The development of a measurement tool to assess Chinese engineering students' self-directed learning abilities

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ABSTRACT: This study reports on the development of a Chinese version of the Personal Responsibility Orientation to Self-Direction in Learning Scale (PRO-SDLS) and on how to construct a valid and reliable measurement by using engineering students as target research subjects. A total of 270 student participants voluntarily completed an on-line survey over a two-week period. The three procedures adopted included translation, a pilot-study and an implementation stage, which were used to develop the Chinese version of the PRO-SDLS. Through factor and reliability analysis, the translated measurement showed strong validity and reliability. The findings indicated that the PRO-SDLS can be applied in different cultural environments and be used to assess accurately engineering students' self-directed learning abilities.

Keywords: Self-directed learning ability, engineering students, factor analysis, measurement development

INTRODUCTION

Self-directed learning ability is one of the skills required for today's fast-changing society [1]. People with a high level of self-directed learning ability must be able to face the phenomenon of half-life knowledge and, then, self-manage the pace of learning to acquire new knowledge [2]. Compared with other academic areas, new concepts and techniques constantly appear in the field of engineering and technology. Whether or not engineering students (future engineers) are equipped with self-directed learning abilities to deal with this cutting-edge field is worthy of further exploration.

In the existing literature, four available psychological measurements can be used to assess students' self-directed learning abilities: Guglielmino's Self-Directed Learning Readiness Scale (SDLRS), Oddi's Continuing Learning Inventory (OCLI), Bartlett and Kotrlik's Inventory of Self Learning (ISL) [3], and Stockdale and Brockett's Personal Responsibility Orientation to Self-Direction in Learning Scale (PRO-SDLS) [4]. The SDLRS, the oldest measurement, was developed in 1970s. The PRO-SDLS, developed in 2010, is the newest instrument to measure self-directed learning ability.

Past studies tended to employ the SDLRS to examine the relationship between engineering students' self-directed learning abilities and learning outcomes. For example, Litzinger et al, and Stewart found that engineering students' self-directed learning abilities positively related to learning performances [5][6]. Although some studies contend that a strong validity and reliability exists in the SDLRS, a *time* issue directly challenges the quality of this measurement [7]. In other words, can the oldest available measurement (1970s) be used for assessing today's (21st Century) students?

The PRO-SDLS developed by Stockdale and Brockett is based on a five-point Likert scale and contains 25 test items. Four constructs, which include initiative, control, self-efficacy and motivation are major variables for this measurement tool. Subsequent studies indicated that the PRO-SDLS is highly valid and reliable [4]. Currently, no Chinese version of the PRO-SDLS has been reported.

Based on the above discussion, this study aimed to develop a Chinese version of the PRO-SDLS and to construct a valid and reliable measurement tool by using the engineering students as the target research subjects. It is expected that the PRO-SDLS could be applied in different cultural environments and be used to assess accurately engineering students' self-directed learning abilities.

RESEARCH METHOD

Research Design

Three adopted procedures were used to develop the Chinese version of the PRO-SDLS:

1. Translation stage: Three experts that specialise in educational culture, adult education and language learning were hired to translate the English version of the PRO-SDLS. Upon completion of the measurement tool's translation, the researcher employed Krippendorff's alpha to verify three translation works. The reliability check showed the alpha coefficient to be 0.9, which demonstrates a high level of agreement (90%) between the experts. Regarding 8% of the disagreement, an experienced professor who specialised in measurement development was hired to double check the controversial parts.
2. Pilot-study stage: In order to confirm the measurement's readability, 20 engineering college students were asked to answer the translated questionnaire. In this stage, some typographical errors and ambiguous meanings in the test items were corrected.
3. Implementation stage: The final version of the Chinese PRO-SDLS was transformed into a Web-based questionnaire by using the Google On-line Survey System. The researcher sent the Web link to the targeted students. The implementation of the on-line survey lasted for two weeks.

Research Subject

Participants were engineering college students at a public university in Taiwan. Convenience sampling was adopted. All students were drawn from the undergraduate courses in the college of engineering. A total of 270 student participants voluntarily completed the on-line survey over a two-week period. The sample size met the requirement of rule 10, which indicates at least 10 cases are needed for each test item (10 x 25=250).

Data Analysis

After data collection, stratified factor analysis was used to test the validity of four constructs in the measurement. Cronbach's alpha was performed to test the internal consistency of the measurement and Pearson product-moment correlation was used to confirm the relationship between four factors.

RESEARCH RESULTS AND DISCUSSION

Descriptive Statistics

Table 1 includes the means, standard deviations, minimum and maximum scores for the Chinese version of the PRO-SDLS. Overall, engineering students’ self-directed learning abilities are moderately strong.

Table 1: Result of descriptive statistic for PRO-SDLS (N = 270).

Factor	Min	Max	Mean	SD
Initiative	9	29	17.62	3.43
Control	8	27	18.73	3.09
Self-efficacy	9	30	19.32	3.43
Motivation	11	33	22.10	3.58

Factor 1: Initiative

Table 2: Result of factor analysis for Factor 1 (N = 270).

Item	Factor 1 loading	Communality
1. Do extra work in a course	0.82	0.68
2. Initiative to learn new things	0.79	0.62
3. Use materials I have found	0.81	0.65
4. Continue to spend time learning	0.79	0.62
5. Collect additional information about interesting topics	0.76	0.58
6. Rely on the instructor to tell me (negative worded item)	0.90	0.99
Eigenvalue = 3.15 Percentage variance = 52.5 KMO & Bartlett’s Test = 0.86 ($p < 0.00$) Cronbach’s alpha = 0.82		

The results of the factor analysis for Factor 1 are summarised in Table 2. The result of KMO and Bartlett's test (0.86; p < 0.00) shows that Factor 1 is appropriate for further factor analysis. Total variance (52.5% > 50%) and eigenvalue (3.15 > 1) for Factor 1 indicate an excellent condition for the original construct (initiative). The reliability coefficient (alpha = 0.82) also indicates strong internal consistency.

Factor 2: Control

The results of factor analysis for Factor 2 are summarised in Table 3. The result of KMO and Bartlett's test (0.72; p < 0.00) shows that Factor 2 is appropriate for further factor analysis. Total variance (62% > 50%) and eigenvalue (2.51 > 1) for Factor 2 indicate a good condition for the original construct (control). The reliability coefficient (alpha = 0.80) also indicates strong internal consistency.

Table 3: Result of factor analysis for Factor 2 (N = 270).

Item	Factor 2 loading	Communality
7. Independently make the changes	0.68	0.49
8. Take responsibility for my own learning	0.83	0.69
9. A problem motivating myself	0.83	0.69
10. Struggle in class (negative worded item)	0.87	0.76
11. Successful at prioritising (negative worded item)	0.84	0.73
12. Effectively organise my study time	0.80	0.64
Eigenvalue = 2.51 Percentage variance = 62 KMO & Bartlett's Test = 0.72 (p < 0.00) Cronbach's alpha = 0.80		

Factor 3: Self-efficacy

The results of factor analysis for Factor 3 are summarised in Table 4. The result of KMO and Bartlett's test (0.73; p < 0.00) shows that Factor 3 is appropriate for further factor analysis. Total variance (75% > 50%) and eigenvalue (2.67 > 1) for Factor 3 indicate an excellent condition for the original construct (self-efficacy). The reliability coefficient (alpha = 0.83) also indicates strong internal consistency.

Table 4: Result of factor analysis for Factor 3 (N = 270).

Item	Factor 3 loading	Communality
13. Confident in my ability	0.84	0.72
14. Confident in my ability to prioritise	0.88	0.78
15. Confident I have the ability to take personal control	0.87	0.78
16. Uncertain about my capacity (negative worded item)	0.84	0.71
17. Unsure about my ability (negative worded item)	0.89	0.80
18. Do not have much confidence (negative worded item)	0.86	0.76
Eigenvalue = 2.67 Percentage variance = 75 KMO & Bartlett's Test = 0.73 (p < 0.00) Cronbach's alpha = 0.83		

Factor 4: Motivation

Table 5: Result of factor analysis for Factor 4 (N = 270).

Item	Factor 4 loading	Communality
19. Do not see any connection (negative worded item)	0.84	0.72
20. Complete most of my college activities	0.87	0.79
21. Really do not know why (negative worded item)	0.86	0.74
22. Do in my courses is personally enjoyable	0.84	0.79
23. The primary reason I complete course requirements	0.84	0.85
24. Do the course activities to avoid guilty (negative worded item)	0.70	0.72
25. Classes are not really personally useful (negative worded item)	0.79	0.73
Eigenvalue = 2.65 Percentage variance = 52 KMO & Bartlett's Test = 0.68 (p < 0.00) Cronbach's alpha = 0.79		

The results of factor analysis for Factor 4 are summarised in Table 5. The result of KMO and Bartlett's test (0.68; $p < 0.00$) shows that Factor 4 is appropriate for further factor analysis. Total variance (52% > 50%) and eigenvalue (2.65 > 1) for Factor 4 indicate a good condition for the original construct (motivation). The reliability coefficient (alpha = 0.79) also indicates strong internal consistency.

Correlation Matrix

Table 6 presents the correlation between four factors in the PRO-SDLS. All factors positively correlated with each other. The correlation coefficients ranged from 0.34 (moderate) to 0.67 (substantial).

Table 6: Results of correlation analysis (N = 270).

Factor	Initiative	Control	Self-efficacy	Motivation
Initiative	1	0.39**	0.35**	0.34**
Control	0.39**	1	0.67**	0.39**
Self-efficacy	0.35**	0.67**	1	0.53**
Motivation	0.34**	0.39**	0.53**	1

**p < 0.01

CONCLUSION

The purpose of this study was to develop a Chinese version of the PRO-SDLS for assessing engineering students' self-directed learning abilities. Through factor and reliability analysis, the translated measurement tool showed strong validity and reliability. In other words, the scale can be applied in a Chinese learning environment. No cultural factors were involved in the measurement. Future studies can adopt this psychological scale to explore other issues related to self-directed learning.

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BIOGRAPHY

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