students' T2 *achievement* and Interest$_{res}$ through mechanism effects on students' motivation.

The completed path analysis for T2 *achievement*, seen in Figure 9-top, depicts the addition of the significant UVI *condition* by T1 *achievement* interaction effect found in Model 12 for Expectancy$_{res}$ (ß = -.33, $p < .03$, $\eta_a^2 = .07$). Recall, the interaction was due to UVI conditioned at-risk students self-reporting higher increases to expectancy ($d = .54$) than control conditioned at-risk students (see Figure 8). In finding (1) the UVI *condition* by T1 *achievement* interaction to effect T2 *achievement* for at-risk students, (2) the UVI *condition* by T1 *achievement* interaction to effect Expectancy$_{res}$ for at-risk students, and (3) the change value for *expectancy* to effect students' T2 *achievement*,

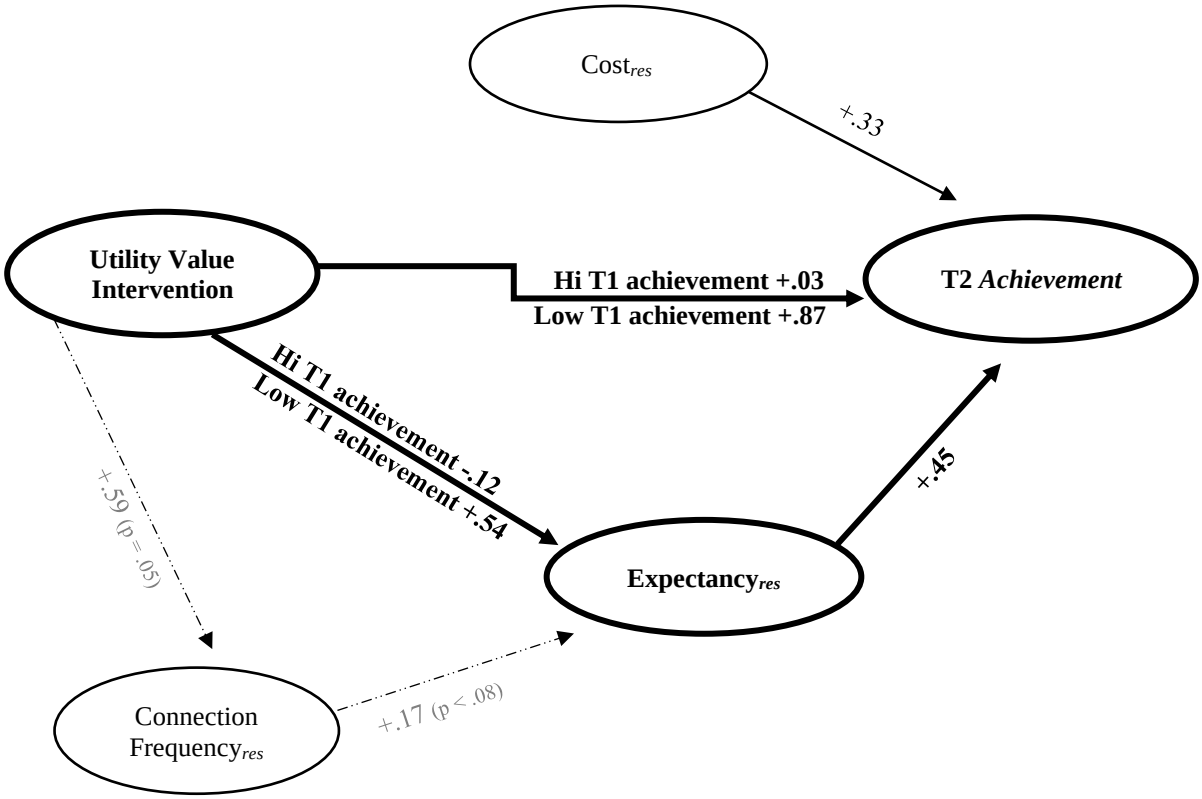
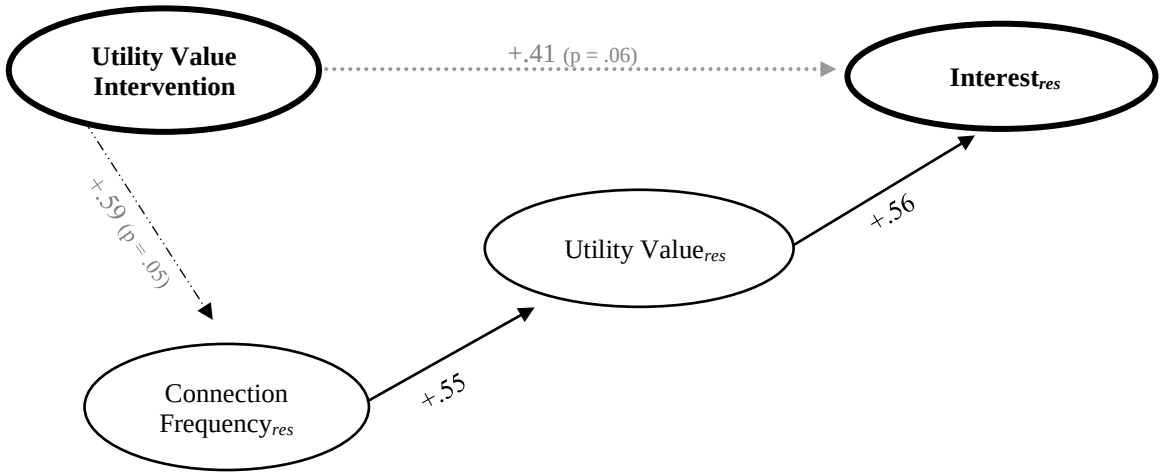


Figure 9. Condition effects on T2 *achievement* (top) and Interest$_{res}$ (bottom) path models. N = 64. Values denoted are standardised regression coefficients. Solid line paths are that of significant effects. Dashed line paths are that of weak effects. Dotted line paths are that of weak effects, reduced to nonsignificant when students' motivation and connection frequency were considered. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 *achievement* mean, predictions of T2 *achievement* and T2 *expectancy*$_{res}$ condition contrasts. Contrasting UVI predictions of note: Low T1 *achievement* students resulted in an adjusted standardised mean difference of d = .54 for T2 *expectancy*$_{res}$ and d = .87 for T2 *achievement*. UVI at-risk students self-reported significantly higher T2 *expectancy*$_{res}$ and earned better scores (almost a full standard deviation higher) on T2 *achievement* than that of control condition at-risk students.



mediation analysis was performed. Found was the UVI *condition* by T1 *achievement* interaction effect on at-risk students' Expectancy$_{res}$, at least, partially mediated the UVI condition by T1 *achievement* interaction effect on at-risk students' T2 achievement (ω_p^2 = .14, 95% CI [0.01, 0.33]). The potential pathway provided by the *cost* change value affecting T2 *achievement* was not found to be UVI condition effected though—an unused pathway to further student benefits.

Completed path analyses for T2 *achievement* and Interest$_{res}$, seen in Figure 9-bottom, also depict, with dashed lines, the addition of a weak UVI condition effect found in Model 11 for Connection Frequency$_{res}$ (ß = .59, p = .05, η_a^2 = .05)—providing a mechanised path through students' motivation for the UVI to indirectly affect students' T2 *achievement* and Interest$_{res}$. UVI mechanised Connection Frequency$_{res}$ effects on students' motivation are, also, depicted for expectancy, with dashed lines, (ß = .17, p < .08, η_a^2 = .04, Model 12) and utility value (ß = .55, p < .01, η_a^2 = .37, Model 13).

Part II: Analysis Extended

This extended analysis was an attempt at rectifying the limitation Hulleman et al. (2017) noted in regard to their connection frequency measure they created lacking operationalisation which captured the quality of the utility value connections students were making. This study attempted to capture the quality of the utility value connections students were making via scaled ratings coding of students' intervention responses—their two short relevance essay prompt responses. Scaled ratings coding of the intervention responses comprised of seven new connection quality measures, CQ *statistical literacy,* CQ *statistical thinking,* CQ *effort,* CQ *accuracy,* CQ *personal life,* CQ *professional/business life,* and CQ *periodicity,* measured as a set for each intervention

response. **Part II** analyses addressed research question 7 and hypothesis, 6, by re-analysing Models 5 and 10, as Models 15 (Table 18) and 16 (Table 19), and Models 11-14, as Models 17-20 (Table 20) from **Part I**, but with the connection quality measures included alongside the previously measured model variables. Essentially, Model 15 is the next hierarchal regression model following Models 1 – 5. The same could be said for Model 16 following Models 6-10, 17 following 11, 18 following 12, 19 following 13, and 20 following 14.

Part II additionally analysed Models 21-25 (Table 21) which provided findings on CQ measures to help determine the quality of connection the self-generated utility value intervention promoted which, in turn, affected students' motivation and achievement. **Part II** concludes with an effects path analysis, as well, specific to the inclusion of the connection quality measures. The multiple testing adjustment method companion table to Table 18 can be found in Appendix N. Again, study findings denoted as significant were those found by the Benjamini–Hochberg method, controlling for the false discovery rate (FDR) amongst multiple tests. First, though, the finalised scaled ratings used by the study's researcher coders on the student connection quality data will be presented as a result (see Table 17). Exemplification of scaled ratings coding of student examples and other info regarding the connection quality coding processes can be provided by the author as needed.

Hierarchical Regression Analysis of T2 achievement-Extended

A single block of connection quality predictors were used to build onto the prior hierarchy of T2 *achievement* models analysed (Blocks 1-5). They were:

Block 7 = CQ-I Connection Utility Elaboration (*statistical literacy usefulness,*

Table 17.
Connection Quality Measures and Coding Examples

Measure	Code	Coding Category Descriptions
Connection Utility Elaboration		
Statistical Literacy Usefulness	1	No connection of a statistical concept claimed/perceived
	2	Connection claimed/perceived statistical concept knowledge to be useful in some context
	3	Connection claimed/perceived statistical concept knowledge to be useful in some context and described how it could be applied usefully, or how it has been applied usefully, in the student supplied context
	Note	Usefulness to the self or others is acceptable as Personal Life and/or Business/Professional Life differentiates between the two. Concept = A unit from the 11/14 provided within Intervention Prompts I and II
Statistical Thinking Usefulness	1	No connection of a statistical tool/technique claimed/perceived
	2	Connection claimed/perceived a statistical tool/technique to be useful in some context
	3	Connection claimed/perceived a statistical tool/technique to be useful in some context and described how it's useful when applied to data in the student supplied context
	Note	Usefulness to the self or others is acceptable as Personal Life and/or Business/Professional Life differentiates between the two.Technique/Tool = Describing/analysing data through self constructed (relative) frequency table-histogram-bar graph-boxplot-distribution, constructing a (relative) frequency table-histogram-bar graph-boxplot-distribution, calculating proportion-frequency-probability-percentage-mode-median-mean-standard deviation, and detecting outliers via z-scores or boxplots (collecting data in and of itself does not qualify; action on data does).
Effort	1	No connection claimed/perceived—no effort to rate
	2	Connection(s) claimed/perceived word count totalled less than threshold, the median word count
	3	Connection(s) claimed/perceived word count totalled at least the threshold, the median word count
	Note	Researcher coders will confirm word counts (all words) and discuss significant differences amongst differing thresholds before establishing "2" and "3" threshold categorisations based on the median word count.
Accuracy	1	No connection claimed/perceived—no accuracy to rate
	2	Connection claimed/perceived inaccurately, or more than half are inaccurate if multiple exist
	3	Connection claimed/perceived accurately, or at least half are accurate if multiple exist
	Note	Categorising as a "2" requires a student made claim, or more than half of a students' claims, to be inaccurate due to applying statistical concept/tool/technique inaccurately, which stems from a lack of understanding the statistical concept/tool/technique.
Connection Utility Contextualisation		
Personal Life	1	No personal life connection claimed/perceived
	2	Connection claimed/perceived to be applied to one's personal life in some context
	3	Connection claimed/perceived to be applied to one's personal life in some context and described how it was, or could be, applied in the student supplied context
	Note	Current statistics course does not qualify as Personal Life.
Professional/Business Life	1	No professional/business life connection claimed/perceived
	2	Connection claimed/perceived to be applied to one's professional/business life in some context
	3	Connection claimed/perceived to be applied to one's professional/business life in some context and described how it was, or could be, applied in the student supplied context
	Note	Courses other than the current statistics course consititute professional/business life.
Periodicity	1	No connection claimed/perceived—no periodicity to rate
	2	Connection(s) claimed/perceived sporadic use of statistics, or no more than once per week
	3	Connection(s) claimed/perceived multiple times per week to daily use of statistics
	Note	When students make a vague claim such as, "I do this often", the response will be categorised as 'sporadic use', a "2", due to a lack of periodicity specificity.

Table 18.

GLS Regression Results for T2 Achievement-Extended

	Model 15			
	β	SE_β	p value	η_a^2
Condition	**1.46****	0.56	0.01	0.15
T1 Achievement	**0.58*****	0.17	0.00	0.25
Condition * T1 Achievement	-0.31	0.21	0.16	0.03
Gender	0.21	0.20	0.29	0.00
Condition * Gender	**-1.23****	0.46	0.01	0.16
T1 Achievement * Gender	-0.16	0.19	0.42	0.00
Condition * Gender * T1 Achievement	**1.50*****	0.41	0.00	0.28
T1 Interest	-0.07	0.21	0.73	0.00
T1 Expectancy	-0.23	0.15	0.13	0.04
T1 Utility Value	-0.10	0.16	0.52	0.00
T1 Cost	-0.15	0.11	0.18	0.03
T1 Connection Frequency	0.09	0.10	0.40	0.00
T2 Expectancy	**0.60*****	0.14	0.00	0.36
T2 Utility Value	**-0.46****	0.19	0.02	0.13
T2 Cost	**0.30****	0.12	0.01	0.15
T2 Connection Frequency	-0.05	0.14	0.72	0.00
T2 Interest	**0.57*****	0.21	0.01	0.17
Connection Quality				
CQ-I Connection Utility Elaboration				
Statistical Literacy Usefulness	-0.27	0.24	0.28	0.01
Statistical Thinking Usefulness	-0.04	0.13	0.76	0.00
Accuracy	-0.03	0.26	0.92	0.00
Effort	*-0.68***	0.30	0.03	0.11
CQ-I Connection Utility Contextualisation				
Personal Life	*0.58***	0.26	0.03	0.11
Professional/Business Life	0.19	0.15	0.21	0.02
Periodicity	-0.21	0.18	0.25	0.01
CQ-II Connection Utility Elaboration				
Statistical Literacy Usefulness	0.06	0.46	0.90	0.00
Statistical Thinking Usefulness	-0.15	0.13	0.25	0.01
Accuracy	-0.24	0.32	0.47	0.00
Effort	0.00	0.38	0.99	0.00
CQ-II Connection Utility Contextualisation				
Personal Life	-0.25	0.22	0.27	0.01
Professional/Business Life	0.00	0.32	0.99	0.00
Periodicity	0.44*	0.24	0.07	0.07
R^2				0.93***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardised regression coefficient. SE_β = standard error of the standardised regression coefficient. $\eta_a^2 = \varepsilon_p^2$ = indices denoting the approximate partial variance explained by an individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .10. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

statistical thinking usefulness, effort, accuracy) and Connection Utility Contextualisation (*personal life, professional/business life, periodicity*), and CQ-II Connection Utility Elaboration (*statistical literacy usefulness, statistical thinking usefulness, effort, accuracy*) and Connection Utility Contextualisation (*personal life, professional/business life, periodicity*).

Model 15: T2 *achievement* Regressed on Predictors from Blocks 1-5 and 7.

This study found, when considering connection quality predictors within the model, significant positive change value motivation effects on students' T2 *achievement* (*expectancy*, ß = .60, p < .01, η_a^2 = .36; *cost*, ß = .30, p = .01, η_a^2 = .15; *interest*, ß = .57, p < .01, η_a^2 = .17). These findings indicated students' *expectancy, cost*, and *interest* to be potential pathways for UVI indirect effects on students' T2 *achievement*. *Expectancy* and *cost* as potential pathways were found in previous models. *Interest* as a potential pathway was found only after analysis was extended to include connection quality predictors. Although students' motivation was hypothesised to provide potential pathways for UVI indirect effects on students T2 achievement through students' utility value and/or connection frequency; expectancy, cost, and interest were instead the potential pathways found through students' motivation when connection quality predictors were considered.

This study, also, found weak connection quality predictor effects on students' T2 *achievement* (CQ-I *personal life*, ß = .58, p = .03, η_a^2 = .11; CQ-I *effort*, ß = -.68, p = .03, η_a^2 = .11). The positive finding of CQ-I *personal life* indicated that quality utility value connections students made to their personal life via the UVI-I to be a weak potential pathway for UVI indirect effects on their T2 *achievement*. The negative finding of CQ-I

effort was a testament to the quality over quantity mantra—as increased effort, defined as a simple word count, did not positively effect students' T2 *achievement.*

Along with the CQ-I *personal life* and the *expectancy, cost, interest* change value effects found, this study also found a significant interaction effect (*condition* by T1 *achievement* by *gender*), found in prior models as well, on students' T2 *achievement* (ß = 1.50, $p < .01$, $\eta_a^2 = .28$). The interaction was due in large part to UVI conditioned at-risk female students and initial high achieving male and female students earning higher T2 *achievement* than their control conditioned counterparts. UVI conditioned at-risk female students earned higher T2 *achievement* than control conditioned at-risk female students ($d = 1.77$, see Figure 10)—an approximately 29.5- percentage point grade difference between groups when connection quality predictors were considered. UVI conditioned high achieving male students earned higher T2 *achievement* than control conditioned high achieving male students when connection quality predictors were considered ($d = 1.42$, see Figure 10)— more than a 23.5-percentage point grade difference between groups. UVI conditioned high achieving female students earned higher T2 *achievement* than control conditioned high achieving female students when connection quality predictors were considered ($d = 1.15$, see Figure 10)— more than a 19-percentage point grade difference between groups. Alarmingly, though, more-at-risk students (low initial achieving males) were impacted negatively ($d = -.96$, see Figure 10).

In summary, students whose expectancy for statistics success increased, associated costs with learning statistics decreased, interest for statistics increased, and made quality utility value connections to their personal life via the UVI-I earned higher T2 *achievement* than students who did not experience the same, but UVI conditioned at-

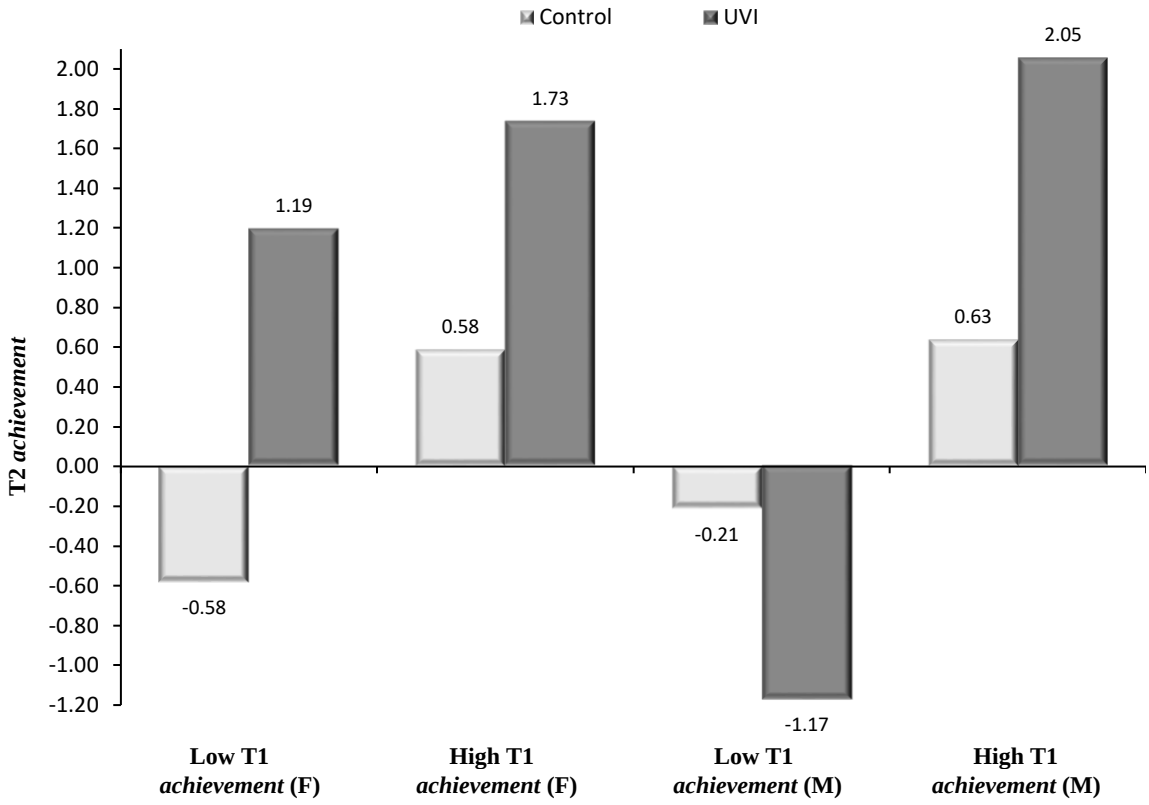


Figure 10. T2 *achievement interaction between condition*, T1 *achievement*, and *gender*, *PII*. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 *achievement* mean, predictions of T2 *achievement* per *condition* and *gender*. The contrasting predictions of note resulted in adjusted standardised mean differences of $d_{fem.T1\text{-}L} = 1.77$, $d_{mal.T1\text{-}H} = 1.42$, and $d_{fem.T1\text{-}H} = 1.15$.

risk female students, who were impacted most by the self-generated utility value intervention, still earned significantly higher T2 *achievement* ($d = 1.77$) than control conditioned at-risk female students. As hypothesised, a self-generated utility value intervention can positively affect achievement differentially for students within the high DFW rate domain of undergraduate statistics when their connection quality predictors are considered.

A preliminary path analysis for UVI effects on students' T2 *achievement* and for potential pathways for UVI indirect effects on students' T2 *achievement*, when connection quality predictors were considered, can be seen in Figure 11. The preliminary

path depicts the significant *condition* by T1 *achievement* by *gender* interaction effect (ß = 1.50, $p < .01$, $\eta_a^2 = .28$), as well as the significant condition effect (ß = 1.46, $p = .01$, $\eta_a^2 = .15$), found in Model 15 for predicting T2 *achievement*. Depicted, as well, are Model 15 change value predictors for *cost* (ß = .30, $p = .01$, $\eta_a^2 = .15$), *expectancy* (ß = .60, $p < .01$, $\eta_a^2 = .36$), *interest* (ß = .57, $p < .01$, $\eta_a^2 = .17$), and the CQ-I *personal life* (ß = .58, $p = .03$, $\eta_a^2 = .11$) predictor which were noted as affecting students' T2 *achievement*—providing potential pathways for the UVI to indirectly affect students' T2 *achievement.* Following the preliminary path analysis extension for when connection quality predictors were included for study outcome variable T2 *achievement*, analysis was then extended for study outcome variable Interest$_{res}$ for when connection quality predictors were included (Model 16, Table 19). The multiple testing adjustment method companion table to Table 19 can be found in Appendix O.

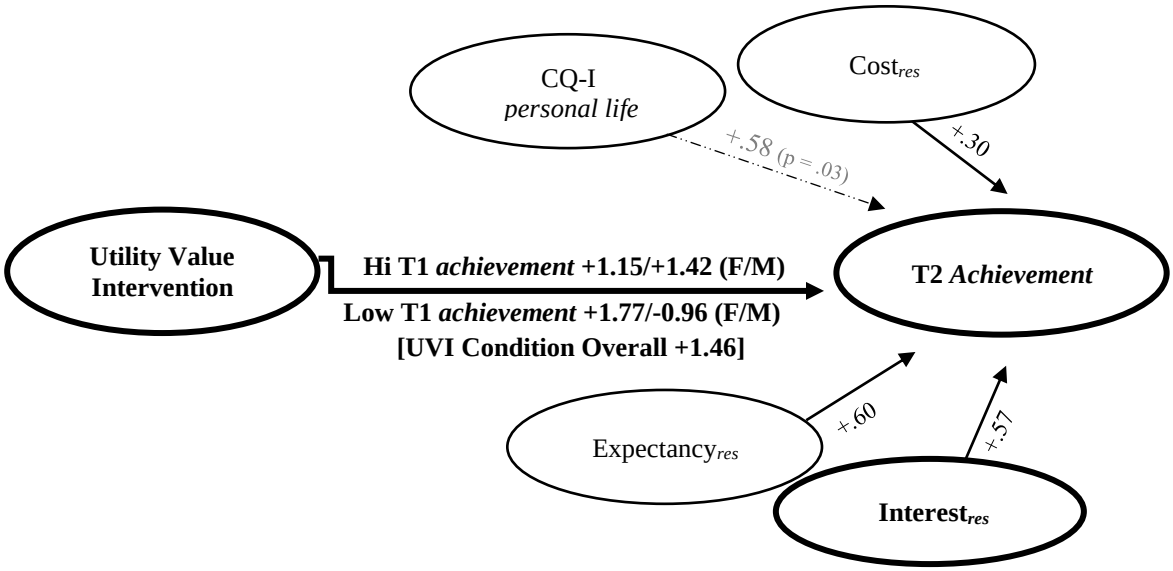


Figure 11. Condition effects on T2 *achievement* preliminary path model extension. N = 64. Values denoted are standardised regression coefficients. Solid line paths are that of significant effects found by the Benjamini–Hochberg method. Dashed line paths are that of weak effects found by the Benjamini–Hochberg method. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure. Low and High T1 *achievement* predictions were based on estimates of one standard deviation below and above the T1 *achievement* mean. UVI conditioned students directly earned better scores (almost one and a half standard deviations higher) on T2 *achievement* than that of control condition students.

Hierarchical Regression Analysis of Interest$_{res}$-Extended

A single block of connection quality predictors were used to build onto the prior hierarchy of Interest$_{res}$ models analysed (Blocks 1-5, sans T2 *interest* from Block 5). They were the same block of connection quality predictors used on T2 *achievement*-Extended and were:

Block 7 = CQ-I Connection Utility Elaboration (*statistical literacy usefulness, statistical thinking usefulness, effort, accuracy*) and Connection Utility Contextualisation (*personal life, professional/business life, periodicity*), and CQ-II Connection Utility Elaboration (*statistical literacy usefulness, statistical thinking usefulness, effort, accuracy*) and Connection Utility Contextualisation (*personal life, professional/business life, periodicity*).

Model 16: Interest$_{res}$ Regressed on Predictors from Blocks 1-5, sans T2 *interest,* and 7. This study found, when considering connection quality predictors within the model, change value motivation effects on students' Interest$_{res}$ (*expectancy*, ß = .23, p = .03, η_a^2 = .11, weak effect; *utility value*, ß = .65, p < .01, η_a^2 = .53, significant effect). These findings indicated students' *expectancy* and *utility value* to be potential pathways for UVI indirect effects on students' Interest$_{res}$. *Utility value* as a significant potential pathway was found in previous models. *Expectancy* as a weak potential pathway was found only after analysis was extended to include connection quality predictors. Although students' motivation was hypothesised to provide potential pathways for UVI indirect effects on students' Interest$_{res}$ through students' utility value and/or connection

Table 19.

GLS Regression Results for Interest$_{res}$-Extended

	Model 16			
	β	SE_β	p value	η_a^2
Condition	-0.03	0.34	0.94	0.00
T1 Achievement	0.19	0.12	0.12	0.04
Condition * T1 Achievement	-0.15	0.15	0.33	0.00
Gender	-0.28*	0.15	0.07	0.07
Condition * Gender	-0.22	0.32	0.51	0.00
T1 Achievement * Gender	-0.15	0.14	0.30	0.00
Condition * Gender * T1 Achievement	0.17	0.33	0.61	0.00
T1 Interest	**0.74*** **	0.12	0.00	0.53
T1 Expectancy	-0.16	0.11	0.17	0.03
T1 Utility Value	**-0.40*** **	0.10	0.00	0.33
T1 Cost	*0.14**	0.07	0.05	0.08
T1 Connection Frequency	**-0.18** **	0.07	0.02	0.13
T2 Expectancy	*0.23** **	0.10	0.03	0.11
T2 Utility Value	**0.65*** **	0.10	0.00	0.53
T2 Cost	**-0.23*** **	0.08	0.01	0.16
T2 Connection Frequency	-0.03	0.09	0.79	0.00
Connection Quality				
CQ-I Connection Utility Elaboration				
Statistical Literacy Usefulness	-0.34*	0.18	0.07	0.07
Statistical Thinking Usefulness	*0.17** *	0.08	0.04	0.09
Accuracy	0.17	0.21	0.42	0.00
Effort	-0.13	0.22	0.57	0.00
CQ-I Connection Utility Contextualisation				
Personal Life	0.11	0.21	0.59	0.00
Professional/Business Life	0.12	0.11	0.29	0.00
Periodicity	0.00	0.13	0.98	0.00
CQ-II Connection Utility Elaboration				
Statistical Literacy Usefulness	*0.64** *	0.30	0.04	0.09
Statistical Thinking Usefulness	*0.21** *	0.09	0.03	0.10
Accuracy	-0.28	0.24	0.25	0.01
Effort	-0.48	0.30	0.12	0.05
CQ-II Connection Utility Contextualisation				
Personal Life	**0.38*** **	0.14	0.01	0.17
Professional/Business Life	0.00	0.21	0.99	0.00
Periodicity	-0.17	0.16	0.28	0.01
R^2				0.96***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardised regression coefficient. SE_β = standard error of the standardised regression coefficient. $\eta_a^2 = \varepsilon_p^2$ = indices denoting the approximate partial variance explained by an individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .10. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

frequency, expectancy and utility value were the potential pathways found through students' motivation when connection quality predictors were considered.

This study, also, found positive connection quality predictor effects on students' Interest$_{res}$ (CQ-I *statistical thinking usefulness*, ß = .17, p = .04, η_a^2 = .09; CQ-II *statistical literacy usefulness*, ß = .64, p = .04, η_a^2 = .09; CQ-II *statistical thinking usefulness*, ß = .21, p = .03, η_a^2 = .10; CQ-II *personal life*, ß = .38, p < .01, η_a^2 = .17). The finding of CQ-I *statistical thinking usefulness* indicated that quality utility value connections students made to the usefulness of statistical thinking techniques and/or tools via the UVI-I to be a weak potential pathway for UVI indirect effects on their Interest$_{res}$. The finding of CQ-II *statistical literacy usefulness* and CQ-II *statistical thinking usefulness* indicated that quality utility value connections students made to the usefulness of being literate of statistical knowledge and concepts and to the usefulness of statistical thinking techniques *and/or tools* via the UVI-II to be weak potential pathways for UVI indirect effects on their Interest$_{res}$. The finding of CQ-II *personal life* indicated that quality utility value connections students made to their *personal life* via the UVI-II to be a significant potential pathway for UVI indirect effects on their Interest$_{res}$.

The weak condition effect on students' Interest$_{res}$ found in prior models remained nonsignificant when connection quality predictors were considered within the model. In summary, students whose expectancy for statistics success increased, utility value for statistics increased, who made quality utility value connections to *statistical thinking usefulness* via UVI-I, and who made quality utility value connections to *statistical literacy usefulness, statistical thinking usefulness, and their personal life* via UVI-II, self-reported higher interest increases than students who did not experience the same.

A preliminary path analysis for UVI effects on students' Interest$_{res}$ and for potential pathways for UVI indirect effects on students' Interest$_{res}$, when connection quality predictors were considered, can be seen in Figure 12. The preliminary path depicts the weak *condition* effect found in Model 7 for predicting Interest$_{res}$ (ß = .41, p = .06, η_a^2 = .04) which was reduced to non-significant once students' motivation, connection frequency, and connection quality were considered. Depicted, as well, are Model 16 change values effects for *expectancy* (ß = .23, p = .03, η_a^2 = .11) and *utility value* (ß = .65, p < .01, η_a^2 = .53), and the Model 16 connection quality predictor effects for CQ-I *statistical thinking usefulness* (ß = .17, p = .04, η_a^2 = .09), CQ-II *statistical*

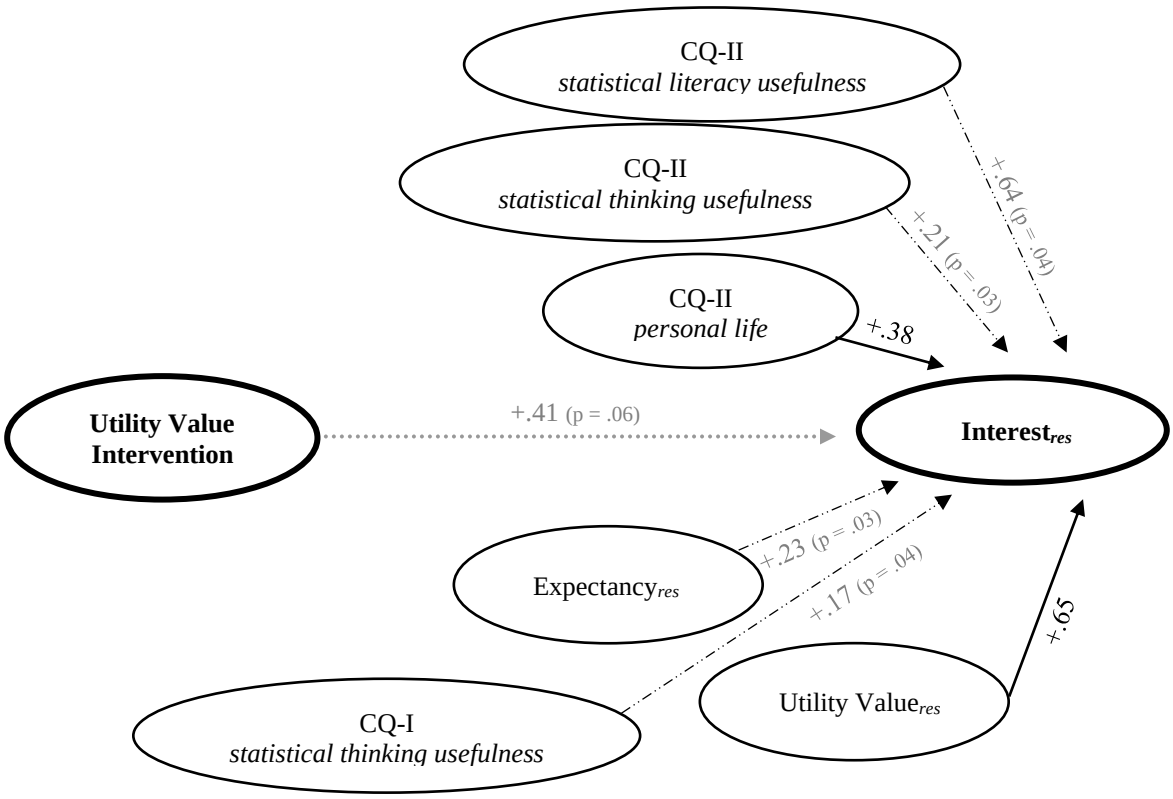


Figure 12. Condition effects on Interest$_{res}$ preliminary path model extension. N = 64. Values denoted are standardised regression coefficients. Solid line paths are that of significant effects found by the Benjamini–Hochberg method. Dashed line paths are that of weak effects found by the Benjamini–Hochberg method. Dotted line paths are that of weak effects, reduced to nonsignificant when students' motivation and connection frequency were considered. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure.

literacy usefulness (ß = .64, p = .04, η_a^2 = .09), CQ-II *statistical thinking usefulness* (ß = .21, p = .03, η_a^2 = .10), and CQ-II *personal life* (ß = .38, p < .01, η_a^2 = .17), which were all found to affect students' Interest$_{res}$—providing potential pathways for the UVI to indirectly affect students' Interest$_{res}$. Following the preliminary path analysis extension for when connection quality predictors were included for study outcome variable Interest$_{res}$, analysis was then extended for motivation and connection frequency model regressions for when connection quality predictors were included (Models 17-20, Table 20). The multiple testing adjustment method companion table to Table 20 can be found in Appendix P.

Regression Analysis of Motivation Residuals and Connection Frequency$_{res}$-Extended

A single block of connection quality predictors were used to build onto the prior Motivation (*expectancy, utility value, cost)* residuals and Connection Frequency$_{res}$ models analysed (Block 6, sans T2 *connection frequency* for Connection Frequency$_{res}$ model). They were the same block of connection quality predictors used on T2 *achievement*-Extended and Interest$_{res}$-Extended and were:

Block 7 = CQ-I Connection Utility Elaboration (*statistical literacy usefulness, statistical thinking usefulness, effort, accuracy*) and Connection Utility Contextualisation (*personal life, professional/business life, periodicity*), *statistical thinking usefulness, effort, accuracy*) and Connection Utility Contextualisation (*personal life, professional/business life, periodicity*), and CQ-II Connection Utility Elaboration (*statistical literacy usefulness, statistical thinking usefulness, effort, accuracy*) and

Table 20.

GLS Regression Results for Motivation Variable Residuals and Connection Frequency$_{res}$-Extended

	17 Connection Frequency$_{res}$				18 Expectancy$_{res}$				19 Utility Value$_{res}$				20 Cost$_{res}$			
	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2
Condition	-0.41	0.45	0.37	0.00	0.02	0.36	0.97	0.00	-0.56*	0.32	0.09	0.05	-0.05	0.43	0.90	0.00
T1 Achievement	0.14	0.13	0.30	0.00	*0.22***	0.11	0.05	0.07	0.01	0.11	0.92	0.00	0.18	0.13	0.19	0.02
Condition * T1 Achievement	-0.29	0.24	0.23	0.01	*-0.45***	0.19	0.03	0.10	-0.16	0.19	0.41	0.00	-0.04	0.25	0.87	0.00
Gender	**0.64****	0.25	0.01	0.12	0.18	0.22	0.43	0.00	0.23	0.20	0.26	0.01	**-0.65****	0.27	0.02	0.11
T1 Interest	**-0.47****	0.20	0.02	0.10	-0.33*	0.18	0.07	0.06	-0.16	0.16	0.34	0.00	**0.55****	0.22	0.02	0.12
T1 Expectancy	0.18	0.14	0.20	0.02	**0.85*****	0.11	0.00	0.57	-0.01	0.11	0.91	0.00	-0.11	0.14	0.43	0.00
T1 Utility Value	0.24	0.17	0.18	0.02	0.01	0.14	0.97	0.00	**0.57*****	0.14	0.00	0.27	-0.22	0.18	0.22	0.01
T1 Cost	0.02	0.13	0.88	0.00	**0.27****	0.11	0.01	0.13	0.14	0.10	0.14	0.03	**0.37*****	0.13	0.01	0.16
T1 Connection Freq.'s	**0.69*****	0.12	0.00	0.43	0.08	0.13	0.54	0.00	0.14	0.12	0.25	0.01	-0.01	0.16	0.97	0.00
T2 Connection Freq.'s	--	--	--		0.04	0.13	0.75	0.00	**0.51*****	0.12	0.00	0.31	-0.08	0.15	0.61	0.00
Connection Quality																
CQ-I Connection Utility Elaboration																
Statistical Literacy Usefulness	0.35	0.29	0.23	0.01	0.01	0.24	0.95	0.00	0.20	0.23	0.40	0.00	0.23	0.31	0.45	0.00
Statistical Thinking Usefulness	0.27*	0.15	0.08	0.05	0.15	0.12	0.20	0.02	0.19	0.12	0.13	0.03	**0.39****	0.16	0.02	0.11
Accuracy	-0.10	0.34	0.77	0.00	0.24	0.28	0.40	0.00	0.13	0.27	0.63	0.00	0.62*	0.34	0.08	0.06
Effort	0.49	0.43	0.26	0.01	0.23	0.35	0.53	0.00	0.08	0.36	0.83	0.00	-0.71	0.45	0.13	0.03
CQ-I Connection Utility Contextualisation																
Personal Life	-0.44	0.31	0.16	0.02	-0.40	0.26	0.13	0.03	-0.35	0.25	0.16	0.03	-0.29	0.32	0.38	0.00
Professional/Business Life	**-0.42****	0.18	0.02	0.10	-0.22	0.15	0.15	0.03	-0.11	0.16	0.47	0.00	-0.18	0.20	0.37	0.00
Periodicity	0.38	0.27	0.16	0.03	0.25	0.20	0.23	0.01	0.38*	0.21	0.07	0.06	-0.16	0.27	0.54	0.00
CQ-II Connection Utility Elaboration																
Statistical Literacy Usefulness	0.39	0.53	0.47	0.00	0.20	0.44	0.66	0.00	-0.13	0.40	0.75	0.00	0.02	0.54	0.98	0.00
Statistical Thinking Usefulness	0.12	0.16	0.47	0.00	0.00	0.14	0.98	0.00	-0.08	0.13	0.52	0.00	0.06	0.17	0.71	0.00
Accuracy	-0.11	0.47	0.82	0.00	-0.32	0.37	0.39	0.00	-0.68*	0.39	0.09	0.05	-0.27	0.49	0.58	0.00
Effort	-0.42	0.47	0.38	0.00	0.09	0.38	0.82	0.00	0.15	0.40	0.70	0.00	0.36	0.50	0.48	0.00
CQ-II Connection Utility Contextualisation																
Personal Life	0.12	0.31	0.71	0.00	0.12	0.24	0.61	0.00	0.23	0.26	0.38	0.00	-0.10	0.32	0.76	0.00
Professional/Business Life	0.12	0.44	0.79	0.00	-0.10	0.34	0.77	0.00	0.30	0.35	0.39	0.00	-0.31	0.44	0.49	0.00
Periodicity	-0.06	0.30	0.84	0.00	-0.16	0.24	0.51	0.00	-0.07	0.22	0.74	0.00	0.39	0.30	0.20	0.02
R^2				0.70***				0.82***				0.83***				0.69***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardized regression coefficient. SE_β = standard error of the standardized regression coefficient. η_a^2 = ε_p^2 = indices denoting the approximate partial variance explained by an individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

Connection Utility Contextualisation (*personal life, professional/business life, periodicity*).

Model 17: Connection Frequency$_{res}$ Regressed on Predictors from Blocks 6 and 7 sans T2 *connection frequency.* This study did not find significant positive effects on students' Connection Frequency$_{res}$ once connection quality predictors were included within the model. The prior finding of UVI conditioned students self-reporting higher increases for connection frequency than control conditioned students was reduced to non-significant. Although hypothesised to be a pathway or pathway mechanism for UVI indirect effects on students' T2 *achievement* and/or motivation, once connection quality predictors were included within the model *connection frequency* was no longer found to be either.

Model 18: Expectancy$_{res}$ Regressed on Predictors from Blocks 6 and 7. This study found, when considering connection quality predictors within the model, a significant initial motivation effect (T1 *cost*, ß = .27, p = .01, η_a^2 = .13), found in prior models as well, on students' Expectancy$_{res}$. The prior weak change value connection frequency effect on students' Expectancy$_{res}$ was reduced to non-significant. Along with the connection frequency effect being reduced to non-significant, the significant interaction effect (*condition* by T1 *achievement*), found in prior models as well, was reduced to a weak interaction effect on students' Expectancy$_{res}$ (ß = -.45, p = .03, η_a^2 = .10). Again, the interaction was due to UVI conditioned at-risk students self-reporting higher increases for expectancy than control conditioned at-risk students (*d* = .47, see Figure 13). This finding indicated at-risk students' *expectancy* to be a weak potential pathway for UVI indirect effects on their T2 *achievement* and/or motivation.

In summary, students who initially associated less costs with learning self-reported higher Expectancy$_{res}$ than those who didn't, but UVI condition at-risk students still self-reported higher Expectancy$_{res}$ than control conditioned at-risk students (d = .47). Although not hypothesised, a self-generated utility value intervention can positively affect at-risk students' expectancy within the high DFW rate domain of undergraduate statistics..

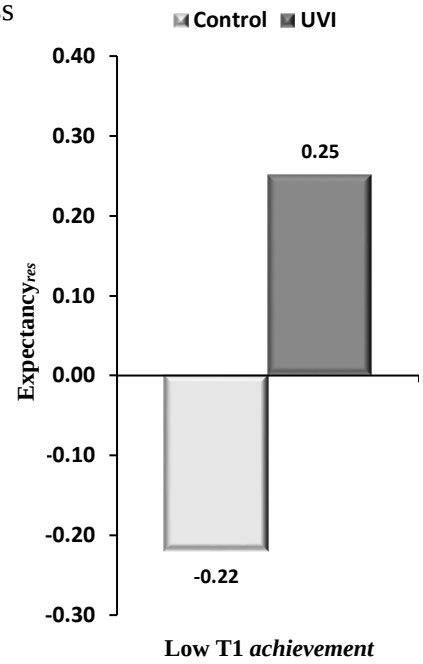


Figure 13. Expectancy$_{res}$ interaction between *condition* and T1 *achievement*, PII. N = 64. Low T1 *achievement*, based on estimates of one standard deviation below T1 achievement mean, predictions of Expectancy$_{res}$ per *condition*. The contrasting predictions for Low T1 *achievement* students resulted in an adjusted standardised mean difference of d = .47.

Model 19: Utility Value$_{res}$ Regressed on Predictors from Blocks 6 and 7. This study found, when considering connection quality predictors within the model, a significant change value connection frequency effect (ß = .51, $p < .01$, $\eta_a^2 = .31$) found in prior models as well, on students' Utility Value$_{res}$. This finding indicated students' *connection frequency* to be a potential pathway through utility value for UVI indirect effects on students' T2 *achievement* and/or Interest$_{res}$, as hypothesised.

Although change value connection frequency effects were found, this study did not find *condition* effects on students' Utility Value$_{res}$. In sum, students whose frequency of connections increased, self-reported higher Utility Value$_{res}$ than those whose didn't. Although a self-generated utility value intervention was hypothesised to positively affect students' utility value within the high DFW rate domain of undergraduate statistics, no such affect was found via the utility value survey measure.

Model 20: Cost$_{res}$ Regressed on Predictors from Blocks 6 and 7. This study found, when considering connection quality predictors within the model, a significant initial motivation effect (T1 *interest,* ß = .55, p = .02, η_a^2 = .12), found in prior models as well, on students' Cost$_{res}$. This study also found connection quality predictor effects on students' Cost$_{res}$ (CQ-I *statistical thinking usefulness*, ß = .39, p < .05, η_a^2 = .11). The finding of CQ-I *statistical thinking usefulness* indicated that quality utility value connections students made to the usefulness of statistical thinking techniques and/or tools via the UVI-I to be a potential pathway mechanism for a cost pathway for UVI indirect effects on students' T2 *achievement* and/or Interest$_{res}$. This study did not find *condition* effects on students' Cost$_{res}$. In sum, students whose initial interest in statistics was higher, and who made quality utility value connections to *statistical thinking usefulness*, self-reported greater Cost$_{res}$ *decreases* than students who did not experience the same. Regression analysis to follow explores UVI effects on connection quality measures found within Models 15-20 to serve as potential mechanisms or as pathways for UVI indirect effects on students' achievement and motivation (Models 21-25, Table 21). The multiple testing adjustment method companion table to Table 21 can be found in Appendix Q.

Regression Analysis of Connection Quality

A single block of predictors (see below) were used for connection quality models analysed (CQ-I *statistical thinking usefulness*, Model 21; CQ-I *personal life*, Model 22; CQ-II *statistical literacy usefulness*, Model 23; CQ-II *statistical thinking usefulness*, Model 24; CQ-II *personal life*, Model 25). The single block consists of the same predictors used to analyse *Connection Frequency*$_{res}$ (Model 11). Only five (Models 21-25) of the fourteen potential connection quality response variables were analysed. The

Table 21.

GLS Regression Results for Connection Quality Variables

	21 CQ-I *statistical thinking usefulness*				22 CQ-I *personal life*				23 CQ-II *statistical literacy usefulness*				24 CQ-II *statistical thinking usefulness*				25 CQ-II *personal life*			
	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2	β	SE_β	p value	η_a^2
Condition	**0.78****	0.32	0.02	0.08	**1.22*****	0.16	0.00	0.50	**1.28*****	0.22	0.00	0.38	0.72*	0.41	0.08	0.04	**0.75*****	0.12	0.00	0.41
T1 Achievement	0.01	0.16	0.94	0.00	0.01	0.13	0.94	0.00	-0.02	0.13	0.86	0.00	-0.05	0.16	0.77	0.00	-0.10	0.12	0.42	0.00
Condition * T1 Achievement	0.23	0.24	0.36	0.00	**0.50****	0.19	0.01	0.10	**0.45****	0.18	0.02	0.09	*0.45***	0.22	0.05	0.05	-0.01	0.17	0.96	0.00
Gender	0.23	0.25	0.36	0.00	-0.04	0.20	0.83	0.00	-0.20	0.18	0.27	0.00	-0.07	0.23	0.77	0.00	-0.28	0.17	0.11	0.03
T1 Interest	-0.07	0.22	0.74	0.00	-0.09	0.17	0.58	0.00	0.12	0.16	0.45	0.00	-0.09	0.20	0.65	0.00	0.08	0.16	0.60	0.00
T1 Expectancy	-0.13	0.16	0.41	0.00	-0.12	0.12	0.32	0.00	0.12	0.11	0.28	0.00	0.14	0.14	0.35	0.00	0.12	0.12	0.28	0.00
T1 Utility Value	0.10	0.19	0.60	0.00	-0.05	0.16	0.78	0.00	-0.18	0.14	0.21	0.01	0.09	0.17	0.60	0.00	-0.08	0.17	0.64	0.00
T1 Cost	0.23	0.15	0.12	0.03	0.16	0.11	0.16	0.02	0.02	0.11	0.88	0.00	0.07	0.14	0.64	0.00	0.11	0.10	0.27	0.00
T1 Connection Freq.'s	-0.11	0.14	0.41	0.00	-0.13	0.10	0.22	0.01	0.07	0.10	0.51	0.00	0.07	0.13	0.60	0.00	0.09	0.10	0.37	0.00
R^2				0.29				0.61***				0.63***				0.39*				0.75***

Note: N = 64. *p < .1 **p < .05 ***p < .01. β = standardized regression coefficient. SE_β = standard error of the standardized regression coefficient. η_a^2 = ε_p^2 = indices denoting the approximate partial variance explained by an individual predictor. R^2 = Pseudo R-squared which compares a constructed model versus the null model--denoting how well the constructed model explains the data based on log likelihood calculated values between models. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

five analysed were found to positively effect T2 *achievement* and/or T2 Motivation (Interest$_{res}$ or Cost$_{res}$) as predictors in prior models.

Block 6, sans T2 *connection frequency* = *condition,* T1 *achievement, condition*-T1 *achievement* interaction*, gender,* T1 Motivation (*expectancy, cost, utility value, interest*) and T1 *connection frequency.*

Model 21: CQ-I *statistical thinking usefulness* Regressed on Predictors from Block 6 sans T2 *connection frequency*. This study found a significant *condition* effect on students' CQ-I *statistical thinking usefulness* (ß = .78, p = .02, η_a^2 = .08). UVI conditioned students made higher quality utility value connections to the usefulness of statistical thinking techniques and/or tools via the CQ-I than control conditioned students (*d* = .78). This finding indicated students' CQ-I *statistical thinking usefulness* to be a potential pathway and/or a pathway mechanism for UVI indirect effects on students' T2 *achievement* and/or motivation, but it should be noted the model itself was not found to be of significance. The UVI-I self-generated utility value intervention does seem to affect students' quality utility value connections to the usefulness of statistical thinking techniques and/or tools.

Model 22: CQ-I *personal life* Regressed on Predictors from Block 6 sans T2 *connection frequency*. This study found a significant interaction effect (*condition* by T1 *achievement)* on students' CQ-I *personal life* (ß = .50, p = .01, η_a^2 = .10). The interaction was due to UVI conditioned initial high achieving students making higher quality utility

value connections to their personal life via the UVI-I than initial high achieving control conditioned students (*d* = 1.72, see Figure 14). Yet, UVI conditioned at-risk students made significantly higher quality utility value connections to their personal life via the UVI -I than at-risk control conditioned students as well (*d* = .72, see Figure 14). This finding indicated students' CQ-I *personal life* to be a potential pathway and/or a pathway mechanism for UVI indirect effects on students' T2 *achievement* and/or motivation. The UVI-I self-generated utility value intervention can affect students' quality utility value connections to their personal life.

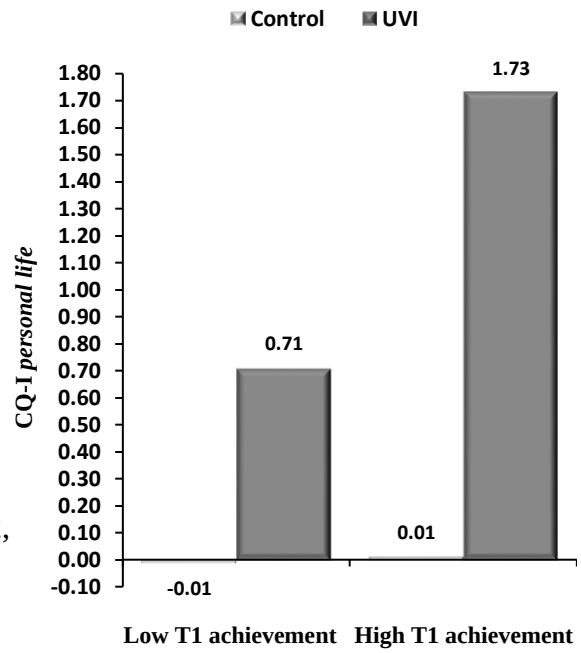


Figure 14. CQ-I *personal life* interaction between *condition* and T1 *achievement*. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 achievement mean, predictions of CQ-I *personal life* per *condition*. The contrasting predictions for Low T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = .72. The contrasting predictions for High T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = 1.72.

Model 23: CQ-II *statistical literacy usefulness* Regressed on Predictors from Block 6 sans T2 *connection frequency*. This study found a significant interaction effect (*condition* by T1 *achievement)* on students' CQ-II *statistical literacy usefulness* (ß = .45, p = .02, η_a^2 = .09). The interaction was due to UVI conditioned initial high achieving students making higher quality utility value connections to the usefulness of being literate of statistical knowledge and concepts via the UVI-II than high achieving control conditioned students (*d* = 1.73, see Figure 15). Yet, UVI conditioned at-risk students made significantly higher quality utility value connections to the usefulness of being

literate of statistical knowledge and concepts via the UVI-II than at-risk control conditioned students as well (*d* = .83, see Figure 15). This finding indicated students' CQ-II *statistical literacy usefulness* to be a potential pathway and/or a pathway mechanism for UVI indirect effects on students' T2 *achievement* and/or motivation. The UVI-II self-generated utility value intervention can affect students' quality utility value connections to the usefulness of being literate of statistical knowledge and concepts.

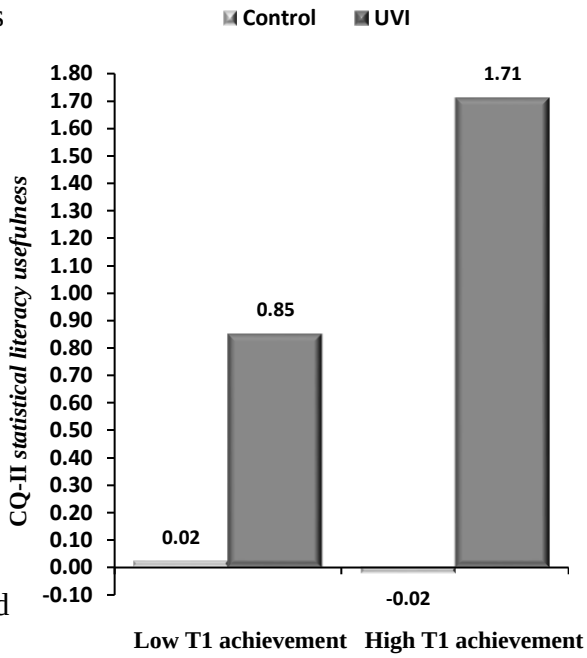


Figure 15. CQ-II *statistical literacy usefulness* interaction between *condition* and T1 *achievement*. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 achievement mean, predictions of CQ-II *statistical literacy usefulness* per *condition*. The contrasting predictions for Low T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = .83. The contrasting predictions for High T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = 1.73.

Model 24: CQ-II *statistical thinking usefulness* Regressed on Predictors from Block 6 sans T2 *connection frequency*. This study found a weak interaction effect (*condition* by T1 *achievement)* on students' CQ-II *statistical thinking usefulness* (ß = .45, $p < .05$, $\eta_a^2 = .05$). The interaction was due to UVI conditioned initial high achieving students making higher quality utility value connections to the usefulness of statistical thinking techniques and/or tools via the CQ-II than high achieving control conditioned students (*d* = 1.17, see Figure 16). This finding indicated initial high achieving students' CQ-II *statistical thinking usefulness* to be a potential pathway and/or a pathway mechanism for UVI indirect effects on initial high achieving students' T2 *achievement* and/or motivation. The UVI-II self-generated utility

value intervention can affect initial high achieving students' quality utility value connections to the usefulness of statistical thinking techniques and/or tools.

Model 25: CQ-II *personal life* Regressed on Predictors from Block 6 sans T2 *connection frequency*. This study found a significant *condition* effect on students' CQ-II *personal life* (ß = .75, p < .01, η_a^2 = .41). UVI conditioned students made higher quality utility value connections to their personal life via the UVI-II than control conditioned students (*d* = .75). This finding indicated students' CQ-II *personal life* to be a potential pathway and/or a pathway mechanism for UVI indirect effects on students' T2 *achievement* and/or motivation. The UVI-II self-generated utility value intervention can affect students' quality utility value connections to their personal life. With preliminary path analyses extensions completed, for when considering connection quality predictors within the model, for T2 *achievement* (Model 15) and Interest*res* (Model 16), findings from Models 17-25 will complete each of the path analysis extensions which will follow.

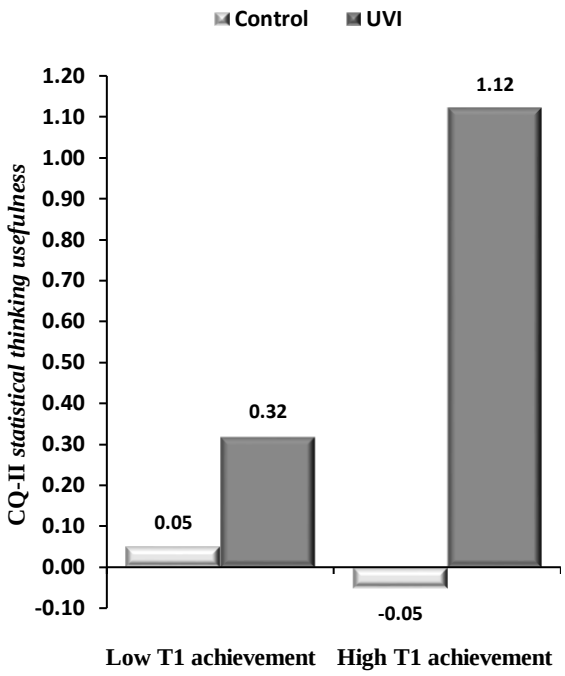


Figure 16. CQ-II *statistical thinking usefulness* interaction between *condition* and T1 *achievement*. N = 64. Low and High T1 *achievement*, based on estimates of one standard deviation below and above T1 achievement mean, predictions of CQ-II *statistical thinking usefulness* per *condition*. The contrasting predictions for Low T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = .27. The contrasting predictions for High T1 *achievement* students resulted in an adjusted standardised mean difference of *d* = 1.17.

Path Analysis-Extended

With preliminary path analysis extensions completed, for when considering connection quality predictors within the model, for T2 *achievement* and Interest$_{res}$, findings from Models 17-25 complete each of the preliminary path extensions by denoting students' motivation (expectancy, utility value, cost), connection frequency, and/or connection quality found to be affected due the UVI and whether the change value for connection frequency, or connection quality predictors, were found to be significant in predicting students' motivation (expectancy, utility value, cost). Student motivation (expectancy, utility value, cost) found to be affected due to the UVI provide potential paths for the UVI to indirectly effect T2 *achievement* and Interest$_{res}$. Change values for connection frequency, or connection quality predictors, found to affect students' motivation (expectancy, utility value, cost) provide potential mechanised paths through students' motivation for the UVI to indirectly effect T2 *achievement* and Interest$_{res}$. Connection frequency and/or connection quality found to be affected due to the UVI would provide a potential path for the UVI to effect T2 *achievement* and Interest$_{res}$ and/or would provide a potential mechanised path for the UVI to effect students' T2 *achievement* and Interest$_{res}$ through mechanism effects on students' motivation.

The completed path analysis for T2 *achievement,* seen in Figure 17-top, depicts the addition of the UVI *condition* by T1 *achievement* interaction effect found in Model 18 for Expectancy$_{res}$ (ß = -.45, p = .03, η_a^2 = .10). Recall, the interaction was due to UVI conditioned at-risk students self-reporting higher increases for expectancy (d = .47) than control conditioned at-risk students (see Figure 13). Depicted in Figure 17-top, as well, is the addition of the significant UVI *condition* by T1 *achievement* interaction effect found

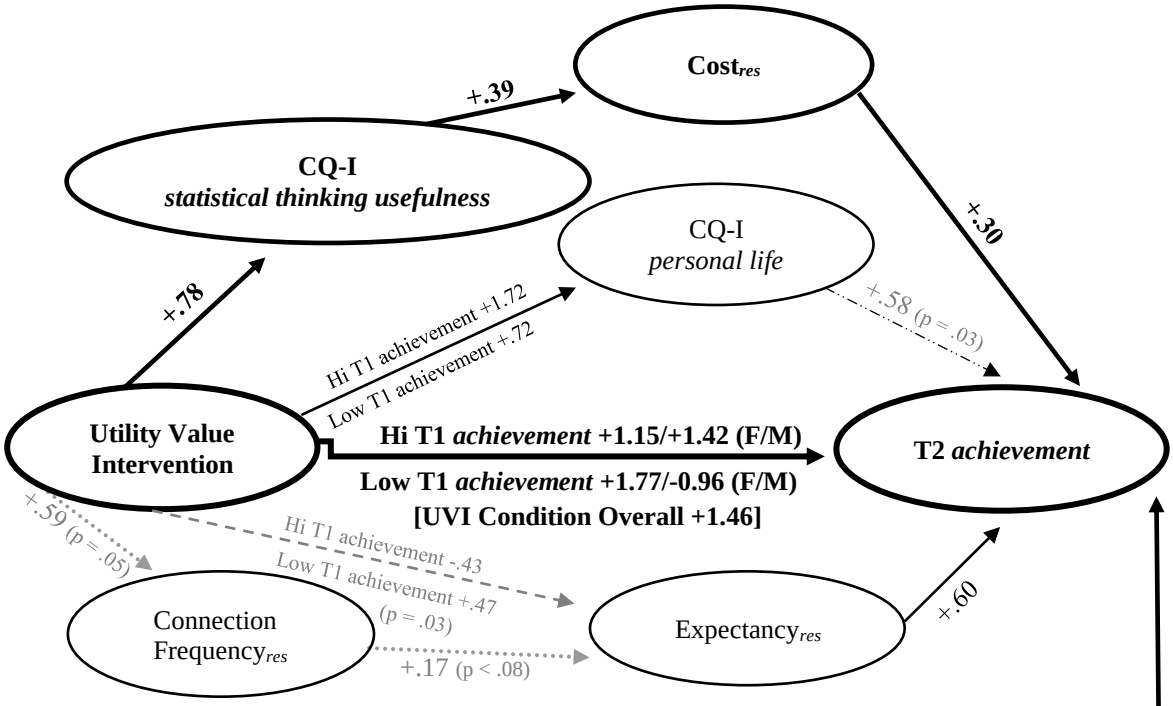
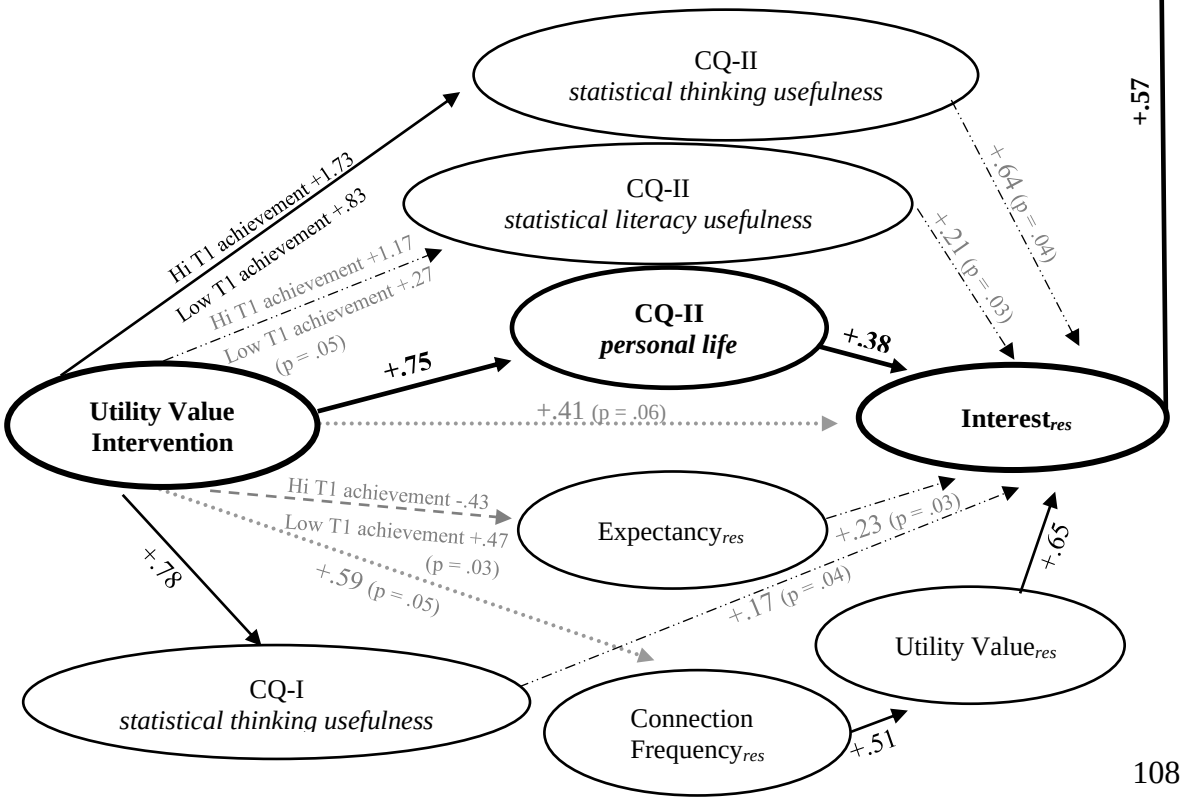


Figure 17. Condition effects on T2 *achievement* (top) and Interest$_{res}$ (bottom) path model. N = 64. Values denoted are standardised regression coefficients. Solid line paths are that of significant effects found by the Benjamini–Hochberg method. Dashed line paths are that of weak effects found by the Benjamini–Hochberg method. Hyphened lined paths are that of significant effects, reduced to weak effects. Dotted line paths are that of weak effects, reduced to nonsignificant. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure. Low and High T1 *achievement* predictions were based on estimates of one standard deviation below and above the T1 *achievement* mean. UVI conditioned students directly earned better scores (almost one and a half standard deviations higher) on T2 *achievement* than that of control condition students. In addition to the direct effects, UVI conditioned students made significantly higher quality utility value connections to their personal life and to statistical thinking usefulness, which significantly increased their self-reporting of interest and significantly lowered their self-reporting of costs for learning statistics, which indirectly significantly increased students' achievement as well.



in Model 22 for CQ-I *personal life* (ß = .50, p = .01, η_a^2 = .10). Recall, the interaction was due to UVI conditioned initial high achieving (*d* = 1.72) and at-risk (*d* = .72) students making higher quality utility value connections to their personal life than control conditioned initial high achieving and at-risk students (see Figure 14).

Completed path analysis extensions for T2 *achievement* and Interest$_{res}$, seen in Figure 17-bottom, depict the addition of a condition effect found in model 21 for CQ-I *statistical thinking usefulness* (ß = .78, p = .02, η_a^2 = .08) providing a mechanised path through students' motivation (cost and interest) for the UVI to indirectly affect students' T2 *achievement.* UVI mechanised CQ-I *statistical thinking usefulness* effects on students' cost are, also, depicted (ß = .39, p = .02, η_a^2 = .11, Model 20). Other connection quality variable additions depicted which provided mechanised paths through students' interest for the UVI to indirectly affect students' T2 *achievement* were due to direct or moderated condition effects found in Models 23 – 25 for CQ-II *statistical literacy usefulness* (ß = .45, p = .02, η_a^2 = .09, Model 23, moderated), CQ-II *statistical thinking usefulness* (ß = .45, p < .05, η_a^2 = .05, Model 24, moderated), and CQ-II *personal life* (ß = .75, p < .01, η_a^2 = .41, Model 25, direct). Motivation variable addition depicted which, also, provided a mechanised path through students' interest for the UVI to indirectly affect students' T2 *achievement* was due to a moderated condition effect found in Model 18 for Expectancy$_{res}$ (ß = -.45, p = .03, η_a^2 = .10). The final variable addition depicted is that of Connection Frequency$_{res}$. Connection Frequency$_{res}$ was found to provide non-mechanised effects on students' utility value (ß = .51, p < .01, η_a^2 = .31).

Summary of Parts I and II Results

Developing undergraduate students' statistical thinking skills was the aim. In associating the development of said skills to undergraduate students' earned achievement in statistics, increasing students' achievement in statistics was the proximate aim. Acknowledging a challenge to increasing students' achievement in statistics as low motivation for the learning thereof, a theoretical framework on motivation, SEVT, was used. SEVT was used to assess students' motivation and to adapt an intervention to the domain of statistics in service of promoting undergraduate students' motivation for learning to thereby increase their achievement. The SEVT intervention employed to accomplish the aforementioned benefits to students' motivation and achievement was that of a self-generated utility value intervention.

Historically, self-generated utility value interventions have been successful, primarily within the domain of undergraduate sciences, but had yet to be extended to the high DFW rate domain of undergraduate statistics. As such, the study's goals included the extending of the self-generated utility value intervention line of research to the high DFW rate domain of undergraduate statistics. Study goals in total comprised of:

1) Adapting Hulleman et al.'s (2017) self-generated utility value intervention to the high DFW rate domain of undergraduate statistics.
2) Replicating Hulleman et al.'s (2017) study within the high DFW rate domain of undergraduate statistics.
3) Determining if undergraduate statistics students' motivation and achievement could be positively affected via the domain adapted self-generated utility value intervention.

4) Determining if at-risk and more-at-risk undergraduate statistics students' motivation and achievement could be differentially affected via the domain adapted self-generated utility value intervention.
5) Validating Hulleman et al.'s (2017) exploratory findings regarding the role of *connection frequency* in undergraduate students' connections between learning content and their lives in affecting their motivation and achievement.
6) Making a contribution, the study's main contribution, by exploratorily investigating the role of connection quality in undergraduate students' utility value connections between learning content and their lives in affecting their motivation and achievement.

In addressing study goals 1 and 2, extending of the self-generated utility value intervention line of research to the high DFW rate domain of undergraduate statistics was carried out successfully via the adaption and replication of Hulleman et al.'s (2017) self-generated utility value intervention and study. In addressing study goals 3 – 6, the study carried out specified its investigation to the following research questions:

1. Does a self-generated utility value intervention affect undergraduate statistics students' achievement?
2. Does a self-generated utility value intervention affect undergraduate students' interest for statistics?
3. Does achievement at-risk (low initial achievement) categorisation, gender, and/or first-generation moderate self-generated utility value intervention effects on undergraduate statistics students' interest and/or achievement?

4. Does a self-generated utility value intervention affect undergraduate statistics students' achievement and/or interest when factors of initial achievement, gender, first-generation, and initial and change values of expectancy, cost, interest, utility value, and connection frequency are considered?
5. Does a self-generated utility value intervention affect undergraduate statistics students' expectancy, cost, utility value, and frequency of connections?
6. Are self-generated utility value intervention effects on undergraduate statistics students' interest and achievement mediated via intervention effects to students' expectancy, cost, utility value, and/or frequency of connection measures?
7. Are self-generated utility value intervention effects on undergraduate statistics students found to be different when the newly minted measures of connection quality are analysed alongside the Hulleman et al. (2017) replicated variables?

Research Question Findings

Research Question 1: Does a Self-Generated Utility Value Intervention Affect Undergraduate Statistics Students' Achievement? Model 1 found UVI conditioned students' post achievement to be significantly affected when directly contrasted to control conditioned students (d = .42, an approximately 7-percentage point grade difference between groups). Regardless, when all study factors, covariates, change variables, and connection quality variables were included, significant effects to UVI conditioned students' post achievement remained. A domain adapted self-generated utility value intervention did positively affect undergraduate statistics students' achievement directly, as hypothesised.

Research Question 2: Does a Self-Generated Utility Value Intervention Affect Undergraduate Students' interest **for Statistics?** Models 6 and 7 found UVI conditioned students' interest to be positively weakly affected when directly contrasted to control conditioned students (d = .39). When all study factors, covariates, and motivation change variables, and connection quality variables were included, though, direct effects to UVI conditioned students' interest were rendered non-significant. A domain adapted self-generated utility value intervention did not affect undergraduate statistics students' interest directly. Once connection quality predictors were introduced into the model, though, students' interest was indirectly significantly affected via UVI effects on students' CQ-II *personal life*. UVI conditioned students were making quality utility value connections to their personal life which was positively affecting their interest in statistics.

Research Question 3: Does Achievement At-Risk (Low Initial Achievement) Categorisation, Gender, and/or First-Generation Moderate Self-Generated Utility Value Intervention Effects on Undergraduate Statistics Students' Interest and/or Achievement? Initial achievement, the additional predictor included in achievement Model 2, was found to moderate condition effects. UVI conditioned at-risk students' achievement was found to be significantly affected via the domain adapted self-generated utility value intervention when contrasted to control conditioned at-risk students (d = .87, an approximately 14.5-percentage point grade difference between groups). Gender, the additional factor included in achievement Model 3, did not moderate the condition effects further though. Achievement at-risk (low initial achievement) did moderate domain adapted self-generated utility value intervention effects on undergraduate statistics students' achievement positively, as hypothesised, but gender did not, initially. Once

motivation, connection frequency, and connection quality variables were introduced into the models, though, achievement at-risk and gender both moderated domain adapted self-generated utility value intervention significant effects on undergraduate statistics students' achievement positively, as hypothesised.

Interest Model 7, which included initial achievement as its additional predictor, and then Model 8, which included gender as its additional factor, did not find either variable additions to moderate the effects of condition on students' interest directly. In fact, Model 8 was rendered completely non-significant, each variable and the model. Achievement at-risk and gender did not moderate self-generated utility value intervention effects on undergraduate statistics students' interest directly. Once connection quality predictors were introduced into the model, though, students' interest was indirectly affected weakly via students' CQ-II *statistical literacy usefulness* which was found to be significantly moderately UVI effected (at-risk by condition). The pathway of effects found positive achievement at-risk moderated domain adapted self-generated utility value intervention effects on undergraduate statistics students' interest indirectly.

Research Question 4: Does a Self-Generated Utility Value Intervention Affect Undergraduate Statistics Students' Achievement and/or Interest When Factors of Initial Achievement, Gender, First-Generation, and Initial and Change Values of Expectancy, Cost, Interest, Utility Value, and Connection Frequency are Considered? Model 5 found UVI conditioned students' achievement to be differentially affected once pre/post motivation and connection frequency variables were included in the analysis. UVI conditioned at-risk females' post achievement was affected most amongst low and high achieving males and females (d = .74, more than a 12-percentage

point grade difference between groups). A domain adapted self-generated utility value intervention did positively affect undergraduate statistics students' achievement differentially when initial achievement, gender, first-generation, and initial and change values of expectancy, cost, interest, utility value, and connection frequency were considered, as hypothesised.

Model 10 found UVI conditioned students' interest to be differentially affected once pre/post motivation and connection frequency variables were included in the analysis, as well, but only because their additions reduced the intervention's positive effects on their interest from weak to nonsignificant. A domain adapted self-generated utility value intervention was not found to affect undergraduate statistics students' interest when their initial achievement, gender, first-generation, and initial and change values of expectancy, cost, interest, utility value, and connection frequency were considered.

Research Question 5: Does a Self-Generated Utility Value Intervention Affect Undergraduate Statistics Students' Expectancy, Cost, Utility Value, and Frequency of Connections? Model 11, response variable connection frequency, included gender and initial motivation, connection frequency, and achievement covariates. The model found UVI condition effects, although weak. UVI conditioned students' connection frequency was found to be weakly affected via the intervention when contrasted to control conditioned students (d = .59). A domain adapted self-generated utility value intervention did positively directly affect undergraduate statistics students' connection frequency as hypothesised, weakly—enabling connection frequency to be a weak potential pathway for intervention indirect effects on students' achievement

and interest, and as a weak pathway mechanism for indirect effects on students' achievement and interest through students' motivation. Once connection quality predictors were introduced into the model, though, the UVI's effect on students' connection frequency was rendered non-significant.

Model 12, response variable expectancy, included gender and initial motivation, connection frequency, and achievement covariates. The model found initial achievement to moderate condition effects. UVI conditioned at-risk students' expectancy was found to be significantly affected via the intervention when contrasted to control conditioned at-risk students (d = .54). A domain adapted self-generated utility value intervention did positively affect at-risk undergraduate statistics students' expectancy—enabling expectancy, for at-risk students, to be a potential pathway for intervention indirect effects on students' achievement and interest. Once connection quality predictors were introduced into the model, though, the UVI's significant effect on students' connection frequency was reduced to a weak effect.

Model 13, response variable utility value, included gender and initial motivation, connection frequency, and achievement covariates. The model did not find condition effects. UVI conditioned students' utility value was not found to be significantly affected via the intervention when contrasted to control conditioned students. A domain adapted self-generated utility value intervention did not directly affect undergraduate statistics students' utility value, as a self-reported measure. Once connection quality predictors were introduced into the models, though, the UVI's effect on students' utility value was evident through the quality utility value connection data collected from the students within their intervention prompt responses which were researcher scaled ratings coded.

Model 14, response variable cost, included gender and initial motivation, connection frequency, and achievement covariates. The model did not find condition effects. UVI conditioned students' cost was not found to be significantly affected via the intervention when contrasted to control conditioned students. A domain adapted self-generated utility value intervention did not directly affect undergraduate statistics students' cost directly. Once connection quality predictors were introduced into the model, though, students' cost was indirectly significantly affected via UVI effects on students' CQ-I *statistical thinking usefulness*. UVI conditioned students were making quality utility value connections to the usefulness of statistical thinking techniques and/or tools which was positively affecting their self-reported cost for statistics.

Research Question 6: Are Self-Generated Utility Value Intervention Effects on Undergraduate Statistics Students' Interest and Achievement Mediated via Intervention Effects to Students' Expectancy, Cost, Utility Value, and/or Frequency of Connection Measures? Model 1 found UVI conditioned students' post achievement to be positively significantly affected when directly contrasted to control conditioned students. Model 2 found UVI conditioned at-risk students' achievement to be positively significantly affected via moderation. Model 5, which included pre/post motivation and connection frequency variables, found UVI conditioned students' achievement to be positively affected via significant beneficial increases to student's expectancy and cost—enabling each to be a potential pathway for intervention indirect effects on students' achievement and for each to potentially mediate intervention direct or moderated effects on students' achievement, the Model 1 and 2 findings.

Model 14, response variable cost, did not find condition direct or moderated effects—therefore Model 1 or Model 2 effects on students' achievement could not be explained through cost, mediation could not occur through cost. Model 12, response variable expectancy, did find condition moderated positive effects—therefore Model 2 positive effects on at-risk students' achievement could be explained through expectancy, mediation could occur through expectancy. In turn, mediation analysis was performed on the condition indirect pathway effects on students' achievement through UVI conditioned positively affected at-risk student expectancy. The positive indirect effects were found to partially mediate the UVI conditioned moderated positive effects on at-risk students achievement (ω_p^2 = .14, 95% CI [0.01, 0.33]). Self-generated utility value intervention moderated positive effects on undergraduate statistics students' achievement was mediated via intervention moderated positive effects on at-risk students' expectancy and expectancy's positive effects on achievement.

Mediation analysis was not performed on students' interest as there were no direct or moderated effects on students' interest which weren't reduced to non-significance. Self-generated utility value intervention effects on undergraduate statistics students' interest was not mediated because there were no such effects to mediate.

Research Question 7: Are Self-Generated Utility Value Intervention Effects on Undergraduate Statistics Students Found to be Different When the Newly Minted Measures of Connection Quality are Analysed Alongside the Hulleman et al. (2017) Replicated Variables? The domain adapted self-generated utility value intervention direct, moderated, and indirect effects on undergraduate statistics students'

achievement before the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables were:

1. Condition direct positive effects on students' achievement
2. Condition moderated positive effects on at-risk students' achievement
3. Condition moderated positive effects on at-risk students' expectancy effecting students' achievement indirectly through expectancy effects on achievement
4. Condition weak positive effects on students' connection frequency positively affecting students' achievement indirectly through weak positive connection frequency effects on students' expectancy which positively affect their achievement

The domain adapted self-generated utility value intervention direct, moderated, and indirect effects on undergraduate statistics students' achievement after the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables were (new or changed intervention effects *italicised*):

1. Condition direct positive effects on students' achievement
2. Condition moderated positive effects on at-risk students' achievement
3. *Weak* condition moderated positive effects on at-risk students' expectancy affecting students' achievement indirectly through expectancy effects on achievement
5. *Condition moderated positive effects on students' CQ-I personal life positively affecting students' achievement indirectly through weak CQ-I personal life positive effects on achievement*

6. *Condition positive effects on students' CQ-I statistical thinking usefulness positively affecting students' achievement indirectly through CQ-I statistical thinking usefulness positive effects on students' cost which positively effect their achievement*

The domain adapted self-generated utility value intervention direct, moderated, and indirect effects on undergraduate statistics students' achievement which did not remain after the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables were:

4. Condition weak positive effects on students' connection frequency positively affecting students' achievement indirectly through weak positive connection frequency effects on students' expectancy which positively affect their achievement

Self-generated utility value intervention effects on undergraduate statistics students' achievement were different when the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables.

The domain adapted self-generated utility value intervention direct, moderated, and indirect effects on undergraduate statistics students' interest before the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables were:

1. Condition weak positive effects on students' connection frequency positively affecting students' interest indirectly through positive connection frequency effects on students' utility value which positively affect their interest

The domain adapted self-generated utility value intervention direct, moderated, and indirect effects on undergraduate statistics students' interest after the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables were (new or changed intervention effects *italicised*):

2. *Weak condition moderated positive effects on at-risk students' expectancy positively affecting students' interest indirectly through weak expectancy positive effects on interest*
3. *Condition positive effects on students' CQ-I statistical thinking usefulness positively affecting students' interest indirectly through CQ-I statistical thinking usefulness weak positive effects on interest*
4. *Condition moderated positive effects on students' CQ-II statistical literacy usefulness positively affecting students' interest indirectly through CQ-II statistical literacy usefulness weak positive effects on interest*
5. *Weak condition moderated positive effects on students' CQ-II statistical thinking usefulness positively affecting students' interest indirectly through CQ-II statistical thinking usefulness weak positive effects on interest*
6. *Condition positive effects on students' CQ-II personal life positively affecting students' interest indirectly through CQ-II personal life positive effects on interest*

The domain adapted self-generated utility value intervention direct, moderated, and indirect effects on undergraduate statistics students' interest which did not remain after the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables were:

1. Condition weak positive effects on students' connection frequency positively affecting students' interest indirectly through positive connection frequency effects on students' utility value which positively affect their interest

Self-generated utility value intervention effects on undergraduate statistics students' interest were different when the newly minted measures of connection quality were analysed exploratorily alongside the Hulleman et al. (2017) replicated variables.

In sum, the UVI, before connection quality measures were introduced, was found to significantly positively effect students' achievement directly, was found to have positive moderated effects on students' achievement due to at-risk and gender categorisations, and was found to indirectly effect students' achievement through the UVI effecting students' expectancy, which effected their achievement—ultimately concluding UVI effects on students' achievement was the product of the UVI enhancing students' motivation through expectancy, not through their utility value. After connection quality measures were introduced, again the UVI was found to significantly positively effect students' achievement directly and was found to have positive moderated effects on students' achievement due to at-risk and gender categorisations, but these direct and moderated effects were now magnified by factors of two and three. Furthermore, while students' expectancy was, again, found to be UVI effected and their expectancy was found to, again, affect their achievement, both ends of this pathway of effects were reduced from significant effects to weak effects—offering up students' expectancy as a proxy for the UVI student achievement effects found previous to the introduction of the connection quality variables. By accounting for students' quality utility value connections they made through connection quality measures, the true UVI pathway of indirect effects was found

for students' achievement through the UVI effecting connection quality variables (CQ-I *statistical thinking usefulness* and CQ-II *personal life*), which positively affected their costs and interest, which effected their achievement—ultimately concluding UVI effects on students' achievement was the product of the UVI enhancing students' motivation through quality utility value connections they made, captured via connection quality variables (CQ-I *statistical thinking usefulness* and CQ-II *personal life*), and mechanising them to effect students' motivation through cost and interest.

As for the 2nd outcome variable, interest, the UVI, before connection quality measures were introduced, was found to have a weak positive effect on students' interest directly but was later reduced to non-significant with the inclusion of students' motivation variables. UVI moderated effects on students' interest were not found. UVI indirect effects on students' interest were found in the form of a pathway of effects from the UVI to connection frequency (weak), from connection frequency to utility value, from utility value to interest. After connection quality measures were introduced, again direct UVI effects on interest were non-significant, but UVI moderated effects on students' interest were found via the UVI indirectly affecting students' interest through UVI moderated effects to connection quality variables (CQ-II *statistical literacy usefulness* and CQ-II *statistical thinking usefulness)* and expectancy, which weakly effected their interest. Aside from the UVI indirect moderated effects on students' interest, additional UVI indirect effects on students' interest supplanted the previously found pathway of indirect effects which were reduced from weak significance to non-significance (UVI to connection frequency (weak), from connection frequency to utility value, from utility value to interest—path reduced from weak to non-significant). By accounting for

students' quality utility value connections they made through connection quality measures, the true UVI pathway of indirect effects was found for students' interest through the UVI effecting a connection quality variable (CQ-II *personal life*), which positively affected their interest—ultimately concluding students' interest is UVI indirectly effected via the UVI enhancing students' motivation through quality utility value connections captured via a connection quality variable (CQ-II *personal life*), and mechanising it to effect students' interest.

Below, Figure 18, you will find a final path analysis displaying only significant UVI direct and indirect effects to students' achievement and interest. The introduction of the connection quality measures has proved through its exploratory analysis to be of extreme benefit as it has further explained the mechanisms behind the self-generated

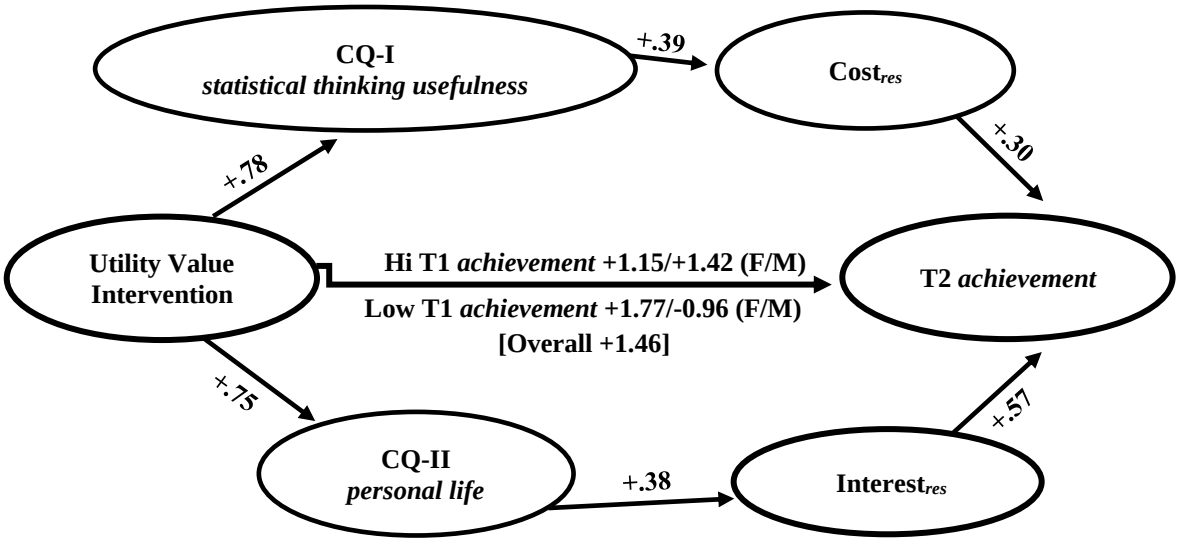


Figure 18. Condition on T2 *achievement* and Interest$_{res}$ significant, direct and indirect, path model effects only. N = 64. Values denoted are standardised regression coefficients. Significant effects found by the Benjamini–Hochberg method. Ovals containing subscript $_{res}$ are residual change values controlled via their respective T1 measure. Low and High T1 *achievement* predictions were based on estimates of one standard deviation below and above T1 *achievement* mean. UVI conditioned students directly earned better scores (almost one and a half standard deviations higher) on T2 *achievement* than that of control condition students. In addition to the direct effects, UVI conditioned students made significantly higher quality utility value connections to their personal life and to statistical thinking usefulness, which significantly increased their self-reporting of interest and significantly lowered their self-reporting of costs for learning statistics, which indirectly significantly increased students' achievement as well.

utility value intervention effecting student achievement. The UVI significantly positively effects and mechanises the quality utility value connections students make, captured via the connection quality measures, which significantly positively effect students' motivation (cost and interest), which significantly positively affect their achievement.

CHAPTER 6. DISCUSSION

In carrying out this study, it was determined undergraduate statistics students' motivation and achievement were positively affected via the domain adapted self-generated utility value intervention. Students' motivation as the costs associated with the learning of statistics and their interest in statistics were indirectly positively affected. Students' motivation as their quality utility value connections, captured via the connection quality measures, were found to be directly positively affected. Students' achievement in statistics was found to be directly and indirectly positively affected. Undergraduate students benefited from the adapted self-generated utility value intervention within the high DFW rate domain of statistics.

In addition to the all-encompassing student effects observed, it was determined at-risk undergraduate statistics students' achievement was differentially positively affected via the domain adapted self-generated utility value intervention as well. Although the self-generated utility value intervention differentially positively affected at-risk students' achievement, more-at-risk students' achievement was not differentially positively affected.

Validation of Hulleman et al.'s (2017) connection frequency measure and theory was successful yet was only weakly positively affected via the intervention—and then the mechanism was reduced to non-significance once connection quality variables were introduced. Furthermore, *connection frequency* only weakly positively affected students' motivation as expectancy (later reduced to non-significance with the introduction of the connection quality variables), while significantly positively affecting students' motivation as utility value (pathway later reduced to non-significance due to the mechanism reduced

to non-significance above). In sum, the weak intervention effects on connection frequency, and its weak effect on students' motivation, were also reduced to non-significance once this study's newly minted connection quality predictors were explored.

The study's main contribution in creating and exploratorily investigating connection quality predictors proved to be extremely fruitful. Connection quality predictors CQ-I *statistical thinking usefulness* and CQ-II *personal life* were both found to be significantly positively affected via the self-generated utility value intervention. They then served as mechanisms for significantly effecting students' achievement indirectly through their significant mechanised effects on students' motivation (cost and interest).

Accomplishing the study's goals and attending to the study's research questions adds to the literature in respect to SEVT, statistics education, undergraduate education, undergraduate statistics education, social psychological intervention research in general, utility value intervention research in general, self-generated utility value intervention research in general, and self-generated utility value intervention research specific to undergraduate statistics. As with all research, though, study limitations were present.

Limitations

First and foremost, creating and testing connection quality exploratorily was of major benefit in attesting to what the intervention induces in students. It set a "base" for the intervention enabling it to be fined tuned for the same domain or environment, or for differing domains and environments. On the flip side, as creating and testing connection quality was exploratory this constituted a limitation in and of itself due to not having the pre-established base now at hand.

Creating and testing connection quality helped further explain, atop of the self-reported motivation measures, why and how the self-generated utility value intervention was effective in bolstering student motivation and achievement. Connection quality will be used in a follow up study, albeit with learned adjustments from this study made to the muti-variable construct. For instance, due to exploratory limitations, although the population of students within the study was overwhelming that of business school students, the variables defined to capture connection quality in a professional/business context were not effective in affecting students' achievement or interest, as opposed to connections in a personal life context, and will likely be replaced, revised, or at least dropped from the construct. Other examples of exploratory limitations, effort, periodicity, and accuracy were not effective in affecting students' achievement or interest and will be scrutinised, revised, replaced, or dropped as well, as they, as currently defined, did not offer any discriminatory power.

Connection quality predictors which did overwhelmingly capture the quality of students' connections made within UVI-I and II were that of CQ-Utility Value Elaboration-*statistical literacy usefulness,* CQ-Utility Value Elaboration-*statistical thinking usefulness, and* CQ-Utility Value Contextualisation-*personal life.* The statistical thinking usefulness connections students' made to their personal life significantly affected their motivation (interest and cost) and their achievement positively, and are, exploratorily, what makes a connection, in the high DFW rate domain of undergraduate statistics, of high quality, but much more work is needed on the exploratory connection quality construct/measures.

The study found condition effects for a connection quality variable which, in turn, effected students' interest, attesting to the intervention's indirect effects on interest through the CQ variables. Even so, direct condition effects on students' interest were not found. In contemplating these two findings alongside one another, the survey measurement tool utilised to capture students' motivation (expectancy, interest, cost, utility value) comes into question as a limitation of the study. The measurement tool was adapted for the high DFW rate domain of undergraduate statistics from Hulleman et al.'s (2017) undergraduate psychology study's. Perhaps a differing measurement tool could better capture the domain specific student motivation, undergraduate statistics students' motivation. With this in mind, four courses of action will be contemplated for the follow up study: 1) further adaptions could be made to the current measurement tool, 2) differing adaptations of existent measurement tools could be used in comparison to one another, 3) a new domain specific tool could be created, and 4) the likeliest of actions to be taken, the same tool could be utilised but a number of student interviews could be implemented within which could shed a better light on the course of action to take with the measurement tool.

In respect to the validity of findings, testing with much larger sample size than that of $n = 64$ would greatly benefit. As such, another limitation of this study was the small sample size used. The same could be said for the generalisability of the findings limitation, but on that point study samples which aren't exclusively business school students would assist in that respect as well—as the study was conducted with business school students almost exclusively. In a similar vein, it should also be re-acknowledged the study took place during the Spring 2021 semester with all that was transpiring with

COVID-19—a historic time for humanity which could have affected students' susceptibility to the intervention's effects differently than most other times in history, another possible limitation on the study's findings. An additional acknowledgement in regard to I as the educator and researcher, although great care was taken in remediating potential risks, they could be tended to best by circumventing the potential risks all together by conducting the study within other educators statistics courses. Last, but not least, the control condition was not a "do-nothing" control group. Intervention effects were likely underestimated because the control group was not a "do nothing" control and justifies classification as a limitation as well. Although listed as a limitation, the conditions were different in the ways that mattered. Students utility value was significantly greater within the intervention as opposed to the control group. This was attested to by the newly introduced multi-variable connection quality construct/measure—and not by the self-reported utility value survey measure.

Hypotheses not Realised

There were a handful of hypotheses not realised by the study—most centred on the intervention's lack of effects on students' interest. Although there were a lack of direct effects for the self-generated utility intervention on, more-at-risk, at-risk, and collectively, students' interest, Hulleman et al. (2017) lacked the hypothesised effects as well. Effects on variables are susceptible to differing environments, domains, and the likes, hence they were hypothesised regardless of the literature, as the literature was primaried within the domain of undergraduate sciences as opposed to undergraduate statistics. Although the self-generated utility value intervention did not directly affect interest, there was a significant indirect effect on interest which was a product of the

intervention and was captured once the connection quality variables were introduced and tested exploratorily.

Other hypothesis not realised by the study concerned 1. self-generated utility value intervention effects on students' self-reported utility value, and then the self-reported utility value's subsequent effect on students' achievement and interest, which were then to mediate direct or moderated intervention effects on students' achievement and interest, and 2. self-generated utility value intervention effects on more-at-risk students' achievement and interest. Of the former, the literature shows a history of students' utility value to be affected due to utility value interventions. Hulleman et al. (2017) acknowledged as well (especially being that many of the studies were of his own findings) and hypothesised the same. Hulleman et al. (2017) instead found intervention effects on students' expectancy, just as this study has in the Part I-Results, supplanting the effects previously found in the literature for utility value, as measured through self-report surveys. Intervention effects on students' expectancy, and their subsequent effect on students' achievement, then mediated the intervention's moderated effects on students' achievement, just as this study has in the Part-I Results. Hulleman et al. (2017) discussed many reasons for this deviation from the literature. The reasons ranged from possible ceiling effects on students' self-reported utility value to the fact expectancy had yet to be tested for this type of intervention effect—and without expectancy tested, self-reported utility value was enabled to act as a proxy for the intervention's effects, until expectancy was tested for effects. Even so, a confirming study had yet to replicate the intervention's effects on the expectancy findings, until this study, and there's always, as mentioned previously, variables which are particular to differing environments, domains,

and the likes, hence effects and mediation were hypothesised for utility value instead of expectancy, regardless of Hulleman et al.'s (2017) findings. This study's Part-I Results, when connection frequency variables were not considered, serves as a confirmation of self-generated utility value interventions effecting undergraduate students' expectancy, not their self-reported utility value, and expectancy's mediation of direct and moderated condition effects on students' achievement.

Of the later, more-at-risk students not benefiting from the intervention was of great concern, as these are the students who are most in need of said benefits, and who do typically benefit from the intervention. A meta-analysis (Voyer & Voyer, 2014) attested to males underwhelming performance to that of females which not only spanned numerous domains but the differing domain levels as well, hence the more-at-risk labeling of males. Before connection quality variables were introduced and tested exploratorily, Model 5 found significant condition moderated effects on at-risk female (d = .74) and high initial achieving male (d = .49) students (with relatively no change between conditions for high initial achieving female students), but more-at-risk UVI conditioned students were significantly negatively affected (d = -.41). Furthermore, when connection quality variables were introduced and exploratorily tested, Model 15 found the significant UVI condition moderated effects to be even higher as at-risk female (d = 1.77), high initial achieving male (d = 1.42), and high initial achieving female (d = 1.15) students thrived due to the intervention, but significant negative effects on more-at-risk UVI conditioned students were further bolstered (d = -.96). The broken record on variables which are particular to differing environments, domains, and the likes, comes to mind again, but as the study was the first of its kind in the high DFW rate domain, being

rash with conclusions is foolish—additional studies are needed. A 19+ to 29+-percentage point difference benefit for UVI conditioned students in comparison to control conditioned students for the three other student groups does not justify the -15-percentage point difference for more-at risk students, but they're nothing to disregard either. The other three groups thrived, especially at-risk female students (29+-percentage point difference between conditions). If confirmed in a follow up study then there is a reason for their exceptionalism due to the intervention and it need be explained. Once discovered the intervention can be fine-tuned to exploit this benefit to effect more-at-risk students. Although not the best of finding at this time, the results are pregnant with potential which can later benefit more-at-risk undergraduate statistics students. Ultimately, though, the study attests to the benefits of:

- Social psychological interventions promotion of students' motivation and achievement.
- Utility value interventions promotion of students' motivation and achievement.
- Self-generated utility value interventions promotion of students' motivation and achievement
- To utilising SEVT to understand how interventions affect students' motivation and achievement.

Implications

Theory

Implications in regard to theory begs the question, what happened to students' self-reported utility value? Why did the self-generated utility value intervention not increase students' self-reported utility value for statistics? In Part I of the study's

analysis, before connection quality measures were introduced, students' utility value was significantly positively affected via their connection frequency, and their connection frequency was positively affected via the self-generated utility value intervention, albeit weakly. Therefore, utility value was affected via the intervention indirectly through the interventions' weak positive effect on students' connection frequency (see Figure 9-bottom). Students' frequency of connections, albeit weakly, was the self-generated utility value interventions' mechanism for affecting students' utility value—which in turn significantly positively affected students' interest for statistics, but not their achievement. Once Part II of the study's analysis, which included the connection quality measures, was conducted, though, the weak self-generated utility value intervention's effect on students' connection frequency was reduced to non-significant. So, again, what happened?

Simply put, the exploratory analysis including the connection quality variables occurred. By including the connection quality variables, which captured the quality utility value connections the students made within their intervention responses, the UVI's direct and indirect effects on students' achievement and interest were able to be better explained. Connection quality variables captured the intervention's effects on students' utility value more effectively than the self-reported survey utility value measure. In effectively capturing students' utility value via the connection quality variables, the UVI was found to significantly positively effect student's utility value, through UVI-I *statistical thinking usefulness* and UVI-II *personal life* connection quality measures, which then acted as a pathway to significantly positively effecting students' interest and as pathway mechanisms for indirect effects on students' achievement through their positive significant effects on students' motivation (cost and interest) which were

pathways to significantly positively effecting students' achievement. In sum, the self-generated utility value intervention induced students with utility value which positively affected their motivation (cost and interest), which positively affected their achievement.

In regard to the intervention, in the Part-I Results, significantly positively affecting students' expectancy which, in turn significantly positively affected their achievement, the mechanism for expectancy looks to no longer be as open of a question for two reasons. One, in this study's Part I Results, pre-connection quality variable introduction, students' expectancy was positively affected, weakly, via their connection frequency, and their connection frequency was positively affected via the self-generated utility value intervention, albeit weakly yet again. Therefore, students' expectancy was not only affected directly via the intervention but indirectly through the interventions' weak positive effect on students' connection frequency (see Figure 9-top). Students' frequency of connections, albeit weakly, was the self-generated utility value interventions' mechanism for affecting students' expectancy—which in turn significantly positively affected students' achievement. Again, these are weak findings of support, but it does offer an explanation as to expectancy's mechanism which could be further explored—if not taking into consideration connection quality's exploratory findings herein.

Two, once the connection quality variables were introduced, capturing students utility value more effectively, the intervention effects, in the Part-II Results, on students' expectancy were reduced to weak, as was expectancy's effect on students' achievement. The intervention does weakly effect students' expectancy, but students' achievement is significantly affected via the intervention's pathway of effects through students' utility

value, as connection quality, to their motivation, as cost and interest, and then their achievement. Students' cost and interest, not expectancy, are their motivational aspects indirectly effected via the deployment of this self-generated utility value intervention, that, in turn, effect their achievement. Therefore, "what's expectancy's mechanism" is no longer the correct question. The mechanism for effecting students' cost and interest would have been instead, but as exploratory findings show, the mechanism for effecting students' cost and interest looks to be students' UVI effected utility value (through connection quality measures).

Methods

Implications in regard to future research methods are aplenty. First and foremost, the connection quality measures introduced herein captured students' utility value more effectively than the self-report survey measure for utility value did, but could the connection quality variables be further defined to capture students' utility value? In short, yes. They were exploratory and as such are a work in progress, but as their initial conception captured utility value more effectively than the self-reported survey utility value measure did, they show great promise. The connection quality measures will be finely tuned in my research moving forward.

Another question which cropped up during this study, which applies to the study methods, was whether the self-generated utility value intervention prompted new connections versus existent connections for the students, and whether one connection is more beneficial for students than the other. The question of what type of connection the intervention currently induces will be addressed by the interviews which will be conducted in my future research. The question of whether one is more beneficial than the

other will be addressed in my future research by revising the intervention so as to have versions which prompt specifically for one or the other (existent or new connections).

Practice

Implications in regard to practice are simple. Although additional study's need confirm the findings herein, the self-generated utility value intervention seems to induce greater motivation and achievement in students within the high DFW rate domain of undergraduate statistics. As such, it behooves statistics educators to explore whether their students would benefit from the intervention being embedded as a normal part of their courses. In such an exploration, though, educators should effectively capture students' affect as the connection quality measures herein have exemplified. This will ensure a more robust understanding is garnered in interpreting the intervention's effects on their students' achievement.

Direction

A quick nod to the act of writing on paper versus typing will be debated moving forward, as the act of writing intervention responses may help deepen any connections students make. Connection quality as a multi-variable construct will continued to be fine-tuned and used in follow up studies. Testing differing motivation capturing tools or constructing a new tool entirely will be on the horizon. Conducting/Collecting student interview data after the study's conclusion, in a follow up study, will also add to the revisional processes of writing vs. typing, the connection quality construct, and motivation capturing tools.

Simple directional desires for follow up studies involve larger sample sizes and a greater diversity in student type (i.e., not exclusively business school students). True

effects from actual "do-nothing" control groups will also be sought in studies moving forward. Finally, the concern regarding the intervention's effects on more-at-risk students will need to be addressed. The undergraduate statistics domain adapted self-generated utility value intervention will undergo a revisionary process in order to rectify the negative effects found for more-at-risk students within this study.

All-in-all, though, a first-of-its-kind study was effective for undergraduate business school statistics students. A simple quick efficient intervention that bestows great benefits upon its recipients. Undergraduate statistics educators as a whole should examine and consider the implementation of the intervention as a regular component within their courses. This domain adapted self-generated utility value intervention significantly affected students' motivation and achievement positively. In close, these study findings herein attest to self-generated utility value intervention effects on students' motivation and achievement within undergraduate statistics as being existent, significant, and extremely positive. With absolute certainty it is known each of my statistics courses will benefit from the intervention being implemented as a regular component of the courses.

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APPENDIX A

PROMPT EXAMPLE – CONTROL (HULLEMAN & HARACKIEWICZ, 2009)

Appendix: Intervention Instructions

Control Group

Unit Review Activity

Now that we have reviewed the main topics and concepts from this unit, it is time to reflect on one specific topic or concept.

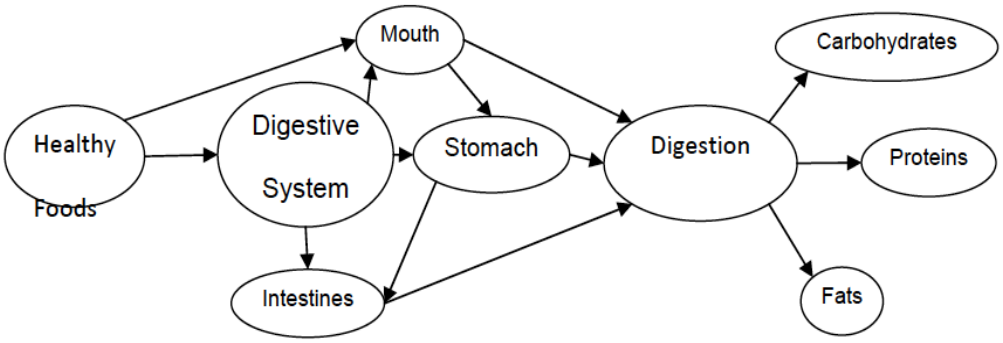
Part A: Pick one of the topics or concepts that we have covered in this unit.

Part B: Summarize main parts of this topic/concept.

You can either: 1) write about it in at least 5 sentences, 2) draw a concept map with a description, or 3) draw a sketch with a description. If you do a concept map or a sketch, be sure to describe it well enough so that the reader can understand it.

For example, if you were studying nutrition, you could choose a topic such as how food is digested. A written summary would include a description of the digestive system, and how foods are broken down in the mouth, stomach, and intestines. This process is called digestion. Food is broken down into carbohydrates, proteins, and fats.

You could also draw a concept map of the digestive system. An example is provided below. Remember that you would also need to add a brief written description with a concept map or diagram.



Remember: Do both Part A (pick a topic) and Part B (summarize the main parts).

The unit we are studying is: _____

Part A: The topic/concept I pick is: _____

Part B: My summary and review (use the back side if needed):

APPENDIX B

PROMPT EXAMPLE – UVI (HULLEMAN & HARACKIEWICZ, 2009)

Relevance Group

Unit Review Activity

Now that we have reviewed the main topics and concepts from this unit, it is time to reflect on one specific topic or concept.

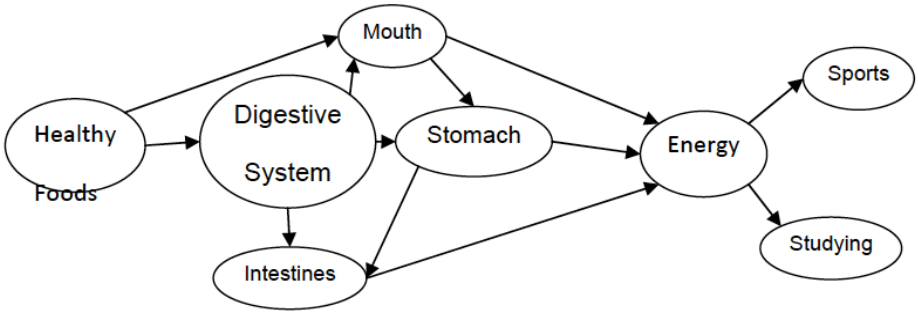
Part A: Pick one of the topics or concepts that we have covered in this unit and briefly summarize the main parts.

Part B: Apply this topic/concept to your life, or to the life of someone you know. How might the information be useful to you, or a friend/relative, in daily life? How does learning about this topic apply to your future plans?

You can either: 1) write about it in at least 5 sentences, 2) draw a concept map with a description, or 3) draw a sketch with a description. If you do a concept map or a sketch, be sure to describe it well enough so that the reader can understand it.

For example, if you were studying nutrition, you could choose a topic such as how food is digested. Briefly summarize the digestive process—how foods are broken down in the mouth, stomach, and intestines to make energy. Then you could write about how this applies to your own life. For example, eating healthy foods helps your body produce energy to play your favorite sport or study for exams.

You could also draw a concept map of how your knowledge of digestion applies to your life. An example is provided below. Remember that you would also need to add a brief written description with a concept map or diagram.



Remember: Do both Part A (pick a topic and summarize) and Part B (apply it to life).

The unit we are studying is: _____

Part A: The topic/concept I pick is: _____

My brief summary:

Part B: My application to life (use the back side if needed):

APPENDIX C

RESEARCH AGENDA – SELF-GENERATED UTILITY VALUE INTERVENTIONS ATTEMPTING TO EFFECT MOTIVATION AND ACHIEVEMENT WITHIN THE DOMAIN OF UNDERGRADUATE STATISTICS

Table Appendix C.
Research Agenda: Self-generated Utility Value Interventions Attempting to Effect Motivation and Achievement within the Domain of Undergraduate Statistics

Study Utility Interventions vs. Control	Conducted	Motivation Constructs	Moderators	Confirmatory Study
SG	**PRCS Study**	**Utility, Intrinsic, Cost, Expectancy**	**Gender, Low Initial Achievement, First Gen.**	**TBA**
SG	TBA	Utility, Intrinsic, **Attainment**, Cost, Expectancy	Others instead? In addition?	None
SG vs. DC vs. SG + DC	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None
AT vs. DC vs. AT + DC	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None
SG vs. AT vs. SG + AT	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None
SG + DC vs. AT + DC	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None
SG vs. AT vs. DC vs. SG + AT + DC	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None
SG + DC + AT vs. Combo's of Two	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None
New intervention and/or new motivation construct focus	None	Utility, Intrinsic, Attainment, Cost, Expectancy	?	None

Note. Utility Value Intervention is coded: DC = Direct Communication, SG = Self-generated, AT = Associated.

APPENDIX D

INTERVENTION #1 (STATISTICS REFLECTION #1, FOL ASSESSMENT) – UVI (ADAPTED FROM HULLEMAN ET AL., 2017)

STATISTICS REFLECTION #1

I would like you to write 1 to 2 paragraphs (75-125 words) about how the *statistics* material that you have been studying in STAT 1102 relates to your life. I am not asking you to summarise the material, just to elaborate on its relevance to your life. So far, you have covered and completed the following *statistics* units in your class:

1) Descriptive Statistics
2) Inferential Statistics
3) Fundamental Elements of Statistics
4) Types of Data
5) Collection of Data
6) Methods for Describing Qualitative and Quantitative Data
7) Numerical Measures of Central Tendency
8) Numerical Measures of Variability
9) Using the Mean and Standard Deviation to Describe Data
10) Numerical Measures of Relative Standing
11) Methods for Detecting Outliers

***** Use 12-point Times New Roman Font, Double-spaced**

DUE Date: **Monday, April 5th**

To Submit: **Canvas>Assignments>MSL Homework>1.1-1.7 & 2.1-2.7 Homework: Statistics Reflection #1 (FOL Assessment)**

APPENDIX E

INTERVENTION #1 (STATISTICS REFLECTION #1, FOL ASSESSMENT) – CONTROL (ADAPTED FROM HULLEMAN ET AL., 2017)

STATISTICS REFLECTION #1

Below is a list of the units we have covered and completed in STAT 1102 so far. For each topic, summarise what you know in about 1 or 2 sentences. I am not asking you to elaborate on the material, just to summarise the information that you can recall.

1) Descriptive Statistics
2) Inferential Statistics
3) Fundamental Elements of Statistics
4) Types of Data
5) Collection of Data
6) Methods for Describing Qualitative and Quantitative Data
7) Numerical Measures of Central Tendency
8) Numerical Measures of Variability
9) Using the Mean and Standard Deviation to Describe Data
10) Numerical Measures of Relative Standing
11) Methods for Detecting Outliers

***** Use 12-point Times New Roman Font, Double-spaced**

DUE Date: **Monday, April 5th**

To Submit: **Canvas>Assignments>MSL Homework>1.1-1.7 & 2.1-2.7 Homework: Statistics Reflection #1 (FOL Assessment)**

APPENDIX F

INTERVENTION #2 (STATISTICS REFLECTION #2, FOL ASSESSMENT) – UVI (ADAPTED FROM HULLEMAN ET AL., 2017)

STATISTICS REFLECTION #2

Below are the statistics units we covered in STAT 1102 this semester. Units in red text are new additions to the list seen in Statistics Reflection #1. Complete parts **a.** and **b.**

a. Choose a topic from below that is personally useful and meaningful to you. In 1 to 2 paragraphs (75 to 125 words), describe how learning about this topic *is useful to your life right now*.

b. Choose a topic below that is personally useful and meaningful to you (it may be the same topic as chosen for **a.**). In 1 to 2 paragraphs (75 to 125 words), describe how learning about this topic *will be beneficial to you in the future* (i.e., education, career, daily life).

150-250 words combined between **a. and **b.****

1) Descriptive & Inferential Statistics
2) Fundamental Elements of Statistics
3) Types of Data and its Collection
4) Methods for Describing QL and QN Data
5) Numerical Measures of Central Tendency
6) Numerical Measures of Variability
7) Data Description: Mean/Standard Deviation
8) Numerical Measures of Relative Standing
9) Methods for Detecting Outliers
10) Probability (Unions, Intersections, Compliments, and Conditionals)
11) Additive & Multiplicative Rules, Independence, and Mutual Exclusivity
12) Bayes's Rule
13) Types of Random Variables
14) Probability Distributions for Discrete and Continuous Random Variables

***** Use 12-point Times New Roman Font, Double-spaced *****

Due Date: **Wednesday, April 21st**

To Submit: **Canvas>Assignments>MSL Homework>1.1-1.7, 2.1-2.7, 3.1-3.7, 4.1-4.3 & 4.5-4.6 Homework: Statistics Reflection #2 (FOL Assessment)**

APPENDIX G

INTERVENTION #2 (STATISTICS REFLECTION #2, FOL ASSESSMENT) – CONTROL (ADAPTED FROM HULLEMAN ET AL., 2017)

STATISTICS REFLECTION #2

Below are the statistics units we covered in STAT 1102 this semester. Units in red text are new additions to the list seen in Statistics Reflection #1. Choose ***one*** specific topic below. In 1 to 2 paragraphs (75 to 125 words), *summarise* the *details* of the *chosen topic* as best you can.

1) Descriptive & Inferential Statistics
2) Fundamental Elements of Statistics
3) Types of Data and its Collection
4) Methods for Describing QL and QN Data
5) Numerical Measures of Central Tendency
6) Numerical Measures of Variability
7) Data Description: Mean/Standard Deviation
8) Numerical Measures of Relative Standing
9) Methods for Detecting Outliers
10) Probability (Unions, Intersections, Compliments, and Conditionals)
11) Additive & Multiplicative Rules, Independence, and Mutual Exclusivity
12) Bayes's Rule
13) Types of Random Variables
14) Probability Distributions for Discrete and Continuous Random Variables

***** Use 12-point Times New Roman Font, Double-spaced *****

Due Date**: Wednesday, April 21st**

To Submit: **Canvas>Assignments>MSL Homework>1.1-1.7, 2.1-2.7, 3.1-3.7, 4.1-4.3 & 4.5-4.6 Homework: Statistics Reflection #2 (FOL Assessment)**

APPENDIX H

MICF SURVEY – MOTIVATION, INTEREST, AND CONNECTION FREQUENCY SURVEY (CLUV ASSESSMENT) (ADAPTED FROM HULLEMAN ET AL., 2017)

Completely Disagree	Strongly Disagree	Disagree	Somewhat Disagree	Somewhat Agree	Agree	Strongly Agree	Completely Agree
1	2	3	4	5	6	7	8

Expectancy Items

1. I know I can learn the material in the class.
2. I expect to do well in this class.
3. I am confident that I will be successful in this class.
4. I am confident I can learn the material in this class.

Utility Value Items

1. I can apply what we're learning in this class to the real world.
2. The course material is relevant to my future career plans.
3. The material in this class is personally relevant to me.
4. I see how what we are studying is important to my future.
5. The material in this class is useful in my everyday life.
6. Learning the course material will help me achieve my future goals.

Cost Items

1. This semester, I have a lot of other demands on my time.
2. This semester, I don't have time to put into this class.
3. Doing well in this class isn't worth all the things that I have to give up.
4. I am unable to invest the effort that is needed to do well in this class.

5. This class requires too much time.

6. Unfortunately, I can't put as much time into this class as I would like.

Interest Items

1. I think the field of statistical science is very interesting.

2. I find the field of statistical science fascinating.

3. I think the field of statistical science is an important discipline

4. I am excited about this class.

5. I would recommend this class to others.

6. My experience in this course has made me want to take more statistics courses.

7. I really enjoy this class.

8. I plan on taking more courses in statistics.

9. I am interested in majoring in statistics.

Never	Rarely	Sometimes	Often	Very Often	All the Time
1	2	3	4	5	6

Connection Frequency Items

1. During a regular class period or lecture, how often do you connect the class material to your life?
2. When reading a chapter from the textbook, how often do you connect the class material to your life?
3. When studying for chapter or unit quizzes, how often do you connect the class material to your life?

APPENDIX I

COMPARISON ANALYSIS ON ENVIRONMENT OF SYNCHRONOUS INSTRUCTION: HYBRID VS. ONLINE

Table Appendix I.
Descriptive Statistics by Environment for Motivation, Connection Frequency, and Achievement Variables

Variable	Hybrid		Online		Total	
	M	SD	M	SD	M	SD
T1 Expectancy	5.87	1.53	5.82	1.19	5.84	1.34
T1 Utility Value	5.00	1.42	4.74	1.61	4.85	1.52
T1 Cost	5.00	1.22	4.96	1.04	4.98	1.12
T1 Connect Freq.	2.98	0.95	3.05	1.15	3.02	1.06
T1 Interest	4.58	1.44	4.25	1.59	4.40	1.52
T1 Achievement	41.68	14.37	43.92	13.14	42.94	13.63
T2 Expectancy	5.87	1.31	5.76	1.43	5.81	1.37
T2 Utility Value	4.75	1.24	4.68	1.60	4.71	1.44
T2 Cost	4.69	1.33	4.27	1.35	4.46	1.35
T2 Connect Freq.	2.94	1.12	3.08	1.42	3.02	1.29
T2 Interest	4.31	1.56	4.36	1.67	4.33	1.61
T2 Achievement	68.01	19.88	68.33	14.59	68.19	16.96

Note: $N = 64$ for all variables. Significant differences were not detected on T1 and T2 variables across environments (all F's < 1.82, all p's > .05).

APPENDIX J

COMPARISON ANALYSIS ON STUDENTS' FIRST-GENERATION STATUS: FG STUDENT VS. NON-FG STUDENT

Table Appendix J.
Descriptive Statistics by Students' First-Generation Status for Motivation, Connection Frequency, and Achievement Variables

Variable	Non-FG		FG		Total	
	M	SD	M	SD	M	SD
T1 Expectancy	5.85	1.24	5.81	1.76	5.84	1.34
T1 Utility Value	4.79	1.54	5.11	1.49	4.85	1.52
T1 Cost	5.06	1.06	4.64	1.32	4.98	1.12
T1 Connect Freq.	2.99	0.99	3.14	1.39	3.02	1.06
T1 Interest	4.34	1.46	4.65	1.82	4.40	1.52
T1 Achievement	42.20	14.08	46.14	11.45	42.94	13.63
T2 Expectancy	5.86	1.26	5.58	1.84	5.81	1.37
T2 Utility Value	4.76	1.45	4.49	1.45	4.71	1.44
T2 Cost	4.52	1.32	4.17	1.46	4.46	1.35
T2 Connect Freq.	3.05	1.27	2.89	1.44	3.02	1.29
T2 Interest	4.38	1.57	4.14	1.81	4.33	1.61
T2 Achievement	68.53	16.80	66.71	18.37	68.19	16.96

Note: $N = 64$ for all variables. Significant differences were not detected on T1 and T2 variables across students' first-generation status (all F's < 1.82, all p's > .05).

APPENDIX K

COMPANION TABLE TO TABLE 14: METHOD ADJUSTED P-VALUES FOR T2 *ACHIEVEMENT* REGRESSIONS

Table Appendix K.

Method Adjusted p-values for T2 Achievement Regressions

	Model 1a Method Adjusted p-value				Model 2a Method Adjusted p-value				Model 3a Method Adjusted p-value				Model 4a Method Adjusted p-value				Model 5a Method Adjusted p-value			
	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***
Condition	0.04	1.00	1.00	**0.14**	0.00	0.01	0.01	**0.00**	0.03	1.00	1.00	**0.11**	0.87	1.00	1.00	0.92	0.34	1.00	1.00	0.58
T1 Achievement					0.00	0.00	0.00	**0.00**	0.00	0.46	0.40	**0.03**	0.00	0.58	0.49	**0.03**	0.00	0.51	0.43	**0.03**
Condition * T1 Achievement					0.02	1.00	1.00	**0.08**	0.12	1.00	1.00	0.30	0.02	1.00	1.00	**0.10**	0.07	1.00	1.00	*0.20*
Gender									0.73	1.00	1.00	0.84	0.01	0.96	0.79	**0.04**	0.45	1.00	1.00	0.68
Condition * Gender									0.30	1.00	1.00	0.53	0.77	1.00	1.00	0.87	0.43	1.00	1.00	0.68
T1 Achievement * Gender									0.85	1.00	1.00	0.91	0.65	1.00	1.00	0.79	0.56	1.00	1.00	0.77
Condition * Gender * T1 Achievement									0.23	1.00	1.00	0.45	0.13	1.00	1.00	0.33	0.02	1.00	1.00	**0.10**
T1 Interest													0.91	1.00	1.00	0.94	0.20	1.00	1.00	0.41
T1 Expectancy													0.00	0.47	0.41	**0.03**	0.59	1.00	1.00	0.78
T1 Utility Value													0.01	0.92	0.76	**0.04**	0.18	1.00	1.00	0.40
T1 Cost													0.00	0.09	0.09	**0.01**	0.64	1.00	1.00	0.79
T1 Connection Freq.'s													0.21	1.00	1.00	0.43	0.04	1.00	1.00	**0.14**
T2 Expectancy																	0.00	0.55	0.47	**0.03**
T2 Utility Value																	0.54	1.00	1.00	0.76
T2 Cost																	0.00	0.42	0.38	**0.03**
T2 Connection Freq.'s																	0.09	1.00	1.00	0.26
T2 Interest																	0.21	1.00	1.00	0.43

Note: N = 64. U = Unadjusted, *B* = Bonferroni Method, *S* = Holm-Bonferroni, Sequential Method. *H* = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .15.

APPENDIX L

COMPANION TABLE TO TABLE 15: METHOD ADJUSTED P-VALUES FOR INTEREST$_{RES}$ REGRESSIONS

Table Appendix L.

Method Adjusted p-values for Interest$_{res}$ Regressions

	Model 1a Method Adjusted p-value				Model 2a Method Adjusted p-value				Model 3a Method Adjusted p-value				Model 4a Method Adjusted p-value				Model 5a Method Adjusted p-value			
	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***
Condition	0.06	1.00	1.00	*0.19*	0.06	1.00	1.00	*0.19*	0.16	1.00	1.00	0.36	0.82	1.00	1.00	0.90	0.24	1.00	1.00	0.46
T1 Achievement					0.16	1.00	1.00	0.36	0.26	1.00	1.00	0.48	0.91	1.00	1.00	0.94	0.41	1.00	1.00	0.68
Condition * T1 Achievement					0.69	1.00	1.00	0.82	0.38	1.00	1.00	0.65	0.99	1.00	1.00	0.99	0.79	1.00	1.00	0.88
Gender									0.25	1.00	1.00	0.47	0.58	1.00	1.00	0.77	0.13	1.00	1.00	0.33
Condition * Gender									0.97	1.00	1.00	0.98	0.85	1.00	1.00	0.91	0.11	1.00	1.00	0.29
T1 Achievement * Gender									0.60	1.00	1.00	0.78	0.57	1.00	1.00	0.77	0.46	1.00	1.00	0.70
Condition * Gender * T1 Achievement									0.43	1.00	1.00	0.68	0.51	1.00	1.00	0.74	0.76	1.00	1.00	0.87
T1 Interest													0.00	0.20	0.18	**0.02**	0.00	0.00	0.00	**0.00**
T1 Expectancy													0.64	1.00	1.00	0.79	0.16	1.00	1.00	0.36
T1 Utility Value													0.54	1.00	1.00	0.76	0.02	1.00	1.00	**0.10**
T1 Cost													0.05	1.00	1.00	**0.16**	0.10	1.00	1.00	0.27
T1 Connection Freq.'s													0.00	0.44	0.38	**0.03**	0.58	1.00	1.00	0.77
T2 Expectancy																	0.11	1.00	1.00	0.30
T2 Utility Value																	0.00	0.00	0.00	**0.00**
T2 Cost																	0.22	1.00	1.00	0.44
T2 Connection Freq.'s																	0.27	1.00	1.00	0.49

Note: N = 64. U = Unadjusted, *B* = Bonferroni Method, *S* = Holm-Bonferroni, Sequential Method. *H* = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .15.

APPENDIX M

COMPANION TABLE TO TABLE 16: METHOD ADJUSTED P-VALUES FOR MOTIVATION VARIABLE RESIDUALS AND CONNECTION FREQUENCY$_{RES}$ REGRESSIONS

Table Appendix M.

Method Adjusted p-values for Motivation Factor Residuals and Connection Frequency $_{res}$ Regressions

	6a Connection Frequency Method Adjusted p-value				6b Expectancy Method Adjusted p-value				6c Utility Value Method Adjusted p-value				6d Cost Method Adjusted p-value			
	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***
Condition	0.05	1.00	1.00	*0.18*	0.16	1.00	1.00	0.36	0.11	1.00	1.00	0.29	0.62	1.00	1.00	0.79
T1 Achievement	0.41	1.00	1.00	0.68	0.06	1.00	1.00	*0.19*	0.79	1.00	1.00	0.88	0.32	1.00	1.00	0.56
Condition * T1 Achievement	0.90	1.00	1.00	0.94	0.03	1.00	1.00	**0.11**	0.95	1.00	1.00	0.97	0.69	1.00	1.00	0.82
Gender	0.03	1.00	1.00	**0.12**	0.97	1.00	1.00	0.98	0.53	1.00	1.00	0.76	0.00	0.05	0.04	**0.00**
T1 Interest	0.23	1.00	1.00	0.44	0.70	1.00	1.00	0.83	0.65	1.00	1.00	0.79	0.00	0.04	0.03	**0.00**
T1 Expectancy	0.43	1.00	1.00	0.68	0.00	0.00	0.00	**0.00**	0.15	1.00	1.00	0.36	0.20	1.00	1.00	0.41
T1 Utility Value	0.44	1.00	1.00	0.68	0.56	1.00	1.00	0.77	0.00	0.00	0.00	**0.00**	0.04	1.00	1.00	**0.14**
T1 Cost	0.71	1.00	1.00	0.83	0.03	1.00	1.00	**0.12**	0.30	1.00	1.00	0.53	0.00	0.14	0.13	**0.00**
T1 Connection Freq.'s	0.00	0.00	0.00	**0.00**	0.80	1.00	1.00	0.88	0.65	1.00	1.00	0.79	0.50	1.00	1.00	0.74
T2 Connection Freq.'s					0.08	1.00	1.00	*0.24*	0.00	0.00	0.00	**0.00**	0.51	1.00	1.00	0.74

Note: N = 64. U = Unadjusted, B = Bonferroni Method, S = Holm-Bonferroni, Sequential Method. H = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .15.

APPENDIX N

COMPANION TABLE TO TABLE 18: METHOD ADJUSTED P-VALUES FOR T2 *ACHIEVEMENT* REGRESSION INCLUDING CONNECTION QUALITY

Table Appendix N.

Method Adjusted p-values for T2 Achievement-Extended Regression

	Model 15 Method Adjusted p-value			
	U	*B*	*S*	***H***
Condition	0.01	1.00	1.00	**0.09**
T1 Achievement	0.00	0.00	0.00	**0.00**
Condition * T1 Achievement	0.16	1.00	1.00	0.48
Gender	0.29	1.00	1.00	0.61
Condition * Gender	0.01	1.00	1.00	**0.09**
T1 Achievement * Gender	0.42	1.00	1.00	0.70
Condition * Gender * T1 Achievement	0.00	0.00	0.00	**0.00**
T1 Interest	0.73	1.00	1.00	0.91
T1 Expectancy	0.13	1.00	1.00	0.44
T1 Utility Value	0.52	1.00	1.00	0.77
T1 Cost	0.18	1.00	1.00	0.52
T1 Connection Frequency	0.40	1.00	1.00	0.70
T2 Expectancy	0.00	0.00	0.00	**0.00**
T2 Utility Value	0.02	1.00	1.00	**0.13**
T2 Cost	0.01	1.00	1.00	**0.09**
T2 Connection Frequency	0.72	1.00	1.00	0.91
T2 Interest	0.01	1.00	1.00	**0.09**
Connection Quality				
CQ-I Connection Utility Elaboration				
Statistical Literacy Usefulness	0.28	1.00	1.00	0.60
Statistical Thinking Usefulness	0.76	1.00	1.00	0.91
Accuracy	0.92	1.00	1.00	0.99
Effort	0.03	1.00	1.00	*0.16*
CQ-I Connection Utility Contextualisation				
Personal Life	0.03	1.00	1.00	*0.16*
Professional/Business Life	0.21	1.00	1.00	0.56
Periodicity	0.25	1.00	1.00	0.59
CQ-II Connection Utility Elaboration				
Statistical Literacy Usefulness	0.90	1.00	1.00	0.98
Statistical Thinking Usefulness	0.25	1.00	1.00	0.59
Accuracy	0.47	1.00	1.00	0.73
Effort	0.99	1.00	1.00	0.99
CQ-II Connection Utility Contextualisation				
Personal Life	0.27	1.00	1.00	0.60
Professional/Business Life	0.99	1.00	1.00	0.99
Periodicity	0.07	1.00	1.00	0.30

Note: N = 64. U = Unadjusted, B = Bonferroni Method, S = Holm-Bonferroni, Sequential Method. H = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. Italicized PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

APPENDIX O

COMPANION TABLE TO TABLE 19: METHOD ADJUSTED P-VALUES FOR INTEREST$_{RES}$ REGRESSION INCLUDING CONNECTION QUALITY

Table Appendix P.

Method Adjusted p-values for T2 Interest$_{res}$-Extended Regression

	Model 16 Method Adjusted p-value			
	U	*B*	*S*	***H***
Condition	0.94	1.00	1.00	0.99
T1 Achievement	0.12	1.00	1.00	0.43
Condition * T1 Achievement	0.33	1.00	1.00	0.66
Gender	0.07	1.00	1.00	0.30
Condition * Gender	0.51	1.00	1.00	0.77
T1 Achievement * Gender	0.30	1.00	1.00	0.62
Condition * Gender * T1 Achievement	0.61	1.00	1.00	0.82
T1 Interest	0.00	0.00	0.00	**0.00**
T1 Expectancy	0.17	1.00	1.00	0.50
T1 Utility Value	0.00	0.00	0.00	**0.00**
T1 Cost	0.05	1.00	1.00	*0.24*
T1 Connection Frequency	0.02	1.00	1.00	**0.13**
T2 Expectancy	0.03	1.00	1.00	*0.16*
T2 Utility Value	0.00	0.00	0.00	**0.00**
T2 Cost	0.01	1.00	1.00	**0.09**
T2 Connection Frequency	0.79	1.00	1.00	0.92
Connection Quality				
CQ-I Connection Utility Elaboration				
Statistical Literacy Usefulness	0.07	1.00	1.00	0.30
Statistical Thinking Usefulness	0.04	1.00	1.00	*0.21*
Accuracy	0.42	1.00	1.00	0.70
Effort	0.57	1.00	1.00	0.82
CQ-I Connection Utility Contextualisation				
Personal Life	0.59	1.00	1.00	0.82
Professional/Business Life	0.29	1.00	1.00	0.61
Periodicity	0.98	1.00	1.00	0.99
CQ-II Connection Utility Elaboration				
Statistical Literacy Usefulness	0.04	1.00	1.00	*0.21*
Statistical Thinking Usefulness	0.03	1.00	1.00	*0.16*
Accuracy	0.25	1.00	1.00	0.59
Effort	0.12	1.00	1.00	0.43
CQ-II Connection Utility Contextualisation				
Personal Life	0.01	1.00	1.00	**0.09**
Professional/Business Life	0.99	1.00	1.00	0.99
Periodicity	0.28	1.00	1.00	0.60

Note: N = 64. U = Unadjusted, B = Bonferroni Method, S = Holm-Bonferroni, Sequential Method. H = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. Italicized PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

APPENDIX P

COMPANION TABLE TO TABLE 20: METHOD ADJUSTED P-VALUES FOR MOTIVATION VARIABLE RESIDUALS AND CONNECTION FREQUENCY$_{RES}$ REGRESSIONS INCLUDING CONNECTION QUALITY PREDICTORS

Table Appendix Q.

Method Adjusted p-values for Motivation Variable Residuals and Connection Frequency$_{res}$-Extended Regressions

	17 Connection Frequency Method Adjusted p-value				18 Expectancy Method Adjusted p-value				19 Utility Value Method Adjusted p-value				20 Cost Method Adjusted p-value			
	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***
Condition	0.37	1.00	1.00	0.70	0.97	1.00	1.00	0.99	0.09	1.00	1.00	0.35	0.90	1.00	1.00	0.98
T1 Achievement	0.30	1.00	1.00	0.62	0.05	1.00	1.00	*0.24*	0.92	1.00	1.00	0.99	0.19	1.00	1.00	0.54
Condition * T1 Achievement	0.23	1.00	1.00	0.57	0.03	1.00	1.00	*0.16*	0.41	1.00	1.00	0.70	0.87	1.00	1.00	0.97
Gender	0.01	1.00	1.00	**0.09**	0.43	1.00	1.00	0.70	0.26	1.00	1.00	0.60	0.02	1.00	1.00	**0.13**
T1 Interest	0.02	1.00	1.00	**0.13**	0.07	1.00	1.00	0.30	0.34	1.00	1.00	0.68	0.02	1.00	1.00	**0.13**
T1 Expectancy	0.20	1.00	1.00	0.54	0.00	0.00	0.00	**0.00**	0.91	1.00	1.00	0.99	0.43	1.00	1.00	0.70
T1 Utility Value	0.18	1.00	1.00	0.52	0.97	1.00	1.00	0.99	0.00	0.00	0.00	**0.00**	0.22	1.00	1.00	0.57
T1 Cost	0.88	1.00	1.00	0.97	0.01	1.00	1.00	**0.09**	0.14	1.00	1.00	0.46	0.01	1.00	1.00	**0.09**
T1 Connection Freq.'s	0.00	0.00	0.00	**0.00**	0.54	1.00	1.00	0.78	0.25	1.00	1.00	0.59	0.97	1.00	1.00	0.99
T2 Connection Freq.'s	--	--	--		0.75	1.00	1.00	0.91	0.00	0.00	0.00	**0.00**	0.61	1.00	1.00	0.82
Connection Quality																
CQ-I Connection Utility Elaboration																
Statistical Literacy Usefulness	0.23	1.00	1.00	0.57	0.95	1.00	1.00	0.99	0.40	1.00	1.00	0.70	0.45	1.00	1.00	0.72
Statistical Thinking Usefulness	0.08	1.00	1.00	0.32	0.20	1.00	1.00	0.54	0.13	1.00	1.00	0.44	0.02	1.00	1.00	**0.13**
Accuracy	0.77	1.00	1.00	0.91	0.40	1.00	1.00	0.70	0.63	1.00	1.00	0.84	0.08	1.00	1.00	0.32
Effort	0.26	1.00	1.00	0.60	0.53	1.00	1.00	0.78	0.83	1.00	1.00	0.94	0.13	1.00	1.00	0.44
CQ-I Connection Utility Contextualisation																
Personal Life	0.16	1.00	1.00	0.48	0.13	1.00	1.00	0.44	0.16	1.00	1.00	0.48	0.38	1.00	1.00	0.69
Professional/Business Life	0.02	1.00	1.00	**0.13**	0.15	1.00	1.00	0.48	0.47	1.00	1.00	0.73	0.37	1.00	1.00	0.69
Periodicity	0.16	1.00	1.00	0.48	0.23	1.00	1.00	0.57	0.07	1.00	1.00	0.30	0.54	1.00	1.00	0.78
CQ-II Connection Utility Elaboration																
Statistical Literacy Usefulness	0.47	1.00	1.00	0.73	0.66	1.00	1.00	0.86	0.75	1.00	1.00	0.91	0.98	1.00	1.00	0.99
Statistical Thinking Usefulness	0.47	1.00	1.00	0.73	0.98	1.00	1.00	0.99	0.52	1.00	1.00	0.77	0.71	1.00	1.00	0.90
Accuracy	0.82	1.00	1.00	0.94	0.39	1.00	1.00	0.70	0.09	1.00	1.00	0.35	0.58	1.00	1.00	0.82
Effort	0.38	1.00	1.00	0.69	0.82	1.00	1.00	0.94	0.70	1.00	1.00	0.90	0.48	1.00	1.00	0.74
CQ-II Connection Utility Contextualisation																
Personal Life	0.71	1.00	1.00	0.90	0.61	1.00	1.00	0.82	0.38	1.00	1.00	0.69	0.76	1.00	1.00	0.91
Professional/Business Life	0.79	1.00	1.00	0.92	0.77	1.00	1.00	0.91	0.39	1.00	1.00	0.70	0.49	1.00	1.00	0.75
Periodicity	0.84	1.00	1.00	0.95	0.51	1.00	1.00	0.77	0.74	1.00	1.00	0.91	0.20	1.00	1.00	0.54

Note: N = 64. U = Unadjusted, B = Bonferroni Method, S = Holm-Bonferroni, Sequential Method. H = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.

APPENDIX Q

COMPANION TABLE TO TABLE 21: METHOD ADJUSTED P-VALUES FOR CONNECTION QUALITY VARIABLE REGRESSIONS

Table Appendix R.

Method Adjusted p-values for Connection Quality Variable Regressions

	21 CQ-I *statistical thinking usefulness*				22 CQ-I *personal life*				23 CQ-II *statistical literacy usefulness*				24 CQ-II *statistical thinking usefulness*				25 CQ-II *personal life*			
	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***	U	*B*	*S*	***H***
Condition	0.02	1.00	1.00	**0.13**	0.00	0.00	0.00	**0.00**	0.00	0.00	0.00	**0.00**	0.08	1.00	1.00	0.32	0.00	0.00	0.00	**0.00**
T1 Achievement	0.94	1.00	1.00	0.99	0.94	1.00	1.00	0.99	0.86	1.00	1.00	0.97	0.77	1.00	1.00	0.91	0.42	1.00	1.00	0.70
Condition * T1 Achievement	0.36	1.00	1.00	0.69	0.01	1.00	1.00	**0.09**	0.02	1.00	1.00	**0.13**	0.05	1.00	1.00	*0.24*	0.96	1.00	1.00	0.99
Gender	0.36	1.00	1.00	0.69	0.83	1.00	1.00	0.94	0.27	1.00	1.00	0.60	0.77	1.00	1.00	0.91	0.11	1.00	1.00	0.42
T1 Interest	0.74	1.00	1.00	0.91	0.58	1.00	1.00	0.82	0.45	1.00	1.00	0.72	0.65	1.00	1.00	0.85	0.60	1.00	1.00	0.82
T1 Expectancy	0.41	1.00	1.00	0.70	0.32	1.00	1.00	0.65	0.28	1.00	1.00	0.60	0.35	1.00	1.00	0.69	0.28	1.00	1.00	0.60
T1 Utility Value	0.60	1.00	1.00	0.82	0.78	1.00	1.00	0.92	0.21	1.00	1.00	0.56	0.60	1.00	1.00	0.82	0.64	1.00	1.00	0.84
T1 Cost	0.12	1.00	1.00	0.43	0.16	1.00	1.00	0.48	0.88	1.00	1.00	0.97	0.64	1.00	1.00	0.84	0.27	1.00	1.00	0.60
T1 Connection Freq.'s	0.41	1.00	1.00	0.70	0.22	1.00	1.00	0.57	0.51	1.00	1.00	0.77	0.60	1.00	1.00	0.82	0.37	1.00	1.00	0.69

Note: N = 64. U = Unadjusted, B = Bonferroni Method, S = Holm-Bonferroni, Sequential Method. H = Benjamin-HochBerg Method. Gender is a dummy-coded variable: 0 = female, 1 = male. Condition compares the utility value intervention (UVI) condition (1) to the control condition (0). **BOLD** PRCS findings of significance reported based on Benjamin-HochBerg Method results controlling for a False Discovery Rate (FDR) < .1. *Italicized* PRCS findings of weak significance reported based on Benjamin-HochBerg Method results controlling for a FDR at .10 < FDR < .20.