ISSN: 2690-0726

Research Article

Journal of Educational and Psychological Research

Just a Methodological Cautionary Note: The Jingle Jangle of Self-Related Beliefs in Motivational Measures

Hye Rin Lee[1]*, Peter McPartlan[2], Osman Umarji[3], Qiujie Li[4] and Jacquelynne S. Eccles [4,5]

[1,2,3,4]*School of Education, University of California, Irvine 3200 Education Bldg. Irvine, CA 92617*

[5]*Institute for Positive Psychology & Education, Australian Catholic University, PO Box 968, North Sydney NSW 2059, Australia*

***Corresponding author:**
Hye Rin Lee, School of Education, University of California, Irvine 3200 Education Bldg. Irvine, CA 92617

Submitted: 16 Apr 2020; **Accepted**: 22 Apr 2020; **Published**: 08 May 2020

Abstract

Many fields in academia face problems with either same named scales measuring what are actually different constructs (i.e., the jingle fallacies) or differently named scales measuring the same construct (i.e., the jangle fallacies). In this study, we examined the overlap between a set of 10 measures of self-related beliefs of academic motivation constructs in two different biology courses: value items (e.g., utility value, interest value, attainment value, and cost value), achievement goal orientation items (e.g., mastery approach, mastery avoidance, performance approach, and performance avoidance), and intrinsic/extrinsic motivation items. Exploratory factor analyses and structural equation modeling indicated that the covariance among the items is not captured by an item-based factor solution, suggesting these named scales are plagued by the jingle jangle fallacy. These findings suggest that researchers should either use these constructs independently of each other or attempt to find a more unified theory of academic self-related motivational beliefs when examining these constructs together, especially in statistical analyses.

Keywords: Jingle Jangle Fallacy, Measurement, Expectancy-Value Theory, Self-Determination Theory, Achievement Goal Theory, Achievement Motivation

Introduction

Uniqueness of Each Achievement Motivation Theory

For the past 50 years, scholars from different backgrounds have created various theories to explain motivation in academic settings [1-3]. Expectancy-value theory (EVT), self-determination theory (SDT), and achievement goal theory (AGT) are three of the most influential achievement motivation theories [4]. Each of these theories is unique because it connects indicators of motivation to certain other self-related attitudes, beliefs, perceptions, and behaviors. For example, EVT focuses on both expectancies of success (i.e., "Can I do this task?") and values of pursuing a particular task (i.e., "Do I want to do this task?") to predict behaviors linked to achievement motivation [1,5]. SDT centers around the distinction between intrinsic versus extrinsic motivation as motivators of achievement behaviors [2]. Intrinsic motivation refers to doing an activity because it is inherently satisfying, in contrast extrinsic motivation refers to doing an activity to attain some other desirable separable outcome [2,6]. Finally, AGT largely distinguishes between two types of goals (i.e., mastery versus performance goal orientation) and two types of goal attitudes (i.e., approach versus avoidance goal attitudes).

Similarities of Achievement Motivation Theories

Scholars have talked about how certain aspects of EVT, SDT, and AGT overlap with each other, forcing us to consider whether these constructs really operate distinctively [4]. Despite efforts to clarify this conceptual confusion of motivational terminology from EVT, SDT, and AGT, similarities among specific items suggest it may in fact be quantitatively detrimental to treat them as unique, independent constructs [7-9]. For instance, a study based in EVT focused on interest value in biology class ask, "How interested are you in biology?" Similarly, a study grounded in mastery approach using AGT might ask, "I want to learn as much as possible in this class." Furthermore, SDT might elicit intrinsic motivation by asking students how true it is that they study "To enjoy the fun of learning about biology." Given how similar the underlying semantics of these three survey questions are, one has to question whether they actually represent three unique constructs or sight variations on a very similar underlying construct. Scholars refer to this dilemma as the jangle fallacy. The jangle fallacies are when scales with different names are supposed to measure different constructs, but actually measure the same construct [10]. These same scholars became concerned about violating the basic assumptions of independence when scales derived from different traditions are used in the same study and then entered into regression based statistical analyses without first determining the underlying factor structure of the full set of items.

The jingle fallacies also exist within the field of motivation. They occur when scales with the same name are supposed to measure the same constructs, but actually measure quite different constructs [11]. For example, prior studies have lumped together certain EVT constructs to create a motivation scale [12]. However, when using these composite motivation scales created based on certain sets

of EVT constructs, we begin to lose sight of understanding and interpreting results. Scales have the same name (e.g., the motivation scale) but they are measuring different constructs because of the way items were combined. Some motivation scholars have recently been moving towards further differentiating subcomponents of value beliefs in EVT [13,14]. For instance, "How beneficial for your daily life is understanding Biology?" and "How impressive do others find your knowledge of Biology?" both attempt to measure utility value. However, one facet of utility value focuses on daily life, while the other facet focus on social life. In this case, the aforementioned items come from the same scale but measure different facets of utility value.

Prominent Jingle Jangle Fallacies

The presence of the jingle jangle fallacy in similar lines of psychological research suggests that it may well be present in the field of achievement motivation. For decades, personality psychologists have examined the jingle jangle fallacy to deal with the wide disarray of competing personality trait concepts and scales [15,16]. This work has helped identify the major dimensions of personality—the "Big Five"-and further resulted in a comprehensive, reliable, and valid structure of personality traits [17]. Even further within personality research, Whiteside and Lynam (2001) assessed the jingle jangle fallacy of impulsivity and documented the fact that frequently used measures of impulsivity fit under the conceptions of impulsivity within the Five Factor Model of personality [18,19]. Recent efforts have also been made to unravel the disconnectedness of different concepts and measures in motivation research, especially Marsh and his colleagues [20-22]. For example, Marsh and his colleagues found that eight motivation orientation constructs, Ego, Competition, Mastery, Intrinsic, Cooperation, Individual, Approach Success, and Avoid Failure, indeed overlapped and at best represented by only two broad categories of Learning and Performance orientations, or what they call the "Big-Two-Factor-Theory" of academic motivation orientation [21].

Concerns for the Field of Motivation

The consequences of the jingle jangle fallacy are: 1. misspecifying theoretical ideas with ambiguous measures of the underlying hypothetical constructs; 2. representing the potentially large effect of a single process as two smaller effects when distinct scales empirically converge; and 3. drawing conclusions and applications from findings when researchers might not truly know what they are measuring. We demonstrate how this can happen when studying self-related beliefs of academic motivation from EVT, SDT, and AGT as just one example of troubling trends observed in recent publications. First, recent studies have attempted to enter similarly worded items (i.e., constructs from task values, mastery and performance achievement goals, and intrinsic and extrinsic goals) that supposedly measure different constructs into regression or SEM analyses as independent predictors [23-25]. An example includes "I find English is interesting," measuring interest value from EVT and "An important reason I do my English work is that I enjoy it," measuring mastery goal from AGT were both included in the SEM model to predict to English test scores [24]. Although theoretically different, a participant who takes this survey might not think that the items are different. Instead they may think that both items refer to how much they like English. Second, recent studies use highly similar items to represent different phenomena [26-28]. As new attempts to integrate existing theories of motivation emerge, we believe that this investigation of self-related academic beliefs from EVT, SDT, and AGT will help highlight the importance of conversations about the overlap of items from different theoretical perspectives [29,30].

Current Study

Our paper investigates the presence of jingle jangle problems in the study of motivational beliefs, specifically using 10 construct scales drawn from EVT, SDT, and AGT. We want to highlight that our paper is written for scholars who are not as familiar with the field of motivation as well as early career scholars who want to pursue further research in the field of motivation. With our intended audience in mind, we do not include "the scale" that best represents each achievement motivation theory. We instead choose commonly used scales, in which individuals who are unfamiliar with the different theoretical traditions may methodologically combine items that overlap.

For the purposes of our study, we particularly focus our attention on the jangle fallacies. But we believe that these two fallacies coexist. We first used exploratory factor analysis (EFA) models on the individual items of the 10 construct scales to examine the extent of jingle jangle problems across just these three prominent motivational theories. We started with EFAs rather than confirmatory factor analysis (CFAs) due to the lack of theory regarding how items from each of these constructs overlap. In addition to this statistical analysis, we conducted a robustness check of how items from EVT, SDT, and AGT go together by implementing a card-sorting method with individuals who have a prior background in the motivation literature, but do not know the purpose of our study. Finally, we used confirmatory factor analysis to compare whether factor structures offered by EFAs fit the data better than factor structures that separate items according to their theoretical origins.

While this is not a comprehensive assessment of the key components underlying the many existing measures of motivational beliefs, it affirms the extent of jingle jangle problems in the study of motivational beliefs. We hope that it stimulates more comprehensive empirical efforts modeled after the work in personality theory and currently being done by Marsh and his colleagues.

Method

Sample and Procedures

Two different datasets were used in this study. We first collected data from 147 undergraduates from a biology and chemistry course that used cooking as the example of fundamental biological chemistry phenomena. But this dataset was limited due to the small sample size. In order to more robustly check our findings and reconfirm whether similar patterns arise with a larger and more diverse sample, we conducted the same analysis on a dataset of 1,080 students from a more mainstream introductory biological sciences course.

Biology and Chemistry of Cooking

The sample consisted of 147 undergraduates in an online summer class at a large public university located in Southern California. Students were enrolled in a five-week course on the biology and chemistry of cooking. Data were collected using an online survey gathered from the students both at the start of the course (time 1) and at the end of the course (time 2). Students completed these surveys as part of their course assignment. The online surveys were accessed through personalized links sent as both text and email messages to allow students to have access to the course motivation questionnaires at their convenience. Measures for value, achievement goals, and

intrinsic/extrinsic motivation were made to be course-specific, such that all items referred to students' attitudes and beliefs about the biology and chemistry of cooking.

Biological Sciences

The sample consisted of all 1,080 first-year biology students at a large public university located in Southern California. Concurrent with their introductory biology courses, all first-year biology students were required to enroll in a one-unit, ten-week study skills course during their first term. During the third week of the term, the study skills course awarded course credit for completing an online survey about their experiences with and attitudes about the biology major, garnering a 96% response rate. Measures for value, achievement goals, and intrinsic/extrinsic motivation were made to be subject-specific, such that all items referred to students' attitudes and beliefs about the field of biology.

Measures (see Table 1 for full list of items)

Value Items

According to Gaspard and Eccles et al. expectancy-value theory (EVT) of achievement- related choices, there are at least four components of task value beliefs that motivate students to learn: intrinsic interest, attainment, utility, and cost [1,7,31,32]. We focused on values in the EVT because prior literature has attempted to disentangle the conceptual difference of subjective task values with SDT, in comparison to the expectancy component of EVT [9].

Table 1: Construct Scale Items from Both Datasets Used for Factor Analyses

Construct	Variable Name BCC	Variable Name BioSci	Item Question BCC	Response Scale BCC	Item Question BioSci	Response Scale BCC
Value Items						
Utility Value	ut1	util9	How beneficial for your daily life is understanding the biology and chemistry of cooking?	slider: (1) not beneficial at all ... (7) very beneficial	How beneficial for your daily life is understanding Biology?	slider: (1) not at all beneficial ... (7) extremely beneficial
Utility Value	ut2	util7	How useful in everyday life and leisure time is knowledge of biology and chemistry of cooking?	slider: (1) not at all useful ... (7) very useful	How useful in everyday life and leisure time is the knowledge of Biology?	slider: (1) not at all useful ... (7) extremely useful
Utility Value	ut3	util10	How applicable in everyday life is knowledge of biology and chemistry of cooking?	slider: (1) not at all applicable ... (7) very applicable	How applicable in everyday life is the knowledge of Biology?	slider: (1) not at all applicable ... (7) extremely applicable
Utility Value	ut4	util11	How much will you be able to impress others with your knowledge of the biology and chemistry of cooking?	slider: (1) not at all ... (7) a lot	How impressive do others find your knowledge of Biology?	slider: (1) not at all impressive ... (7) extremely impressive
Utility Value	ut5	util8	How important is it to you to get a good grade in this course for your academic career?	slider: (1) not at all important ... (7) very important	How important is it to you to get a good grade in your Bio Sci classes for your academic career?	slider: (1) not at all important ... (7) extremely important
Interest Value	int1	int9	How often do you wonder about the science behind cooking?	slider: (1) never ... (7) very often	How often do you wonder about Biology?	slider: (1) not at all often ... (7) extremely often
Interest Value	int3	int8	How interested are you in the science behind food and cooking?	slider: (1) not at all interested ... (7) very interested	How interested are you in Biology?	slider: (1) not at all interested ... (7) extremely interested

Interest Value	int4	int10	How much fun will learning about the biology and chemistry of cooking be?	slider: (1) not at all fun ... (7) very fun	How much fun is learning about Biology?	slider: (1) not at all fun ... (7) extremely fun
Attainment Value	att1	att7	How important to you, personally, is it to be a person who understands the science behind cooking?	slider: (1) not at all important ... (7) very important	How important to you, personally, is it to be a person who understands Biology?	slider: (1) not at all important ... (7) extremely important
Attainment Value	att2	att8	How important is it that others see you as knowledgeable about the science behind food and cooking?	slider: (1) not at all important ... (7) very important	How important is it that others see you as knowledgeable about Biology?	slider: (1) not at all important ... (7) extremely important
Attainment Value	att3	att9	How important to your identity is it to be knowledgeable about the science behind food and cooking?	slider: (1) not at all important ... (7) very important	How important to your identity is it to be knowledgeable about Biology?	slider: (1) not at all important ... (7) extremely important
Cost Value	co1	costp5	How stressful will this class be?	slider: (1) not at all stressful ... (7) very stressful	How stressful will your Bio Sci classes be?	slider: (1) not at all stressful ... (7) extremely stressful
Cost Value	co2	costp4	How frustrating will this class be?	slider: (1) not at all frustrating ... (7) very frustrating	How frustrating will your Bio Sci classes be?	slider: (1) not at all frustrating ... (7) extremely frustrating
Cost Value	co3	costp6	How emotionally draining will this class be?	slider: (1) not at all draining ... (7) very draining	How emotionally draining will your Bio Sci classes be?	slider: (1) not at all draining ... (7) extremely draining
Cost Value	co4	costo5	How much do you have to sacrifice to do well in this course?	slider: (1) nothing ... (7) an incredible amount	How much will you have to sacrifice to do well in your Bio Sci classes?	slider: (1) nothing ... (7) an extreme amount
Cost Value	co5	costo6	How many other valued activities does this class require you to give up?	slider: (1) none ... (7) an incredible amount	How many other valued activities will your Bio Sci classes require you to give up?	slider: (1) none ... (7) an extreme amount
Cost Value	co6	costo4	How many opportunities will you be missing out on if you commit fully to this class?	slider: (1) none ... (7) an incredible amount	How many opportunities will you be missing out on if you commit fully to your Bio Sci classes?	slider: (1) none ... (7) an extreme amount
Cost Value	co7	coste5	How much will your other commitments get in the way of you putting forth effort in class?	slider: (1) not at all ... (7) completely	How much will your other commitments get in the way of you putting forth effort in your Bio Sci classes?	slider: (1) not at all ... (7) an extreme amount
Cost Value	co8	coste6	How much time will you have for this class after taking care of more important activities?	slider: (1) not nearly enough ... (7) enough	How much time will you have for your Bio Sci classes after taking care of more important activities?	slider: (1) none ... (7) an extreme amount

Cost Value	co9	coste4	How much effort will you have left for this class after taking care of more important activities?	slider: (1) not nearly enough ... (7) enough	How much effort will you have left for your Bio Sci classes after taking care of more important activities?	slider: (1) none ... (7) an extreme amount
Achievement Goal Orientation Items						
Achievement Goal Orientation	map1	map2	I want to learn as much as possible in this class	slider: (1) not at all true of me ... (7) very true of me	How important is it to you to learn as much as possible in Biology?	slider: (1) not at all important ... (7) extremely important
Achievement Goal Orientation	map2	map1	It is important for me to understand the ntent of this course as thoroughly as possible	slider: (1) not at all true of me ... (7) very true of me	How important is it to you to understand the content of Biology as thoroughly as possible?	slider: (1) not at all important ... (7) extremely important
Achievement Goal Orientation	mav5	mav1	Sometimes I'm afraid that I may not understand the content of this class as thoroughly as I'd like	slider: (1) not at all true of me ... (7) very true of me	How afraid are you may not understand the content of Biology as thoroughly as you'd like?	slider: (1) not at all afraid ... (7) extremely afraid
Achievement Goal Orientation	mav10	mav2	I am often concerned that I may not learn all that there is to learn in this class	slider: (1) not at all true of me ... (7) very true of me	How concerned are you of not learning all that there is to learn in Biology?	slider: (1) not at all concerned ... (7) extremely concerned
Achievement Goal Orientation	pap6	pap1	It is important for me to do well compared to others in this class	slider: (1) not at all true of me ... (7) very true of me	How important is it to you to do well compared to others in Biology?	slider: (1) not at all important ... (7) extremely important
Achievement Goal Orientation	pap17	pap2	It's important to me that others think I'm smart in class	slider: (1) not at all true of me ... (7) very true of me	How important is it to you that others think you're smart in Bio Sci classes?	slider: (1) not at all important ... (7) extremely important
Achievement Goal Orientation	pav3	pav1	It is important for me not to do worse than the other students	slider: (1) not at all true of me ... (7) very true of me	How important is it to you not to do worse than the other Biology students?	slider: (1) not at all important ... (7) extremely important
Achievement Goal Orientation	pav7	pav2	I just want to avoid doing poorly in this class	slider: (1) not at all true of me ... (7) very true of me	How much do you want to avoid doing poorly in this Bio Sci class?	slider: (1) do not want to avoid at all ... (7) want to avoid extremely
Achievement Goal Orientation	pav16	pav3	I don't want to look like I'm not as smart as the other students	slider: (1) not at all true of me ... (7) very true of me	How much do you want avoid looking like you're not as smart as the other Biology students?	slider: (1) do not want to avoid at all ... (7) want to avoid extremely
Intrinsic/Extrinsic Motivation Items						
Intrinsic/Extrinsic Motivation	im1	ie1	To enjoy the fun of learning about the science behind food and cooking	slider: (1) not at all important ... (7) very important	How much do you enjoy the fun of learning about Biology?	slider: (1) do not enjoy at all ... (7) enjoy extremely
Intrinsic/Extrinsic Motivation	im2	ie2	To challenge myself academically	slider: (1) not at all important ... (7) very important	How much do you want to challenge yourself academically in Biology?	slider: (1) do not want to challenge at all ... (7) want to challenge extremely

Intrinsic/Extrinsic Motivation	im3	ie3	To develop new knowledge about the science behind food and cooking	slider: (1) not at all important ... (7) very important	How much do you want to develop new knowledge about Biology?	slider: (1) do not want to develop new knowledge at all ... (7) want to develop knowledge extremely
Intrinsic/Extrinsic Motivation	em4	ie4	To improve my GPA by getting a good grade	slider: (1) not at all important ... (7) very important	How much do you care about improving your GPA by getting a good grade in Biology?	slider: (1) do not care at all ... (7) care extremely
Intrinsic/Extrinsic Motivation	em5	ie5	To prove my ability by getting a good grade	slider: (1) not at all important ... (7) very important	How much do you want to prove your ability by getting a good grade in Biology?	slider: (1) do not want to prove ability at all ... (7) want to prove ability extremely
Intrinsic/Extrinsic Motivation	em6	ie6	To avoid lowering my GPA by getting a bad grade	slider: (1) not at all important ... (7) very important	How much do you care that your GPA could be lowered if you get a bad grade in Biology?	slider: (1) do not care at all ... (7) care extremely
Intrinsic/Extrinsic Motivation	em7	ie7	To avoid looking incompetent by getting a bad grade	slider: (1) not at all important ... (7) very important	How much do you care that you could look incompetent if you get a bad grade in Biology?	slider: (1) do not care at all ... (7) care extremely

Note: BCC refers to the biology and chemistry of cooking course and BioSci refers to the biological sciences course.

To access these 4 major...we adapted value items from Gaspard and Eccles et al. [1,33]. However, we modified the items to make them either course specific or domain specific and the construct scale-anchors to be item-specific (e.g., "How stressful will this class be?" had response values of 1 = *not at all stressful* to 7 = *very stressful*). For each of the components of value beliefs, we asked between three to nine items. Specifically, utility items were assessed focusing on life domains within context of time. Interest items emphasized curiosity and fun of learning. Attainment items aimed at the importance of knowing biology to their identity. Cost items assessed effort cost (i.e., sensed exhaustion), opportunity cost (i.e., time lost for other tasks), and psychological cost (i.e., feeling negative emotions) [34]. These items were measured on a frequency-based slider Likert scale from 1 to 7 where the construct scale-anchors corresponded to the question (e.g., "How beneficial for your daily life is understanding X?" or "How interested are you in X?"). Gaspard reported good construct scale reliability for these items, in which all scales for interest value, attainment value, utility value, and cost value had $\alpha > .70$ [33].

Achievement Goal Orientation Items

Items were adapted from Elliot & McGregor (2001) for this present investigation [35]. We used this measure because it made a distinction between not only mastery and performance goal orientations, but also between approach and avoidance goal orientations. Students who endorse mastery approach goal orientations strive to master the material, understand the topic, and improve competence [36]. Students who endorse mastery avoidance goal orientations attempt to avoid failing at mastering the material and understanding the topic. In contrast, students who uphold performance approach goal orientations endorse the desire to gain favorable achievement to others but students who uphold performance avoidance goal orientations attempt to avoid negative achievement [36]. For the purposes of this study, we modified 9 items to make them more specific to the course or domain of biology. In particular, there were 2 mastery approach items (e.g., "I want to learn as much as possible in this class"), 2 mastery avoidance items (e.g., "I am often concerned that I may not learn all that there is to learn in this class"), 2 performance approach items (e.g., "It is important for me to do well compared to others in this class"), and 3 performance avoidance items (e.g., "It is important for me not to do worse than the other students). For the biology and chemistry of cooking course, these items were measured on a Likert scale from 1 = *not at all true of me* to 7 = *very true of me*. For the biological sciences course, these items were measured on a Likert scale from 1 to 7 where the construct scale-anchors corresponded to the question. Elliot & McGregor reported Cronbach's alphas of .87, .84, .96, and .82 for mastery approach, mastery avoidance, performance approach, and performance avoidance, respectively [35].

Intrinsic/Extrinsic Motivation Items

The Academic Motivation Scale for college students constructed by Vallerand et al. was adapted for this current research. We used this measure due to its use of intrinsic (i.e., completing an activity for pleasure and satisfaction) and extrinsic (i.e., engaging in an activity for a means to an end and not for its own sake) motivation in a college setting [37-39]. For the biology and chemistry of cooking course, items were adjusted to be unique to the course and measured using a slider Likert scale from 1 = *not at all important* to 7 = *very important*. For the biological sciences course, items were adjusted to be unique to the domain of biology and measured using a slider Likert scale from 1 to 7 where the construct scale-anchors corresponded to the question. There were three intrinsic motivation items (e.g., "To enjoy the fun of learning about the science behind food and cooking") and four extrinsic motivation items (e.g., "To improve my GPA by getting a good grade"). Vallerand et al. stated internal consistency as the Cronbach's alphas ranged from .83 to .86 for the subset of items we used [37].

Analysis Plan

Exploratory Factor Analysis

All EFA analyses were done in R Studio using principle axis factor method and promax rotation with the psych package [40,41]. Our main focus is on exploratory factor analyses among these self-related motivational belief construct scales using value items, achievement goal orientation items, and intrinsic/extrinsic motivation items, in order to determine whether or not the jingle jangle fallacy exists in the psychological motivation literature. To confirm our factor structure findings, we compared the structures across two datasets.

Confirmatory Factor Analysis (see Supplemental Material online)

After conducting EFAs, our primary focus of confirmatory factor analyses was to compare competing models based on the original scales and EFA results, in order to further assess the jingle jangle fallacy using these self-related belief construct scales (i.e., value items, achievement goal orientation items, and intrinsic/extrinsic motivation items). CFA models were only conducted on the biological sciences course due to the limited sample size for the biology and chemistry of cooking course data. For the biological sciences course, we used split-sample cross validation, conducting an EFA on one half of the sample followed by a CFA on the other half.

All CFA analyses were done with MPlus 8.3 using maximum likelihood, which is robust against multivariate normality [42]. Model fits were evaluated by chi-square statistics, comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA), and standardized root mean square residuals (SRMR). The following typical model fit guidelines were used: CFI and TLI equal to or greater than .95, RMSEA values below .08, and SRMR values equal to or greater than .05 indicate an excellent model fit, and CFI and TLI greater than .90 and SRMR values less than .10 demonstrate an acceptable model fit [43].

Robustness Check: Exploratory Card-Sorting Method (see Supplemental Material online for more detail)

As a further robustness check of what we found from the EFAs, we asked individuals to sort index cards by their intended construct. We reasoned existence of the jingle jangle fallacies would be further supported if participants were observed grouping items from different theories together due to being insufficient differences to warrant separating them. Participants were given index cards with items from the biology and chemistry course survey and asked to sort them into piles that they believe capture the range of constructs. Although many of these participants were somewhat familiar with motivational theory, they were not told the list of motivational constructs from which the items were drawn.

Results

Exploratory Factor Analyses

Biology and Chemistry of Cooking

EFA using all of the items from the ten construct scales showed a 9-factor solution (based on examination of the scree plot and eigenvalues greater than 1) to be the most appropriate solution (refer to Figure 1). Even though the total number of factors do not differ much from the original scale, the ways in which the variables loaded are very distinct from the original scale. The nine-factor loadings and correlation amongst the factors for time 1 are presented in Table 2 and 3, respectively. The primary factor contained items related to utility value, interest value, attainment value, intrinsic motivation, and mastery approach. The items focused on pleasure for pure learning and knowledge applicability for the biology and chemistry of cooking course. The second factor included items related to emotional cost, loss of valued alternatives cost, and outside effort cost scales. The items focused on emotional and weighing different options cost for the biology and chemistry of cooking course. The third factor included items related to performance approach and avoidance. The items focused on comparing performance in relation to other students in the course. The fourth factor included items related to extrinsic motivation and performance avoidance. The items focused on grades for the course. The fifth factor included items related to time and effort cost. The sixth factor included items related to attainment value. The items focused on how the self and others identify with being knowledgeable about the course material. The seventh factor included utility items. The items focused on how applicable the course material is to their life. The eighth factor included mastery avoidance and performance avoidance items. The items focused on feelings of concern-either about the course content or how they will look in front of their peers in the course. The ninth factor included a utility item.

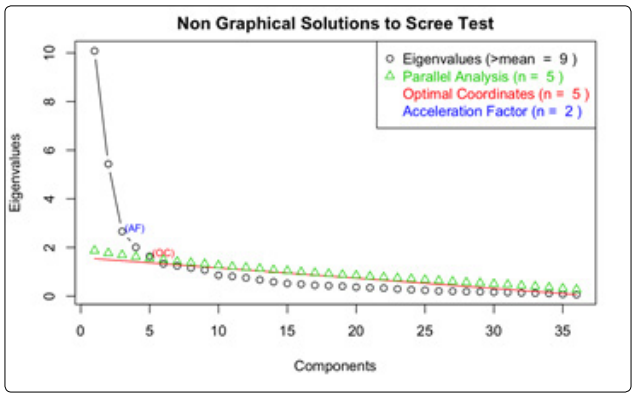


Figure 1: Scree plot for the biology and chemistry of cooking course time 1 stable self-beliefs exploratory factor analysis

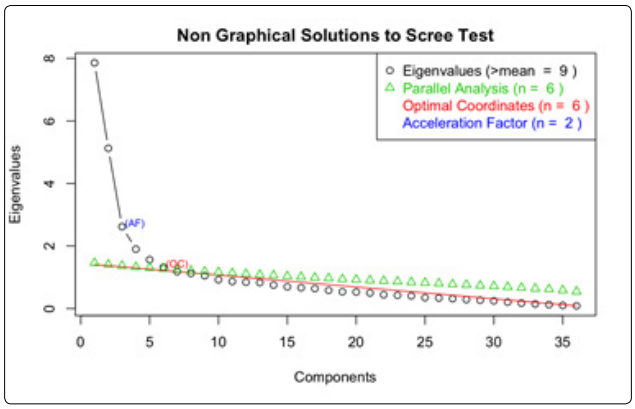


Figure 2: Scree plot for the biological sciences course sample 2 stable self-beliefs exploratory factor analysis

Table 2: Biology and Chemistry of Cooking Course Pre-Survey (or Time 1) Stable Self-Beliefs Nine Factor Loadings Using EFA

Items	Factors								
	1	2	3	4	5	6	7	8	9
ut1	0.47						0.62		
ut2	0.42						0.69		
ut3	0.61						0.42		
ut4	0.66					0.44			
ut5									0.61
int1	0.65								
int3	0.80								
int4	0.76								
att1	0.68					0.38			
att2						0.66			
att3	0.38					0.63			
co1		0.65							
co2		0.81							
co3		0.84							
co4		0.69							
co5		0.71							
co6		0.70							
co7		0.50							
co8					0.76				
co9					0.75				
im1	0.86								
im2	0.55								
im3	1.00							0.32	
em4				0.50					0.48
em5	0.35			0.40					
em6				0.78					
em7				0.73					
map1	0.82								
map2	0.72								
pav3			0.76						
mav5								0.63	
pap6			0.85						
pav7				0.62					
mav10								0.76	
pav16			0.38			0.34		0.47	
pap17			0.37			0.35		0.33	

Note: Only factor loadings higher than 0.30 are included. The highest loading for each item is in bold.

Table 3: Correlation Amongst the Factors for the Biology and Chemistry of Cooking Course

Factor	1	2	3	4	5	6	7	8	9
1	--								
2	-0.005	--							
3	0.368	0.255	--						
4	0.228	0.383	0.430	--					
5	0.125	0.232	0.362	0.424	--				
6	0.582	0.187	0.345	0.309	0.330	--			
7	0.251	-0.154	0.134	0.005	-0.025	0.060	--		
8	0.711	-0.049	0.223	0.144	0.064	0.401	0.255	--	
9	0.286	0.019	0.351	0.136	0.080	0.229	0.062	0.175	--

Biological Sciences

Similar to the biology and chemistry of cooking course, EFA using all of the items from the ten construct scales showed a 9-factor solution (based on examination of the scree plot and eigenvalues greater than 1) to be the most appropriate solution (refer to Figure 2). The nine-factor loadings and correlation amongst the factors for sample 2 are presented in Table 4 and 5, respectively.

Table 4: Biological Sciences Course Sample 2 Stable Self-Beliefs Nine Factor Loadings Using EFA

Items	Factors								
	1	2	3	4	5	6	7	8	9
util7	0.35					0.61			
util8			0.89						
util9						0.71			
util10						0.66			
util11					0.76				
int8	0.91								
int9					0.45				
int10	0.91								
att7	0.45								
att8				0.71	0.32				
att9				0.70					
costp4		0.54							
costp5		0.73							
costp6		0.82							
costo4		0.65							
costo5		0.77							
costo6		0.72							
coste4									0.42
coste5		0.63							
coste6									
ie1	0.88								0.64
ie2									
ie3	0.53								
ie4			0.86						
ie5								0.52	
ie6			0.76						
ie7								0.63	
map1	0.32		0.51						

map2	0.44		0.35						
mav1		0.38							
mav2									
pap1			0.48				0.54		
pap2				0.43				0.66	
pav1			0.47				0.54		
pav2			0.71						
pav3								0.85	

Note: Only factor loadings higher than 0.30 are included. The highest loading for each item is in bold.

Table 5: Correlation Amongst the Factors for the Biological Sciences Course

Factor	1	2	3	4	5	6	7	8	9
1	--								
2	0.396	--							
3	0.178	-0.104	--						
4	0.527	0.265	0.342	--					
5	0.270	0.550	-0.020	0.242	--				
6	0.310	0.632	-0.071	0.226	0.536	--			
7	0.307	0.315	0.154	0.389	0.392	0.330	--		
8	0.161	0.240	-0.011	0.179	0.217	0.245	0.077	--	
9	0.333	0.375	0.043	0.375	0.414	0.211	-0.171	-0.214	--

Similarities among Datasets

Both EFAs split items from the same theoretical background, reforming them into factors consisting of items from multiple theories (refer to Table 6). For example, both datasets suggested a single factor with items related to interest value, attainment value, intrinsic motivation, and mastery approach. The specific items focused on enjoyment of learning and understanding. Both datasets also had a single factor with items related to extrinsic motivation and performance avoidance. This factor centered around grades in biology. Lastly, both datasets had a single factor composed of items related to being knowledgeable about biology material related to their identity.

Table 6: Item Questions that Cluster Together Across Datasets

Group #	Construct Name	BCC Item Question	BioSci Item Question
Group 1			
	Interest Value	How interested are you in the science behind food and cooking?	How interested are you in Biology?
	Interest Value	How much fun will learning about the biology and chemistry of cooking be?	How much fun is learning about Biology?
	Attainment Value	How important to you, personally, is it to be a person who understands the science behind cooking?	How important to you, personally, is it to be a person who understands Biology?
	Intrinsic Motivation	To enjoy the fun of learning about the science behind food and cooking	How much do you enjoy the fun of learning about Biology?
	Intrinsic Motivation	To develop new knowledge about the science behind food and cooking	How much do you want to develop new knowledge about Biology?
	Mastery Approach	I want to learn as much as possible in this class	How important is it to you to learn as much as possible in Biology?
Group 2			
	Cost Value	How stressful will this class be?	How stressful will your Bio Sci classes be?
	Cost Value	How frustrating will this class be?	How frustrating will your Bio Sci classes be?

	Cost Value	How emotionally draining will this class be?	How emotionally draining will your Bio Sci classes be?
	Cost Value	How much do you have to sacrifice to do well in this course?	How much will you have to sacrifice to do well in your Bio Sci classes?
	Cost Value	How many other valued activities does this class require you to give up?	How many other valued activities will your Bio Sci classes require you to give up?
	Cost Value	How many opportunities will you be missing out on if you commit fully to this class?	How many opportunities will you be missing out on if you commit fully to your Bio Sci classes?
	Cost Value	How much will your other commitments get in the way of you putting forth effort in class?	How much will your other commitments get in the way of you putting forth effort in your Bio Sci classes?
Group 3			
	Extrinsic Motivation	To improve my GPA by getting a good grade	How much do you care about improving your GPA by getting a good grade in Biology?
	Extrinsic Motivation	To avoid lowering my GPA by getting a bad grade	How much do you care that your GPA could be lowered if you get a bad grade in Biology?
	Performance Avoidance	I just want to avoid doing poorly in this class	How much do you want to avoid doing poorly in this Bio Sci class?
Group 4			
	Cost Value	How much time will you have for this class after taking care of more important activities?	How much time will you have for your Bio Sci classes after taking care of more important activities?
	Cost Value	How much effort will you have left for this class after taking care of more important activities?	How much effort will you have left for your Bio Sci classes after taking care of more important activities?
Group 5			
	Attainment Value	How important is it that others see you as knowledgeable about the science behind food and cooking?	How important is it that others see you as knowledgeable about Biology?
	Attainment Value	How important to your identity is it to be knowledgeable about the science behind food and cooking?	How important to your identity is it to be knowledgeable about Biology?

Note: BCC refers to the biology and chemistry of cooking course and BioSci refers to the biological sciences course.

Confirmatory Factor Analyses

Following the initial exploratory analyses, we examined competing models using CFAs. For the biological sciences course, three models using the sample 1 data were fit to the data (refer to Figure S1-S3, respectively). We compared Model 1, Model 2, and Model 3 against each other. Each of these models used the full-set of items.

Model 1 was a 10-factor model consisting of 36 items, with each item loading on a factor representing the original scale from which it was taken (see Figure S1).

Model 2 also aligned items by their original scales, but accounted for the fact that the 2x2 AGT framework makes it clear that its four constructs fit under the respective umbrellas of mastery and performance orientation (see Figure S2). It was therefore identical to Model 1 except that it added two second-order factors. Mastery goal orientation was a second-order factor subsuming mastery approach and mastery avoidance. Performance goal orientation was a second-order factor subsuming performance approach and performance avoidance.

Model 3 consisted of the same items, but were organized according to the nine-factor EFA solution based on sample 2 of the biological sciences course (see Figure S3). To control for method variance associated with the fact that items from different scales had different wording and scale anchors, we correlated the errors of items that loaded onto the same factor and came from the same original scale. For example, for the first factor, we correlated utility item errors with other utility item errors, interest item errors with other interest item errors, and so on. This process was slightly different only for the factor with cost items, for which we correlated errors by the subcomponent of cost each item represented (i.e., emotional cost, loss of valued alternatives).

Overall, we found that there was poor model fit for all models (see Table 7). However, in both data sets, the best-fitting model was the nine-factor model. Furthermore, chi-square tests of competing models showed that for the biological sciences course, the nine-factor model fit the data significantly better than Model 1 and Model 2, respectively: $\Delta\chi2 = 230.34$, $\Delta df = 63$, $p < .001$ and $\Delta\chi2 = 412.48$, $\Delta df = 76$, $p < .001$. The fit of the model informed by the EFA, was not great, but was significantly better than the models that separated items by their original scales (refer to Online Supplementary materials).

Table 7: Model Fit Indexes for CFA Models

Dataset Name	Model #	(df) X^2	CFI	TLI	RMSEA	SRMR
BioSci Course						
	1	(549) 1707.76***	.78	.75	.06	.10
	2	(562) 1889.90***	.75	.72	.07	.11
	3	(486) 1477.42***	.80	.77	.06	.34

Note: BioSci refers to the biological sciences course. Models 1, 2, and 3 were compared. Bold indicates models with the jingle jangle problem. *** $p < .001$.

Robustness Check: Exploratory Card-Sorting Method

Our exploratory analyses from the card-sorting task showed the jingle jangle fallacy as well (see Supplementary Material online). Participants sorted items into piles that crossed across the original scales from which they were drawn, splitting up existing scales among different, new categories of items. In step 1, when the number of piles participants could create was unconstrained, 55.74% of the piles created included items from different scales, and 60.21% of the items were sorted into piles that included items from different scales. This suggests that when given the chance to understand motivational constructs through the items themselves, motivational self-beliefs from multiple theoretical perspectives are perceived to overlap considerably.

Discussion

Within psychological research, myriad academic motivation measures and conceptions are frequently created. However, when validity checks do not consider whether the theoretical construct is divergent from constructs used in existing motivational theories, we increase our risk of encountering the jingle jangle fallacy. We are not saying that the motivational theories are conceptually the same. But we are saying that the lack of attention to what items goes into a statistical model can influence the results without a priori historical background on achievement motivation theories.

In the current study, we investigated whether the jingle fallacies (i.e., when scales with the same name really measure a different construct) and jangle fallacies (i.e., when scales with different names really measure the same construct) exist between scales examining self-related beliefs towards academic motivation, looking specifically at task value, achievement goal orientations, and intrinsic/extrinsic motivation. These self-value and goal measures were chosen because they are commonly used to explain motivational behaviors, but emerged from different theoretical perspectives.

Both EFAs and CFAs revealed the jingle fallacies, and potentially the jangle fallacies as well. First, the nine-factor exploratory analyses from both datasets revealed that some items with the same name loaded onto a different factor (i.e., jingle fallacies). For example, "How important is it to you to get a good grade in your Bio Sci classes for your academic career?" and "How beneficial for your daily life is understanding Biology?" both measure utility value but loaded onto different factors. Conversely, some items with different names loaded onto the same factor (i.e., potentially, the jangle fallacies). For instance, "How interested are you in biology?" (interest value, EVT), "How much do you enjoy the fun of learning about biology?" (intrinsic motivation, SDT), and "How important is it to you to learn as much as possible in biology?" (mastery approach orientation, AGT) all loaded onto the same factor in both datasets (i.e., revealing the potential presence of the jangle fallacy). We refer to potential jangle fallacies because highly correlated items do not mean that they are the same thing (e.g., lighting and thunder are highly correlated in a factor analysis, but are conceptually distinct; similarly, these items come from distinct theoretical traditions).

Second, using confirmatory factor analyses, the 10-factor model fit significantly worse than the EFA derived nine-factor model. This finding indicates motivational constructs from different theories empirically converge. Yet, we cannot conclude that we found a definitive structure of achievement motivation using EVT, SDT, and AGT because our nine-factor model did not fit well on its own. Furthermore, identifying a definitive structure was not intended in these analyses. The purpose of this investigation was to warn researchers of the outcomes when putting similarly worded items into a regression or SEM analysis.

Third, our robustness check from the card-sorting task showed the jingle jangle fallacy too (see Supplementary Material online). Individuals sorted the cards where motivational self-belief constructs from different theories were combined into the same pile. This finding also likely translates to how participants would feel when taking a survey about motivational self-beliefs. They would feel as though there is no true difference between some of the overlapping measures.

Previous researchers have identified the jingle jangle fallacy within the field of personality and motivation [18,20,21,22,44]. In spite of these important findings, we continue to create new scales without considering divergent validity with respect to existing motivational theory and fall victim to the jingle jangle fallacy when we analyze them concurrently [23]. Our purpose in the present study was to reiterate and emphasize the hazard of treating various self-related beliefs measures as independent constructs, particularly when doing regression-based and SEM analyses. Many scales were not created using the multi-trait-multi- method approach nor did they go through the rigor of showing the difference from existing items [44,45].

Even though components of task values, achievement goals, and intrinsic/extrinsic motivation theoretically are different, our findings show overlap among scale items used to measure these distinct self-related beliefs. This is likely because the perception of the value of a particular task (i.e., task values) relates to what individuals want to achieve when doing a task (i.e., achievement goal orientation), and to the reason for engaging in a task (i.e., intrinsic/extrinsic motivation). At the level of the individual, task values, achievement goal orientations, and intrinsic/extrinsic motivation are viewed as integral properties of the self- system because they subside in the realm of symbolic representations, which are the valanced

psychological structures related to knowledge that increasingly become connected to higher order belief systems [46]. That is, an individual's sense of how useful biology is to daily life (i.e., utility value) share a highly common cause to their sense of interest in the subject matter (i.e., interest value), sense of identity importance (i.e., attainment value), desire to have a mastery orientation goal (i.e., mastery approach), and a natural inclination to learn (i.e., intrinsic motivation).

Because we did not include all possible measures of self-related motivational beliefs, we cannot say we have identified a Big-Nine-Factor Theory of self-beliefs academic motivation that could generalize or replicate across different samples. We also adapted measures. However, this is what a novice in the motivation field would do: adapt the items for their study and choose a scale recognizable to them. The overarching aim of this study was to show that supposedly distinct motivation theoretical models and constructs would empirically converge, especially without careful attention to measure choice. From our data, we can conclude that we found evidence of the jingle jangle fallacy in this specific set of items. Considering this, we warn researchers to be careful when they specify task values, achievement goal orientations, or intrinsic/extrinsic motivation as independent predictors in the same statistical model. Though such models may pass the standards of multicollinearity testing, results may be misleading, representing the potentially large effect of a single motivational process as two smaller effects.

We acknowledge that factor analysis techniques are based on the assumption that there is a common cause of the identified factors rather than a belief that the covariance reflects reciprocal causation amongst the items over time. Although motivational constructs are likely to cause one another to a certain extent, we choose this statistical method because our intent was not to identify reciprocal causation, but to warn researchers of the potential pitfalls of mistakenly assuming that measures coming from different theoretical perspectives should be entered into statistical models as independent (or separate) predictors. Social network analysis or multi- dimensional scaling analysis with a larger sample would account for motivational dimensions dangling together because they depend on one another for causal or probable reasons [47,48]. At the same time though, social network analysis or multi- dimensional scaling analysis comes with a cost because these methods like any other general linear modeling approaches assume homogeneity of causal dynamics for all sampled units (in this case, students in our study), which could likely reveal more noise than signal. As a result, we first suggest dispensing the homogeneity assumption that each variable and the causal dynamics among variables are relevant and similar for all people, in order to then apply person-in-context frames to highlight how units of analysis exist and function differently at various levels of the system [49].

In summary, our investigation is important because it is the first to look at the relations between this set of self-related motivational beliefs. We hope that current and future researchers think carefully before generating more supposedly unique motivational constructs without establishing both the need and true independence of the new constructs [50-60].

Our purpose in the present study was to reiterate and emphasize the hazard of treating various self-related beliefs measures as independent constructs, particularly when doing regression-based and SEM analyses. Many scales were not created using the multi-trait-multi-method approach, did not go through the rigor of showing the difference from existing items, and failed to model dynamical causal processes [44,45]. Failing to model these models during development among underlying constructs may lead to incorrect conclusions about the underlying factor structure. The ability to know which factors to control for in a regression model to get causally informative estimates depends on knowing the true developmental process.

Acknowledgements

The authors would like to acknowledge and sincerely thank Drew Bailey, Mark Warschauer, Stephen Peck, and Sandra Simpkins for providing feedback on a prior draft of the paper.

Funding

This work was supported by the National Science Foundation [grant number 1535300]; and the National Science Foundation Graduate Research Fellowship [award number DGE-1839285].

References

1. Eccles-Parsons JS, Adler TF, Futterman R, Goff SB, Kaczala CM et al (1983) Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), *Achievement and achievement motivation* 75-146
2. Deci EL, Ryan RM (1985) *Intrinsic motivation and self-determination in human behavior*. New York: Plenum Press.
3. Pintrich PR, Smith DAF, García T, McKeachie WJ (1991) *A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ)*. Ann Arbor: University of Michigan, National Center for Research to Improve Postsecondary Teaching and Learning.
4. Rosen JA, Glennie EJ, Dalton BW, Lennon JM., Bozick RN (2010) *Noncognitive Skills in the Classroom: New Perspectives on Educational Research. RTI International*. PO Box 12194, Research Triangle Park, NC 27709-2194.
5. Wigfield A, Eccles JS (2000) Expectancy–value theory of achievement motivation. *Contemporary Educational Psychology 25*: 68-81.
6. Ryan RM, Deci EL (2000) Intrinsic and extrinsic motivations: Classic definitions and new directions. Contemporary Educational Psychology *25*: 54 - 67.
7. Eccles JS, Wigfield A (2002) Motivational beliefs, values, and goals. *Annual Review of Psychology 53*: 109-132.
8. Murphy PK, Alexander PA (2000) A motivated exploration of motivation terminology. *Contemporary Educational Psychology 25*: 3-53.
9. Wigfield A, Cambria J (2010) Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review 30*: 1-35.
10. Kelley EL (1927) *Interpretation of educational measurements*. Yonkers, NY: World.
11. Thorndike EL (1904) *An introduction to the theory of mental and social measurements*. New York, NY: Columbia University Press.
12. Leaper C, Farkas T, Brown CS (2012) Adolescent girls' experiences and gender-related beliefs in relation to their motivation in math/science and English. *Journal of Youth and*

Adolescence 41: 268-282.
13. Gaspard H, Häfner I, Parrisius C, Trautwein U, Nagengast B (2017) Assessing task values in five subjects during secondary school: Measurement structure and mean level differences across grade level, gender, and academic subject. *Contemporary Educational Psychology 48*: 67-84.
14. Gaspard H, Wigfield A, Jiang Y, Nagengast B, Trautwein U et al (2018) Dimensional comparisons: How academic track students' achievements are related to their expectancy and value beliefs across multiple domains. *Contemporary Educational Psychology 52*: 1-14.
15. McCrae RR., Costa PT (1987) Validation of the five-factor model of personality across instruments and observers. *Journal of Personality and Social Psychology 52*: 81-90.
16. Navon D, Norman J (1983) Does global precedence reality depend on visual angle? *Journal of Experimental Psychology: Human Perception and Performance 9*: 955-965.
17. John OP, Naumann LP, Soto CJ (2008) Paradigm shift to the integrative Big Five trait taxonomy. *Handbook of Personality: Theory and Research 3*: 114-158.
18. Whiteside SP, Lynam DR (2001) The Five Factor Model and impulsivity: Using a structural model of personality to understand impulsivity. *Personality and Individual Differences 30*: 669-689.
19. McCrae RR, Costa PT Jr (1990) Personality in adulthood. Guilford Press.
20. Marsh HW (1994) Sport motivation orientations: Beware of jingle-jangle fallacies. *Journal of Sport and Exercise Psychology 16*: 365-380.
21. Marsh HW, Craven RG, Hinkley JW, Debus RL (2003) Evaluation of the Big-Two-Factor Theory of academic motivation orientations: An evaluation of jingle-jangle fallacies. *Multivariate Behavioral Research 38*: 189-224.
22. Marsh HW, Pekrun R., Parker PD, Murayama K, Guo J et al. (2019) The murky distinction between self-concept and self-efficacy: Beware of lurking jingle-jangle fallacies. *Journal of Educational Psychology 111*: 331-353.
23. Areepattamannil S, Freeman JG, Klinger DA (2011) Influence of motivation, self-beliefs, and instructional practices on science achievement of adolescents in Canada. *Social Psychology of Education 14*: 233-259.
24. Liem AD, Lau S, Nie Y (2008) The role of self-efficacy, task value and achievement goals in predicting learning strategies, task disengagement, peer relationship, and achievement outcome. *Contemporary Educational Psychology* 33: 486-512.
25. Van Nuland HJ, Dusseldorp E, Martens RL, Boekaerts M (2010) Exploring the motivation jungle: Predicting performance on a novel task by investigating constructs from different motivation perspectives in tandem. *International Journal of Psychology 45*: 250-259.
26. Lau S, Nie Y (2008) Interplay between personal goals and classroom goal structures in predicting student outcomes: A multilevel analysis of person- context interactions. *Journal of Educational Psychology 100*: 15-29.
27. Lepper MR, Corpus JH, Iyengar SS (2005) Intrinsic and extrinsic motivational orientations in the classroom: Age differences and academic correlates. *Journal of Educational Psychology 97*: 184-196.
28. Huguet P, Régner I (2007) Stereotype threat among schoolgirls in quasi-ordinary classroom circumstances *J Educ Psychol 99*: 545-560.
29. Dweck CS (2017) From needs to goals and representations: Foundations for a unified theory of motivation, personality, and development. *Psychological Review* 124: 689-719.
30. Hodis FA (2018) Examining individuals' strivings for value, control, and truth effectiveness: Implications for educational psychology research. *Educational Psychology Review 30*: 1001-1030.
31. Wigfield A, Tonks S, Klauda ST (2009) Expectancy-value theory. In KR Wentzel & Wigfield (Eds.), Handbook of motivation at school 55-75.
32. Eccles JS (2005) Subjective task values and the Eccles et al. model of achievement related choices. In A. J. Elliot & C. S. Dweck (Eds.), *Handbook of competence and motivation 105*-121.
33. Gaspard H, Dicke AL, Flunger B, Schreier B, Häfner I (2005)7math. *Journal of Educational Psychology 107*: 663-677.
34. Perez T, Cromley JG, Kaplan A (2014) The role of identity development, values, and costs in college STEM retention. *Journal of Educational Psychology 106*: 315-329.
35. Elliot AJ, McGregor HA (2001) A 2× 2 achievement goal framework. *Journal of Personality and Social Psychology 80*: 501-519.
36. Elliot AJ (1999) Approach and avoidance motivation and achievement goals. *Educational Psychologist 34*: 169-189.
37. Vallerand RJ, Pelletier LG, Blais MR., Briere NM, Senecal C et al. (1992) The Academic Motivation Scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement 52*: 1003-1017.
38. Vallerand RJ, Pelletier LG, Blais MR, Brière NM, Senecal C et al. (1993) On the assessment of intrinsic, extrinsic, and amotivation in education: Evidence on the concurrent and construct validity of the Academic Motivation Scale. *Educational and Psychological Measurement 53*: 159-172.
39. Deci EL (1975) *Intrinsic motivation*. New York: Plenum Press.
40. R Core Team (2018) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. ISBN 3-900051-07-0, URL http://www.R-project.org/.
41. Revelle W (2018) psych: Procedures for Personality and Psychological Research, Northwestern University, Evanston, Illinois, USA, https://CRAN.R-project.org/package=psych Version = 1.8.12.
42. Muthén LK, Muthén B (2008 –2014) *Mplus user's guide*. Los Angeles CA: Author.
43. Kline RB (2005) Methodology in the social sciences. Principles and practice of structural equation modeling (2nd ed.). Guilford Press.
44. Weidman AC, Steckler CM, Tracy JL (2017) The jingle and jangle of emotion assessment: Imprecise measurement, casual scale usage, and conceptual fuzziness in emotion research. *Emotion 17*: 267-295.
45. Campbell DT, Fiske DW (1959) Convergent and discriminant validation by the multitrait-multimethod matrix. *Psychological Bulletin 56*: 81-105
46. Peck S, Roeser RW, Zarrett NR, Eccles JS (2006) Self and identify processes in school motivation, learning, and achievement. *Handbook of Educational Psychology* 391-424.
47. Cramer AO, Van der Sluis S, Noordhof A, Wichers M, Geschwind N et al. (2012) Dimensions of normal personality as networks in search of equilibrium: You can't like parties if you don't like people. *European Journal of Personality 26*: 414-431.

48. Martınez A, Dimitriadis Y, Rubia B, Gómez E, De La Fuente P (2003) Combining qualitative evaluation and social network analysis for the study of classroom social interactions. *Computers & Education 41*: 353-368.
49. Peck SC (2007) TEMPEST in a gallimaufry: Applying multilevel systems theory to person-in-context research. *Journal of Personality 75*: 1127-1156.
50. Deci EL, Ryan RM (1991) A motivational approach to self: Integration in personality. In R. Dienstbier (Ed.), *Nebraska Symposium on motivation 38*: 237-288
51. Dweck CS (2006) *Mindset: The new psychology of success*. New York: Random House.
52. Heyman GD, Dweck CS (1992) Achievement goals and intrinsic motivation: Their relation and their role in adaptive motivation. *Motivation and Emotion 16*: 231-247.
53. Krapp A (2002) Structural and dynamic aspects of interest development: Theoretical considerations from an ontogenetic perspective. *Learning and Instruction 12*: 383-409.
54. Midgley C, Maehr ML, Hruda LZ, Anderman E, Anderman L et al (2000) Manual for the patterns of adaptive learning scales. *Ann Arbor: University of Michigan*.
55. Norman WT (1963) Toward an adequate taxonomy of personality attributes: Replicated factor structure in peer nomination personality ratings. *The Journal of Abnormal and Social Psychology 66*: 574-583.
56. Pintrich PR (2000) An achievement goal theory perspective on issues in motivation terminology, theory, and research. *Contemporary Educational Psychology 25*: 92-104.
57. Pintrich PR, Smith DAF, García T, McKeachie WJ (1993) Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement 53*: 801-813.
58. Rieger S, Göllner R, Spengler M, Trautwein U, Nagengast B et al. (2017) Social cognitive constructs are just as stable as the Big Five between grades 5 and 8. *AERA Open, 3,* 2332858417717691.
59. Suls J, Mullen B (1982) From the cradle to the grave: Comparison and self-evaluation across the life-span. In J. Suls (Ed.), *Psychological perspectives on the self*-Hillsdale, NJ: Lawrence Erlbaum 97-125.
60. Wolf EJ, Harrington KM, Clark SL, Miller MW (2013) Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement 73*: 913-934.

Online Supplemental Materials

Exploratory Card-Sorting Method

We explored whether those familiar with the 10 self-related beliefs motivational constructs (or value items, achievement goal orientation items, and intrinsic/extrinsic motivation items) could sort index cards with the item questions by their intended construct. To reduce bias, we did not ask individuals who were familiar with our study design.

8 participants were given an envelope with the 37 items from the biology and chemistry of cooking course. All of the item questions were the same as Table 1 except for an additional interest value question (i.e., "How curious are you to learn about the science behind cooking?"). This question was left out from our other analyses because it was not asked in the biological sciences course to compare across datasets. Each index card had one survey item on one-side and a randomly assigned number on the other-side. First, they were told to individually sort the index cards into as many piles as needed to capture the range of constructs. Then if participants had more than 7 piles, they shuffled the pile of index cards and repeated the same task as before, but sorted the index cards into no greater than 7 piles. If participants had more than 5 piles, they shuffled the pile of index cards and repeated the same task as before, but sorted the index cards into no greater than 5 piles. For each card-sorting task, we asked them to ignore how the questions were worded, but to focus on the semantics that tap similar latent constructs. Additionally, they wrote how many piles they had and the corresponding index card number for each pile after sorting.

Table S1: Numbers that Correspond to Each Item Name for Index Card Sorting Task

Item Names		Number Corresponding Index Cards
Value Items		
	Utility Value 1	15
	Utility Value 2	28
	Utility Value 3	16
	Utility Value 4	14
	Utility Value 5	12
	Interest Value 1	21
	Interest Value 2	20
	Interest Value 3	32
	Interest Value 4	25
	Attainment Value 1	27
	Attainment Value 2	9
	Attainment Value 3	13
	Cost 1	19
	Cost 2	29
	Cost 3	30

	Cost 4	22
	Cost 5	18
	Cost 6	1
	Cost 7	6
	Cost 8	8
	Cost 9	35
Achievement Goal Orientation Items		
	Mastery Approach 1	34
	Mastery Approach 2	7
	Mastery Avoidance 5	10
	Mastery Avoidance 10	2
	Performance Approach 6	4
	Performance Approach 17	5
	Performance Avoidance 3	36
	Performance Avoidance 7	37
	Performance Avoidance 16	31
Intrinsic/Extrinsic Motivation Items		
	Intrinsic Motivation 1	23
	Intrinsic Motivation 2	11
	Intrinsic Motivation 3	17
	Extrinsic Motivation 4	3
	Extrinsic Motivation 5	24
	Extrinsic Motivation 6	33
	Extrinsic Motivation 7	26

Note: Each index card had the item question on one side of the card (refer to Table 1 for exact wording of each item) and a randomly assigned number on the other side

Table S2: Results from the Index Card Sorting Task

Participant's ID	Step #	Pile #	Pile Label Given By Participant	Number Corresponding to Index Card	Constructs Put Together
A	Step 1	Pile 1	Performance Avoidance	26, 31, 33	Extrinsic Motivation, Performance Avoidance
		Pile 2	Cost	1, 6, 8, 18, 19, 22, 29, 30, 35	Cost
		Pile 3	Interest	20, 21, 23, 25, 32	Interest Value, Intrinsic Motivation
		Pile 4	Mastery Goal	7, 2, 10, 17, 34	Mastery Approach, Mastery Avoidance, Intrinsic Motivation
		Pile 5	Competence	11, 24	Intrinsic Motivation, Extrinsic Motivation
		Pile 6	N/A	3	Extrinsic Motivation
		Pile 7	Social Avoidance	4, 5, 9, 14, 36, 37	Performance Approach, Attainment Value, Utility Value, Performance Avoidance
		Pile 8	Utility Value	12, 15, 16, 28	Utility Value
		Pile 9	Attainment Value	13, 27	Attainment Value
	Step 2	Pile 1	Performance Avoidance	26, 31, 33	Extrinsic Motivation, Performance Avoidance
		Pile 2	Cost	1, 6, 8, 18, 19, 22, 29, 30, 35	Cost
		Pile 3	Interest	20, 21, 23, 25, 32	Interest Value, Intrinsic Motivation
		Pile 4	Mastery Goal	7, 2, 3, 10, 17, 34	Mastery Approach, Extrinsic Motivation, Mastery Avoidance, Intrinsic Motivation
		Pile 5	Competence	11, 24	Intrinsic Motivation, Extrinsic Motivation
		Pile 6	Social Avoidance	4, 5, 9, 14, 36, 37	Performance Approach, Attainment Value, Utility Value, Performance Avoidance
		Pile 7	Value	12, 15, 16, 28, 13, 27	Utility Value, Attainment Value
	Step 3	Pile 1	Cost	1, 6, 8, 18, 19, 22, 29, 30, 35	Cost
		Pile 2	Interest	20, 21, 23, 25, 32	Interest Value, Intrinsic Motivation
		Pile 3	Competence	7, 2, 3, 10, 17, 34, 11, 24	Mastery Approach, Extrinsic Motivation, Mastery Avoidance, Intrinsic Motivation

		Pile 4	Avoidance Value	4, 5, 9, 14, 36, 37, 26, 31, 33	Performance Approach, Attainment Value, Utility Value, Performance Avoidance, Extrinsic Motivation
		Pile 5	Value	12, 15, 16, 28, 13, 27	Utility Value, Attainment Value
B	Step 1	Pile 1	Focus on Cost	1, 6, 8, 18,19, 22, 29, 30, 35	Cost
		Pile 2	Focus on Learning	2, 10, 7, 13, 15, 17, 20, 21, 23, 25, 27, 32, 34	Mastery Avoidance, Mastery Approach, Attainment Value, Utility Value, Intrinsic Motivation, Interest Value
		Pile 3	Focus on Real-World Application	16, 28	Utility Value
		Pile 4	Focus on School/ Grades	3, 11, 12, 24, 26, 33, 37	Extrinsic Motivation, Intrinsic Motivation, Utility Value, Performance Avoidance
		Pile 5	Focus on Social Status/Others' Opinion	4, 5, 9, 14, 31, 36	Performance Approach, Attainment Value, Utility Value, Performance Avoidance
C	Step 1	Pile 1	Need to be knowledgeable	24, 14, 27, 9, 13	Extrinsic Motivation, Utility Value, Attainment Value
		Pile 2	Avoid negative evaluation of one's ability from others	31, 5, 26, 4, 36	Performance Avoidance, Performance Approach, Extrinsic Motivation
		Pile 3	To intellectually challenge oneself	10, 2, 34, 7, 11	Mastery Avoidance, Mastery Approach, Intrinsic Motivation
		Pile 4	Enjoy learning subject matter	21, 20, 17, 32, 25, 23	Interest Value, Intrinsic Motivation
		Pile 5	Cost of taking the class	22, 18, 1, 6	Cost
		Pile 6	Load of other commitment	35, 8	Cost
		Pile 7	Negative emotional consequence of class	30, 29, 19	Cost
		Pile 8	Benefit/Positive influence of knowing the subject matter in daily life	28, 16, 15	Utility Value
		Pile 9	Get good grade for career development purposes	3, 37, 33, 12	Extrinsic Motivation, Performance Avoidance, Utility Value

	Step 2	Pile 1	Need to be competent, either to self or others	24, 14, 27, 13, 36, 4, 26, 31, 5	Extrinsic Motivation, Utility Value, Attainment Value, Performance Avoidance, Performance Approach
		Pile 2	Get a good grade/GPA for academic career	12, 33, 37, 3	Utility Value, Extrinsic Motivation, Performance Avoidance, Extrinsic Motivation
		Pile 3	Need to challenge oneself	10, 2, 34, 7, 11	Mastery Avoidance, Mastery Approach, Intrinsic Motivation
		Pile 4	Enjoy learning food/ cooking science	21, 20, 17, 32, 25, 23	Interest Value, Intrinsic Motivation
		Pile 5	Benefit of knowing the content knowledge	28, 16, 15	Utility Value
		Pile 6	Load of other tasks in life/Time management/Task coordination	35, 8, 6	Cost
		Pile 7	Things to give up or suffer from	30, 29, 19, 22, 1, 18	Cost
	Step 3	Pile 1	Others' opinion on one's choice/behavior	31, 26, 9, 5	Performance Avoidance, Extrinsic Motivation, Attainment Value, Performance Approach
		Pile 2	Things to give up or suffer from	22, 19, 29, 30, 18, 1	Cost
		Pile 3	To intellectually challenge oneself (for one's own satisfaction)	2, 33, 37, 3, 12, 36, 24, 27, 13, 4, 11, 25, 23, 10, 34, 14	Mastery Avoidance, Extrinsic Motivation, Performance Avoidance, Utility Value, Attainment Value, Performance Approach, Intrinsic Motivation, Interest Value, Mastery Approach
		Pile 4	Know the subject matter for practical convenience or benefits	15, 21, 20, 17, 32, 16, 28, 7	Utility Value, Interest Value, Intrinsic Motivation, Mastery Approach
		Pile 5	Load of other tasks in life/Time management/Task coordination	35, 6, 8	Cost
D	Step 1	Pile 1	Love to learn	2, 10, 11, 17, 20, 21, 23, 25, 34	Mastery Avoidance, Intrinsic Motivation, Interest Value, Mastery Approach
		Pile 2	Perception of ability	14	Utility Value

		Pile 3	Identity	7, 9, 12, 13, 15, 16, 27, 28, 32	Mastery Approach, Attainment Value, Utility Value, Interest Value
		Pile 4	Cost	1, 6, 8, 18, 19, 22, 29, 20, 35	Cost, Interest Value
		Pile 5	Performance goals	3, 4, 5, 24, 26, 31, 33, 36, 37	Extrinsic Motivation, Performance Approach, Performance Avoidance
E	Step 1	Pile 1	Strong importance of the perceptions of others	3, 14, 24, 13, 36, 37, 12, 10, 33, 31, 26, 5, 4, 9, 2	Extrinsic Motivation, Utility Value, Attainment Value, Performance Avoidance, Mastery Avoidance, Performance Approach
		Pile 2	Love of learning	11, 7, 34, 17, 23	Intrinsic Motivation, Mastery Approach
		Pile 3	Differentiation between #1 & #2	16, 25, 21, 27, 15, 28, 20	Utility Value, Interest Value, Attainment Value
		Pile 4	Pessimism	19, 22, 29, 30, 6, 8, 35, 1, 18	Cost
F	Step 1	Pile 1	Social comparisons/ Self-Consciousness	4, 5, 9, 14, 26, 31, 36	Performance Approach, Attainment Value, Utility Value, Extrinsic Motivation, Performance Avoidance
		Pile 2	Identity	13, 24, 27	Attainment Value, Extrinsic Motivation
		Pile 3	Career	12	Utility Value
		Pile 4	Usefulness	15, 16, 28	Utility Value
		Pile 5	Cost	1, 6, 8, 18, 19, 22, 29, 30, 35	Cost
		Pile 6	Driven by GPA	3, 33, 37	Extrinsic Motivation
		Pile 7	Driven by learning and challenging oneself	2, 7, 10, 11, 34	Mastery Avoidance, Mastery Approach, Intrinsic Motivation
		Pile 8	Curiosity and interest	17, 20, 21, 32	Intrinsic Motivation, Interest Value
		Pile 9	Fun	23, 25	Intrinsic Motivation, Interest Value
	Step 2	Pile 1	Social comparisons/ Self-Consciousness	5, 36, 31, 4, 9, 14, 26	Performance Approach, Performance Avoidance, Attainment Value, Utility Value, Extrinsic Motivation
		Pile 2	Identity and career	13, 27, 24, 12	Attainment Value, Extrinsic Motivation, Utility Value
		Pile 3	Usefulness	15, 28, 16	Utility Value

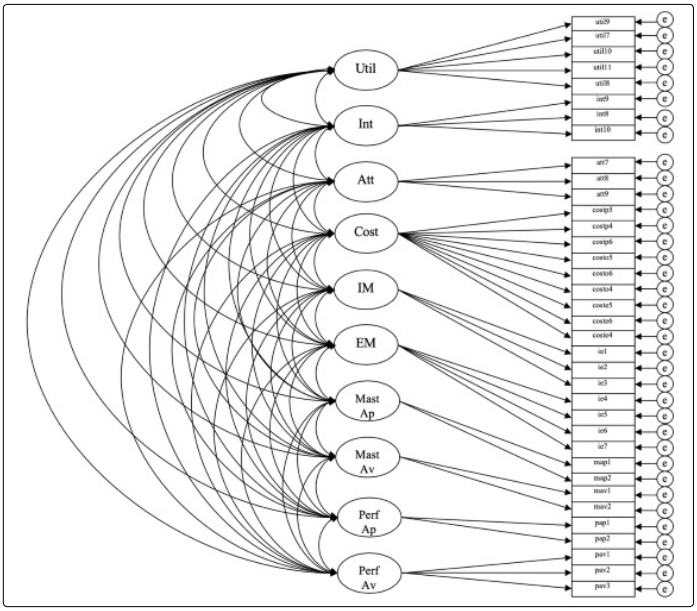
		Pile 4	Cost	19, 30, 29, 8, 35, 1, 18, 22, 6	Cost
		Pile 5	Driven by GPA	3, 33, 37	Extrinsic Motivation
		Pile 6	Driven by learning and challenging oneself	34, 2, 10, 7, 11	Mastery Avoidance, Mastery Approach, Intrinsic Motivation
		Pile 7	Curiosity, interest, and fun	20, 17, 21, 32, 23, 25	Intrinsic Motivation, Interest Value
	Step 3	Pile 1	Identity and social comparisons	5, 36, 31, 4, 9, 14, 26, 13, 27, 24, 12	Performance Approach, Performance Avoidance, Attainment Value, Utility Value, Extrinsic Motivation
		Pile 2	Usefulness	15, 28, 16	Utility Value
		Pile 3	Cost	19, 30, 29, 8, 35, 1, 18, 22, 6	Cost
		Pile 4	Driven by GPA	3, 33, 37	Extrinsic Motivation
		Pile 5	Learning, curiosity, interest, and fun	34, 2, 10, 7, 11, 20, 17, 21, 32, 23, 25	Mastery Avoidance, Mastery Approach, Intrinsic Motivation, Interest Value
G	Step 1	Pile 1	Learning science as fun	25, 23	Interest Value, Intrinsic Motivation
		Pile 2	Curiosity of learning science	20, 21, 32	Interest Value
		Pile 3	Pile 3	34, 27, 7, 17	Mastery Approach, Attainment Value, Intrinsic Motivation
		Pile 4	Worry/Concern about understanding	10, 2	Mastery Avoidance
		Pile 5	Challenging yourself	37, 11	Performance Avoidance, Intrinsic Motivation
		Pile 6	GPA	24, 33, 12, 3	Extrinsic Motivation, Utility Value
		Pile 7	Emotionally taxing	19, 29, 30	Cost
		Pile 8	Social comparison	31, 26, 36, 4	Performance Avoidance, Extrinsic Motivation, Performance Approach
		Pile 9	Looking smart	14, 13, 9, 5	Utility Value, Attainment Value, Performance Approach
		Pile 10	Not much value for it	1, 18, 8, 22	Cost
		Pile 11	Higher value	35, 6	Cost
		Pile 12	Usefulness	15, 16, 28	Utility Value
	Step 2	Pile 1	Curiosity and fun	25, 23, 21, 32, 20	Interest Value, Intrinsic Motivation
		Pile 2	Emotionally taxing	30, 29, 19	Cost

		Pile 3	Gaining knowledge	2, 10, 27, 7, 13, 17, 34, 11	Mastery Avoidance, Attainment Value, Mastery Approach, Intrinsic Motivation
		Pile 4	Grades	3, 24, 33, 37, 12	Extrinsic Motivation, Performance Avoidance, Utility Value
		Pile 5	Social comparison	9, 14, 5, 36, 26, 31, 4	Attainment Value, Utility Value, Performance Approach, Performance Avoidance, Extrinsic Motivation
		Pile 6	Value	35, 22, 1, 18, 8, 6	Cost
		Pile 7	Usefulness	28, 15, 16	Utility Value
	Step 3	Pile 1	Interest	20, 25, 23, 21, 32	Interest Value, Intrinsic Motivation
		Pile 2	Social Comparison, Extrinsic Motivation, Praise	9, 14, 5, 36, 26, 31, 37, 33, 12, 24, 3, 4	Attainment Value, Utility Value, Performance Approach, Performance Avoidance, Extrinsic Motivation
		Pile 3	Gaining Knowledge, Intrinsic Motivation	11, 13, 2, 10, 27, 7, 17, 34	Mastery Avoidance, Attainment Value, Mastery Approach, Intrinsic Motivation
		Pile 4	Value	30, 19, 29, 6, 35, 22, 1, 18, 8	Cost
		Pile 5	Usefulness	16, 15, 28	Utility Value
H	Step 1	Pile 1	Identity	13, 27	Attainment Value
		Pile 2	Utility	28, 16, 15	Utility Value
		Pile 3	Grade/Performance Goal	3, 12, 24, 33, 37	Extrinsic Motivation, Utility Value, Performance Avoidance
		Pile 4	Affective	19, 23, 25, 29, 30	Cost, Intrinsic Motivation, Interest Value
		Pile 5	Others oriented	4, 36, 31, 26, 14, 9, 5	Performance Approach, Performance Avoidance, Extrinsic Motivation, Utility Value, Attainment Value
		Pile 6	Actually learn (the why & all)	34, 17, 11, 10, 7, 2	Mastery Approach, Intrinsic Motivation, Mastery Avoidance
		Pile 7	Opportunity Cost	1, 6, 8, 18, 22, 35	Cost
		Pile 8	Curiosity/Interest	32, 21, 20	Interest Value

	Step 2	Pile 1	Personal Standing	13, 27, 4, 36, 31, 26, 14, 9, 5	Attainment Value, Performance Approach, Performance Avoidance, Extrinsic Motivation, Utility Value
		Pile 2	Utility	28, 16, 15	Utility Value
		Pile 3	Grade/Performance Goal	3, 12, 24, 33, 37	Extrinsic Motivation, Utility Value, Performance Avoidance
		Pile 4	Affective	19, 23, 25, 29, 30	Cost, Intrinsic Motivation, Interest Value
		Pile 5	Actually learn (the why & all)	34, 17, 11, 10, 7, 2	Mastery Approach, Intrinsic Motivation, Mastery Avoidance
		Pile 6	Opportunity Cost	1, 6, 8, 18, 22, 35	Cost
		Pile 7	Curiosity/Interest	32, 21, 20	Interest Value
	Step 3	Pile 1	Personal Standing	13, 27, 4, 36, 31, 26, 14, 9, 5	Attainment Value, Performance Approach, Performance Avoidance, Extrinsic Motivation, Utility Value
		Pile 2	Value	28, 16, 15, 1, 6, 8, 18, 22, 35	Utility Value, Cost
		Pile 3	Grade/Performance Goal	3, 12, 24, 33, 37	Extrinsic Motivation, Utility Value, Performance Avoidance
		Pile 4	Affective and curiosity	19, 23, 25, 29, 30, 32, 21, 20	Cost, Intrinsic Motivation, Interest Value
		Pile 5	Actually learn (the why & all)	34, 17, 11, 10, 7, 2	Mastery Approach, Intrinsic Motivation, Mastery Avoidance

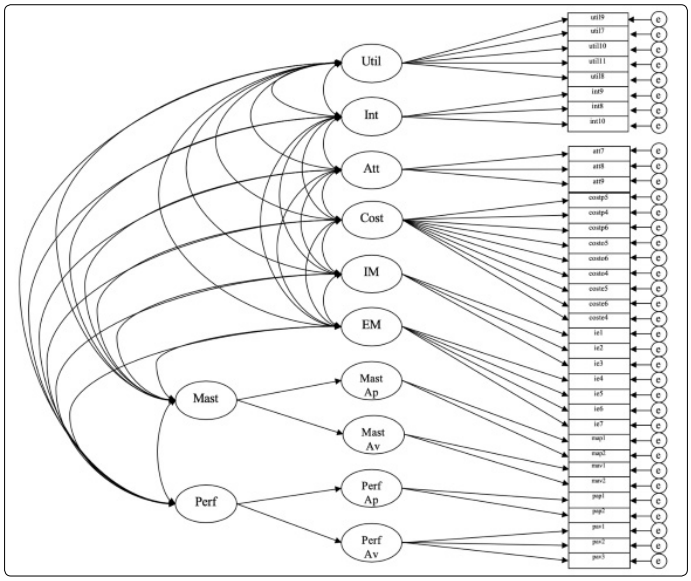
Note: Not all participants required three steps because they had less than 7 piles or 5 piles from prior steps. That is, they were first told to individually sort the index cards into as many piles as needed to capture the range of constructs. Then if participants had more than 7 piles, they shuffled the pile of index cards and repeated the same task as before, but sorted the index cards into no greater than 7 piles. If participants had more than 5 piles, they shuffled the pile of index cards and repeated the same task as before, but sorted the index cards into no greater than 5 piles.

Figure S1: Biological Sciences Course CFA Model 1



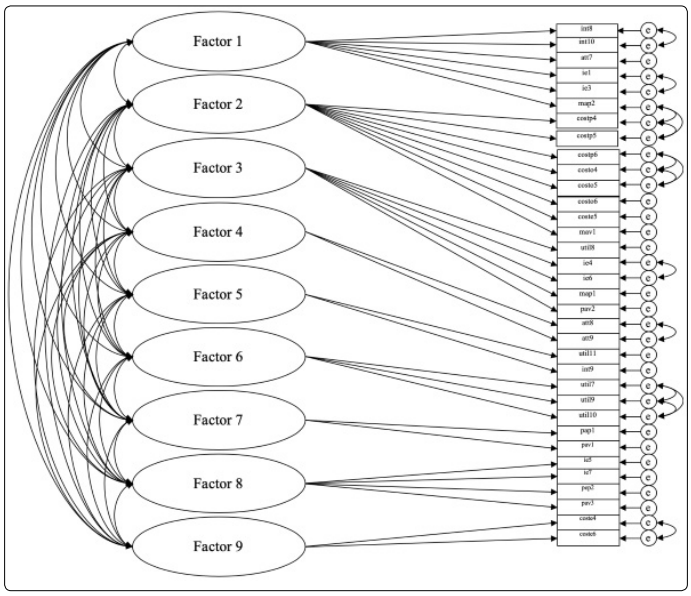
Note: Item driven standardized model using all items with no correlated errors for the biological sciences course. Util was coded as utility value; int was coded as interest value; att was coded as attainment value; cost was coded as cost value; im was coded as intrinsic motivation; em was coded as extrinsic motivation; mastap was coded as mastery approach; mastav was coded as mastery avoidance; perfap was coded as performance approach; perfav was coded as performance avoidance. The item name corresponds to Table 1.

Figure S2: Biological Sciences Course CFA Model 2



Note: Higher order item standardized model using all items with no correlated errors for the biological sciences course. Util was coded as utility value; int was coded as interest value; att was coded as attainment value; cost was coded as cost value; im was coded as intrinsic motivation; em was coded as extrinsic motivation; mastap was coded as mastery approach; mastav was coded as mastery avoidance; perfap was coded as performance approach; perfav was coded as performance avoidance. The item name corresponds to Table 1.

Figure S3: Biological Sciences Course CFA Model 3



Note: 9-Factor standardized model with correlated construct errors for the biological sciences course. The item name corresponds to Table 1.