



Assessing experiential learning styles: A methodological reconstruction and validation of the Kolb Learning Style Inventory

Chris Manolis ^{a,1}, David J. Burns ^{a,*}, Rashmi Assudani ^{b,2}, Ravi Chinta ^{b,3}

^a Dept. of Marketing, Xavier University, 3718 Ledgewood Ave., Cincinnati, OH 45207-1214, USA

^b Dept. of Management, Xavier University, 3718 Ledgewood Ave., Cincinnati, OH 45207-1215, USA

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ABSTRACT

To understand experiential learning, many have reiterated the need to be able to identify students' learning styles. Kolb's Learning Style Model is the most widely accepted learning style model and has received a substantial amount of empirical support. Kolb's Learning Style Inventory (LSI), although one of the most widely utilized instruments to measure individual learning styles, possesses serious weaknesses. This study transforms the LSI from a type (categorical measure) to a degree (continuous measure) style of learning style measure that is not only more parsimonious but is also easier to use than the existing LSI. Two separate studies using samples of engineering and computer science graduate students (Study 1) and undergraduate and graduate students pursuing quantitative degrees (Study 2) culminating in a corroborative multi-sample validation were employed, producing a methodologically sound option to the existing LSI. Implications for future research and guidance for learning and teaching methods are discussed.

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1. Introduction

Some suggest that the nature of education is in the midst of a transformation (e.g., Kolb & Kolb, 2006). Education has traditionally been viewed as the means to convey information – students were viewed as identical empty vessels to fill with information (Freire, 1998). Is such an approach to education able to produce knowledge? Several suggest that the use of the traditional pedagogical method of lecture may add relatively little to students' knowledge since it does not acknowledge individual differences and since it ignores the role of experience in knowledge formation (e.g., Bringle & Hatcher, 2003). Furthermore, reliance on lecture may be turning students into passive underachievers (Guyton, 2000) – students who may possess many facts, but are unable to apply such information to real-world issues (Bransford & Nye, 1989). A move to an experientially based education explicitly acknowledging different learning styles (what has been called transformational learning (Pedrosa de Jesus, Almeida, Teixeira-Dias, & Watts, 2006)) has been forwarded as a more effective alternative to traditional pedagogy (e.g., Jacoby, 1996).

Coffield, Moseley, Hall, and Ecclestone (2004) identified 71 learning style models. The most influential learning style model is Kolb's model (Kaye, 2005). An appeal of Kolb's Experiential Learning

Model is its focus on the experiential learning process rather than on fixed learning traits (Turesky & Gallagher, 2011), providing for an acknowledgement and incorporation of personal change and development in the model (Healey & Jenkins, 2000). Furthermore, the model lends itself to a number of theoretical perspectives, including cognitivism, phenomenology, and adult learning (Holman, Pavlica, & Thorpe, 1997). Moreover, numerous studies lend empirical support to the model (e.g., Abdulwahed & Nagy, 2009; JilardiDamavandi, Mahyuddin, Elias, Daud, & Shabani, 2011; Massey, Kim, & Mitchell, 2011). Consequently, the model is broadly employed in a wide variety of educational settings (Duff, 2004).

Learning based on experience, often labeled as experiential learning (Kolb, 1984), is viewed as an integral part of how humans learn, grow, and develop. Kolb (1976) proposed the Experiential Learning Model to conceptualize experiential learning as a means to better understand the different ways that individuals learn experientially. In order to measure and validate empirically the various learning styles involved in experiential learning, Kolb developed the Learning Style Inventory (LSI). The LSI identifies four distinct learning styles: diverging, assimilating, converging, and accommodating. Such "typing" or classification of individual learning styles was a methodological breakthrough in late 1970s, and, as a seminal work, sparked considerable research over the past three decades on the phenomenon of learning based on experience.

As with any influential research, the work of Kolb has not been without critique. Several questions have been raised concerning his theory and the LSI used to assess learning styles. In response, Kolb has refined the LSI scale over the years. Despite the various refinements of Kolb's inventory, however, the instrument still appears to

* Corresponding author. Tel.: +1 513 745 3956; fax: +1 513 745 3692.

E-mail addresses: Manolis@xavier.edu (C. Manolis), Burnsd@xavier.edu (D.J. Burns), Assudanir@xavier.edu (R. Assudani), Chintar@xavier.edu (R. Chinta).

¹ Tel.: +1 513 745 2046; fax: +1 513 745 3692.

² Tel.: +1 513 745 1082.

³ Tel.: +1 513 745 3796.

possess several weaknesses which limit its use, including low reliability, questionable validity, and low predictive powers. Furthermore, the instrument presupposes that individuals can only possess one learning style. At present, no instrument succinctly and efficiently measures Kolb's learning styles.

The purpose of this paper is to produce a revised instrument to measure learning styles for use by educators and researchers which is valid, easy to administer, and acknowledges that individuals can simultaneously possess more than one learning style. An empirically robust scale useful in easily and effectively measuring not only one's primary learning style but additional styles as well will provide educators with a tool to assess students' learning styles which, in turn, will permit educators the ability to develop and implement optimal experience opportunities in their classes. Such a scale will also permit education researchers to easily compare and relate empirically the learning style inventory with other related measures or constructs. Moreover, psychometrically speaking, if the number of items comprising the scale can be reduced while keeping the structure of the scale intact, education researchers will possess a more powerful empirical measurement tool.

The remainder of the paper is structured as follows. First, experiential learning will be explored. Second, Kolb's Experiential Learning Model and the LSI, including its refinements and challenges, will be examined. Third, the study is presented and results are reported. Finally, the implications of the study as a methodological basis for future research and pedagogy are discussed.

2. Experiential learning

Experiential learning is based on self-efficacy. Bandura (1986) observed that individuals tend to attempt undertakings that they believe they can complete successfully and tend to avoid undertakings that they believe exceed their capabilities. Hence, self-efficacy can be expected to affect an individual's choices and the activities in which they engage. The most important factor affecting self-efficacy is personal experience (Bandura, 1991). Experiential learning is based on the importance of personal experience in the educational process. Individuals can possess an unlimited amount of information, but may be unwilling to engage in tasks, where that information can be employed productively when they have no experience in doing so. Experiential learning provides students the opportunity to directly apply the information they possess in order to build self-efficacy and learn from the experiential undertakings.

Experiential learning, therefore, differs from the mere conveyance of information.

Learning is the process whereby knowledge is created through the transformation of experience. This definition emphasizes several critical aspects of the learning process as viewed from the experiential perspective. First is the emphasis on the process of adaptation and learning as opposed to content or outcomes. Second is that knowledge is a transformation process, being continuously created and recreated, not an independent entity to be acquired or transmitted. Third, learning transforms experience in both its objective and subjective forms. Finally, to understand learning, we must understand the nature of knowledge, and vice versa (Kolb, 1984, p. 38).

Experiential education is "education that occurs as a direct participation in the events of life" (Houle, 1980, p. 221). Dewey (1938) is perhaps the most famous proponent of experiential education. He proposed that experience should be a central component of the educational process. For an experience to be educational, Dewey believed that the experience must possess continuity and interaction. Continuity refers an "experience chain," where one experience leads to additional experiences prompting an individual to learn more. Interaction refers to the degree

to which an experience relates to the goals of an individual. In experiential education, students' personal experiences come to the forefront. An educator's role, therefore, changes from transmitter of information to organizer and facilitator of meaningful experiences oriented around students' individual needs. After reviewing existing research, Kolb and Kolb (2006) conclude that experiential learning is an effective educational approach. Specifically, they note that experiential learning is effective in increasing students' meta-cognitive abilities, enhancing their ability to apply information to actual situations, and giving them the ability to become self-directed learners.

3. Kolb's Experiential Learning Model

Perhaps the most well-known approach to experiential learning is Kolb's. Although educational achievement depends on students' abilities and aptitudes, it also relies on their individual learning styles (Kolb, 1984), where learning style is "the consistent way in which a learner responds to or interacts with stimuli in the learning context" (Loo, 2002, p. 252). Kolb's Experiential Learning Model defines learning as "the process whereby knowledge is created through the transformation of experience" (Deryakulu, Büyükoztürk, & Özçınar, 2009, p. 703) and reflects the influence of Piaget, Lewin, Dewey, and Jung (Koob & Funk, 2002). The Experiential Learning Model is based on six propositions:

1. Learning is best conceived as a process, not in terms of outcomes.
2. Learning is a continuous process grounded in experience.
3. Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world.
4. Learning is a holistic process of adaptation.
5. Learning results from synergistic transactions between the person and the environment.
6. Learning is the process of creating knowledge (Kolb & Kolb, 2006, p. 47).

The Experiential Learning Model is also based on the existence of four learning modes – concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). Although all four modes are a part of learning, individuals are thought to develop preferences for specific modes over time (Koob & Funk, 2002). These modes can be depicted along two continuums or dimensions – perceiving, the extent to which an individual emphasizes abstractness over concreteness (AC–CE continuum), and processing, the extent to which an individual emphasizes action over reflection (AE–RO continuum). An individual's learning style represents a combination of the two independent dimensions. The four resulting learning styles are divergers (CE/RO), assimilators (AC/RO), convergers (AC/AE), and accommodators (CE/AE) (see Fig. 1). Next, each style will be briefly reviewed.

The *diverging* learning style describes individuals who learn by way of concrete experience and reflective observation (Sugarman, 1985). Individuals with a diverging learning style experience a situation and then later look at the situation through many perspectives, learning from each (DiMuro & Terry, 2007). The strengths of individuals with this learning style lie in their imaginative and creative abilities and their ability to relate with others (Turesky & Gallagher, 2011). These individuals are more inclined to work in groups, have strong communication skills, and are open to personal feedback (Kolb & Kolb, 2005).

The *assimilating* learning style is based on learning abilities that use abstract conceptualization and reflective observation (Sugarman, 1985). Individuals who learn via this style take in a wide variety of information and arrange it in the most logical form (DiMuro & Terry, 2007). These individuals prefer information that is logical, valid, and well thought through (Kolb & Kolb, 2005). The strengths of individuals with this learning style lie in their ability to systematically plan, organize, analyze and engage in inductive reasoning (Turesky & Gallagher,

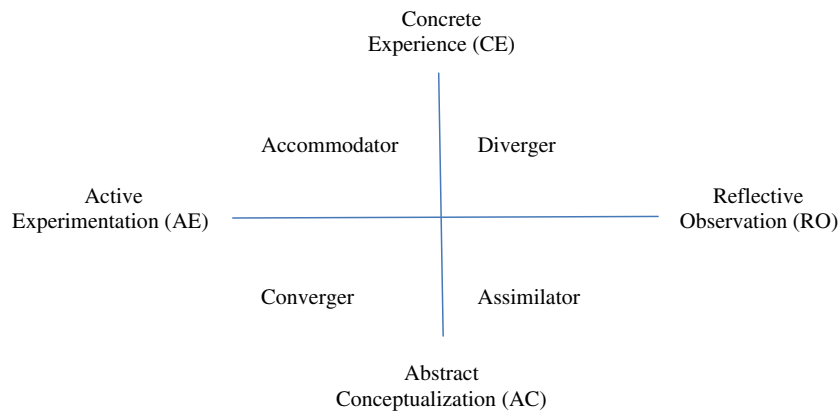


Fig. 1. Kolb's Experiential Learning Model.

2011). They tend to prefer reading, lectures, and time to analyze different aspects of the information they have received (Kolb & Kolb, 2005).

The *converging* learning style involves using abstract conceptualization and active experimentation (Sugarman, 1985). These individuals find practical uses for the ideas and theories that they have learned (DiMuro & Terry, 2007). They are proficient at solving new problems with the solutions to past problems. The strengths of individuals with this learning style lie in their ability to set goals, solve problems and make decisions (Turesky & Gallagher, 2011). They prefer to learn by “first hand” techniques such as experimenting, simulating, and using practical applications for what they have learned (Kolb & Kolb, 2005).

The *accommodating* learning style uses both concrete experience and active experimentation to learn and process information (DiMuro & Terry, 2007). They prefer active involvement in concrete situations (Sugarman, 1985). Individuals adhering to this style learn primarily from experiencing something new and carrying out plans that involve new experiences and challenges by which they learn (Kolb & Kolb, 2005). The strengths of these individuals lie in their ability to implement plans and tasks and become involved in new activities (Turesky & Gallagher, 2011). These individuals make decisions more on intuition than logic and prefer setting goals and working in teams in order to accomplish tasks (Kolb & Kolb, 2005).

Although Kolb's Experiential Learning Model is one of the most influential models of learning (Duff, 2004), it is not without distracters. Garner (2000), for instance, dispels the notion of relationships between Kolb's learning styles and Jung's typologies (Jung, 1977), the supposed basis for Kolb's learning styles (Kolb, 1984). Similarly, the relationship that Kolb believes exists between his learning styles and the Myers–Briggs Type Inventory (which is also based on Jung) has not been observed (Garner, 2000). Nevertheless, Kolb's learning styles have gained widespread acceptance and have provided a foundation for understanding experiential learning. Although there appears to be little evidence supporting a Jungian connection, Kolb's learning styles still appears to be a valuable schema (Turesky & Gallagher, 2011).

Learning styles appear to be of primary concern to educators. Since pedagogy is “the study of *how* learning takes place” (Fletcher, Potts, & Ballinger, 2008, p. 378), learning styles would seem to be of the utmost importance. Indeed, Fletcher, Potts, and Ballinger state that “an understanding of the preferred learning style of an individual provides an insight into the teaching methods that are likely to be most effective for that individual” (2008, p. 383). This is consistent with Kolb, who stated that “to understand knowledge, one must understand the psychology of the learning process, and to understand learning, we must understand epistemology – the origins, nature, methods, and limits of knowledge” (1984, p. 37).

Claxton and Murrell (1987) suggest that knowledge of students' learning styles can be important to improving curricula and teaching. Similarly, Gyeong and Myung (2008) state that “If students' learning styles are assessed, learning activities that further reinforce strengths or that develop weaker phases can be systematically planned to maximize thinking and problem-solving abilities” (p. 101). Gyeong and Yoo (2008) also suggest that students need to be made aware of their primary learning styles so that they can be encouraged to use and develop the other learning styles. This is consistent with Kolb (1976) who stressed that students must understand each of the learning modes and resulting learning styles. Garcia-Otero and Teddlie (1992) observed that students who know their learning styles are more likely to transfer their knowledge into practice compared with students who do not know their learning styles. Consequently, Ju An and Sook Yoo state that the learning styles of students “must be identified” (2008, p. 102). Similarly, Kolb and Kolb (2006) suggest that educators need to know students' learning styles such that they can adapt their teaching styles and pedagogy to maximize student learning.

3.1. Measuring learning styles

In order to structure experiential activities optimally in their classrooms, instructors must be able to assess student learning styles. Indeed, a key to Kolb's model is the ability to accurately measure individual learning styles. The Learning Style Inventory (LSI) is a scale developed to do just that. The original LSI was a simple, nine-item self description questionnaire (Kolb, 1976). In this version of the LSI, respondents are instructed to rank order four words in a way that best describes his/her learning style. One word in each item corresponds to one of four learning modes – concrete experience (CE: sample word, *feeling*), reflective observation (RO: *watching*), abstract conceptualization (AC: *thinking*), and active experimentation (AE: *doing*).

Not surprisingly, the scale has been extensively examined since it was initially developed. Merritt and Marshall (1984), for instance, found the original LSI to be satisfactorily valid and reliable. Merritt and Marshall (1984) also found support for a normative version of the original scale (consisting of ratings instead of rankings) as an alternative measure. Specifically, Merritt and Marshall found that the “results of this study indicated that the alternate (normative) version was as reliable as the original version, was equivalent in measuring characteristics defined in the original learning style scales, and demonstrated construct validity that was at least comparable to that for the ipsative instrument” (1984, p. 463). This was an important study because it not only suggests that Kolb's early work and theories

about experience and learning styles appear to be valid and reliable, but it also encouraged others to build on and improve Kolb's work.

Support for the LSI scale, however, was far from unanimous. In fact, most of the research that has examined the LSI has been far less affirming (e.g., Fox, 1985; Freedman & Stumpf, 1978; Geller, 1979; Lamb & Certo, 1978; West, 1982). Indeed, test–retest measurements indicate that the scale does not reliably measure learning style. Furthermore, serious questions exist concerning the scale's validity and predictive ability. Regardless, the original scale found extensive use (e.g., Baker, Simon, & Bazeli, 1986; Laschinger, 1986). Given the level of empirical support which exists for Kolb's model, Sugarman (1985) suggests that the model cannot be abandoned due to problems in the measuring scale. Instead, he suggests that an improved scale is required.

In addition to the normative version mentioned above, the LSI has been revised several times since its original development and, not surprisingly, the revised scales have been tested extensively for evidence of reliability and validity. Efforts have also been undertaken to develop different learning style scales. For instance, Honey and Mumford (1992) created the Learning Styles Questionnaire (LSQ) for use in the business community. In its measurement scheme, LSQ stresses observable behavior rather than motives or preferences. The LSQ was constructed to observe managers in the business world to determine how they learn most effectively and the type of environment in which they excel. Thus, they constructed the LSQ in order to measure observable behavior rather than the psychology behind the behavior. Honey and Mumford (1992) were not satisfied with the original LSI because they felt that the use of single word descriptors as the basis of classification for a particular learning style was potentially inaccurate. The LSQ, therefore, utilizes a Likert type response format with 80 statements (items). Honey and Mumford (1992) feel that the LSQ diverges from the LSI in two important ways. First, they constructed their questionnaire around recognizable managerial behaviors. Further, their approach suggests that answers secured from the questionnaire represent a starting versus finishing point. Honey and Mumford (1992) observed that the LSQ and LSI yield similar results with close correspondence.

The LSQ is considered by some to be a superior method of analyzing individual learning behavior “on account of the distribution of its scores, its temporal stability, and its construct and face validity” (Allinson & Hayes, 1988, p. 269). Allinson and Hayes (1988) reason that the LSQ is superior to LSI because it is more capable of measuring an individual learning style since it has the ability to distinguish similar dimensions in two independent samples. Allinson and Hayes (1988) note, however, that the LSQ possesses no predictive ability. Duff (2001) observed no evidence of construct validity in the LSQ scale and Duff and Duffy (2002) observed little reliability and validity for the LSQ and its variable dimensional structure. These researchers ultimately conclude that, even after modification, the LSQ is inadequate to assess individual learning styles.

Another revision of the LSI is the Self-Scoring LSI, composed of twelve questions about how one learns best (Kolb, 1984). The twelve scores are then combined and graphed. A positive score when AC and CE are combined indicates a more abstract thinker while a negative AC–CE score indicates a more concrete thinker. Likewise, a positive or negative score on the AE–RO scale indicates that the respondent is either more active or more reflective, respectively. The point of intersection of the two combination scores (AC–CE and AE–RO) indicates which of the four learning style categories one belongs.

The revised instrument maintains the ipsative forced ranking inherent to the original scale. Accordingly, many of the criticisms levied against the original LSI have also been applied to this revised version (Henson & Hwang, 2002). So, although the revised scale appears to possess improved internal consistency over the original scale (Loo, 1996; Willcoxson & Prosser, 1996), the reliability may have gotten worse (Henson & Hwang, 2002). Consequently, Henson and Hwang

state “the lack of reliability in LSI scores is substantial enough to warrant either (a) discontinuation of use or (b) considerable revision of the instrument” (2002, p. 720). Even with the questions concerning validity and reliability, the LSI is still widely used since it is regarded as appreciating diversity and acknowledging differences in learning (Koob & Funk, 2002). (Pickworth and Schoeman (2000) examined a normative (Likert) version of the revised instrument (Geiger, Boyle, & Pinto, 1993) and observed improved psychometric properties).

Research examining the revised LSI has also produced mixed results regarding the hypothesized factor structure. Cornwell, Manfred, and Dunlap (1991), Geiger et al. (1993), and Metallidou and Platsidou (2008) have observed a two-factor solution consisting of an AC–AE factor and a CE–RO dimension. Loo (1996) and Yahya (1998), however, observed support for Kolb's dimensions (AC–CE and AE–RO). Loo (1999) also observed supporting results, but individual items did not factor as expected. Consequently, Metallidou and Platsidou (2008) propose the need for additional research to address this apparent inconsistency.

Although the LSI is frequently used as a predictive tool (e.g., Scott & Koch, 2010), only one study (Hudak & Anderson, 1990) provides any support for using it as such. To the contrary, most studies find little connection between the results of the LSI and knowledge acquisition, and the use of problem-solving strategies (e.g., Metallidou & Platsidou, 2008), and academic performance (e.g., Deryakulu et al., 2009). In response, Metallidou and Platsidou (2008) reiterate the presence of “serious concerns” regarding the continuing use of the instrument. Even though Loo states “these criticisms ... do not take away from the usefulness of the LSI as a pedagogical tool” (1999, p. 216), at the very least, they minimize the usefulness of the scale and the meaning that can be applied to findings from using the instrument.

In response to the problems inherent in the existing scales, Romero, Tepper, and Tetrault (1992) developed the Problem Solving Style Questionnaire (PSSQ) as another alternate measure. The PSSQ is a 14-item scale developed to measure the same dimensions as the LSI. Although early studies suggest that the scale may possess internal consistency and test–retest consistency (Romero et al., 1992) and discriminant and convergent validity (Tepper, Tetrault, Braun, & Romero, 1993), more recent studies have not been as supportive. Duff (2004), for instance, reports little support for the internal consistency or the factor structure of the instrument. Hence, the instrument has received relatively little use.

Kolb revised his instrument again (Kolb, 1999). In this revised scale, he randomized items to reduce response-set biases identified in prior versions (Freedman & Stumpf, 1978; Ruble & Stout, 1991; Veres, Sims, & Locklear, 1991). This approach improved test–retest reliability. The form consisted of twelve sentences, each with four possible endings. Respondents are instructed to rank each of the sentence items, leading to a 48-item scale. This form, however, has received less use and critique than the previous forms (Kaye, 2005). Kaye (2005) observed evidence for internal validity and reliability for the scale. Similarly, Pedrosa de Jesus et al. (2006) observe a degree of predictive ability between the instrument and students' classroom activities. Interestingly, the 1985 version of the scale has continued to be primary instrument used in research on learning styles even though this revised instrument appears to be superior.

Although the latest revision to Kolb's scale addresses some of the problems identified in earlier versions of the scale and shows promise, problems remain, thereby limiting the scale's usefulness. The ipsative nature of the scale, for instance, limits the psychometric qualities of the scale (Henson & Hwang, 2002). Furthermore, the magnitude or degree by which an individual possesses a particular learning style cannot be determined — the scale only determines which style is an individual's style. Similarly, by identifying an individual's single learning style, the identification of “substyles” which individuals may possess is impossible. Finally, the length of the scale (48 questions) limits its use.

4. The study

Research appears to support Kolb's theory and the existence of the proposed learning styles (e.g., Abdulwahed & Nagy, 2009; JilardiDamavandi et al., 2011; Massey et al., 2011). Although the ability to accurately assess student learning styles would seem to be a requirement for classroom instructors, a valid, reliable, efficient instrument does not appear to exist. The objective of this study is to attempt to address this need. Specifically, this study pursues a reconstruction of the LSI in an attempt to yield a parsimonious measure of learning style "degree." While learning style "type" suggests a single, dominant learning style, learning style "degree" acknowledges the contextual nature of learning, and, therefore, suggests an individual's dominant style *in combination with* other contemporaneous learning styles. By measuring learning style "degree" (both the dominant as well as the less dominant styles) versus "type" (only the dominant style), the reach and scope of the experiential learning phenomenon can be expanded.

Three research objectives define the current study. The first is to develop an inventory that measures degree (versus type or category) of learning styles. The aim is to construct a scale that captures all of Kolb's learning styles simultaneously and allows these dimensions to be compared both among themselves and with other relevant constructs. The second objective is to shorten considerably the length of the LSI by empirically reducing the number of items utilized in the scale with a shortened scale, researchers will be armed with a potentially more powerful empirical tool that does not demand as much data as was needed previously to utilize effectively. The third objective is to validate this newly devised measure and verify its validity.

5. Methodology

The research design utilized in this study consists of three distinct phases and two separate studies culminating in a corroborative multi-sample validation effort (see Fig. 2).

5.1. Study 1

The first study involves the administration of the 48-item Kolb Learning Style Inventory (Kolb, 1999). To measure the degree to which study participants possess the learning styles and to permit the identification of substyles or learning styles which an individual possesses at a lesser degree than their primary style (instead of simply identifying a single dominant style), respondents were not asked to rank responses in an ipsative fashion. Instead, participants were asked to respond to each of the questions using a 7-point Likert scale.

The sample was comprised of 81 engineering and 66 computer science graduate students at an Ivy League university in the United States. Approximately 72% of the study participants were male. The relative gender imbalance is not perceived to be a problem since most studies examining Kolb's learning styles have not identified a gender effect (e.g., Jones, Reichard, & Mokhtari, 2003; Kayes, 2005; Yahya, 1998).

5.1.1. Results

To verify the factor structure and to reduce the number of scale items, the data were factor analyzed using Principal Component Analysis. Using a criterion of Eigenvalue > 1, the resulting solution consisted of three factors, one more than the two dimensions proposed by Kolb. After rotating the solution using Varimax rotation, factor composition was determined by selecting items with factor scores of .5 or above (see Table 1). The resulting scale consists of 17 items.

The observed factors bear some resemblance to the dimensions identified by Kolb (abstract conceptualization/concrete experience (AC/CE) and active experimentation/reflective observation (AE/RO)), but substantial variance was noted. The first factor (ROAE) observed

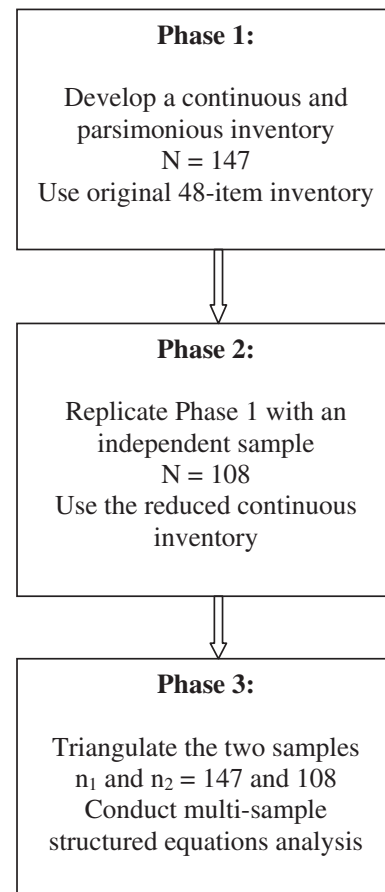


Fig. 2. Research design.

in this study approximates the second dimension proposed by Kolb. However, instead of active experimentation and reflective observation reflecting opposite ends of a continuum, they appear to be positively correlated. The factor is comprised of seven items, six of which represent Kolb's original RO orientation and one that represents the original AE orientation. The other two factors identified in this study appear to relate to the other two learning modes as identified by Kolb, but they

Table 1
Factor loadings (reduced Kolb Learning Style Inventory).^a

Item #	Factor 1	Factor 2	Factor 3	Variance
	(ROAE)	(CE)	(AC)	
	7-Items	5-Items	5-Items	
1		0.69		0.48
2	0.64			0.41
3			0.53	0.28
4		0.51		0.26
5	0.71			0.50
6			0.67	0.45
7		0.73		0.53
8			0.77	0.59
9		0.83		0.69
10	0.72			0.51
11	0.54			0.30
12	0.57			0.32
13			0.80	0.64
14	0.74			0.55
15		0.85		0.73
16			0.56	0.31
17	0.55			0.30
Variance	0.41	0.54	0.45	

^a Item numbers in column 1 correspond to questions in the Appendix 1.

represent two different factors instead of representing opposite ends of the same dimension as proposed by Kolb. The second factor (CE) is comprised of five items originally used by Kolb to measure the CE orientation. The third factor (AC) is comprised of five items originally used to measure Kolb's AC learning orientation. Each of the factors possess satisfactory Cronbach's alphas (factor one = .84, factor two = .85, and factor three = .79). Thus, although the results suggest a modified measure compared to the Kolb's original inventory scales, the new scale nonetheless captures most, if not all, of Kolb's original dimensions.

The findings are consistent with the contentions of Hunsaker (1981) who believed that Kolb's model actually consists of a primary dimension (AC–CE) and a secondary dimension (AE–RO). Georgiou, Zahn, and Meira (2008) agreed, stating that the AC and CE modes provide knowledge, while the AE and RO modes act as facilitating transformers of that knowledge (2008). It is interesting that the “secondary” dimension folds into a single dimension in the present study. Likewise, the present model suggests that it is not necessary to treat each mode equally as in Kolb's model (Georgiou et al., 2008).

A confirmatory factor analysis was then conducted to verify statistically the structure of the reduced instrument and the accompanying factors. The test of a measurement model with the three hypothesized latent variables described above produced an adequate fit ($\chi^2(113) = 210.25$, $p < 0.001$, $CFI = 0.90$, $IFI = 0.90$, $RMSEA = 0.078$ (the $\chi^2(136)$ for the null model was 1067). All parameter estimates loaded significantly on to their respective factors (p 's < 0.001) with an average loading of .67 (ranging from .51 and .85). Two of the factors, namely, the ROAE and AC factors, were positively and significantly correlated ($r = 0.43$, $p < 0.01$).

Individual item reliability for all scale items was also computed. A widely accepted critical value, .50, specifies that at least 50% of the variance in an item is due to the hypothesized dimension (Bagozzi, 1991; Fornell & Larcker, 1981). Just under two-thirds of the individual item reliabilities (11 of 17) either met, exceeded, or came very close to exceeding the critical value of .50 with an average variance of .46 (ranging from .26 to .73). The dimension-related indices of average variance extracted are considered additional indicators of reliability. Because all three factors explained or came very close to explaining at least 50% of the variance (.42, .54, and .45 for ROAE, CE, and AC, respectively) in the average item, the items were deemed satisfactory.

5.2. Study 2

The second study involved administering the newly generated reduced Kolb Learning Style Inventory (RLSI) to a second sample in order to verify its psychometric properties. As described below, the second sample was comparable to the first sample, yet independent. For the RLSI to be applicable in varying situations and with varying groups, it should have similar structural properties across comparable yet independent samples. If a scale is not equivalent across similar yet independent samples, then the relationship between learning style preferences to other variables can be confounded by scaling differences, causing the comparison of standings on the scale across samples to become superfluous. Using a structural equation, multiple-group modeling approach, three hypotheses tested were:

H1. The RLSI possesses the same number of latent variables (factors) with the same indicators and the same specification of fixed and free parameters across the two independent samples.

H2. Scale item factor coefficients are equal across the two independent samples.

H3. The covariance matrix for the three empirically derived factors is invariant across the two independent samples.

The second sample consisted of 108 undergraduate and graduate students from a Midwestern university in the United States. Instructors

administered the surveys during regular class times and no non-response was noted. The sample was composed of students pursuing quantitative-based majors, with 39% of the sample consisting of undergraduate computer science majors; 26% graduate engineering students, 18% undergraduate math/statistics majors, with the remainder consisted primarily of undergraduate students in accounting/finance and physics. The sample was approximately 71% male. The sample for study two was chosen to minimize differences across the two samples allowing for the scale to be compared directly across the two similar yet independent samples for structural invariance. Specifically, the students across the two samples were thought to possess similar learning styles based on their chosen majors.

5.2.1. Results

The results of the CFA for Study 2 revealed a well-fitting model estimating the same three hypothesized latent variables uncovered in Study 1 ($\chi^2(113) = 167.65$, $p < 0.001$, $CFI = 0.94$, $IFI = 0.94$, $RMSEA = 0.067$ (the $\chi^2(136)$ for the null model was 1024.18)). All parameter estimates loaded significantly on to their respective factors (p 's < 0.001) with an average loading of .68 (ranging from .34 to .94), and the factors were not significantly (at the .05 level) correlated with one another.

The individual item reliability calculations revealed that approximately 60% of the individual item reliabilities (10 of 17) either met, exceeded, or came very close to exceeding the critical value of .50, with an average variance of .50 (ranging from .12 to .88). All three factors explained or came very close to explaining at least 50% of the variance (.47, .55, and .49 for ROAE, CE, and AC, respectively) in the average item, and, as before, the items were deemed satisfactory (see Table 2).

Hypothesis H1 examined whether an analysis of each sample results in the same number of latent variables (factors) with the same indicators with the same specification of fixed and free parameters. Table 3 presents the χ^2 estimates and summary fit indices generated by this test of form. The significant χ^2 value (377.90, $df = 226$, $p < .001$) was not surprising given the results of the single-group analyses. The relatively high values for the fit indices ($CFI = 0.916$, $IFI = 0.919$, $RMSEA = 0.074$), however, leads to the conclusion that the model form holds similarly for the two samples. Thus, H1 is supported.

The hypothesis that the factor coefficients were equal for the two groups (H2) was tested next. This hypothesis restricted the regression of the items on the factors (i.e., slopes relating the measures to

Table 2
Study 2 factor loadings (reduced Kolb Learning Style Inventory).^a

Item #	Factor 1	Factor 2	Factor 3	Variance
	(ROAE)	(CE)	(AC)	
	7-Items	5-Items	5-Items	
1		0.74		0.55
2	0.91			0.83
3			0.43	0.18
4		0.34		0.12
5	0.84			0.71
6			0.81	0.65
7		0.76		0.57
8			0.63	0.48
9		0.85		0.72
10	0.82			0.68
11	0.48			0.16
12	0.44			0.19
13			0.94	0.88
14	0.61			0.37
15		0.89		0.80
16			0.58	0.34
17	0.62			0.38
Variance	0.47	0.55	0.49	

^a Item numbers in column 1 correspond to questions in the Appendix 1.

Table 3
Factor inter-correlations (reduced Kolb Learning Style Inventory).^a

	Factor 1 (ROAE)	Factor 2 (CE)	Factor 3 (AC)
Factor 1 (ROAE)	1.00		
Factor 2 (CE)	0.04 (Study 1) 0.08 (Study 2)	1.00	
Factor 3 (AC)	0.43 (Study 1) 0.15 (Study 2)	0.08 (Study 1) −0.18 (Study 2)	1.00
Cronbach's alpha	0.84 (Study 1) 0.87 (Study 2)	0.85 (Study 1) 0.70 (Study 2)	0.79 (Study 1) 0.81 (Study 2)

^a The only significant correlation between factors is between Factors 1 and 3 in Study 1 ($p < 0.01$).

the latent variables) to be equal for the two samples. Although the χ^2 estimate of 402.25 with 240 degrees of freedom was statistically significant ($p < .001$), the relatively high goodness of fit measures accompanying this test ($CFI = 0.911$, $IFI = 0.912$, $RMSEA = 0.074$) provided evidence that the factor structure is invariant across the two groups. The χ^2 difference ($\Delta\chi^2$) between H2 and H1 is 24.25 with 14 degrees of freedom which, when compared to a cut-off critical χ^2 value of 23.69 at $p < 0.05$, suggests that differences in factor coefficients across the two samples are barely significantly different. The individual parameter estimates for the two samples (models) however indicate that the two sets of factor coefficients are in fact highly similar. The average difference in standardized factor coefficients across the two samples, for instance, is 0.085 with the single largest difference equal to 0.571. This suggests that the $\Delta\chi^2$ test is very sensitive (Hair, Anderson, Tatham, & Black, 1998).

The final test of invariance added the restriction that the covariance matrix for the three empirically derived factors was invariant across the two samples (H3). This hypothesis implies that the factor covariances (or interfactor correlations) are equal in the two samples. Table 4 shows a χ^2 estimate 407.49 with 243 degrees of freedom ($p < .001$) and fit indices that were still reasonably and relatively high ($CFI = 0.910$, $IFI = 0.911$, $RMSEA = 0.074$), thus providing continued support for the invariance prediction. An examination of interfactor correlations revealed similar values across the samples, and the $\Delta\chi^2$ of H3 and H2 (5.24 with 3 degrees of freedom) is not significant (at the .05 level). In the end, there appears to be ample evidence to suggest that the factor intercorrelations are equivalent across the two independent groups or samples, and H3 is supported.

Overall, the multi-sample analysis corroborates the consistency of the empirically derived models across the two independent samples. Such empirical triangulation provides the confidence to suggest that the factors derived from the RLSI are both valid and robust.

6. Discussion

To facilitate experiential learning in a fashion that acknowledges the unique learning styles of students, educators must be able to effectively and efficiently measure students' learning styles. The scales that have been developed previously to accomplish this objective, however, have possessed limitations. Although the early versions of the LSI were concise and easy to use, the lack of test–retest reliability

Table 4
Two group comparisons for replicative model.

Hypothesis	χ^2	df	CFI	IFI	RMSEA
Baseline	2091.18	272	–	–	–
H1	377.90	226	0.916	0.919	0.074
H2	482.25	248	0.911	0.912	0.074
H3	487.49	243	0.910	0.911	0.074

and the presence of significant validity problems severely restricted their applicability. Attempts by others to develop alternative measures to assess learning style tended to result in scales with similar problems. The revision by Kolb (1999) was able to overcome some of the problems in the previous scales, but significant problems remained. Furthermore, the length of the scale has limited its use.

The present study has attempted to revise and improve the Kolb (1999) version of the LSI scale. A more efficient RLSI is produced by reducing the 48-item, original measure to a 17-item version while retaining measurement validity. Moreover, measuring learning style according to the revised scale allows for the determination of not only which learning style is dominant for an individual, but also how he/she scores on the remaining, non-primary styles. Preliminary testing appears to support the RLSI.

The data from two separate, distinct, and independent samples resulted in a three-factor measurement model. In practice, measurement models are often judged to provide adequate fit even though the χ^2 value is statistically significant (Anderson & Gerbing, 1988). This judgment is generally supported by values of various fit indices. In the present case, the three-factor model was judged to provide an adequate fit based on the CFI , IFI and $RMSEA$ indices. In addition, all scale items across two different samples of respondents produced significant (at the .05 level) factor loadings on their posited underlying dimension.

The new scale also represents a more fluid measure of learning styles. Vince (1998) notes that, although Kolb's original model informed the practice of including reflection and action; it does little to encourage the recognition of "ever shifting visions of the whole" (p. 314). In this sense, individual learning styles are not static but evolutionary (O'Connor & Yballe, 2007), and the meta-processes that guide individuals' tacit thought contribute to this evolutionary process. One implication of this is that learning styles are fluid and exist along a continuum (Pfeifer & Borozan, 2011). This study builds on and contributes to this assertion.

The results suggest that although the four modes suggested by Kolb may be valid, little evidence is provided to confirm Kolb's two dimensions. This finding is consistent with several other studies (some of which were discussed earlier) that provided little support to the proposed dimensions. Hence, Kolb's learning dimensions warrant further study. In fact, since Kolb's styles were developed based on his two dimensions, the results of this study point suggest the need to revisit the learning styles. As opposed to Kolb's two dimensions, each comprising two of the learning modes, the current results suggest three unidimensional factors. The resulting learning styles, therefore, will be based on one's relative position on each of the three dimensions. Additional research is needed to identify each learning style and the characteristics associated with each. Until such time, significant information on individual learning approaches can be obtained by considering one's score on each of the three factors independently.

6.1. Implications

The results have significant implications for education and pedagogy. Conceptualizing and generating an improved measure of Kolb's inventory offer educators the means to gain increased information into student learning styles. The results of numerous studies suggest that teaching pedagogy that is oriented toward student learning styles tends to be more effective compared with pedagogy wherein teaching and learning styles conflict (e.g., Abdulwahed & Nagy, 2009; Gaur, Kohli, & Khanna, 2009; Pfeifer & Borozan, 2011). Specifically, they note that convergence of teaching and learning styles will not only increase the learning effectiveness of students, but will also increase student flexibility, permitting them to alter their learning styles in response to varying environments. With the RLSI, educators will possess the ability to more clearly assess student learning styles and, hence, design educational experiences that maximize student

learning. As Sharp (2006) states, “instructors are encouraged to use teaching strategies that both match students’ learning styles at times, and stretch students into less preferred styles” (p. 96). This is only possible if educators first know the learning styles of their students.

The continuous nature of the RLSI (as opposed to the original ipsative nature of the scale devised by Kolb) provides important additional insight into understanding student learning styles. Pigeonholing students into a single learning style without appreciating the “strength” of that style or that other less dominant styles may unnecessarily curtail student learning is problematic. Kolb (1984) himself states that individuals learn in each of the four styles. The RLSI offers a more holistic measure that is also easy to use and cost effective.

The development of a continuous learning style scale also has implications for leadership development. Knowing a student’s dominant learning style is informative for leadership development. Yet, knowing the student’s less dominant learning styles is also important for effective leadership. Effective leadership is often contingency-based and certain situations may call for specific learning styles on the part of leaders.

6.2. Future research

Future research opportunities abound. First, as mentioned above, research into better understanding the newly proposed learning style scale is in order. Given that Kolb’s four learning styles were determined based on two continuums that were not supported by this research, learning styles based on the current three factors will need to be more fully clarified.

The ipsative nature of the earlier versions of the LSI limited research relating learning styles to other psychological constructs. The normative nature of the proposed scale will facilitate such research. Examining how learning styles relate to other constructs has the potential to provide for a much richer understanding of learning styles.

The current scale was validated based on two homogeneous samples of students from a single culture. To test/establish the generalizability of the new measure, future studies should evaluate it with additional samples representing different demographic groups thereby measuring learning styles in varying contexts and/or cultures.

Given that the Kolb (1999) scale seemed to possess greater predictive powers compared with other learning style scales, and since the current study began with items from that scale, the proposed scale should possess predictive powers that exceed that of other scales purporting to measure learning style. Research to evaluate the predictive powers of the RLSI is, therefore, needed. Establishing the predictive power of the RLSI will greatly increase its value. Sharp (1997) suggests, for example, that individual learning styles be considered when designing lectures and assignments in order to reach students with varying learning styles. Similarly, Rhee and Sigler (2010) employed Kolb’s learning style inventory to form teams in the design of a service learning course. If the predictive power of the proposed scale can be established, the use of the scale would be justified and could potentially extend the use of Kolb’s Experiential Learning Model.

6.3. Conclusion

This study represents the first step in developing a scale to effectively and efficiently determine individual learning styles. Research into learning style has been hindered by the absence of a valid, reliable, and easy-to-use scale to assess learning styles. The ability to accurately and efficiently assess student learning styles will allow educators to consider student learning styles when designing curricula and pedagogy. By doing so, educators may be able to increase the effectiveness of their instruction, particularly where experiential learning is concerned.

Appendix 1. Reduced Learning-Style Inventory (RLSI)

1. When I learn I like to watch and listen.
2. When I learn I like to think about ideas.
3. I learn best when I trust my hunches and feelings.
4. I learn best when I listen and watch carefully.
5. I learn best when I rely on logical thinking.
6. When I am learning I have strong feelings and reactions.
7. When I am learning I tend to reason things out.
8. I learn by feeling.
9. I learn by watching.
10. I learn by doing.
11. When I am learning I am an observing person.
12. When I am learning I am a logical person.
13. I learn best from observation.
14. I learn best from a chance to try out and practice.
15. I learn best when I can try things out for myself.
16. When I learn I like to observe.
17. When I learn I like to be active.

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