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Validity and Reliability Issues of Two Learning Style Inventories in a Greek Sample: Kolb's Learning Style Inventory and Felder & Soloman's Index of Learning Styles

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This study aimed at investigating the psychometric properties of two inventories for the measurement of learning style preferences in a Greek sample: Kolb's (1985) Learning Style Inventory (LSI) and the Index of Learning Styles (ILS) by Felder & Soloman (1999). The inventories were administered in a total of 340 Greek university undergraduate students of different disciplines (education, psychology, and polytechnics) and primary school teachers. Regarding the LSI, our sample was found to strongly prefer the accommodative and the divergent learning style. Results indicated that in the Greek sample the LSI had a satisfactory reliability but its construct validity was weakly supported. No significant differences were found in relation to discipline, a finding that calls the discriminant validity of the inventory into question. Regarding the ILS, our sample showed a preference for the visual and the sensing learning style; its reliability was barely acceptable but the construct and the discriminant validity were well-supported. In conclusion, this study revealed psychometric weaknesses in both inventories suggesting that they could be used as a tool to encourage self-development of an individual within a discipline group, but not as a tool for grouping them according to given learning styles.

This paper is concerned with two learning style models: (a) Kolb's (1984) experiential learning theory, which is one of the most influential and commonly used models in higher education, and (b) Felder & Silverman's (1988) learning style model, which originally was designed to capture learning differences among engineering students. Both models have developed inventories for measuring learning style preferences. Kolb designed and later refined (Kolb, 1985) the self-report Learning Style Inventory (LSI) to assess learning styles. In the Felder & Silverman (1988) model, learning style preferences are assessed by the Index of Learning Styles (ILS), which was developed by Felder & Soloman (1999). The present study aimed at checking the psychometric properties of the above instruments in a sample of Greek university undergraduate students and primary school teachers.

The Learning Style Inventory (LSI) is one of the most widely distributed instruments and claims to provide a valuable framework for the design and management of learning activities (Healey & Jenkins, 2000; Sadler-Smith, 2001). Although the LSI has been used extensively, it has also been challenged mainly for its construct validity (a detailed critique is presented bellow). The Index of Learning Styles (ILS) has been used far less than the LSI and its psychometric properties are to a great extent still under close scrutiny. Thus, the aim of the present study is to contribute to the discussion regarding the psychometric soundness of these instruments. Moreover, our aim was to add to the existing research evidence from Greek samples, which at the moment is very limited (Andreou, Andreou, & Vlachos, 2006; Andreou, Andreou, & Vlachos, 2008; Metallidou & Platsidou, 2008; Platsidou & Zagora, 2006).

Kolb's Learning Style Model

Kolb (1984) based his theory of experiential learning on peoples' different approaches of perceiving and processing information. In his model, learning is described as a four-stage interactive process that involves four distinct learning modes, which represent different types of learning: concrete experience (CE), reflective observation (RO), abstract conceptualization (AC), and active experimentation (AE). The combinations of the learning modes form four learning styles: the accommodative (AE/CE), the divergent (CE/RO), the assimilative (RO/AC), and the convergent (AC/AE). Every individual utilizes each of the four learning modes to some extent, but he/she has also a preferred learning style for grasping and transforming the information. In particular, the accommodator would rely on concrete experiences mixed with active experimentation in a hands-on experience. The diverger would start from concrete experience and would combine it with reflective observation in order to come up frequently with a creative solution. The assimilator would be concerned mainly with reflective observation in order to develop models and abstract theories for explaining reality. Finally, the converger would grasp information through abstract understanding of the immediate experience and puts into practice her/his ideas in a deductive fashion. The effective learner can use each of the four styles in different learning situations rather than only rely on his/her preferred style

(Kolb, Boyatzis, & Mainemelis, 2000). Although Kolb's work has been criticized for logical inconsistencies in the theory construction (Coffield et al., 2004; Garner, 2000; Holman, Pavlica, & Thorpe, 1997; Vince, 1998), it still remains a very popular learning style model (Demirbas & Demirkan, 2007; Kayes, 2005; Marriott, 2002).

As regards the psychometric properties of the LSI, relevant research has generally supported its internal reliability (e.g., Heffler, 2001; Sadler-Smith, 2001; Willcoxson & Prosser, 1996), although some studies have detected the presence of measurement errors such as a response-set bias (Henson & Hwang, 2002; Ruble & Stout, 1990). The validity of the instrument, however, has been at best described as fair (Curry, 1991). Specifically, construct validity research findings have not been conclusive (e.g., Cornwell, Manfredo, & Dunlap, 1991; Mainemelis, Boyatzis, & Kolb, 2002). Some studies confirmed the factor structure of the inventory as predicted by Kolb (1984; 1985), in contrast to others (de Ciantis & Kirton, 1996; Geiger, Boyle, & Pinto, 1992; Loo, 1996, 1999; Ruble & Stout, 1990). The criticism is focused mainly on conflicting evidence in support of Kolb's bipolar dimensions as well as on the interdependent nature of ipsative scores of the measure (high scores on one dimension leading to low scores on the other dimension and forcing artifact negative correlations between dimensions) (for reviews see Brew, 2002; Henson & Hwang, 2002; Kayes, 2005; Koob & Funk, 2002). In spite of the above criticism, the efficiency and value of the LSI as a pedagogical tool is supported by many studies (e.g., Loo, 1999).

Also, there is considerable evidence of discriminant validity of the LSI. Kolb (1984) advocated that certain learning styles are considered characteristic of special educational choices and professions and based this claim on the assumption that different learning strategies, epistemological positions, and modes of discourse or educational processes are required or employed in different disciplines or fields of study (Kolb et al., 2000; Nulty & Barret, 1996). A number of studies corroborated the above, as they revealed significant differences in students' learning style preferences across different disciplines (such as social studies, English, science and mathematics) (Clump & Skogsberg, 2003; Jones, Reichard, & Mokhtari, 2003; Yean & Lee, 1994). Specifically, it was found that art students have a preference towards the divergent and assimilative learning styles (Kruzich, Friesen, & Van Soest, 1986; Willcoxson & Prosser, 1996), social science students towards the accommodative style (Kruzich et al., 1986) while science students towards the convergent learning style (Andreou et al., 2008; Willcoxson & Prosser, 1996).

Felder & Silverman's Learning Style Model

Felder and Silverman's learning style model (1988) was first applied in the context of engineering education, with the aim of capturing the most important learning style differences among engineering students and, thus, providing a good basis for engineering instructors to formulate a teaching approach that would address the learning needs of all students (Felder, 1993; Felder & Spurlin, 2005). The model categorizes individuals' preferences in terms of type and mode of information perception (i.e., sensory or intuitive; verbal or visual), approaches for the organization and processing of information (i.e., inductive or deductive; active or reflective), and the rate at which students progress towards understanding (i.e., sequential or global) (de Vita, 2001). In this way, individuals are classified according to their preference for one or the other pole of each of the following four scales: (a) sensing (concrete thinkers, practical, oriented towards facts and procedures) / intuitive (abstract thinkers, innovative, oriented towards theories and underlying meanings); (b) visual (prefer visual representations of presented material, such as pictures, diagrams and flow charts) / verbal (prefer written and spoken explanations); (c) active (learn by trying things out, enjoy working in groups) / reflective (learn by thinking things through, prefer working alone or with a single familiar partner); (d) sequential (linear thinking process, learn in small incremental steps) / global (holistic thinking process, learn in large leaps). The dichotomous learning style dimensions of this model are continua, not either/or categories. The learners' preference on each scale may be strong, moderate or mild, may change with time, and may vary from one subject or learning environment to another (Felder, 1993; Felder & Spurlin, 2005).

Relevant research data support a claim of construct validity of the instrument (Felder & Brent, 2005). Factor analysis studies suggest that most of the ILS scales are well-defined, although two of them (the sequential-global and the sensing-intuitive) have shown a moderate degree of overlapping (Felder & Spurling, 2005; Livesay, Dee, Nauman, & Hites, 2002; van Zwanenberg, Wilkinson, & Anderson, 2000; Zywno, 2003). In addition, the ILS has evidenced satisfactory convergent and discriminant validity in student and faculty samples from various disciplines, such as engineering, humanities and polytechnics (Felder & Brent, 2005; Felder & Spurlin, 2005). For example, it was found that, although all students were on average visual learners, the engineering students were

consistently more visual and sensing than the education and the liberal arts students; the last two groups were more reflective and global than their counterparts in engineering and science (Kuri & Truzzi, 2002 and Lopez, 2002 as cited in Felder & Spurlin, 2005; Litzinger, Lee, Wise, & Felder, 2005). Finally, the learning style profiles for engineering faculty members differ from those of engineering students in a manner which is consistent to the theory; e.g., faculty members were significantly more reflective, intuitive and global and preponderantly visual than students of the same discipline (Rosati, 1996 as cited in Felder & Spurlin, 2005). These differences were attributed to the increased experience and expertise of faculty in the specific discipline (Felder & Silverman, 1988; Felder, 1993). The issue of reliability of the ILS, however, is still in dispute; in almost all studies, the test-retest reliability is satisfactory, but the internal consistency reliability proves to be low and barely acceptable (Felder & Spurlin, 2005; Livesay et al., 2002; van Zwanenberg, et al., 2000; Zywno, 2003).

Based on the above critiques as well as the critiques related to the ipsative nature of the instrument, it is argued that the ILS may be best used for assessing the relative strengths of learning preferences within an individual, rather than for comparing learning style preferences among individuals (van Zwanenberg et al., 2000). Others claim that the ILS is a suitable instrument for assessing learning styles, although they recommend that the research on reliability and validity of the instrument should be continued (Felder & Spurlin, 2005; Livesay et al., 2002; Zywno, 2003).

Aims and Hypotheses of the Present Study

The present study aimed to check the psychometric properties of the above inventories (LSI and ILS) in a Greek sample of students from three disciplines (education, psychology, and polytechnics) and of professionals from the discipline of education (primary school teachers). Specifically, the study aimed at examining the following:

(a) the internal consistency reliability of the two inventories. It was expected that the LSI would show a satisfactory reliability (Hypothesis 1a) (e.g., Heffler, 2001; Sadler-Smith, 2001), whereas the reliability indices of the ILS would be low (Hypothesis 1b) (e.g., Felder & Spurlin, 2005).

(b) the construct validity of the instruments. Research evidence has provided a weak support for the construct validity of the LSI (e.g., Cornwell et al., 1991; Mainemelis et al., 2002; de Ciantis & Kirton, 1996; Loo, 1996, 1999), whereas the construct validity of the ILS has been adequately supported (Felder & Spurling, 2005; Livesay et al., 2002; van Zwanenberg et al., 2000; Zywno, 2003). Given that the empirical results concerning the construct validity of the LSI are inconclusive, we are not in a position to make a clear prediction for its validity in the Greek sample. As regards the construct validity of the ILS, following the results of previous factorial models, the prediction was that most of the theoretical scales would be well-defined, although the sequential-global and the sensing-intuitive scales would possibly overlap (Hypothesis 2).

(c) the discriminant validity of the two inventories. As described earlier, both learning style models claim that different learning style preferences predominate in various disciplines or fields of study (Felder & Spurling, 2005; Kolb et al., 2000). Thus, it was expected that learning style profiles would be differentiated among samples of different disciplines in both inventories (Hypothesis 3a & 3b, respectively).

As regards the learning style preferences of students and professionals from the same discipline, in the LSI, the in-service teachers (given their social background) were expected to show a greater preference for the assimilative and the divergent learning styles than the education students, as older individuals were found to become more reflective and observational in the learning environment (Truluck & Courtney, 1999) (Hypothesis 4a). In the Felder and Soloman's (1999) inventory, differentiated learning profiles of the teachers and the education students were also expected, since previous evidence has shown such differences in the learning style profiles of engineering faculty members and students (Hypothesis 4b).

Method

Participants

A total of 340 participants were involved in the study fitting into four groups: (a) 64 in-service primary school teachers with 10 up to 28 years (M = 17) of teaching experience and being 35 to 55 years old; (b) 108 undergraduate university students in the Department of Primary Education (also regarded as pre-service teachers); (c) 89 undergraduate students in the Department of Psychology; and (d) 79 undergraduate students in various Departments of the School of Polytechnics. The sample consisted of 103 (30.4%) males and 237 (69%) females.

Research Instruments

Two self-report instruments were used to assess the participants' learning styles: (a) the Learning Style Inventory (Kolb, 1985) and (b) the Index of Learning Style (Felder & Soloman, 1999).

Learning Style Inventory. Twelve short statements concerning learning situations were presented and the participants were required to rank order four preferences for learning organized in four columns (e.g., When I learn: "I like to deal with my feelings," "I like to watch and listen," "I like to think about ideas," and "I like to be doing things"). After summing up each of the four columns, a total score for each of the four learning modes (concrete experience-CE, reflective observation-RO, abstract conceptualization-AC and active experimentation-AE) was obtained for each participant. Combined scores between the learning modes were also obtained to address the participants' preferences for each of the four learning styles: convergent (AC/AE), divergent (CE/RO), assimilative (RO/AC), and accommodative (AE/CE).

Index of Learning Style. Forty-four forced-choice items were presented to the participants (e.g., "I understand something better after I (a) try it out, (b) think it through"). After summing their scores, their preferences on each of the four bipolar learning styles scales (as described by the Felder & Silverman model) were assessed by a subtraction score between the first and the second pole of each scale: active-reflective (act/ref), sensing-intuitive (sen/int), visual-verbal (vis/vrb), and sequential–global (seq/glo). A positive subtraction score indicated a preference for the first pole of the scale, whereas a negative subtraction score indicated a preference for the second pole.

Results

Reliability and Construct Validity of the Two Learning Style Inventories

Cronbach alpha coefficients for the four learning modes of the LSI were found to be satisfactory, as expected (Hypothesis 1a): concrete experience $\alpha = 0.81$, reflective observation $\alpha = 0.72$, abstract conceptualization $\alpha = 0.76$ and active experimentation $\alpha = 0.76$. In the ILS, the reliability indices for most of the learning style scales were moderate (sensing-intuitive $\alpha = 0.62$) to low (active-reflective $\alpha = 0.45$, visual-verbal $\alpha = 0.51$, sequential-global $\alpha = 0.45$), as predicted in Hypothesis 1b.

As regards the construct validity of the two instruments, firstly, in accordance with previous factorial models, a two-forced factor principal component analysis was applied on the four learning modes of the LSI (with varimax rotation) (see Table 1). Factor 1 loaded the CE/RO bipolar dimension and factor 2 loaded the AE/AC dimension. The results supported the bipolar factor structure of the LSI but not in the pairing proposed by Kolb.

Subsequently, the construct validity of the ILS was checked. In previous studies, factorial models with eight factors (Litzinger et al., 2005) and five factors (Zywno, 2003) were obtained. We tested those models in our data but they were not adequately fitted. Specifically, in the eight-factor model, which accounted for 38.75% of the total variance, only the four factors were found to be well-defined (i.e., they may be considered as independent) whereas, in the other four factors, the learning style scales showed considerable overlapping making it obvious that this model can hardly explain the theory parsimoniously and consistently. On the other hand, our five-factor model accounted for the 28.3% of the total variance and all its factors were relatively well defined. Factors 1, 2 and 5 were similar to those found by Zywno (2003) and loaded the sensing-intuitive, the visual-verbal and the sequential-global scales, respectively. Factors 3 and 4, however, were differentiated in our model; they both loaded the active-reflective scale, while in the Zywno model factor 3 loaded the active-reflective scale and factor 4 was equally associated with the sensing-intuitive and the sequential-global scales. As a result of the poor fit of the above models, we tested a four-factor model, which is presented in Table 2. In this model, each factor loaded most of the items assumed to be related to the respective learning style scale (and few items were misfit), suggesting that the original four learning style scales are moderately well defined. However, the variance explained by this model was quite low (24%).

Discriminant Validity of the Inventories

When assessed by the LSI, participants in total were found to show a strong preference in descending order for the accommodative ($M = 64.8$, $SD = 9.1$), the divergent ($M = 62.7$, $SD = 7.2$), the convergent ($M = 57.5$, $SD = 6.8$) and, last, the assimilative learning style ($M = 55.3$, $SD = 9.5$). Means and standard deviations for all sample groups are given in Table 3. To explore any differences related to the participants' different disciplines, we applied a 4 (discipline groups) X 4 (learning styles) MANOVA. The main effect of discipline was not found to be significant for any of the learning styles across the four discipline groups. It must be underlined that the two groups from the same discipline, i.e., the education students and teachers, showed no significant differences in their learning style profiles.

Table 1
Results of Principle Component Analysis on the LSI

Scale	Factor 1	Factor 2
CE	-0.97	
RO	0.71	
AE		-0.96
AC		0.68
Eigen value	1.80	1.21
Variance %	45.0	30.3
Cumulative %		75.3

Table 2
Results of Principle Component Analysis on the ILS

	Factors			
Items	1	2	3	4
38	0.56			
14	0.54			
2	0.52			
26	0.46			
6	0.45		0.41	
18	0.44		0.38	
34	0.42			
30	0.40			
32	0.39			
39	0.39			
36	0.38			
35	0.33			
29	0.31			
31		0.69		
7		0.61		
11		0.60		
15		0.48		
40		-0.40		
19		0.35		
23		0.35		
3		0.33		
27				
4				
21			0.54	
41			0.44	
9			0.43	
10	0.41		0.42	
13			0.40	
22	0.31		-0.39	0.37
33			0.38	
37			0.36	
5			0.33	
1				
44				
25				-0.58
8				0.47
42				0.45
17				-0.42
28				0.35
12				0.30
16				
20				
43				
24				
Eigen value	3.05	2.76	2.47	2.34
Variance %	6.94	6.29	5.61	5.31

Note: Loadings under 0.30 are omitted

Taking into account the concerns about the construct validity of the instrument, we decided to also apply a MANOVA on the learning modes. In this case, the main effect of the discipline was found to be significant in two out of the four groups. Specifically, in the abstract conceptualization learning mode, the education students had higher scores than the psychology students [$F(3,336) = 3.9$, $p < 0.05$, $\eta^2 = 0.03$]; in the active experimentation, the education students had lower scores than both the psychology and the polytechnic students [$F(3,336) = 7.9$, $p < 0.05$, $\eta^2 = 0.07$].

As regards the ILS, the participants' reports of their preferences for the eight learning styles (two styles in each bipolar scale) showed that they strongly preferred the visual ($M = 2.71$, $SD = 4.44$) and the sensing ($M = 2.70$, $SD = 4.63$) learning styles; a moderate preference was also reported for the sequential ($M = 1.41$, $SD = 4.11$) and a lower preference for the active learning style ($M = 0.68$, $SD = 4.14$); the reflective, global, intuitive and verbal were the least preferred learning styles. Table 4 presents the learning style preferences for the four bipolar scales of the four sample groups.

Subsequently, we applied a 4 (discipline groups) X 4 (learning style scales) MANOVA in order to investigate any discipline group differences in the participants' learning style preferences. The main effect of discipline was found significant in two of the four

Table 3
Means (Standard Deviations) and Statistical Indices for the LSI Scales in Relation to Disciplines

	Total	In-service teachers (n=64)	Education students (n=108)	Psychology students (n=89)	Polytechnic students (n=79)	F	p	η^2
Learning styles								
Accommodative	64.82 *(9.06)*	62.54 *(9.27)*	64.92 *(9.05)*	64.76 *(9.50)*	66.61 *(8.09)*	2.41	0.07	0.02
Divergent	62.67 *(7.21)*	63.88 *(6.79)*	62.61 *(5.99)*	61.61 *(7.04)*	62.95 *(8.99)*	1.28	0.28	0.01
Convergent	57.49 *(6.75)*	56.18 *(6.78)*	57.30 *(5.95)*	58.66 *(6.37)*	57.51 *(7.99)*	1.73	0.16	0.02
Assimilative	55.34 *(9.46)*	57.51 *(9.27)*	54.99 *(9.08)*	55.51 *(10.35)*	53.85 *(8.89)*	1.86	0.14	0.02
Learning modes								
Concrete experience	36.04 *(7.52)*	36.60 *(7.48)*	36.85 *(7.18)*	34.70 *(7.76)*	36.00 *(7.90)*	1.48	0.22	0.01
Reflective observation	26.63 *(7.13)*	27.29 *(6.46)*	25.76 *(6.67)*	26.92 *(7.45)*	26.95 *(7.45)*	0.82	0.49	0.01
Abstract conceptualization	28.71 *(6.18)*	30.23 *(6.10)*	29.23 *(5.61)*	28.59 *(6.24)*	26.90 *(6.58)*	3.91	0.01	0.03
Active experimentation	28.78 *(6.62)*	25.95 *(6.75)*	28.06 *(6.39)*	30.06 *(6.41)*	30.61 *(6.24)*	7.90	0.00	0.07

Table 4
Means (Standard Deviations) and Statistical Indices for the ILS Scales in Relation to Disciplines

	Total	In-service teachers (n=64)	Education students (n=108)	Psychology students (n=89)	Polytechnic students (n=79)	F	p
Act(+) Ref(-)	0.68 *(4.14)*	0.33 *(3.78)*	0.88 *(4.33)*	-0.15 *(4.02)*	1.62 *(4.13)*	2.821	.039
Sen(+) Int(-)	2.70 *(4.63)*	3.35 *(5.00)*	3.29 *(4.49)*	2.28 *(4.66)*	1.83 *(4.36)*	2.196	.088
Vis(+) Vrb(-)	2.71 *(4.44)*	2.62 *(4.68)*	3.23 *(4.88)*	1.32 (*3.75*)	3.65 *(3.98)*	4.711	.003
Seq(+) Glo(-)	1.41 *(4.11)*	1.74 *(4.46)*	1.66 *(4.28)*	1.80 *(3.58)*	0.38 *(4.06)*	2.210	.087

learning style scales, the active-reflective and the visual-verbal (see Table 4). The application of Scheffe's multiple comparison test showed that the polytechnic students reported a higher preference for both the active [$F(3,336) = 2.82$, $p < .05$, $n^2 = 0.03$] and the visual learning style [$F(3,336) = 4.71$, $p < .05$, $n^2 = 0.04$] as compared to the psychology students. Also, in the visual learning style the education students reported a higher preference compared to the psychology students. Finally, no significant differences were found between the education students and teachers. Overall, these results offer some support to the discriminant validity of the ILS.

Discussion

The present study aimed to contribute to the investigation of the psychometric properties of two learning style inventories: Kolb's (1985) LSI which has been extensively used (and criticized) in higher education and Felder and Soloman's (1999) ILS which is a relatively new and less known instrument. Specifically, we attempted to investigate psychometric rigor of the ILS in order to define its applicability in relation to the widely used Kolb's LSI. As both inventories have been sparsely administered in Greek samples, we decided to address the issues of internal consistency reliability and construct and discriminant validity of the two instruments.

Reliability and Validity of Kolb's LSI

Kolb's inventory indicated a quite satisfactory reliability as regards learning modes, consistently to our Hypothesis 1a. This finding is in line with other research data that generally support the internal consistency reliability of the LSI both in international samples (Heffler, 2001; Sandler-Smith, 2001; Loo, 1996; Willcoxson & Prosser, 1996) as well as in a Greek sample (Andreou et al., 2006). Construct validity, however, was found to be problematic, as the bipolar factor structure of the LSI identified in the present study was not in line with the one proposed by Kolb (1984, 1985). This is not a surprising finding, since evidence in the same direction was obtained in other relevant studies (de Ciantis & Kirton, 1996; Geiger et al., 1992; Wilson, 1986) and it is attributed to the limitations of the ipsative scores (Cornwell & Dunlap, 1994). Conclusively, research findings from the Greek as well as from the international studies call into question the construct validity of this instrument.

In assessing the validation and the robustness of an inventory, the issue of discriminant validity is of major importance. Different discipline groups of participants were expected to be related to different learning modes and learning style preferences (Jones et al., 2003; Kolb, 1985; Kolb et al., 2000) (hypothesis 3a). However, no significant differences in the learning style profiles of the four discipline groups were found. When the learning modes were employed in the analysis, some differences were revealed. In the abstract conceptualization learning mode, the education students had higher scores than the psychology students and, in the active experimentation, they had lower scores than both the psychology and the polytechnic students. It must be noted, however, that no significant differences were found between the two same-discipline groups, the education students and the in-service teachers. These findings only partially confirmed our hypotheses (3a and 4a respectively) and offer a limited support of the discriminant validity of the LSI.

Other relevant studies, however, have found that the LSI is adequate, to a large extent, to discriminate participants' preferences regarding learning styles or modes, in relation to their discipline (e.g., Andreou et al., 2006; Clump & Skogsberg, 2003; Jones et al., 2003; Reading-Brown & Hayden, 1989; Yean & Lee, 1994; Willcoxson & Prosser, 1996). Apparently, there is a discrepancy between the results of our study and the existing research evidence, which is crucial for drawing safe conclusions regarding the discriminant validity of the inventory. To further investigate this inconsistency, we compared the learning styles profiles of our discipline groups with those found in other relevant studies. In our study, both the education and the polytechnic students were found to prefer in descending order the accommodative, the divergent, the convergent and, last, the assimilative learning styles. Results obtained in another Greek study of Andreou et al. (2006) showed that the education students' major preference was for the divergent style; this partially agrees to what we found, as our education students' preference for the divergent learning style was also high and close to their major preference. Regarding the polytechnic students in the Andreou et al. study (2006), however, their major preference was found to be for the convergent learning style, while this, in our findings, was one of the least preferred styles by the specific discipline group. The picture regarding students' learning profiles gets even more obscured when relevant international studies are considered, as they also vary in the reported results. For example, a number of studies have shown that the education students prefer mainly the divergent or the assimilative learning style (Kolb, 1995; Kruzich et al., 1986; Willcoxson & Prosser, 1996), a finding that is consistent with the result obtained in the Andreou et al. (2006) study but not with ours. In other studies, the polytechnic students were found to prefer the convergent learning style (Katz, 1988; Reading-Brown & Hayden, 1989; Willcoxson & Prosser,

1996), a finding which stands in stark contrast with our results. Finally, other studies have also shown incongruent learning style profiles of groups of students from other disciplines. For example, in the social sciences, some studies reported the accommodative learning style as the students' major preference (Kruzich et al., 1986; Wilson, 1986), others reported the assimilative and the divergent (Jones et al., 2003), while in one study (Tsang, 1993) social work students were found to shift from starting as accommodators in the first year of their studies, to becoming assimilators at the end of the same year, and to finishing as convergers their second year. In a number of studies in science students, findings are even more complicated: some reported the convergent style as their major preference (Katz, 1988; Reading-Brown & Hayden, 1989; Willcoxon & Prosser, 1996), others the accommodative and the divergent (Andreou et al., 2006) and, finally, others the assimilative and the convergent (Jones et al., 2003). This blurred picture leads to the conclusion that convergent validity of the LSI cannot be supported, since data collected from various samples of the same discipline with the LSI do not present similar learning style preferences.

In conclusion, although Kolb's theory of learning styles is well grounded and comprehensive, it lacks empirical rigor (Garner, 2000). Our study adds to the existed research concerning Kolb's work on learning styles measurement in a critical, evaluative manner. Although a considerable number of studies refer to the LSI as an adequate measurement, most of them use the learning modes to highlight the different approaches to learning and the different stages within the learning process (Kruzich et al., 1986; Nulty & Barrett, 1996). It is argued that Kolb's learning cycle has a positive role to play in informing or differentiating students about the learning processes, which is accomplished by the learning modes measurement (Garner, 2000). However, when research aims to assign students to learning styles (pairing the learning modes in the way described by the theory) and associate those with individual differences such as gender, discipline, career choice, age and expertise, psychometric problems and inconsistencies arise, such as those revealed in the present study regarding construct, discriminant and convergent validity.

Reliability and Validity of Felder & Soleman's ILS

Felder and Silverman (1988) have proposed an empirically based model to describe learning style preferences. Having started with the engineering students, Felder later on focused his attention to various discipline students and faculty groups with the aim of formulating teaching approaches that address the learning needs of different groups of students in a satisfactory way (Felder & Brent, 2005).

Consistent with all the relevant studies (Felder & Spurlin, 2005; Livesay et al. 2002; Seery, Gaughran, & Waldmann, 2003; van Zwanenberg et al., 2000; Zywno, 2003), our findings revealed that the ILS scales have moderate to low reliability indices (Hypothesis 1b). Although it is suggested that for attitude-assessing instruments an alpha of at least 0.5 is an acceptable criterion (Tuckman, 1999), the weak internal consistency reliability of the ILS still needs to improve in order to be adequate for measuring learning styles preferences. As Litzinger et al. (2005) proposed, a possible solution may reside in the elimination of the weakest item(s) in each scale, which in their study improved the scale reliability indices up to 0.04 units. Evidently, there is a need for a refinement of the ILS that, taking into consideration the research evidence, will attempt to overcome the weak reliability of the instrument.

In the next step, the examination of the construct validity of the ILS revealed that a four-factor model fitted the data best. Although our results did not confirm the five-factor or the eight-factor models found in other studies (Litzinger et al., 2005; Zywno, 2003), in our model each factor related well to one of the learning style scales (the active-reflective, the sensing-intuitive, the visual-verbal and the sequential-global). This model supports a claim of construct validity of the ILS in the Greek sample.

To discuss the validity issues in the ILS, the following data need to be considered. First, inspection of the participants' learning style profiles revealed that they were in average sensing (M = 6.87), visual (M = 6.86), and sequential (M = 6.22) learners rather than intuitive (M = 4.17) and verbal (M = 4.15). The same profile was obtained in another Greek study (Platsidou & Zagora, 2006) of 136 education, business and finance students; they were mostly visual (M = 7.24), sensing (M = 6.96), and sequential (M = 5.82) learners rather than intuitive (M = 4.04) and verbal (M = 3.76). Second, the effect of discipline must be considered, as the present study revealed some significant differences in two of the four learning style scales. Specifically, the polytechnic students were found to have a stronger preference for the active and the visual learning style than the psychology students. Also, the in-service teachers were found to be more visual than the psychology students. To our knowledge, no cited data exist regarding the learning style preferences (measured with the ILS) of teachers or psychology and primary education students, therefore we are not able to further elaborate on the specific discipline results. However, previous research in various disciplines has shown that preferences of engineering students differed from

preferences of students of other fields of study (such as humanities and science) (see Kuri & Truzzi, 2002 and Lopez, 2002 as cited in Felder & Spurling, 2005). These results evidenced satisfactory discriminant validity in student and faculty groups (Felder & Brent, 2005; Felder & Spurlin, 2005). On the other hand, in the present study, no significant differences were found in the same discipline groups, the teachers and the education students, contrary to what was expected due to age and expertise (Felder & Brent, 2005) and to what was found in previous studies (e.g., Rosati, 1996 as cited in Felder & Spurlin, 2005). It is concluded that our study offers a limited support to the discriminant validity of the ILS in the Greek sample.

As in the case of the LSI, convergent construct validity of the ILS was checked by comparing the learning style profiles of our engineering students with those obtained in previous studies (as noted above, no data exist for the other discipline groups). Data from different studies (Felder & Spurling, 2005; Kuri & Truzzi, 2002) have shown that the engineering and the polytechnic students reported similar learning style preferences: their major preference was for the visual learning style and their minor was for the sequential. The same highest and lowest preferences were found in our polytechnic students. This highly consistent evidence supports a claim of convergent construct validity of the ILS.

Conclusion

The present study has shown that there are psychometric weaknesses and limitations in both inventories. It is hoped that the ongoing research on these inventories will improve their weak points. Nevertheless, consistent to what the relevant literature review and research evidence has shown, the learning style inventories can be used as a tool to encourage self-development of an individual within a discipline group and not as a tool for grouping them according to given learning styles (Coffield et al., 2004; Rayner, 2007).

A great amount of the criticism and the dispute regarding the application of the learning style models in teaching is related to the inappropriate use of learning styles to label students and then to recommend pedagogic strategies that supposedly match their profiles (e.g., Coffield et al., 2004; Garner, 2000). In fact, we agree with this critique; the alleged role of the learning style profiling of a learner as a means to adapt or personalise a learning environment to suit the needs of the learner is quite simplistic and certainly not supported by the research evidence. On the other hand, we also agree with those considering learning styles as a useful tool for supporting communication between student and teacher, encouraging the student to reflect on his/her own learning experience and actively seek different ways in which it can be improved.

As Kozhevnikov (2007) suggests, learning styles represent heuristics that learners use to process information and facilitate learning. Teachers should be aware of the possible drawbacks and selectively use learning style models and inventories to support the development of students' self-awareness and metacognitive skills. Knowledge of learning styles can be used to increase the self-awareness of students (and teachers) about the strengths and weaknesses of their own learning and that of others (Melis & Monthienvichienchai, 2004). The potential of such awareness lies in enabling individuals to see and to question their long-held habitual behaviour (Sadler-Smith, 2001). This is surely a considerable improvement on a student who merely "sponges" whatever he/she considers as knowledge from the teacher.

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