Diagnosis of Creative Students at University: Development and Validation of the Learner Scale for Problem-Solving Styles

Bushra A. Alakashee  
*Corresponding Author, University of Sharjah, College of Arts  
Humanities & Social Sciences, Education, UAE*

Basim N. Al-Samarrai  
*University of Sharjah, College of Arts  
Humanities & Social Sciences, Education, UAE*  
E-mail: balakashee@sharjah.ac.ae  
Tel: 009715053670032

**Abstract**

Problem solving is the key to creativity. The Learner Scale for Problem-Solving Styles (LSPSS) is a new instrument that supports university students in understanding their creativity abilities in solving problems and offers professors an aid in the design of teaching and assessment strategies that enhances student creativity. Based on Kirton’s adaption-innovation theory, three key styles are identified to support creativity in problem solving: (1) idea generation (preferences to improve present ideas or to generate new ideas); (2) method (precision and efficiency); and (3) managing structure (preferences to conform to the formal, impersonal rules and group norms or informal, personal rules and perception individuality). These key styles of creativity were the basis for our development of the LSPSS and included an exploratory factor analysis of a sample of 130 students, and a conformity factory analysis using a new sample of 218 students. The results supported the LSPSS and its factors: sufficiency to originality, rule/group conformity and efficiency. The subscales’ reliabilities were moderate and satisfied. The discriminate validity for LSPSS was also evident.

**Keywords:** Innovation, Problem solving style, Kirton’ adaption -innovation theory, Big Five Factor Model of personality, Construct Validity

**Introduction**

Innovation is a remarkably challenged concept in modernized and changing societies. In 2016, the Organization for Economic Co-operation and Development (OECD, 2016) opined about an international consensus that education can foster innovation in society at large by developing “skills for innovation.” Hoidn and Kärkkäinen (2014) referred to these skills as “21st century” skills and included problem solving, critical thinking, creativity, and imagination.

Among innovation skills, problem solving has increasingly received special interest in higher education either at the organizational or individual level because they consider problem solving critical to successful innovation at university and in future work settings. This interest has been translated into three practices. First, administrators and beneficiaries in higher education systems have adopted the idea that institutes are in charge of enabling students in all study fields and levels to develop skills to
solve novel problems requiring creative and unique solutions (Hoidn and Kärkkäinen, 2014; European Commission, 2011; and CAA (Commission for Academic Accreditation, United Arab Emirates, 2011).

Second, higher education systems that have adopted national qualification frameworks as a strategy to assess their efficiency and effectiveness place problem solving within these frameworks as generic competency. For example, the Qualifications Framework for the United Arab Emirates (QFEmirates) includes descriptors that identify the nature of problems that require solutions from students and suggests gradual levels of practice that start with presenting a few accepted solutions to very structured problems and finish with a presentation of novel solutions. (National Qualifications Authority, 2012).

Third, many degree programs in higher education have integrated problem-solving skills into their curriculum and adopted teaching strategies that help students develop these skills and assessment methods to judge the mastery of the skills and effectiveness of the creative learning environments.

Problem solving, and innovation are important constructs to educators in higher education and psychologists. Problem solving is considered an essential cognitive process applied in contexts including education and workplaces. Cognitive style, in addition to cognitive abilities, has been recognized by many psychologists as an important construct for problem-solving processes and individual differences (e.g. Hayes and Orrel, 2004). Cognitive style defined how an individual prefers to perform mental actions, including problem solving and decision making (Goldsmith, 1994). We study cognitive styles, essential factors to improve individual’s skills in employability, to help conceptualize the connection between cognition and personality; in this manner, we can understand, predict, and improve academic achievement (Sternberg & Grigorenko, 1997).

Psychologists and style professionals usually adopt a theory or model if integrated conceptual elements are presented; if tools satisfactorily possess the psychometric attributes; and if evidence of validation in multiple contexts is provided. Among the theories of cognitive styles, Kirton introduced a style theory to conceptualize behaviors of problem solving into innovative environments and identify styles of innovators and adaptors in solving problems. For Kirton, “adaptors and innovators are both capable of generating original, creative solutions but which reflect their different overall approaches to problem solving” (Mudd (1995, p. 167). He also developed an inventory to characterize innovative and adaptive behaviors of workers into organizations when solving problems is involved (Kirton, 1999). The conceptual cohesion of Kirton adaption-innovation theory, its widespread use in organizations since 1967, and the numerous examples in the literature have proved its validation. Notably, the literature has mostly been within work contexts and encouraged further examination within other contexts including learning environments.

Research on style has identified criticisms, obstacles, and challenges when assessing style construct, in general, and adaption-innovation, specifically (e.g. Sternberg and Grigorenko, 1997; Rayner, 2015; Peterson, Rayner and Armstrong, 2009). Regarding this connection, our review of the literature drew attention to the following psychometric problems (later section provides more details): insufficient evidence that current adaption-innovation inventories are appropriate for use in universities; the use of unipolar Likert scales to assess a bipolar variable like problem-solving styles; and use of long measures even though shorter assessment instruments have become more desirable and accepted.

The Kirton adaption-innovation theory as being a promising creative theory and the current developments in style measures have provided motivation to develop a new scale for assessing problem-solving styles for university learners. The new scale is based on Kirton theory and developed by considering the measure developments to ensure accepted psychometric quality.
(Body Title)
Kirton Adaption-Innovation Theory

Based on Kirton’s (1976) long observations of preferred behaviors of workers in organizations when involved in solving problems at work, he concluded that these behaviors could be grouped into two problem-solving styles: adaption and innovation. Adaptation includes preferences for finding solutions using usual means, feeling secure if the criteria are accepted in general, and doing “things better.” Innovation includes preferences to generate unusual solutions that change the context, working without considering accepted paradigms, and initiating changes based on different methods of doing things. Later studies on Kirton theory (Kirton, 1999; Tullett and Kirton, 1995; Loo and Shomai, 1997; and Xu and Tuttle, 2012) have identified three dimensions of the adaption-innovation continuum: (1) sufficiency of originality (“so”) is when adaptors prefer to generate few feasible ideas, whereas innovators generate many possibly impractical solutions; (2) efficiency (“e”) is when adaptors prefer to use methodical, efficient, and disciplined approaches, whereas innovators approach tasks from unusual angles; and (3) rule/group conformity (“R/GC”) where adaptors prefer to use existing rules and work inside constraints, whereas innovators challenge rules and break perceived restraints.

Kirton’s theory is one pioneering theory in the style field and is significant in different aspects. First, Kirton’s work has been extremely influential and helped organizations understand individual differences in cognitive styles in the workplace (Mud, 1995). Thus, Mud described the theory as “a theory of organizational behavior rather than an intra-individual theory of psychological process” (p. 165). Second, theorists have adopted many ideas presented by Kirton. For example, Zangh (2011) referred to five dimensions of preferences considered by Kirton: “high degrees of structure versus low degrees of structure, cognitive simplicity versus cognitive complexity, conformity versus nonconformity, authority versus autonomy, and group versus individual” (p. 312). Third, Kirton theory was the first to explain the roles of each of style and abilities required for solving problems, and he showed that style and level of creativity in problem solving were distinct concepts (Mudd, 1996). Fourth, Kirton’s theory is highly concerned with “how executive functioning and individual differences in thinking and action influence key aspects of human performance” (Rayner, 2015).

The Kirton Adaption-Innovation Inventory (KAI) comprises 32 items that reflect what behaviors an individual prefers when solving problems (Kirton, 1999). On a 5-point Likert scale, the inventory respondent indicates the ease of maintaining adaptive and innovative behaviors when solving problems. On the KAI, an individual can score between 32 and 160 points and is classified as an adapter if the score is lower than the mean; 96 (Kirton, 2003) or an innovator if higher than the mean. In addition to the general score on the inventory, the respondent could have three subscale scores: SO; R/GC, and E. The lower the SO score, the E score, and the R/GC conformity score, he more adaptive the individual. High scores on these subscales are indicative of innovation behaviors in problem solving.

Measures of Adaptation-Innovation: Review and Assessment

Research on style has generally been subjected to evaluation and was described as being relatively absent in comparison with increasing research for other fields in psychology (Sternberg and Grigorenko, 1997) and considered “an unexpectedly gargantuan, complex, and disparate field of research” p. 113, (Rayner, 2015). One of the main criticisms in style research is “... consistent psychometric failings across the field in respect to measures of validity, reliability, and effect sizes produced in empirical research” p. 113, (Rayner, 2015). Additionally, problems with convergent and discriminate validly of style measures were identified (Sternberg and Grigorenko, 1997). In a global e-survey on the state of style field, most style researchers were most concerned about “unreliable measurement, lack of validity, … abundance of concepts and tests.” (Peterson, Rayner b, and Armstrong, 2009 p. 512).
Regarding adaption-innovation measures, this research investigates psychometric problems. First, the development of measures for the problem-solving styles of adaptors and innovators are the KAI (Kirton, 1999) and the AI-W scale (Label; “Adaptor-Innovator in the Workplace”) by Xu and Tuttle (2012), which was guided by Kirton adoption-innovation theory. This theory describes the preference behaviors of adopters and innovators within the context of work. In this connection, Kirton cautioned that the KAI was designed for adults in the workplace and its reliability can diminish when used with other groups (Riding and Rayner, 2000). Sternberg and Zhang (2005) distinguished types of styles in learning settings from those in workplaces in their following statement, “sometimes the pattern of styles that leads to success in a course in a given discipline is not the pattern of styles that leads to success later in a job in that discipline” p.246. Additionally, the validation of KAI and AI-W has involved large samples of students and these measures have demonstrated satisfactory statistical indicators of validity, but such processes and outcomes have not ensured they are content valid to be used with students in university. Ensuring that the items of measure cover all the expected problem-solving preferences that occur in actual learning environments is difficult. In support of this perspective, in their research on assessing problem-solving styles of middle school students, Selby, et. al (1993) realized that some concepts of work mentioned in items on KAI are not familiar to this group. Thus, we assert that developing a new scale based on Kirton theory and validating its items within a university learning environment is necessary.

Another potential criticism of measures of problem-solving styles is the use of a Likert scale to assess a bipolar variable like problem-solving style. According to Kirton (1976), problem-solving style is a bipolar psychological phenomenon measured on a continuum scale with two ends labeled adaptive and innovative. Notably, Kirton developed an inventory that comprises equal numbers of unipolar items that reflect adaptive and innovative preference behaviors at work when solving problems. Research has identified psychometric problems by using unipolar items to assess a bipolar variable. Kirton (1999) observed that individuals with a strong preference style perceive that preference is the most socially acceptable. In other words, response choice on the KAI is motivated by the variable of social desirability. To avoid this problem, using bipolar statements to measure the problem-solving style of adapters and innovators is appropriate. Based upon their observations of the Big Five Personality Inventory Schweizer1, Rauch and Gold (2011) recommended that a bipolar scale can be a valuable research tool with satisfactory psychometric quality that leads to items with higher degree of homogeneity. Selebe et al. (2004) developed a new scale for cognitive styles by using bipolar scale to reduce the effect of social desirability problems. Additionally, Xu and Tuttle (2012) developed a workable adaption and innovation inventory using nine ordered categories of a bipolar scale.

Short assessment instruments have become increasingly desirable in psychology. Research on cognitive and personality assessment has considered that short scales provide benefits (e.g. Sandy, Gosling, Schwartz & Koelkebeck, 2016). Personality assessment studies have developed and validated short scales that help individuals avoid feeling burdened when answering a long inventory. Researchers have developed and validated brief personality scales that have become widely accepted, for example, the continuous attempts to produce shortened versions of measures from the Five-Factor Model (FFM) of personality traits (Costa & McCrae, 1995) and Big Five Inventory (BFI; John &Srivastava, 1999) with 44 items; the Big Five mini-markers with 40 items (Saucier, 1994); ultra-short versions with one or two items for each FFM dimension (Gosling, Rentfrow, & Swann, 2003); and a single-item scale created from the Ten-Item Personality Inventory in a social network design (Denissen, Geenen, Selfhout, and Van Akin, 2008).

Other examples of a short personality scale are presented in Russell, Peplau and Cutrona (1980) and Diener, Emmons, Larsen, and Griffin (1985). Russell et. al. (1980) presented a shortened version of the UCLA Loneliness Scale by reducing the number of items from 20 to four. Diener et. al. (1985) developed the Satisfaction with Life Scale by using five Likert-type items. In the area of cognitive style, Xu and Tuttle (2012) introduced a 9-item scale of problem-solving style of adapters and innovators at work.
Another challenge to professionals in universities is the proprietary nature of the existing sole measure. Selebe et al. (2004) and Xu and Tuttle (2012) have identified that alternative assessment instruments for problem-solving style for researchers or practitioners are necessary because the current widely accepted instruments such as KAI are limited in accessibility to professionals unless they satisfy extensive training requirements.

Rational of a New Cognitive Style Scale and Research Objectives

Because of the significance of problem solving, innovation, and style in education, this research develops a measure to identify problem-solving styles by adopting the Kirton adaption-innovation theory and applying the measure to innovative learning environments including universities. The new measure of problem-solving style is designed with a high concern to circumvent the criticisms, obstacles, and challenges observed in current practices when assessing style construct, in general, and adaption-innovation, specifically. The new measure responds to the following psychometric needs: a short, high quality measure with high quality; a user-friendly instrument, easily scored and interpreted and freely available for application in academic research and college settings in the Arab world; and a measure of style based on bipolar items measuring adaptation and innovation and capturing the most common cognitive preferences that innovative and adaptive students enact when solving problems in learning situations. Within these specifications the study objectives are as follows:

1. Develop a novel measure of problem-solving styles appropriate to learning settings.
2. Assess the theoretical model of the measure of problem-solving styles.
3. Assess the reliability of the measure of problem-solving styles.
4. Assess the discriminant validity of the measure of problem-solving styles.

Construction of Learner Scale for Problem-Solving Style

Three important recommendations for the scale construction processes in the area of psychological testing were adopted. First, the development of a careful and systematic scale construction plan can ensure a high level of content validity that leads to better construct validity (Anastasi and Urbina, 1997). Second, the rational–empirical approach to scale construction might create a theoretically meaningful scale related to the desired psychometric criteria free of unwanted error variance that emerged from social desirably variable (Murphy and Davidshofer, 2001). Finally, using samples of a target population and experts for the initial generation of items can guarantee the scale items are representative of and relevant to the facets of the construct (Haynes, Richard, and Kubany, 1995).

Following these recommendations, this study developed a scale construction plan comprising four stages: generate an item pool based on style statements published in inventories; adapt the initial scale to be more responsive to Kirton’s theory of problem-solving style for adopters and innovators; ask a panel of experts to evaluate the initial scale; and formulate a bipolar item scale. The first stage is essential to develop a content-valid learner scale of problem-solving styles that reflects students’ preferences in solving problems and emphasizes the importance of the university learning context, rather than work environments. We collected a large set of items from various cognitive style measures: the KAI (Kirton, 1999); AI-W scale (Xu and Tuttle, 2012); learning style orientation measure (Towler and Dipboye, 2003); and VIEW (Selby, Treffinger, Isaksen and Lauer , 2004). Next, we screened the selected statements and ignored the unobvious and redundancy. The outcome of that step was the selection of 60 statements.

The purpose of next stage was to maintain the developed scale within the theoretical framework of Kirton adaptation-innovation theory with emphasis on the behaviors of adapters and innovators through the three dimensions of problem-solving style: Sufficiency of originality; rule/group conformity and efficiency. To accomplish this objective, we developed a table of characteristics for adaption and innovation behaviors in terms of efficiency, conformity, and originality (Table 1). These
Descriptors were driven by resources managing Kirton theory (Mudd, 1995; Summers, Sweeney and Wolk, 2000; Pounds, and Bailey, 2001).

**Table 1:** Characteristics of Adaptation and Innovation

<table>
<thead>
<tr>
<th>Dimension</th>
<th>Adaptor</th>
<th>Innovator</th>
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<tbody>
<tr>
<td>SO</td>
<td>generate few feasible ideas</td>
<td>generate many possibly impractical solutions</td>
</tr>
<tr>
<td></td>
<td>make things better</td>
<td>make things different</td>
</tr>
<tr>
<td></td>
<td>prefer defined problems</td>
<td>redefine agreed problems</td>
</tr>
<tr>
<td>E</td>
<td>use methodical, efficient, and disciplined approach</td>
<td>approach tasks from unusual angles</td>
</tr>
<tr>
<td></td>
<td>prefer details</td>
<td>avoid thoroughness</td>
</tr>
<tr>
<td></td>
<td>perform routine work</td>
<td>little attention to details</td>
</tr>
<tr>
<td></td>
<td>progress incrementally toward a defined goal</td>
<td>little tolerance for routine</td>
</tr>
<tr>
<td>R/GC</td>
<td>use existing rules</td>
<td>challenge rules</td>
</tr>
<tr>
<td></td>
<td>Work inside constraints</td>
<td>breaking perceived restraints</td>
</tr>
<tr>
<td></td>
<td>Focus on the accepted means of solution</td>
<td>unconcerned with consensus</td>
</tr>
<tr>
<td></td>
<td>seek consensus and group norms</td>
<td>use unusual means as a solution</td>
</tr>
</tbody>
</table>

A panel of three experts on psychology and university curriculum was asked to examine the selected statements and classify according to the specified descriptors. Statements that do not fit in any category or absence of agreement among the experts were discarded. In this step, each expert was interviewed to discuss their selection of statements and views regarding their contents. In total, 45 statements were selected to reflect the behaviors of adapters and innovators in SO, R/GC, and E.

In the third stage, we constructed 18 bipolar-type items with seven numerical categories. Each item in the scale includes one general statement and two ends written as positive expressions, one describes personal adaptive preference when solving problems and the other represents personal innovative preference. Using positive, rather than negative, expression for the ends of the continuum is helpful to reduce the effects of the social desirability variable, that is, choosing a socially accepted response. Within the two ends, a continuum comprises seven numbered and sequential categories (i.e., 1–7). Respondents are required to circle one of the seven categories that best describes their personal preference (appendix 1 presents the LSPSS structure and its item). After developing the list of items, the experts examined each item to judge its appropriateness and relation to learning situations and make suggestions regarding necessary modifications for the items. Three items were discarded because of inappropriateness and absence of agreement among the panel members.

**Method**

**Participants**

When exploratory factor analysis and conformity factor analysis are required, using two separate samples is recommended (Kline, 2005). The first sample in this research was assigned to the exploratory factor analysis to determine the number of factors and their items. The sample comprised 130 subjects: undergraduate students studying introductory statistics; aged 18–20; 23% male and 77.6% female; 89% were medicine majors; and 11% were science and engineering majors. The second sample was assigned to run conformity factor analysis to test the factor structure of the LSPSS and comprised 240 subjects: undergraduate students studying psychology and biostatistics courses at two universities in the United Arab Emirates who participated for course credit; aged 18–24 with a mean age of 20 years; 32.4% male and 67.6% female; 58.9% were medicine majors; 28.1% were humanities majors; and 13% were science and engineering majors.
Measures

**NEO Five-Factor Inventory.** The research adopted the Arabic version of NEO Five-Factor Inventory (NEO-FFI-S) (Al-Ansari, 1997), which comprises 60 self-report items measuring five personality traits: extraversion, agreeableness, conscientiousness, neuroticism, and openness to experience. Each factor is assessed by 12 items regarding typical behaviors or reactions. The participants were asked to describe themselves at the present time by answering on a 5-point Likert-type scale, ranging from “strongly disagree” to “strongly agree.” Extraversion assesses the extent to which the individual actively engages with the world. Those high on extraversion are talkative and assertive (not shy). Agreeableness includes attributes such as friendliness, kindness, helpfulness, and other prosocial behaviors. Conscientiousness assesses the extent to which an individual is organized, persistent, accurate, and thoughtful. Neuroticism reflects the extent to which an individual is emotionally stable (not nervous or irritable). Openness to experience includes characteristics such as imagination, insight and versatility. Al-Ansari (1997) reported Cronbach’s reliabilities for the five factors in three samples and their averages are 0.67 for extraversion, 0.65 for agreeableness, 0.80 for conscientiousness, 0.73 for neuroticism and 0.45 for openness to experience.

Data Analyses

To accomplish the research objectives, a measure model was developed, and three types of statistical analyses were used. The first analysis included an exploratory factor analysis (EFA) to develop the measurement model of the LSPSS and specify the number of factors and items retained. The EFA included principal components analysis, varimax rotation, eigenvalues, scree plot, item loadings, and percentage of variance. We developed a measure model of LSPSS based on Kirton adaption-innovation theory and the EFA results (Figure 1). The measure model comprises three latent factors, namely, SO, E, and R/GC, and each contains three indicators. The conformity factor analysis (CFA) was the second statistical analysis used to evaluate the LSPSS model of factor structure.

**Figure 1:** Confirmatory Factor Model with Three Factors and Nine Indicators

The CFA comprised five goodness-of-fit indices to judge the measurement model fit: ratio of the chi-square value to degrees of freedom ($\chi^2/df$), root mean square error of approximation (RMSEA), the Bentler-Bonett non-normed fit index (NNFI), the comparative fit index (CFI), and the goodness-of-
fit index (GFI). Additionally, the composite reliability of the three subscales were obtained to assess the internal consistency of the indicators that measure a given factor. The third statistical analysis aimed to obtain the convergent and discriminant validity of LSPSS by using correlation coefficients among and between scale factors and the Arabic version of NEO-FFI-S factors. The EFA and CFA were performed by using SPSS16.0 software and AMOS17.0 software.

Results
Exploratory Factor Analysis

We used EFA to develop a measurement model of the LSPSS that explains the number of factors and items retained. To accomplish the objective, we adopted the following major recommendations indicated in many factor analysis articles and practiced by many researchers who have used EFA to develop psychology constructs (e.g. Floyd and Widaman, 1995; Yong and Pearce, 2013; Costello and Osborne, 2005; Levine, 2005; Reise, Waller, and Comrey, 2000; Hinkin, Tracey, & Enz, 1997). First, ratio of subjects to item was to determine the appropriate sample size to conduct the exploratory analysis. A ratio between 5:1 to 10:1 is considered the appropriate ratio for determining sample size in factor analysis. In this research, the sample included 130 subjects to respond to 15 bipolar items of the problem-solving styles for learners’ scale. This sample size is appropriate to be subjected to the EFA.

Second, principal components analysis was used for data analysis and varimax rotation was used to simplify and clarify the data structure.

Third, eigenvalues and a scree plot were considered as criteria to determine the number of factors retained. The results from using a scree plot show that three factors were the best for interpretation and a small decrease in the absolute size of the slop after the three factors was observed. The obtained eigenvalues of the three factors are above 1.0; according to Karines’ criterion (Yong and Pearce, 2013), they are appropriate, and factors should be retained.

Fourth, sizes of item loadings were the basis for whether an item was eliminated from the scale. Fifteen items were retained because their loadings exceeded 0.30 [this size of item loading is acceptable if the ratio of subjects to item is between 5:1 and 10:1 (Floyd and Widaman, 1995)]. Four items were included in the first factor and labeled R/GC. Six items were included in the second factor and labeled SO. Five items were included in the third factor and labeled E. To construct a short style scale, we retained the three items with the best loadings in each dimension and were classified within the dimension by the three experts in the prior stage. This operation responds to the Kirton adaption-innovation theory, which recognizes the three dimensions are of equal importance (Kirton, 2003).

Table 2 presents the last edition of the problem-solving styles for learners’ scale, loadings of its nine items, and percentages of variances for factors. The results show that the SO factor explained almost 27% of variance, and its item factor loadings were 0.611–0.744. The E factor explained 14.71% of variance, and its item factor loadings were 0.540–0.759. The R/GC factor explained 12.26% of variance, and its item factor loadings were 0.500–0.753.

Table 2: Three-factor model ...... loadings of nine items

<table>
<thead>
<tr>
<th>Indicator</th>
<th>SO</th>
<th>E</th>
<th>R/GC</th>
<th>PV</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 I like to show high interest and self-confidence in … Resolving problems available in textbooks or solved in class (Exploring new problems available in external resources).</td>
<td>.744</td>
<td></td>
<td></td>
<td>26.96</td>
</tr>
<tr>
<td>2 I intend to generate ideas that lead to … Improve current approaches to solutions in my study field (Improve current approaches to solutions in my study field).</td>
<td>.611</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 I prefer to offer ideas and solutions that are … Limit in number, practical, and definite. (Many, novel, indefinite, and possible impractical).</td>
<td>.680</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 I intend to …when working on assignments or projects in course. Follow professor’s instructions and rules (change the instructions and rules specified by professors if necessary).</td>
<td>.540</td>
<td></td>
<td></td>
<td>14.71</td>
</tr>
</tbody>
</table>
Indicator SO E R/GC PV
5 I enjoy approaching an assignment or a problem that has … A clear structure tasks, well-defined solution steps (unstructured tasks, and no definitive solution). .753
6 When doing assignment tasks in course I value … working in group following group norms. (Working independently following my own perceptions.) .759
7 I like to accomplish assignment or project tasks in … consistent, understood, and methodical ways (unexpected and undisciplined ways). .500 12.26
8 When solving problem, I like to … Focus on details and instructions, do routine tasks, and one task at time. (Focus with little tolerance for detailed and routine tasks, and deal with multiple tasks at time.) .632
9 Professor like my work when I .. Solve problems with ways that are tried in classes and agreed with their own ways to solution. (Manipulate problems with ways untried in class and explore my own solution.) .753

SO: Sufficiency of Originality; E: Efficiency; R/GC: Rule/Group Conformation; PV: Percent variance explained

Conformity Factor Analysis
CFA is used to evaluate the measurement models of factor structure (Bagozzi and Foxall, 1995). Five goodness-of-fit indices assess the measurement model fit: ratio of the chi-square value to degrees of freedom (\(\chi^2/df\)), RMSEA, the Bentler-Bonett NNFI, the CFI, and the GFI. Each index has an acceptable and reasonable rang, and if more than two conditions are not fulfilled, the model has a structure error and must be respecified. A cutoff value of 2.0 for (\(\chi^2/df\)) is recommended (Hoetler, 1983). Models resulting in NNFI, CFI, and GFI of 0.90 are considered acceptable (Bentler and Bonnett, 1980), and that RMSEA has the maximum level of 0.06 is also acceptable (Hu and Bentler, 1998).

Table 3: Fit Indices of the Single and Three-factor Models

<table>
<thead>
<tr>
<th>Model</th>
<th>(\chi^2)</th>
<th>df</th>
<th>(\chi^2/df)</th>
<th>RMSEA</th>
<th>NNFI</th>
<th>GFI</th>
<th>CFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Factor Model</td>
<td>85.3</td>
<td>27</td>
<td>3.15</td>
<td>0.087</td>
<td>0.721</td>
<td>0.71</td>
<td>0.784</td>
</tr>
<tr>
<td>Three-Factor Model</td>
<td>54.24</td>
<td>24</td>
<td>2.06</td>
<td>0.061</td>
<td>0.823</td>
<td>0.957</td>
<td>0.899</td>
</tr>
<tr>
<td>Standard levels</td>
<td>2.0</td>
<td>0.06</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td>0.90</td>
<td></td>
</tr>
</tbody>
</table>

N = 240; RMSEA = root mean square error of approximation; NNFI = non-normed-fit index; GFI = goodness-of-fit index; CFI = comparative fit index

Two models were subjected to CFA: a three-latent variable model in which each of the indicators was constrained to load on its respective latent variable, and a single-factor model in which all the indicators were constrained to load on one latent variable. The results are reported in Table 3. In single-factor model, the analysis demonstrates that the model did not fit the data because \(\chi^2/df\) ratio and RMSEA are 3.15 and 0.087 respectively, and exceed the maximum acceptable fit indices of 2.0 and 0.06. The NNFI, GFI, and CFI are 0.721, 0.71, and .0.784 respectively; less than the minimally acceptable fit indices of 0.90 (Bentler and Bonett, 1980); and indicate that the single-factor model leaves considerable variance. Notably, the findings indicate that the three-factor model provides a satisfactory fit to the data. In this model, the \(\chi^2/df\) ratio and RMSEA are 2.06 and 0.061, respectively, and fulfill the standard levels. The values for the indices of NNFI, CFI, and GFI are 0.823, 0.957, and 0.899, respectively. CFI and GFI fulfilled the criterion of 0.90.

Reliability
The composite reliability of the latent constructs assesses the internal consistency of the indicators that measure a given factor and 0.60 is considered the minimally acceptable level of reliability (O'Rourke
The results of composite reliability were 0.723 for the E construct, 0.729 for the R/GC construct, and 0.666 for the SO construct. Composite reliabilities for all three factors exceed the minimally acceptable level of reliability and suggest that satisfactory reliability has been attained.

### Discriminant Validity

According to Campbell (1960), to demonstrate discriminant validity, a scale should not correlate significantly with the variables from which it should differ. The first evidence of the discriminant validity of LSPSS is observed in the correlational analyses among the three problem-solving styles constructs. Table 4 presents the results of the correlation coefficients. E was moderately related to R/GC and SO (r= 0.33 and r=0.372), and R/GC was moderately related to SO. (r= 0.364). In general, the correlations among the three factors of problem-solving styles are reasonably distinct and their levels were reasonably high for all the factors. All three factors of LSPSS were highly correlated with the scale, and their correlations were greater than 0.74.

#### Table 4: Correlation Matrix among the Factors of LSPSS

<table>
<thead>
<tr>
<th></th>
<th>LSPSS</th>
<th>Efficiency</th>
<th>Conformity</th>
</tr>
</thead>
<tbody>
<tr>
<td>E</td>
<td>0.757**</td>
<td>0.330**</td>
<td>0.364**</td>
</tr>
<tr>
<td>R/GC</td>
<td>0.780**</td>
<td>0.372**</td>
<td></td>
</tr>
<tr>
<td>SO</td>
<td>0.745**</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(* = p < 0.05; ** = p < 0.001)

The second evidence of the discriminant validity of LSPSS can be tested through correlations among the three problem-solving styles constructs and major components of the Arabic version of the NEO-FFI-S (Al-Ansari, 1997). Table (5) presents how the correlation coefficients vary significantly. The correlations between the LSPSS constructs and measures of conscientiousness, neuroticism and openness (except R/GC construct) are significant but low and range from \( r = 0.256 \) (\( p < .000 \)) to \( r = 0.118 \) (\( p < 0.05 \)); the correlations between the measures of LSPSS and extraversion and agreeableness (except the SO construct) are nonsignificant [between \( r = 0.106 \) (\( p < 0.10 \)) and \( r = -.065 \) (\( p < 0.10 \))]. We conclude that sufficient discriminant validity exists between the LSPSS and components of the NEO-FFI-S to permit independent application of the LSPSS in academic research settings.

#### Table 5: Matrix of Correlations among the Factors of LSPSS and Traits of the Arabic Version of the NEO-FFI-S

<table>
<thead>
<tr>
<th></th>
<th>EXT</th>
<th>AG</th>
<th>CON</th>
<th>NEU</th>
<th>OP</th>
</tr>
</thead>
<tbody>
<tr>
<td>LSPSS</td>
<td>0.019</td>
<td>0.12</td>
<td>0.308**</td>
<td>0.185*</td>
<td>0.191*</td>
</tr>
<tr>
<td>E</td>
<td>-0.065</td>
<td>0.088</td>
<td>0.256**</td>
<td>0.143*</td>
<td>0.199**</td>
</tr>
<tr>
<td>R/GC</td>
<td>0.106</td>
<td>0.036</td>
<td>0.241**</td>
<td>0.134*</td>
<td>0.060</td>
</tr>
<tr>
<td>SO</td>
<td>-0.012</td>
<td>0.141*</td>
<td>0.159*</td>
<td>0.118*</td>
<td>0.160*</td>
</tr>
</tbody>
</table>

EXT = Extraversion; AG = Agreeableness; OP = Openness; CON = Conscientiousness; NEU = Neuroticism;

### Discussion

The purpose of the study is to present the Learner Scale for Problem-Solving Styles (LSPSS) as a new scale of cognitive style. The development of this measure is based on the widely accepted cognitive style theory called Kirton adaption-innovation theory. The measure tried to avoid the main psychometric problems of cognitive style and measurement theory observed in the literature. The LSPSS is different from other scales of cognitive styles because this scale is a short, bipolar, and accessible measure that covers the main behaviors of innovation expected to specifically occur among learners in university environments.
To ensure its content validity, the development of LSPSS was based upon a scale construction plan comprising a review of style instruments in the literature, judgments of experts, and an EFA for responses of a sample of 130 students on the initial Arabic-language version of the scale. The statistical results showed all item factor loadings for the subscales (0.50 to 0.759) exceeded the criterion of 0.30. All factors explained 53.93% of the variance: SO (26.96%); E (14.71%), and R/GC (12.26%). These data agree with the principle specified by Bobic, Davis and Cunningham (1999). Explained variance is a measure of item homogeneity, and a high percentage of explained variance would suggest item redundancy, whereas a very low percentage is an indication of a unique, unclear defined dimension.

Comparisons among the percentage of the total variance reported in the present study (54%) and those obtained from the 32 item-KAI in Canadian and Japanese samples (23.2–34.5) (Loo and Shomai, 1997) and for learning style orientation measure (35%) (Towler and Dipboye, 2003) revealed that the three factors of LSPSS account for the highest percentage of the total variances. Notably, high similarity is observed between the study’s percentages of variance and the percentages of variance reported in the samples from the United Kingdom, Australia, and the United States (49.4%–53.2%) for 13 item-KAI (Foxall, 1992).

The second objective is to assess the factor structure of the LSPSS. The model fit indices obtained showed that the measurement model of the LSPSS supported the three-factor model of problem-solving style proposed by Kirton adaption-innovation theory. This study also examined the one factor model, and the results did not conform this model; notably, we did not extend the model to four factors, as in Tayler (1989) and Im and Hu (2005). Their justification was that the three-factor model of KAI did not explain a high amount of item variance. This study showed high percentage of variance explained by LSPSS and the fourth model was not justified.

This study’s results were almost similar to the factor evidences in Kirton’s original study (Kirton, 1999) and previous cross-nation studies concerning comparisons of the factor structure of the KAI across nations. The KAI has been translated into six languages: English, Italian, French, Dutch, Slovak (Tullert and Kirton, 1995) and Japanese (Loo and Shomai, 1997). Their sound psychometric and factor analysis data supported the assumption that the KAI is a valid three-factor measure of adaptation-innovation cognitive style. Despite the differences in language, subjects, and item content, the LSPSS and AI-W scale by Xu and Tuttle (2012) are too alike in many of the factor structures and psychometric features. Both scales support the three-factor model comprised of the following traits: sufficiency to originality, rule/group conformity, and efficiency.

An evaluation of composite reliability and discriminate validity were the other objectives when assessing the construct validity of LSPSS. The results showed all the psychometric indices were satisfied. Composite reliabilities of the LSPSS factors were on average moderate and satisfied, after consideration for the small number of indicators in each factor. The research presented two findings of discriminate validity for LSPSS. First, the correlation results support that the LSPSS factors were clearly distinct among themselves. Second, we observe that the degree of distinctiveness of the three factors varies across the Arabic version of NEO-FFI-S constructs, but their levels are satisfactory. These psychometric characteristics are almost similar to those reported in the KAI (Kirton, 1999) and AI-W scale studies (Xu and Tuttle, 2012).

Generalizability is an important feature for a psychology scale. Thus, additional research to examine the psychometric features of LSPSS by using samples of students from other universities and countries is necessary. If the stability of the loadings and correlations occurs across samples from different countries, the generalizability of the LSPSS is confirmed. Additional research is also required to examine the criterion validity of LSPSS that assumes a relationship between the cognitive style scale and academic achievements at universities. Identification of the strength and direction of the relationship between the two variables has an educational implication. A significant positive relationship might indicate high coordination between the instructional teaching and assessment models that professors specify and students’ style of thinking. Otherwise, professors must re-examine their course materials to match the students’ style of thinking. Because of its importance, style scales
developers have examined this relationship while considering scale validity, and literature has demonstrated a significant relationship between style measures and academic achievement.

**Implications of LSPSS**

The LSPSS has three important implications concerning learning effectiveness of students, design of curriculum and instruction, and efficiency of teamwork at universities. First, the LSPSS can help students identify and understand their unique preferred approach to solving problems and how difference in styles contribute to individual differences in performance in class. With this awareness, students can identify their own methods for optimal problem solving; select problem-solving strategies and tasks that align with their thinking styles; and benefit from the strengths of other classmates while working on projects and assignments.

Second, the LSPSS provides a critical tool to enable professors to identify problem-solving styles for students. Awareness of students’ styles is essential for developing an effective curriculum and innovating higher education. Students might benefit the most from study programs if their styles of problem solving approximately match the tasks provided in instruction and assessment. A course should provide various options regarding methods of teaching and assessments that respond to the learning needs of adapters and innovators in the class. This strategy enables students to benefit more from course materials and develop better problem-solving performance (Sternberg and Zhang, 2005 and Darwish, 2016). For example, an assignment involving a complex open-ended problem would be welcomed by students classified as innovators and conducted in a manner that professors expect. Teaching should be differentiated to help the adopters and innovators in a class improve achievement and attain learning outcomes.

Third, the LSPSS is expected to be an appropriate tool to enhance collaboration and teamwork dynamics and build student project teams. A student team that includes innovators and adopters will develop effective problem-solving strategies. Students in the problem-solving group benefit from each other’s strength. For instance, adopters prefer applying traditional approaches of problem solving and well-structured problems, whereas innovators benefit from complex open-ended problems and freedom to modify problem-solving tools to fulfill their needs while going off in unusual directions, seeking novelty, and taking risks.

**Conclusion**

The Learner Scale for Problem-Solving Styles (LSPSS) is a new measure for assessing problem solving style that depends on Kirton adaptation-innovation theory for use with university students. The measure attempts to avoid main psychometric problems observed in the field of cognitive style. LSPSS is a short, bipolar, and accessible measure covering the main behaviors of innovation practiced by university students. The development plan comprised a review of style instruments in the literature, judgments of experts, and the EFA for 130 student responses on the initial version of the scale. The LSPSS was also subjected to conformity factory analysis and other psychometric analyses by using the responses of a new sample of 218 students on the last version. The results showed that the composite reliabilities of the LSPSS factors were on average moderate and satisfied. The discriminate validity for LSPSS was evident: the three LSPSS factors were clearly distinct among themselves, and the degree of distinctiveness of the three factors varies across the traits of the Arabic version of NEO-FFI-S, but their levels are satisfactory.
Acknowledgments
Many thanks to expert group, namely, Dr. Abdalla El Mneizel; Dr. Osama Samaneh, and Siddiq Abdel Monim, for their feedback on the LSPSS and its items throughout the research process. Many thanks are also given to Ghada Al-Masery for her contributions in data entry and analysis.

References


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(Learner Scale for Problem-Solving Styles (LSPSS): Development, Factor Structure, and Construct Validity) (Not sure what is this??)

Appendix I – Learner Scale for Problem Solving Styles (LSPSS)

For each pair of statements circle the number that corresponds most closely with how you think about yourself when solving problems

<p>| | | | | | | | | | |</p>
<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
<td>7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. I like to accomplish assignment or project tasks in … Consistent, understood and methodical ways.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>unexpected and undisciplined ways.</td>
</tr>
<tr>
<td>2. When solving problem, I like to … Focus on details and instructions, do routine tasks, and one task at time.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Focus with little tolerance for detailed and routine tasks, and deal with multiple tasks at time.</td>
</tr>
<tr>
<td>3. Professor like my work when I … Solve problems with ways that are tried in classes and agreed with their own ways to solution.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Manipulate problems with ways untired in class and explore my own solution.</td>
</tr>
<tr>
<td>4. I intend to … when working on assignments or projects in course. Follow professor’s instructions and rules</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Change the instructions and rules specified by professors if necessary.</td>
</tr>
<tr>
<td>5. I enjoy approaching an assignment or a problem that has … A clear structure tasks, well-defined solution steps.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>unstructured tasks, and no definitive solution.</td>
</tr>
<tr>
<td>6. When doing assignment tasks in course I value … working in group following group norms.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>working independently following my own perceptions.</td>
</tr>
<tr>
<td>7. I like to show high interest and self-confidence in … Resolving problems available in textbooks or solved in class</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Exploring new problems available in external resources.</td>
</tr>
<tr>
<td>8. I intend to generate ideas that lead to … Improve current approaches to solutions in my study field</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Discover new approaches to solutions in my field.</td>
</tr>
<tr>
<td>9. I prefer to offer ideas and solutions that are … Limit in number, practical, and definite.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Many, novel, indefinite, and possible impractical.</td>
</tr>
</tbody>
</table>