Development and validation of a scale to measure the engineering self efficacy for engineering students

Seung Hee Kang Korea[1], Jinyoung Lee Korea[2], Yeon Won Lee Korea[3]

[1~3] Innovation Center for Engineering Education, Pukyong University, Korea

sheekang@pknu.ac.kr[1], nouvelle02@pknu.ac.kr[2]
ywlee@pknu.ac.kr[3]

Abstract

There is a little research identifying engineering students' self-efficacy. This study outlined the development of an engineering self-efficacy scale for engineering students and validated the scale. Self-efficacy is typically viewed as task-specific. Bandura also discussed the concept at a domain-linked level and general level.

An initial pool of test items was generated using a variety of resources, including literature reviews. Based on the result of literature review, we developed 33 preliminary items that represented the important components of engineering self-efficacy. After test items were constructed and approved by 3 experts, the scale was administered to 241 engineering students. After confirming the validation of the ESES(engineering self-efficacy scale) to examine the differences among the grades, it was administered to 328 engineering students ranging in grade from 1st to 4th grade.

Exploratory factor analysis of the data provided support for the internal validity and reliability of the scale. It is argued that the scale can be used for both research and applied purposes.

Introduction

Self-efficacy beliefs are the thoughts or ideas people hold about their abilities to perform those tasks necessary to achieve a desired outcome (Bandura, 1986). Self-efficacy can influence people's behaviour either positively or negatively, based on their perception of their abilities concerning a particular task. Bandura (1997) claims that self-efficacy determines the courses of action people choose to pursue, how much effort they put forth in given endeavours, how long they will persevere in the face of obstacles and failures, their resilience to adversity, whether their thought patterns are self-hindering or self-aiding, how much stress and depression they experience in coping with taxing environmental demands, and the level of accomplishments they realize. In fact, a substantial amount of research is available to support these claims(Marra, & Bogue, 2006).

Self-efficacy beliefs are sensitive to contextual factors in that self-efficacy judgements are both more task-and situation-specific, and in that individuals make use of them in reference to some type of a goal(Ponton et al, 2001).

Research has been conducted which evaluates self-efficacy and persistence in engineering (Lent et al, 2003). However, there is little research about engineering self-efficacy in Korea, and the self-efficacy scale test in engineering was not develop in Korea. Therefore, there is a need to develop engineering self-efficacy scale in Korea.

The purpose of this study is to develop the scale of engineering self-efficacy in Korea and examine the validation of the scale.

Participants

The participants of this study were divided in two groups. The first group was to validate the ESES. Participants for validating it include 241 engineering students. To examine the differences between the grades, we administered the ESES to 328 engineering students ranging in grade from 1st grade to 4th grade (1st=81, 2nd=66, 3rd=103, 4th=73). All participating students were at Pukyong National University, enrolled in the spring semester of 2009.

Procedure

The participants of this study were divided in two groups. The first group was to validate the ESES. Participants for validating it include 241 engineering students. To examine the differences between the grades, we administered the ESES to 328 engineering students ranging in grade from 1st grade to 4th grade (1st=81, 2nd=66, 3rd=103, 4th=73). All participating students were at Pukyong National University, enrolled in the spring semester of 2009.

Procedure

This study first examined the literature related to the self-efficacy and engineering education. Based on the literature review, we developed the items about engineering self-efficacy. First we developed 50 items which were examined by 3 experts. After discussion with the experts, we finally developed 33 items.

To examine the validation of this scale, we administered this scale to 241 engineering students. After collecting the data, we analyzed the data by the factor analysis. As a result, the scale was divided 4 factors which were major related to self-efficacy(major se), career related to self-efficacy(career se), teamwork related to self-efficacy(teamwork se), and creativity related to self-efficacy(creativity se).

To examine the usefulness, we administered this scale to 328 engineering students. Using data, we analyzed the differences among the grades (from 1st grade to 4th grade).

Instrument

Engineering self-efficacy scale

To develop the engineering self-efficacy scale, we first examined the related literature, and we found the key components of ESES. Based on the results, we developed 33 items. To assess engineering self-efficacy of engineering students, we administered it to participants. This scale used likert-scale items.

General self-efficacy scale

To examine the concurrent validity of ESES, we administered it to the same participants as the general self-efficacy scale(Cha, 1996), This scale consists of 3 factors which are confidence, self-regulation, and preference to task-difficulties. This scale is assessed using likert-scale items.

Analysis

Factor analysis and multivariate analysis of variance (MANOVA) were used to analyse the data in this study. Statistical analysis was done using SPSS.

Results

Structural validity

The factor structure of the ESES(engineering self efficacy scale) was validated via principal components factor analyses(PCA). Varimax rotation was used in the analysis and the selection criterion was eigen values greater than 1.1. When all 33 items were entered into the PCA, 4 primary factors were identified. The first factor reflected items measuring major knowledge, second factor reflected items measuring career adjustment, third factor reflected items measuring teamwork skill, and the final factor reflected items measuring creativity. Factor ladings are illustrated in table 1. The corresponding variances accounted for by the 4 factors were 50.32%.

Table 1: Principal components analysis of the ESES items

Item	Factor			
	Major se	Career expectation se	Teamwork se	Creativity se
5. I can succeed in my math courses.	.719	.229	.129	.069
19. I prefer major subjects to liberal arts subjects.	.660	.226	.080	.262
22. I can succeed in a project related with major.	.653	.136	.246	.162
27. I think my choice of major was good.	.607	.446	.087	.138
26. I can operate a complex machine by following its manual.	.590	.108	.255	.122
3. When I see a new machine, I am curious to know how it is made.	.556	.068	.106	.179
31. I can complete the physics requirements for most engineering majors.	.545	.394	.150	.314
23. I try to know the current trends of engineering (technology).	.449	.425	.071	.290
24. I can succeed in an engineering curriculum which was given up by many students.	.447	.275	.422	.026
4. I have a clear objective of getting a job after graduation.	.009	.732	.097	.060
2. I picture myself as an engineer in the future.	.255	.723	.101	-.007
14. I have examined the information about the field where I would to work after graduation.	.123	.667	-.006	.190
18. I can understand and define the problems in engineering field.	.186	.581	.212	.179
17. I can adjust the trend changes of my major.	.383	.550	.178	.228
15. I can understand the my role in a team	.069	.530	.333	.393
30. I can do my best to solve the problems in engineering field.	.398	.526	.382	.180
20. I can monitor and improve when doing a project.	.302	.486	.370	.149
10. I can learn the skill requirements for most engineering majors	.481	.484	.334	.010
32. I can consider the limited condition when I resolve a project.	.308	.396	.383	.382
1. I can cope with my team members.	.330	.072	.716	.017
29. I can ask for help when I have a trouble in working on a project.	.167	.006	.706	.099
28. I can make friends with people from different backgrounds and/or values.	-.117	.261	.683	.281
8. I can help and support my team members when they have a trouble.	.186	.190	.674	.194
13. I can relate to the people around me in my classes.	.359	.193	.672	.021
16. I can persuade them, if they were against my opinion.	.025	.170	.572	.423
21. I can make sure to explain my ideas to other people when I have a speech or discussion.	.278	.178	.532	.326
12. I can analyze problems and find solutions in new situations.	.124	.164	.242	.792
11. I can think of something original, which others did not think about.	.120	.184	.055	.765

6. I like to solve a problem in new ways, even though it takes more time and effort.	.199	.093	.067	.697
7. I can handle a project effectively in unexpected situation.	.157	.216	.156	.673
9. I can find different solutions when I encounter problems.	.331	-.047	.346	.506
25. I always think about other solution even though there are existing answers.	.184	.441	.085	.495
33. I can concentrate upon the task for quite a long time.	.408	.305	.195	.428

Internal reliability

All factors demonstrated good internal reliability. The Cronbach's alpha was .82 for the first factor, .87 for the second factor. .84 for the third factor and .81 for the forth factor respectively. The overall Cronbach's alpha for the 33 item scale was .94 indicating good internal reliability for the scale.

Concurrent reliability

Concurrent validity is demonstrated where a test correlates well with a measure that has previously been validated. The two measures may be for the same construct, or for different, but presumably related, constructs. To investigate the concurrent validity of ESES, we administered more generalized academic self-efficacy scale to the same group participants. A peason's correlation was computed between ESES scores and a score of general academic self-efficacy. The two self-efficacy sores yielded a high positive correlation($r=.77$, $p<.001$).

Grade differences

The analysis of grade differences of the 4 factors of the ESES was performed using MANOVA(table 2). The results showed that there were significant differences between the grade of ESES. So this result showed that this scale can use to assess the degree of engineering self-efficacy of engineering students.

Table 2. Mean scores and standard deviations of the 4 factors.

grade	Major se		Career expectation se		Teamwork se		Creativity se	
	M	SD	M	SD	M	SD	M	SD
1(n=81)	29.47	4.85	32.22	5.30	25.46	4.34	22.56	3.99
2(n=66)	29.45	5.72	34.03	6.50	26.18	4.47	23.06	4.72
3(n=103)	29.73	5.20	33.22	5.50	26.19	3.57	22.63	3.65
4(n=73)	31.08	5.25	35.22	5.63	26.74	4.12	24.34	3.81
Total(n=328)	29.91	5.25	33.58	5.77	26.13	4.08	23.08	4.04

Table 3. Results of MANOVA analysis.

	Multivariate			Univariate		
factor	Wilks' Lamda	F	df	MS	F	df
Major se	.94	1.79*	12	44.39	1.62	2
Career E se				124.23	3.83*	2
Teamwork se				21.49	1.29	2
Creativity se				53.52	3.34*	2

*p<.05

Conclusion

As a result of factor analysis, there are 4 factors as the construct of engineering self-efficacy scale. The first factor reflected items measuring major knowledge, second factor reflected items measuring career adjustment, third factor reflected items measuring teamwork skill, and the final factor reflected items measuring creativity.

And this scale has good good internal reliability and good concurrent validity.

The analysis of grade differences of the 4 factors of the ESES showed that there were significant differences between the grade of ESES.

So this result showed that this scale can use to assess the degree of engineering self-efficacy of engineering students. And this engineering self-efficacy scale can be used as a valid instrument.

References

01. Pajares, F. (1996). Self-efficacy beliefs in academic settings. Review of Educational Research, 66(4), 543-578.
02. Lent, R. W., Brown, S. D., Shmidt, J., Brenner, B., Lyons, H., & Treistman, D. (2003). Relation of contextual supports and barriers to choice behaviour in engineering majors: Test of alternative social cognitive models. Journal of Counseling Psychology, 50(4), 458-465.
03. Besterfield-Scare, M., Moreno, M., Shuman, L. J., & Atman, C. J. (2001). Gender and ethnicity differences in freshmen engineering student attitudes: A cross-institutional study. Journal of Engineering Education, 90(4), 477-489.
04. Shunk, D. H. (1991). Self-efficacy and academic motivation. Educational Psychologist, 26, 207-231.
05. Hutchison, M. A., Follman, D. K., Sumpter, M. A., & Bodner, G. M. (2006). Factors influencing the self-efficacy beliefs of first-year engineering students. Journal of Engineering Education, 95(1), 39-47.
06. Ponton, M.K., Edmister, J. H., Ukeiley, L.S., & Seiner, J. M.(2001). Understanding the role of self-efficacy in engineering education. Journal of Engineering Education, 90(2), 247-251.
07. , Tabachnick, B. G., & Fidell, L. S. (1996). Using multivariate statistics(3rd Ed). New York: HarperCollins Publishers Inc.
08. Cha, J, E.(1996). Development of general self-efficacy, Educational Psychology, 34, 19-31.
09. Marra, R. M., & Bogue, B. (2006). Women engineering students' self efficacy-A longitudinal multi-institution study. Proceedings of the 2006 WEPAN Conference.
10. Lent, R. W. et al. (2005).