Assessing Convergent and Discriminant Validity of the Motivation Construct for the Technology Integration Education (TIE) Model

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Motivation researchers have given high priority to the nomological validity of the motivation construct by creating diverse models such as the technology integration education (TIE) model as part of the technological, pedagogical, and content knowledge (TPACK) research agenda. However, researchers have not given equally high priority to convergent validity and discriminant validity. This study incorporated the multitrait-multimethod (MTMM) matrix to discover evidence of convergent validity and discriminant validity for self-determination theory motivation and social cognitive theory motivation. The researchers found limited evidence of convergent validity and discriminant validity for the motivation construct.

INTRODUCTION

Motivation is perennially important because it has diverse implications for academic research in education, psychology, business, and public administration (Greene, 2005; Perry & Hondeghem, 2008; Rainey, 2014) and real-world applications for teachers, parents, coaches, and others (Ryan & Deci, 2000a, 2000b). Motivation is among the most studied constructs in the social sciences. In industrial and organizational psychology, along with job satisfaction (Cranny, Smith, & Stone, 1992; Locke, 1969; Spector, 1992, 1987, 1997), motivation may be the most studied construct (Latham, 2012; Pinder, 2008). In educational psychology, along with self-efficacy (Bandura, 1977a, 1977b, 1997, 2009; Bandura & Locke, 2003; Gist & Mitchell, 1992), motivation may be the most studied construct (Brophy, 2010; Schunk, Pintrich, & Meece, 2008; Stipek, 2002; Weiner, 1972, 1980, 1986, 1990).

Education motivation textbooks have identified expectancy value, attribution, social cognitive, goal-setting, and self-determination theory as leading theories (Brophy, 2010; Schunk et al., 2008; Stipek, 2002). Schunk, Pintrich, and Meece (2008) defined motivation with this language: "**Motivation** *is the process whereby goal-directed activity is instigated and sustained*…. Motivation involves **goals** that provide impetus for and direction to action" [bold/italics original] (p. 4).

The purpose of our study was to compare the motivation constructs of self-determination theory (Cullen & Greene, 2011; Deci, 1975, Deci & Ryan, 2003, 2008, 2012; Deci, Vallerand, Pelletier, & Ryan, 1991; Ryan, 2012; Ryan & Deci, 2000a, 2000b, 2002, 2009; Vallerand et al., 1992; Vallerand & Ratelle,

2002) and social cognitive theory (Garcia-Duncan & McKeachie, 2005; Pintrinch, 1988a, 1988b, 1989; Pintrinch, Smith, Garcia, & McKeachie, 1993; Wood & Bandura, 1989). By comparison, we mean convergent validity and discriminant validity. The comparison method we used was Campbell and Fiske's (1959) multi-trait multi-method (MTMM) matrix, which is one of the most frequently used methods to assess convergent validity and discriminant validity (Netemeyer, Bearden, & Sharma, 2003). Although there are other methods for analyzing convergent validity and discriminant validity such as the confirmatory factor analysis (CFA) matrix and CFA individual parameters (Kenny & Kashy, 1992; Marsh & Bailey, 1991; Muis, Winne, & Jamieson-Noel, 2007), these are large sample techniques (Kenny & Kashy, 1992; Ployhart, 2008; Marsh & Bailey, 1991; MacCallum, R. C., Widaman, K. F., Zhang, S., & Hong, S., 1999; Muis et al., 2007; Russell, 2002; Sharma, 1996; Spector, 1987, 1992; Tabachnick & Fidell, 2013; Viswanathan, 2005). Moreover, to provide evidence of nomological validity for how motivation relates to other constructs, we adopted the learning performance model of Holland and Piper's (2014) technology integration education (TIE) model.

THEORETICAL FRAMEWORK

Measurement Theory, Reliability, and Validity

In Schmidt, Viswesvaran, and Ones' (2000) provocatively titled "Reliability is not validity and validity is not reliability," they challenged two fellow researchers' apparent confusion: "In a truly radical article, Murphy and DeShon (2000) reject the basic measurement model that is the foundation of most research in I-O [Industrial-Organizational] psychology" (p. 901). Thus, we review briefly "the basic measurement model" in terms of total research error and classical measurement theory to understand the differences and relationships between reliability and validity.

Social scientists try to minimize total research error, which is comprised of two broad categories: (a) sampling error and (b) nonsampling error. Nonsampling error can be divided further into four subcategories: (a) administration errors, (b) response errors, (c) nonresponse errors, and (d) design errors. Design errors can be divided further into six subcategories: (a) selection error, (b) population specification error, (c) sampling frame error, (d) experimental error, (e) surrogate information error, and (f) measurement error (Aaker, Kumar, & Day, 2001). And measurement error can be divided further into (a) random error and (b) systematic error (Churchill, 1979; Gall, Gall, & Borg, 2007; Viswanathan, 2005).

Classical measurement theory is framed frequently with the following formula: $X_O = X_T + X_S + X_R$. X_O represents the observed score. X_T represents the true score. X_S represents systematic (nonrandom) error. X_R represents random (nonsystematic) error (Churchill, 1979; Netemeyer et al., 2003; Viswanathan, 2005). Reliability refers to the extent that measures are consistent and free from random error (Churchill, 1979; Peter, 1979; Viswanathan, 2005). Validity refers to measuring what is intended to be measured and is free from systematic error (Churchill, 1979; Peter, 1979; Schmidt, Viswesvaran, & Ones, 2000; Viswanathan, 2005). As Churchill and Iacobucci (2002) summarized, "Reliability is a necessary, but not a sufficient condition for validity" (p. 414).

Components of Construct Validity

There are many typologies for classifying validity (Churchill, 1979; Netemeyer et al., 2003; Spector, 1992; Stone-Romero, 1994; Venkantraman & Grant, 1986; Viswanathan, 2005). According to Viswanathan (2005), to demonstrate the presence of construct validity, researchers must answer these questions: "Does a measure measure [*sic*] what it aims to measure; does a measure or operationalization correspond to the underlying construct it is aiming to measure?" (p. 63). Moreover, construct validity is not easily demonstrated because it consists of several components that require multiple sources of evidence (Spector, 1992; Viswanathan, 2005).

Table 1 shows the components of construct validity, definitions, and sources of evidence integrated from several sources (Netemeyer et al., 2003; Spector, 1992; Venkantraman & Grant, 1986; Viswanathan, 2005).

TABLE 1
COMPONENTS OF CONSTRUCT VALIDITY

Components	Definitions	Sources of Evidence
Content Validity	the extent that measurement instrument items are relevant and representative of the target construct	*a priori* theory, item generation pool, expert assessment of items
Face Validity	the extent that measurement instrument items linguistically and analytically look like what is supposed to be measured	*post hoc* theory, expert assessment of items
Predictive Validity	the extent that a measure predicts another measure	regression analysis, discriminant analysis
Concurrent Validity	the extent that a measure simultaneously relates to another measure that it is supposed to relate	correlation analysis
Convergent Validity	the extent that different measures of the same construct converge or strongly correlate with one another	correlation analysis, multitrait-multimethod (MTMM) matrix, confirmatory factor analysis (CFA), structural equation modeling (SEM)
Discriminant Validity	the extent that measures of different constructs diverge or minimally correlate with one another	correlation analysis, multitrait-multimethod (MTMM) matrix, confirmatory factor analysis (CFA), structural equation modeling (SEM)
Known-groups Validity	the extent that a measure differentiates between groups that are known to differ on the construct	means analysis, standard deviations analysis
Nomological Validity	the extent that a measure relates to other measures in a theoretical network	correlation analysis, regression analysis, path analysis, structural equation modeling (SEM)

Note: Integrated from Netemeyer, Bearden, and Sharma (2003), Spector (1992), Venkantraman and Grant (1986), and Viswanathan (2005).

FIGURE 1
TECHNOLOGY INTEGRATION EDUCATION (TIE) MODEL

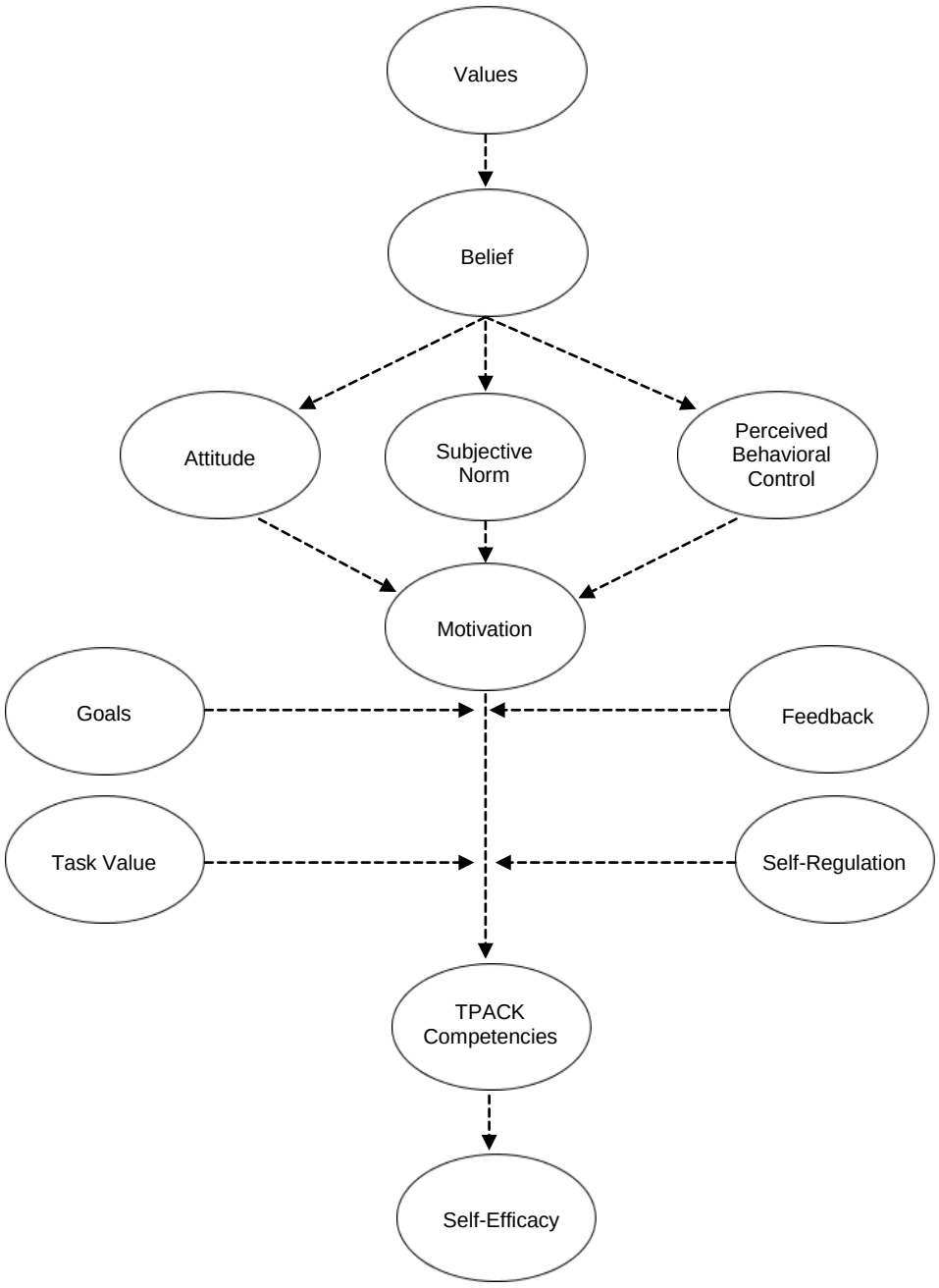

Figure 1. Reprinted from "A Technology Integration Education (TIE) Model: Millennial Preservice Teachers' Motivations about Technological, Pedagogical, and Content Knowledge (TPACK) Competencies," by D. D. Holland and R. T. Piper, 2014, *Journal of Educational Computing Research*, *51*(3), p. 271. Copyright 2014 by Baywood Publishing Co., Inc.

Nomological Validity and Technology Integration Education (TIE) Model

Graham (2011) noted that "Solid theories are essential to a robust and scientifically oriented discipline…." (p. 1953). Metaphorically, we can say that a construct does not live in isolation and it is perpetually searching for relationships with other constructs. A construct is given life by relating it via propositions to other constructs as part of the theory-building process and by relating variables (measured constructs) via hypotheses to other variables as part of the theory-testing process (Bacharach, 1989). Nomological validity is this process of theory-building and theory-testing for identifying multiple construct and variable relationships (Cronbach & Meehl, 1955).

To understand how the motivation construct relates to other constructs in a nomological network (Cronbach & Meehl, 1955; Spector, 1992; Viswanathan, 2005), we adopted the Holland and Piper (2014) technology integration education (TIE) model. Figure 1 shows the 12-construct TIE model, which includes eight primary constructs and four moderator constructs. Because "in many areas of investigation, associational or correlational evidence is all that we have or will ever be likely to have" (Vogt, 2007, p. 36), the TIE model is illustrated with dash-line arrows to represent correlational relationships.

RESEARCH QUESTION

Based on this review of measurement theory, reliability, and validity, components of construct validity, and nomological validity and the technology integration education (TIE) model, we investigated this research question: To what extent does convergent validity and discriminant validity exist for the motivation construct?

METHODS

Sample

The sample was a nonrandom, purposive sample that was collected during the 2012-2013 and 2013-2014 academic years from a small rural university. The sample consisted of 88 females and 53 males, or 90 elementary education majors and 51 secondary education majors, or 37 juniors and 104 seniors. Eighty-three students were age 18 - 22; 49 students were age 23 - 26; nine students were age 27 - 32. Thus, all 141 participants were Millennials.

Instrument

The 141 students completed an online survey at the end of their respective courses. The first part of the survey measured motivation with three variables (amotivation, extrinsic motivation, and intrinsic motivation) based on self-determination theory. This measure of motivation was similar to the Cullen and Greene (2011) survey. We adopted the 5-point Likert response categories that ranged from *strongly disagree* (1) to *neither agree nor disagree* (3) to *strongly agree* (5), instead of the 6-point, Likert response categories that Cullen and Greene had used. We made this change because with a 6-point response category responders are forced toward disagreeing or agreeing with an item when they may genuinely have a neutral view.

The second part of the survey measured motivation with three variables (task value, extrinsic goal orientation, and intrinsic goal orientation) based on social cognitive theory, expectancy-value theory, and achievement goal theory (Garcia-Duncan & McKeachie, 2005). This measure of motivation was similar to the Motivated Strategies for Learning Questionnaire (MSLQ), which includes measures for nine variables for learning strategies and six variables for motivation. These six motivation variables include (a) task value, (b) extrinsic goal orientation, (c) intrinsic goal orientation, (d) control of learning beliefs, (e) self-efficacy for learning and performance, and (f) test anxiety. Because the first, three social cognitive variables most closely match the three self-determination motivation variables, we selected task value ("judgments of how interesting, useful, and important the course content is"), extrinsic goal orientation ("a focus on grades and approval from others"), and intrinsic goal orientation ("a focus on learning and

mastery") (Garcia-Duncan & McKeachie, 2005, p. 119). The MSLQ can be found at Pintrich, Smith, Garcia, and McKeachie (1993) and Artino and Stephens (2009).

Table 2 shows a comparison of items for the three self-determination motivation variables and the three social cognitive motivation variables. About the six variables, we offer these observations. First, amotivation (self-determination) is a measure of indifference whereas task value (social cognition) is a measure of importance or interest. Second, extrinsic motivation (self-determination) is a measure related to rewards and technology whereas extrinsic motivation (social cognition) is a measure related to rewards and grades. Third, intrinsic motivation (self-determination) is a measure related to enjoyment of new things whereas intrinsic motivation (social cognition) is a measure related to likeability of course content. Thus, based on a comparison of individual items, the three corresponding "matched" variables are not measuring identical facets of the motivation construct.

TABLE 2
COMPARISON OF ITEMS FOR THREE SELF-DETERMINATION MOTIVATION VARIABLES VERSUS THREE SOCIAL COGNITIVE MOTIVATION VARIABLES

Self-Determination Motivation Items	Social Cognitive Motivation Items
Partial Specific Instructions: Why do you use technology in your teaching and lesson plans?	No Specific Instructions.
Amotivation	Task Value
1. Honestly, I don't know. I really feel I am wasting my time in using technology.	1. I think I will be able to use what I learn in this course in other courses.
2. I once had good reasons for learning to use technology; however, I wonder whether I should continue.	2. It is important for me to learn the course material.
	3. I am very interested in the content area of this course.
	4. I think the course material in this class is useful for me to learn.
	5. I like the subject matter of this course.
	6. Understanding the subject matter of this course is very important to me.
Extrinsic Motivation	Extrinsic Motivation
1. Because I experience enjoyment and satisfaction while using technology.	1. Getting a good grade in this class is the most satisfying thing for me right now.
2. Because I think that technology will help me better prepare my students for future careers.	2. The most important thing for me right now is improving my overall grade point average, so my main concern in this class is getting a good grade.
3. For the good feeling I have when I am using technology to communicate my own ideas to others.	3. If I can, I want to get better grades in this class than most of the other students.
4. For the enjoyment I experience while using a new tool in my lesson planning.	4. I want to do well in this class because it is important to show my ability to my family, friends, employer, or others.
5. To prove to myself that I am capable of using technology.	
6. Because I must show that I use technology to get a job.	

TABLE 2 (CONTINUED FROM PREVIOUS PAGE)

Intrinsic Motivation	Intrinsic Motivation
1. In order to obtain a better job than my peers.	1. In a class like this, I prefer course material that really challenges me so I can learn new things.
2. For the enjoyment I experience when I discover new things and ways of teaching.	2. In a class like this, I prefer course material that arouses my curiosity, even if it is difficult to learn.
3. Because it will enable me to enter the job market I like.	3. The most satisfying thing for me in this course is trying to understand the content as thoroughly as possible.
4. For the enjoyment that I experience when I try new things.	4. When I have the opportunity in this class, I choose course assignments that I can learn from even if they don't guarantee a good grade.
5. For the enjoyment that I experience when I exceed my personal accomplishments.	

Multitrait-Multimethod (MTMM) Matrix

We chose the Multitrait-Multimethod (MTMM) because it is "among the most frequently employed methods of investigating" convergent and discriminant validity (Netemeyer, et al., 2003, p. 77) and because it is relatively easy for understanding the required correlational coefficient patterns. Despite this popularity and relative ease of understanding MTMM, we want to emphasize three points. First, we recognize that there are limits to MMTM such as "ambiguity of what constitutes satisfactory results and the use of correlations that are based on observed variables to draw conclusions about underlying trait and method factors" (Kenny & Kashy, 1992, p. 162). Second, we recognize that there are other methods such as confirmatory factor analysis (CFA), but they require relatively large samples (Hair, Black, Babin, & Anderson, 2010; Kenny & Kashy, 1992; Muis et al., 2007; Tabachnick & Fidell, 2013).

Third, we recognize that theoretically MTMM may require two "different" methods such as a Likert scale and Thermometer scale similar to what Churchill (1979) used to illustrate MTMM. However, if by different methods, we mean self-report methods versus nonself-report methods such as interviews, observations, assessment reports, and archival records (Bedian, 2014), then self-report methods that include a scale that measures categorical-nominal variables such as the Job Description Index (JDI) and a scale that measures continuous-interval variables such as the Job Satisfaction Survey (JSS) are not different methods.

Campbell and Fiske (1959) stated that "Some evaluation of validity can take place even if the two methods are not entirely independent" (pp. 83-84). These methods requirements of *different* and *independent* are not always followed in actual convergent and discriminant validity comparisons. For example, Spector (1992) compared two different measures of job satisfaction. The Job Satisfaction Survey (JSS) developed by Spector is a 6-point Likert scale. The Job Descriptive Index (JDI) is a 3-point categorical scale that asks respondents to assess job-facet items using yes, no, or uncertain (Fields, 2013), which would be somewhat similar to a 3-point, continuous Likert scale. About the different methods of JDI and JSS, Spector (1992) offered this observation:

> The use of this tool [MTMM] requires that at least two constructs are measured, and each has been measured with at least two separate methods. This last requirement can greatly limit where the tool can be used, because it is not always possible to measure constructs with multiple methods…. Both scales [JSS and JDI that measure job satisfaction] were administered to a sample of 102 employees…. The availability of data from the same respondents for both scales allowed an MTMM analysis, **considering each scale as a separate method** [bold added]. (pp. 50-51)

Thus, following Spector (1992), because we have data from the same respondents for both motivation Likert scales, we too consider each scale as a separate method. We recognize this is a heroic assumption and limits the quality of our convergent and discriminant conclusions using MTMM.

RESULTS

Descriptive Statistics and Reliabilities

Table 3 shows the means, standard deviations, and reliabilities for the six motivation variables. Amotivation has the lowest mean (2.09) and task value has the highest mean (4.18). As Iacobucci and Duhachek (2003) emphasized, "Reliability is deemed so important that even when authors are not creating a scale but only using established scales, readers nevertheless expect a reliability index to be reported" (p. 478). Thus, we reported the reliabilities of the six motivation variables. The six variables meet the acceptable consensus threshold of .70 or higher (Vogt, 2007).

TABLE 3
DESCRIPTIVE STATISTICS AND RELIABILITIES

Variable	Mean	Standard Deviation	Cronbach's alpha
Self-Determination Theory			
Amotivation	2.09	.57	.76
Extrinsic Motivation	3.72	.55	.81
Intrinsic Motivation	3.79	.51	.78
Social Cognitive Theory			
Task Value	4.18	.70	.93
Extrinsic Motivation	3.93	.66	.80
Intrinsic Motivation	3.92	.60	.78

Note: N = 141.

Table 4 shows the correlation coefficients for the three self-determination motivation variables and three social cognitive motivation variables. Only the correlations between amotivation and intrinsic motivation (social cognitive) and between extrinsic motivation (social cognitive) and intrinsic motivation (social cognitive) were not significant. Correlations at .17 or higher were significant ($p < .05$).

The multitrait-multimethod (MTMM) matrix identifies three categories of correlation coefficients: (a) validity, (b) heterotrait-monomethod, and (c) heterotrait-heteromethod. In the discussion, we identify how each of these three categories relates to convergent validity and discriminant validity based on our results.

TABLE 4
MULTITRAIT MULTIMETHOD MATRIX FOR THREE SELF-DETERMINATION MOTIVATION VARIABLES VERSUS THREE SOCIAL COGNITIVE MOTIVATION VARIABLES

Variables	AM	EM	IM	TV	EGO	IGO
Self-Determination Motivation						
Amotivation	1.00					
Extrinsic	-.33[b]	1.00				
Intrinsic	-.54[b]	.70[b]	1.00			
Social Cognitive Motivation						
Task Value	-.17[a]	.27[c]	.26[c]	1.00		
Extrinsic GO	-.18[c]	.41[a]	.28[c]	.26[b]	1.00	
Intrinsic GO	-.06[c]	.16[c]	.24[a]	.64[b]	.13[b]	1.00

Note: [a]Validity correlation coefficients. [b]Heterotrait-monomethod correlation coefficients.
[c] Heterotrait-heteromethod correlation coefficients.

DISCUSSION

Objective Cutoff Value

DeVellis (2012) raised and answered this thought-provoking question: "How strong should correlations be to demonstrate construct validity? There is no cutoff that defines construct validity" (p. 67). DeVellis' answer certainly applies to two components of construct validity, convergent and discriminant validity and their respective pattern of correlations. There are no objective cutoff numerical values that determine "How strong is strong?"

Convergent Validity

Convergent validity may exist when two measures of the same variable are more highly correlated with each other than with measures of other variables. Convergent validity is determined by viewing the validity correlation coefficients, which were marked by the superscript *a* in Table 4. These three coefficients should be significant (which they are) and should be higher than other coefficients in their respective column or row.

Task value should have a higher correlation with amotivation (r = -.17) than with any of the other four variables, which it is not the case. Only the correlation between amotivation and intrinsic goal orientation (r = - .06) is lower. Thus, this pattern suggests that there is little convergence between task value and amotivation. However, because amotivation (self-determination) is a measure of indifference whereas task value (social cognition) is a measure of importance or interest, these differences among items may explain the absence of convergent validity.

Extrinsic goal orientation should have a higher correlation with extrinsic motivation (r = .41) than with any of the other four variables, which it is not case. However, only the correlation between extrinsic motivation and intrinsic motivation is higher (r = .70). Thus, this pattern suggests that there is some convergence between extrinsic goal orientation and extrinsic motivation.

Intrinsic goal orientation should have a higher correlation with intrinsic motivation (r = .24) than with any of the other four variables, which it is not case. However, only the correlation between intrinsic goal orientation and task value is considerably higher (r = .64). Thus, this pattern suggests that there is some convergence between intrinsic goal orientation and intrinsic motivation.

Discriminant Validity

Discriminant validity may exist when measures of different variables are significantly, but only slightly correlated with each other or not correlated with each other. Discriminant validity is determined by comparing validity correlation coefficients to the heterotrait-monomethod correlation coefficients, which were marked by the superscript *b* in Table 4, and to the heterotrait-heteromethod correlation coefficients, which were marked by the superscript *c* in Table 4. This comparison involves three conditions.

First, the validity correlation coefficients should be higher than the heterotrait-heteromethod correlation coefficients that share the same column and row. For task value, the validity correlation coefficient (r = -.17) is not higher than all the heterotrait-heteromethod correlation coefficients that share the same column and row. For extrinsic goal orientation, the validity correlation coefficient (r = .41) is higher than all the heterotrait-heteromethod correlation coefficients that share the same column and row. For intrinsic goal orientation, the validity correlation coefficient (r = .24) is not higher than all the heterotrait-heteromethod correlation coefficients that share the same column and row.

Second, the validity correlation coefficients should be higher than the heterotrait-monomethod correlation coefficients. This condition is more stringent than the heterotrait-heteromethod condition because the heterotrait-monomethod condition "suggests that the correlations between different measures for a trait should be higher than correlations among traits which have methods in common" (Netemeyer, et al., 2003, p. 79). However, the three validity correlations (r = -.17, .41, .26) are not consistently higher than the heterotrait-monomethod correlations (r = -.33, -.54, .70, 26, .64, .13).

Third, discriminant validity may exist when the pattern of correlations is "the same in all of the hetero-trait triangles…and is a check on the significance of the traits when compared to the methods" (Churchill, 1979, p. 71). This pattern is identified by rank ordering the correlations from highest positive to highest negative within each of the four triangles. The upper left-hand triangle's correlations are .70, -.54, -.33 and the lower right-hand triangle's correlations are .64, .23, .16. The lower left-hand triangle's correlations are .16, -.06, -18 and the mid-center triangle's correlations are .28, .27, .26. Clearly, the pattern of correlations is not the same for each of these triangles.

Answering the Research Question

For convergent validity, the patterns of correlation revealed that there is (a) little convergence between task value and amotivation, (b) some convergence between extrinsic goal orientation and extrinsic motivation, and (c) some convergence between intrinsic goal orientation and intrinsic motivation.

For discriminant validity, based on the first two conditions, the validity correlation coefficients were neither consistently higher than the heterotrait-heteromethod correlation coefficients nor consistently higher than the heterotrait-monomethod correlation coefficients. For the third condition, the pattern of correlations was not the same for each of the four hetero-trait triangles.

Our research question stated: To what extent does convergent validity and discriminant validity exist for the motivation construct? We conclude that there is limited evidence for convergent validity and discriminant validity for the motivation construct. Again, there are not clearcut, objective numerical values to assess convergent validity and discriminant validity using the MTMM matrix. Consequently, we must make subjective assessments that may concern other researchers. However, as Thompson (2000) emphasized, "Clearly, research is in part an inherently subjective business, and researchers must inescapably make the necessary judgments" (p. 304).

CONCLUSION

Contributions

Our study makes three contributions. First, we emphasized the importance for establishing convergent validity, discriminant validity, and nomological validity as part of the construct validation process that is continually ongoing (Whetten, 1989). Second, we expanded the recognition opportunities for researchers at small universities by using the small sample technique of the MTMM matrix that should encourage these researchers to consider discovering evidence of convergent and discriminant validity more frequently. Third, we found limited evidence of convergent validity and discriminant validity for the motivation construct.

Limitations

Our study has several limitations. First, based on a comparison of individual items, the three corresponding "matched" motivation variables are not measuring identical facets of the motivation construct. Second, the ideal use of MTTM requires "different" methods such as Likert or Thermometer scales (Churchill, 1979), but MTMM has been used with similar Likert-like scales (Spector, 1992). Our two Likert scales are not technically different methods. Third, because of a relatively small sample, we could not use a more "objective" assessment such as confirmatory factor analysis (CFA) for convergent and discriminant validity.

Future Opportunities

Holland and Piper (2014) reached this conclusion:

> The TIE model advances a robust research agenda because it incorporates [besides motivation and TPACK competencies] further the possible roles that values, beliefs, attitudes, subjective norms, perceived behavioral controls, and self-efficacy, along with goals, feedback, task value, and self-regulation, play in the human capital formation processes. (p. 286)

As researchers continue to test the nomological validity of the technology integration education (TIE) model, they should also consider testing convergent validity and discriminant validity of all 12 constructs, including and especially motivation.

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