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EDUCATION POLICY | RESEARCH ARTICLE

The effectiveness analysis for the education and training of research equipment in South Korea

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Abstract: Professional manpower education and training on research equipment handling are very important for the efficient management, utilization, and operation of research equipment, which in turn is essential for obtaining excellent research results. The government-level efforts to offer such are an essential ingredient of a successful national R&D strategy and are needed for the construction of new and enhancement of the existing national research facility and equipment on a national level. Such education and training program is also needed for human resource development and for the creation of new jobs in the field of science and technology. In this paper, the results of an analysis that was done of the effectiveness of professional manpower education and training on research equipment handling, the first such analysis that was done, are presented and discussed. The policy implications of the analysis results, which have academic originality and value, are also presented. It is expected that the results of this research will help promote professional manpower education and training on research equipment handling and will contribute to the program development for such.

Subjects: Strategic Management; Management Education; Management of Technology; Education Policy

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PUBLIC INTEREST STATEMENT

Professional manpower is essential for the efficient management, utilization, and operation of research equipment, which in turn is needed for the accurate analysis of newly obtained research results in the hope of coming up with excellent research results for the field of science and technology. The government-level efforts to offer such are an essential ingredient of a successful national R&D strategy and are needed for the construction of new and enhancement of the existing national research facility and equipment on a national level. Such education and training program is also needed for human resource development and for the creation of new jobs in the field of science and technology. In this paper, the results of the effectiveness analysis of professional manpower education and training on research equipment handling, and the policy implications of such, are presented and discussed.

Keywords: research equipment; research equipment handling education; research equipment handling training; effectiveness analysis; research equipment engineer; government; science and technology; scientist

1. Introduction

Professional manpower is essential for the efficient management, utilization, and operation of research equipment, which in turn is needed for the accurate analysis of newly obtained research results in the hope of coming up with excellent research results for the field of science and technology. In particular, research equipment engineers are essential because scientists can come up with excellent research results only with their support in terms of efficiently managing, utilizing, and operating the research equipment to be used (Toral, Barrero, Martinez-Torres, Gallardo, & Duran, 2009). In a transformational environment, R&D and integrating teaching and R&D had better circumstances to develop further (Kohtamäki, 2013). The R&D education can boost the national economic growth (Anselin, Varga, & Acs, 2002; Massey, 1990).

In South Korea, research equipment utilization is low because professional manpower education and training on research equipment handling has not been given the emphasis it deserves. The malfunction and breakdown rates of expensive research equipment in universities, as well as the management costs of such have increased as the equipment has been handled by unskilled graduate school students, teaching assistants, and research assistants in the absence of dedicated professional manpower. This poses problems for research equipment investment because it shortens the service life of the research equipment. Also, numerous research equipment units become idle or underutilized and are eventually discarded because the presence of professional manpower to handle them is not determined before introducing them. More importantly, the dearth of skilled professional manpower for handling research equipment is preventing the creation of excellent research results.

In general, research equipment experts are of the opinion that a research equipment engineer ideally should manage and operate only three research equipment at a time and cannot manage and operate more than 10. Moreover, the existing professional manpower cannot be adequately trained due to the absence of professional research equipment engineer education institutes and training programs. Although the existing research institutes have research equipment engineer recruitment plans, they are hard-pressed to come up with a training program or course for research equipment engineers due to the dearth of such professional manpower. Also, the short-term training offered by research institutes cannot fundamentally address the need for professional manpower training for the handling of new research equipment. Thus, the R&D support of scientists is limited due to the absence of a program and curriculum for professional manpower education and training on research equipment handling.

The research equipment engineer manpower level is low basically because of the low wages. Many research equipment engineers who already have such a job opt to leave their jobs mainly for this reason. This weakens the profession and the country's R&D infra (Duggleby et al., 2004). In advanced countries, research equipment engineers make contributions in various areas with regard to research equipment introduction planning, operation, management, etc. Their job is a professional occupation, and their role is systematic. They are also paid well.

In 2008, the National Science and Technology Council (NSTC) of South Korea decided to train and utilize global science and technology talents as part of its Science and Technology Basic Plan 577 strategy. Such decision was made as part of the expansion and implementation of the National Research Facility and Equipment section of the Science and Technology Basic Plan in 2009. The Ministry of Education, Science, and Technology (MEST) of South Korea carried out research equipment engineer recruitment and training expansion in 2011 for R&D job creation in accordance with the national science and technology policy.

In this paper, the importance, appropriateness, and urgency of research equipment engineer education and training are discussed, and the results of a pioneering survey that was conducted among research equipment engineer education and training graduates on the effectiveness of such education and training program are analyzed. The policy implications of such analysis results, which have academic originality and value, are also discussed. It is expected that the results of this research will help promote professional manpower education and training on research equipment handling and will contribute to the program development for such.

2. Effectiveness of education and training

The effectiveness of education and training is a fascinating subject. Keogh and Daley (1983) defined an effective education and training program as one that boosts the organizational productivity by addressing the employees' problems and improving individual achievement. Also, he insisted that the learning contents of the education course should be applicable to the work environment. Miller (1990), on the other hand, defined an effective education and training program as one that causes a positive change in the attitudes and behaviors of the people who underwent it, which translates into the improvement of their job attitudes and performance, as well as their human relationships. Haas (2006), for his part, defined it as one that increases the employees' job satisfaction and morale, as well as the quality and quantity of their job performance. He insisted that the effectiveness of an education and training program could be measured in terms of the changes that transpire in the knowledge, behavior, and reactions of the learners/trainees. The earlier relevant studies suggested education and training transition to boost the effects of education and training. This means that the education and training program participants can apply the knowledge, technologies, and attitude changes that they have obtained from the education and training program that they participated in to their job performance. Therefore, the measure of the attainment of the objectives of the education and training program is the participants' education and training transition as reflected in their job performance. The education and training transition completion can be measured in the behavior evaluation stage or the result evaluation stage. The theory model (education and training input factor → amount of education obtained → transition) includes the education and training design (learning principle, education and training data composition, job relation of education and training), the characteristics of the education contents and training participants (abilities, technologies, motives, characteristics), and the work environment (supervisory support, organizational culture). The amount of education obtained plays the mediational role for transition.

The effect of education and training pertains to the level of immanent and phenomenal changes that occurred as a consequence of the education and training undergone (Abrams & Middleton, 2017; Jimenez, Snchez, McMahon, & Viola, 2016). Satisfaction with the education and training program is a satisfaction index of the education and training participants. Validation of education and training refers to the determination of whether the objectives of the education and training program were attained. This includes the changes that transpired in the education and training participants (Isba, Woolf, & Hanneman, 2017; Rowden, 2005). Noe and Schmitt (1986) reported their research finding that the personal characteristics of the participants and the motivational factor influenced the education and training transition. Further, they developed a model for the relation between the factor and the transition. This model explains that the locus of control influences the responses, careers, job attitudes, expectations, and self-efficacy of the organization members for the technology feedback, and that these in turn influence the education and training program participant's learning motivation. Also, the program participant's personal perception of the work environment influences his or her learning motivation, which in turn influences the degree of his or her learning from the education and training program (Anderson, Ellwood, & Coleman, 2017; Drake & Fumia, 2016). Finally, the program participant's learning leads to education transition through behavior change. Noe and Schmitt's motive-and-effect model for the evaluation of the effectiveness of an education and training program is shown in Figure 1.

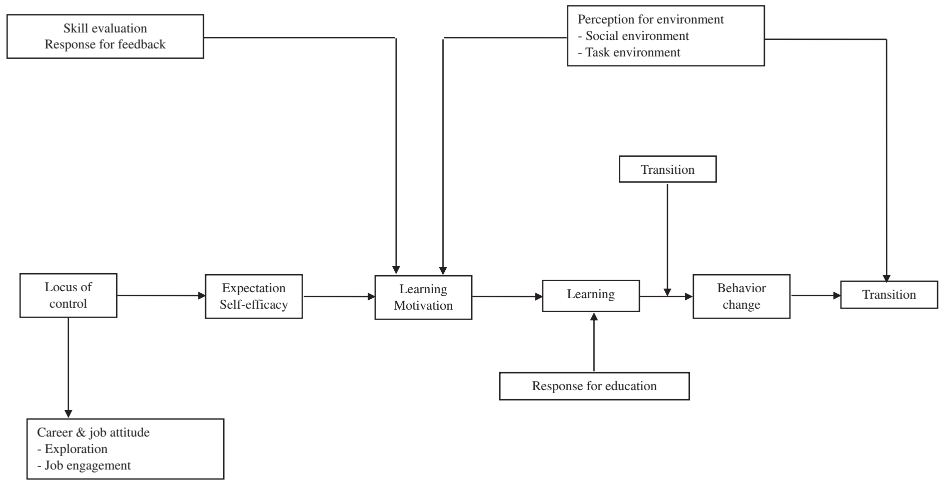

Figure 1. Noe and Schmitt's motive-and-effect model for education performance.

Baldwin and Ford (1988) suggested three training input factors (characteristics of the education and training program participants, education and training program design, and work environment) for learning and transition. The characteristics of the education and training program participants consist of their abilities, technologies, personal characteristics, and motives. The education and training design factors consist of the education and training contents, process, learning principle, etc. The work environment includes the organization's support culture, support from the boss and colleagues, learning technology utilization opportunities, work limitations, etc. The education result is defined as the learning amount and the education result maintenance (Burke, Goldman, Hart, & Hodapp, 2016; Higley, 2017). Baldwin and Ford's transition process model is shown in Figure 2. The education result and education input factor have both direct and indirect effects on learning transition. For the direct effects, the program participant's learning motive, expected result, self-efficacy, and abilities influence his or her work transition (Wiethoff, 2004). As for the indirect effect, the program participant influences his or her learning. The education result and effect factors are classified into the program participant's characteristics, the education and training program design, the situational factors, and the environmental factors (Brinkerhoff, 2005). The program participant's characteristics are his or her abilities, motives, background, attitudes, etc. The education and training program design consists of the lecturer, education contents, process, target establishment, feedback, education method, etc (Alvarez, Salas, & Garofano, 2004; Kraiger, McLinden, & Casper, 2004).

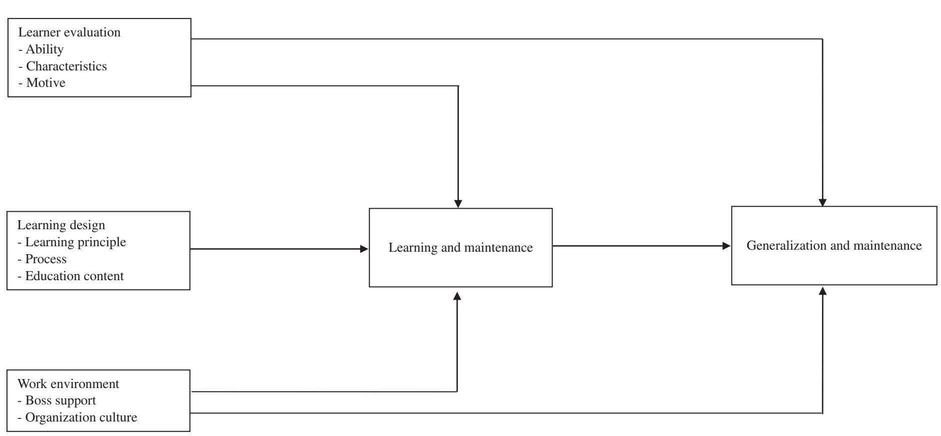

Figure 2. Baldwin and Ford's transition process model.

3. Education and training on research equipment handling

In this paper, an education and training program on research equipment handling is presented and discussed through the evidence from South korea. Education and training on research equipment handling is being offered as part of the research equipment engineer training program. In South Korea, the education and training on research equipment handling is being provided by the government in accordance with Article 23 (Training and Utilization of Human Resources in Science and Technology) and Article 28 (Expansion, Sophistication, Management, and Utilization of Facilities and Equipment for Research and Development) of the Framework Act on Science and Technology, as well as Article 42 (Efforts to Upgrade R&D Facilities and Equipment) of the Enforcement Decree of the Framework Act on Science and Technology.

First, with regard to the concept of "research equipment engineer," in South Korea, the job of a technician is not seen as a specialized job and is not highly regarded because the treatment and image of a technician as professional manpower are not good. The concept of "engineer," on the other hand, is one who has specialized technology knowledge. This is more suitable for the advancement of the status of the professional manpower. The status of the research equipment engineer in the country is lower than that of the professional engineer but higher than that of the technician. The research equipment engineer utilizes and manages the research equipment through the knowledge and technology he or she has acquired from the education and training program on research equipment handling for R&D personnel. The status of the research equipment engineer is described in Table 1. A cooperative network is established, and the education capability is maximized, through the government's selection and management of a research equipment handling education institute that will offer education and training on research equipment handling. Education activities are carried out for professional manpower training. Online support and license systems are needed for education and training management and for the provision of employment support for the education and training of research equipment engineers, and education and training on research equipment handling, as well as a national policy on such are needed for employment promotion and stability. The research equipment education institute assigns one research equipment expert (mentor) to one to three trainees (mentees) for the education and training on research equipment handling. The trainees select a research equipment handling education program from among the three major programs offered, which are listed in Table 2.

Table 1. Scope of research equipment engineer

Classification	Content
Euipment Operator	The manpower can operate research equipment through the manual.
Euipment Technician	The manpower can operate research equipment through short-term education.
Euipment Engineer	The manpower can operate and manage research equipment through professional education, knowledge, and technology.
Euipment Specialists	The manpower can operate, manage, and apply research equipment through advanced knowledge and technology.

Table 2. Three major research equipment education programs

Classification	Core equipment
Scientific analysis equipment education	NMR, (Bio) TEM, FIB, SIMS, XPS/AES, EPMA, ESCA, LC/MS(/MS), MALDI-TOF(/MS), SEM, AFM, SPM, CLSM, HR) XRD, XRF, AMS, ICP (/MS), AAS, DNA Sequencing, TA, GC, LC, HPLC, IC, EA, FT-IR, TOC, FACS, PSA, Mesopore, Image Analyzer, (RT) PCR, UV-Vis Spectometer, etc.
Test and instrumentation equipment education	UTM, VT, DQA, EMC, 3D measuring instrument, fuel substance test analysis instrument, etc.
Production and process equipment education	CNC, SMT, semiconductor production equipment, PCB production equipment, LED device production equipment, etc.

Table 3. Basic and professional education

Classification	Content	Annual education hours	Executing organization
Basic education	Safety education (12 h) Management education (12 h) General research equipment theory education (126 h)	150 (6 h a day)	Operation institute
Professional education	Theory education	50	Government-designated research equipment handling education institute
	Practice education	800	

Table 4. General research equipment education

Contents
Bioassay, atomic absorption, capillary electrophoresis, X-ray, electroanalytical methods, flame emission, flow injection analysis, gas chromatography, hyphenated techniques, immunoassays, infrared, ion chromatography, liquid chromatography, mass spectrometry, NMR, photoluminescence analysis, Raman analysis, surface analysis, structure analysis, UV-Vis-NIR analysis, electron microscopy, isotope analysis, MRI, microanalysis and thin-film analysis

The research equipment handling education is divided into theory education (25%) and practice education (75%), and mentoring, regular training, and career counseling are steadily provided. The details of the basic and professional education programs are shown in Table 3, and the features of the general research equipment handling education are shown in Table 4. The operation institute manages and supports the research equipment handling education institute for the education, training, and employment of research equipment engineers, and the research equipment handling education institute establishes a cooperative network for research equipment handling education cooperation. The institute also designates a research equipment handling education cooperation institute for the education and training of research equipment engineers and experts, and can shoulder the experiment costs, materials, research equipment usage fee, etc.

4. Research method for effectiveness analysis

In this study, the learner characteristics, education and training characteristics, and organizational climate characteristics were selected as the independent variables for the research equipment handling education and training effectiveness analysis. The one-step learning satisfaction, two-step scholastic achievement awareness, and three-step transition awareness were measured using Kirkpatrick's four-stage training evaluation model for the education and training effect measurement. The reaction evaluation measures the learning satisfaction, the learning evaluation measures the scholastic achievement awareness, and the transition evaluation measures the transition awareness, for an objective evaluation. The research design is shown in Figure 3. In this research, 50 research equipment handling education and training graduates were surveyed. The reason for this was that the education and training program was completed recently, and the education program participation period was the same for all the program participants. A total of 50 people completed the research equipment handling education and training program on full government scholarship basis. The survey respondents are described in Table 5. The questions were rechecked, and the Cronbach α was measured for the test tool validity. The independent-variable measurement questionnaire contents are shown in Table 6. The internal-consistency index consisted of the learner characteristics (0.861), the education and training characteristics (0.832), and the organizational climate characteristics (0.829). On the other hand, the dependent-variable measurement questionnaire contents are shown in Table 7. The internal-consistency index consisted of the learner satisfaction (0.883), the scholastic achievement awareness (0.890), and the transition awareness (0.917). The questionnaire contents were selected based

Figure 3. Research design.

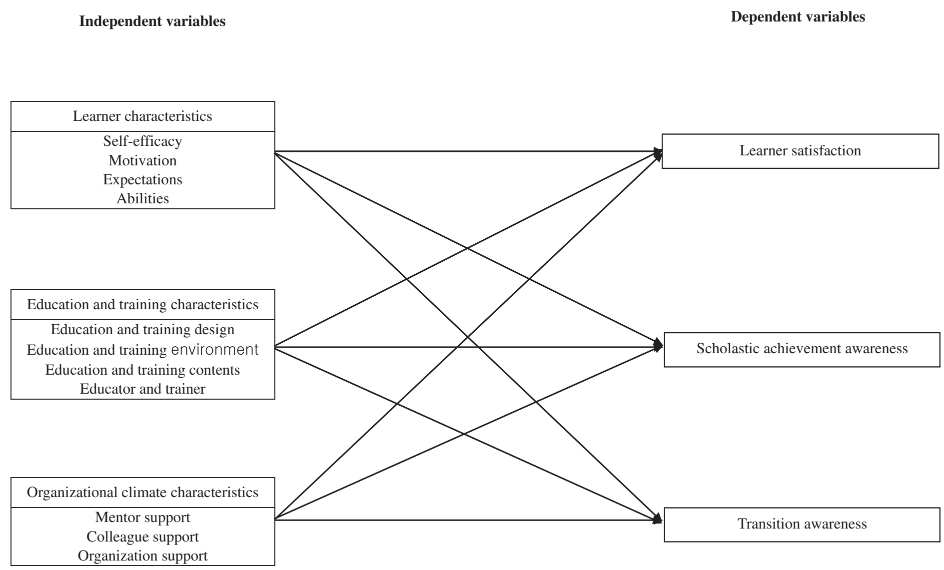

Table 5. Survey respondents

Classification	No. of respondents	Ratio (%)
Men	38	76
Women	12	24
20s	48	96
30s	2	4
College graduate	39	78
Post-college graduate	11	22
Major in natural science	32	64
Major in engineering	10	20
Major in others	8	16

Table 6. Independent-variable measurement questionnaire contents

Independent variable	Dependent variable	Item	Internal-consistency index	
Learner characteristics	Self-efficacy	6	0.861	0.887
	Motivation	5		
	Expectations	5		
	Abilities	7		
Education and training characteristics	Education and training design	5	0.832	
	Education and training environment	3		
	Education and training contents	6		
	Educator and trainer	5		
Organizational climate characteristics	Mentor support	5	0.829	
	Colleague support	5		
	Organization support	7		

Table 7. Dependent-variable measurement questionnaire contents

Dependent variable	Item	Internal-consistency index	
Learner satisfaction	7	0.883	0.861
Scholastic achievement awareness	6	0.890	
Transition awareness	6	0.917	

on Kirkpatrick's evaluation model. The Cronbach α was larger than 0.80 in the reliability test for the consistency measurement of the measurement instrument and the measurement error decrease. The survey respondent data were prepared for the information analysis of the surveyed individuals. The entry and stepwise multiple regression analysis methods were used for the influence verification of the education effect.

5. Research design and analysis results for the research equipment handling education and training

5.1. Influence analysis for learner satisfaction

Among the independent variables, the learner characteristics, education and training characteristics, and organizational climate characteristics were the influence variables. The dependent variable of learner satisfaction was subjected to reaction evaluation. In this study, multiple regression analysis was performed for the regression equation analysis. The influence of learner satisfaction is described in Table 8. The multiple regression analysis result was statistically significant ($F = 81.106$, $p < 0.001$). The results for both the independent and dependent variables were statistically significant. The influence analysis for learner satisfaction for the regression equation coefficient is described in Table 9. Below is the detailed formula.

Table 8. Influence for learner satisfaction

Classification	Sum of squares	Mean square	*F*	Significance probability
Linear regression analysis	28.308	9.906	81.106***	0.000
Residual	16.401	0.117		
Sum	44.709			

***$p < 0.001$.

Table 9. Influence analysis for learner satisfaction

Variable	Non-standardized coefficient		Standardized coefficient	*t*	Significance probability	R^2 adj
	B	Standard error	*β*			
Constant	0.110	0.211		0.401	0.610	0.634
Learner characteristics	0.117	0.091	0.121	1.472	0.149	
Education and training characteristics	0.714	0.080	0.672	10.001***	0.001	
Organizational climate characteristics	0.060	0.051	0.030	0.709	0.351	

***$p < 0.001$.

$Y = 0.110 + 0.117X_1 + 0.814X_2 + 0.060X_3$

Y: Learner satisfaction

X_1: Learner characteristics

X_2: Education and training characteristics

X_3: Organizational climate characteristics

The influence of the learner characteristics, education and training characteristics, and organizational climate characteristics on learner satisfaction was determined to be about 63% (R^2 adj = 0.634), as shown in Table 9. The result for education and training characteristics was statistically significant (t = 10.001, p < 0.001), but that for the learner characteristics was not (t = 1.472, p > 0.001). The result for organizational climate characteristics was also not statistically significant (t = 0.709, p > 0.001). Thus, the education and training characteristics (β = 0.672) was found to have influenced learner satisfaction. Multiple regression analysis was performed for the analysis of the influence of the education and training design, education and training environment, education and training contents, and educator and trainer on learner satisfaction. The influence of the education and training characteristics on learner satisfaction is described in Table 10. The multiple regression analysis result was statistically significant (F = 65.230, p < 0.001). The results for both the independent and dependent variables were statistically significant. The regression equation coefficient for the analysis of the influence of the education and training characteristics on learner satisfaction is described in Table 11. Below is the detailed formula.

Table 10. Learner satisfaction influence for education and training characteristics

Classification	Sum of squares	Mean square	*F*	Significance probability
Linear regression analysis	29.912	7.708	65.230***	0.000
Residual	14.701	0.116		
Sum	43.963			

***p < 0.001.

Table 11. Influence analysis for learner satisfaction of education and training characteristics

Variable	Non-standardized coefficient		Standardized coefficient	*t*	Significance probability	R^2 adj
	B	Standard error	*β*			
Constant	0.435	0.202		1.630	0.112	0.687
Education and training design	0.156	0.071	0.138	1.871	0.083	
Education and training environment	0.387	0.061	0.391	5.679***	0.001	
Education and training contents	0.090	0.080	0.040	1.168	0.191	
Educator and trainer	0.329	0.049	0.334	5.431***	0.003	

***p < 0.001.

$Y = 0.435 + 0.156X_1 + 0.387X_2 + 0.090X_3 + 0.329X_4$

Y: Learner satisfaction

X_1: Education and training design

X_2: Education and training environment

X_3: Education and training content

X_4: Educator and trainer

The influence of the education and training design, education and training environment, education and training contents, and educator and trainer on learner satisfaction was about 69% (R^2adj = 0.687), as shown in Table 11. The result for the education and training environment was statistically significant (t = 5.679, $p < 0.001$), as that for the educator and trainer (t = 5.431, $p < 0.001$). The result for the education and training design, however, was not statistically significant (t = 1.871, $p > 0.001$), as for the education and training contents (t = 1.168, $p > 0.001$). Thus, among the education and training characteristics, the education and training environment and the educator and trainer influenced learner satisfaction.

5.2. Influence analysis for scholastic achievement awareness

Among the independent variables, the learner characteristics, education and training characteristics, and organizational climate characteristics were the influence variables. The dependent variable of scholastic achievement awareness was subjected to reaction evaluation. Multiple regression analysis was performed for the regression equation analysis. The influence factors for scholastic achievement awareness are shown in Table 12. The multiple regression analysis result was statistically significant (F = 41.001, $p < 0.001$). The results for both the independent and dependent variables were statistically significant. The influence analysis for scholastic achievement awareness for the regression equation coefficient is described in Table 13. Below is the detailed formula.

$Y = 0.030 + 0.453X_1 + 0.411X_2 + 0.050X_3$

Y: Scholastic achievement awareness

X_1: Learner characteristics

X_2: Education and training characteristics

X_3: Organizational climate characteristics

Table 12. Influence for scholastic achievement awareness

Classification	Sum of squares	Mean square	F	Significance probability
Linear regression analysis	26.761	7.121	41.001***	0.000
Residual	23.852	0.187		
Sum	47.001			

***$p < 0.001$.

Table 13. Influence analysis for scholastic achievement awareness

Variable	Non-standardized coefficient		Standardized coefficient	*t*	Significance probability	R^2 adj
	B	Standard error	*β*			
Constant	0.030	0.331		0.070	0.900	0.431
Learner characteristics	0.453	0.107	0.392	4.137***	0.004	
Education and training characteristics	0.411	0.090	0.319	1.043	0.003	
Organizational climate characteristics	0.050	0.070	0.065	1.021	0.313	

***$p < 0.001$.

The influence of the learner characteristics, education and training characteristics, and organizational climate characteristics on scholastic achievement awareness was about 43% (R^2 adj = 0.431), as shown in Table 13. The result for the learner characteristics was statistically significant ($t = 4.137$, $p < 0.001$), but that for the education and training characteristics was not ($t = 1.043$, $p > 0.001$), as that for the organizational climate characteristics ($t = 1.021$, $p > 0.001$). Thus, the learner characteristics influenced the scholastic achievement awareness. Multiple regression analysis was performed for the influence analysis of self-efficacy, motivation, expectations, and abilities. The result regarding the influence of the learner characteristics on scholastic achievement awareness is presented in Table 14. The multiple regression analysis result was statistically significant ($F = 20.131$, $p < 0.001$), as were the results for both the independent and dependent variables. The regression equation coefficient analysis of the influence of the learner characteristics on scholastic achievement awareness is shown in Table 15. Below is the detailed formula.

Table 14. Scholastic achievement awareness for the learner characteristics

Classification	Sum of squares	Mean square	F	Significance probability
Linear regression analysis	18.001	4.634	20.131***	0.000
Residual	26.591	0.211		
Sum	43.070			

***$p < 0.001$.

Table 15. Influence analysis for scholastic achievement awareness

Variable	Non-standardized coefficient		Standardized coefficient	*t*	Significance probability	R^2 adj
	B	Standard error	*β*			
Constant	0.556	0.314		1.901	0.004	0.381
Self-efficacy	0.001	0.100	−0.318	−0.351	0.617	
Motivation	0.379	0.123	0.340	2.901**	0.008	
Expectations	0.218	0.108	0.251	2.030*	0.003	
Abilities	0.290	0.114	0.220	2.123*	0.017	

*$p < 0.05$; **$p < 0.01$.

$$Y = 0.317 + 0.235X_1 + 0.171X_2$$

Y: Transition awareness

X_1: Mentor support

X_2: Colleague support

X_3: Organization support

The influence of self-efficacy, motivation, expectations, and abilities was about 38% (R^2 adj = 0.381), as shown in Table 15. The result for motivation was statistically significant (t = 2.901, p < 0.01), as that for expectations (t = 2.030, p < 0.05) and abilities (t = 2.123, p < 0.05). The result for self-efficacy, however, was not statistically significant (t = −0.351, p > 0.05). Thus, among the learner characteristics, the motivation, expectations, and abilities influenced the scholastic achievement awareness.

5.3. Influence analysis for transition awareness

Among the independent variables, the learner characteristics, education and training characteristics, and organizational climate characteristics were the influence variables. The dependent variable of transition awareness was subjected to reaction evaluation. Multiple regression analysis was performed for the regression equation analysis. The influence factors for transition awareness are shown in Table 16. The multiple regression analysis result was statistically significant (F = 31.003, p < 0.001), as were the results for both the independent and dependent variables. The regression equation coefficient for the influence analysis for transition awareness is presented in Table 17. Below is the detailed formula.

Table 16. Influence for transition awareness

Classification	Sum of squares	Mean square	F	Significance probability
Linear regression analysis	23.231	5	31.003***	0.000
Residual	33.400	110		
Sum	58.331	117		

***p < 0.001.

Table 17. Influence analysis for transition awareness

Variable	Non-standardized coefficient		Standardized coefficient	t	Significance probability	R^2 adj
	B	Standard error	β			
Constant	−0.390	0.349		0.001	0.303	0.480
Learner characteristics	0.331	0.101	0.209	0.007	0.012	
Education and training characteristics	0.301	0.121	0.221	0.008	0.011	
Organizational climate characteristics	0.380	0.008	0.310	3.410***	0.001	

***p < 0.001.

$Y = -0.390 + 0.331X_1 + 0.301X_2 + 0.380X_3$

Y: Transition awareness

X_1: Learner characteristics

X_2: Education and training characteristics

X_3: Organizational climate characteristics

The influence of the learner characteristics, education and training characteristics, and organizational climate characteristics on transition awareness was about 48% (R^2 adj = 0.480), as shown in Table 17. The result for the organizational climate characteristics was statistically significant (t = 3.410, p < 0.001), but that for the learner characteristics was not (t = 0.008, p > 0.001), as that for the education and training characteristics (t = 0.007, p > 0.001). Thus, the organizational climate characteristics influenced the transition awareness. Multiple regression analysis was performed for the influence analysis of mentor support, colleague support, and organization support. The influence of the education and training characteristics on transition awareness is described in Table 18. The multiple regression analysis result was statistically significant (F = 23.001, p < 0.001), as were the results of both the independent and dependent variables. The regression equation coefficient for the analysis of the influence of the organizational climate characteristics on the transition awareness is presented in Table 19. Below is the detailed formula.

$Y = 0.556 + 0.001X_1 + 0.379X_2 + 0.218X_3 + 0.290X_4$

Y: Scholastic achievement awareness

X_1: Self - efficacy

Table 18. Transition awareness for the education and training characteristics

Classification	Sum of squares	Mean square	*F*	Significance probability
Linear regression analysis	19.021	5.801	23.001***	0.000
Residual	21.340	0.768		
Sum	43.781			

***p < 0.001.

Table 19. Influence analysis for transition awareness for the organizational climate characteristics

Variable	Non-standardized coefficient		Standardized coefficient	*t*	Significance probability	R^2 adj
	B	Standard error	*β*			
Mentor support	0.317	0.008		0.047**	0.003	0.320
Colleague support	0.235	0.006	0.328	0.106*	0.005	
Organization support	0.171	0.009	0.213	−0.087	0.009	

*p < 0.05; **p < 0.01.

X_2: Motivation

X_3: Expectation

X_4: Ability

The influence of mentor support, colleague support, and organization support was about 32% (R^2 adj = 0.320), as shown in Table 19. The result for mentor support was statistically significant (t = 0.047, p < 0.01), as that for colleague support (t = 0.106, p < 0.05), but that for organization support was not statistically significant (t = −0.087, p > 0.05). Thus, among the organizational climate characteristics, mentor and colleague support influenced the transition awareness.

6. Policy discussion for education and training on research equipment handling

In this paper, the scientific implication can obtain results of correct studies and excellent results through the education and training of research equipment. Researchers can possess both research capability and utilization capability of research equipment to produce improved research result. It can create ideas for the new research method and contribute to the improvement and development of research equipment. The managerial implication can be operated efficiently and without the failure of research equipment, research equipment lifespan can be extended through the education and training of research equipment. In particular, it can contribute to laboratory safety management for the researcher protection through the stable operation of research equipment. Professional manpower education and training on research equipment handling can contribute to effective research equipment operation, R&D efficiency and national research equipment management system improvement, and national competitiveness enhancement. This is because the know-how accumulated by the research equipment handling expert mentors over a long time will be passed on to their mentees through the practice education that they will provide to the latter. This will pave the way for excellent research data analysis and R&D result creation by the country's scientists and researchers because the local professional manpower who have acquired the necessary know-how in research equipment operation from the aforementioned education and training program will support the local scientists and researchers in the research development field by being the ones to manage and operate the research equipment to be used in the researches, allowing the scientists and researchers to concentrate on their researches. In addition, the country's overseas dependence on the introduction of research facilities and equipment can also be lowered because the local professional manpower can contribute to the development of original research technologies and research equipment and their parts. This in turn can contribute to R&D budget loss prevention, national wealth creation, domestic research equipment promotion, etc. The construction of a network of research equipment engineers can also contribute to the research equipment utilization and analysis improvement. Dedicated professional manpower is needed particularly for the large research equipment in the research development field and for the mutual utilization of research equipment, as well as the improvement of the test, analysis, and measurement levels. As mentioned earlier, the professional manpower of research institutes will contribute to the country's R&D activity, which will lead not only to increased R&D productivity but also to the creation of a cyclical structure, such as the recruitment of new research equipment professionals. Global and original research data can be analyzed through the advanced analysis technology equipment. The education and training of research equipment handling experts can also contribute to the development of analytical technologies and equipment. Further, education and training of research equipment handling experts at the national level will lead to the reduction of the investment cost of research equipment manpower education, as well as to increased education investment. It can also create new jobs utilizing retired research equipment and high-career experts. The professional manpower can perform basic research equipment inspection, as well as periodic maintenance and management inspection of all the equipment at the research institutes. This can greatly reduce the operation and maintenance costs of such equipment. Finally, education and training on research equipment handling can contribute to the reduction of the R&D budget and to professionalization through the conduct of a research equipment introduction review by the professional manpower before the purchase of new research equipment.

7. Conclusions

In this paper, the results of the effectiveness analysis of professional manpower education and training on research equipment handling, and the policy implications of such, are presented and discussed. First, the importance and validity of professional manpower education and training on research equipment handling is discussed, along with the status of such education and training program in South Korea. Then the policy implications of the results of the effectiveness analysis of such education and training program are drawn.

In the effectiveness analysis of the education and training program, the learner characteristics, education and training characteristics, and organizational climate characteristics were the influence variables, and learner satisfaction, scholastic achievement awareness, and transition awareness were the dependent variables. The education and training characteristics, particularly the education and training environment and the educator and trainer, were found to influence learner satisfaction. It was also found that an infrastructure environment for education and training on research equipment handling is needed to boost the effectiveness of such program, and that practice education to be given by mentors is needed. As for scholastic achievement awareness, it was found to be influenced by the learner characteristics, particularly the learner's motivation, expectations, and abilities. Job creation, treatment improvement, the certificate system, and an education and training program were also found to be needed to boost the effectiveness of education and training on research equipment handling. Lastly, for transition awareness, it was found to be influenced by the organizational climate characteristics, particularly mentor and colleague support. Here, academic contributions for the promotion and development of education and training on research equipment handling are expected.

Education and training on research equipment handling can contribute to the more effective and efficient operation of research equipment, and to the national research equipment management system. Scientists and researchers can concentrate on their researches because it is the professional manpower who will manage and operate the research equipment that they will use for their researches. This can contribute to the improvement of the country's research result creation and utilization in the field of science and technology.

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References

Abrams, E., & Middleton, M. (2017). Towards multidimensional approaches to research on rural science education. *Cultural Studies of Science Education*, *12*(1), 167–176. doi:10.1007/s11422-016-9748-2

Alvarez, K., Salas, E., & Garofano, C. M. (2004). An integrated model of training evaluation and effectiveness. *Human Resource Development Review*, *3*(4), 385–416. doi:10.1177/1534484304270820

Anderson, L., Ellwood, P., & Coleman, C. (2017). The impactful academic: Relational management education as an intervention for impact. *British Journal of Management*, *28*(1), 14–28. doi:10.1111/bjom.2017.28.issue-1

Anselin, L., Varga, A., & Acs, Z. (2002). Geographical spillovers and university research: A spatial econometric perspective. *Growth Chang*, *31*, 501–515. doi:10.1111/0017-4815.00142

Baldwin, T. T., & Ford, J. K. (1988). Transfer of training: A review and directions for future research. *Personnel Psychology*, *41*(1), 14–28. doi:10.1111/j.1744-6570.1988.tb00632.x

Brinkerhoff, R. O. (2005). The success case method: A strategic evaluation approach to increasing the value and effect of training. *Advances in Developing Human Resources*, *7*(1), 86–101. doi:10.1177/1523422304272172

Burke, M. M., Goldman, S. E., Hart, M. S., & Hodapp, R. M. (2016). Evaluating the efficacy of a special education advocacy training program. *Journal of Policy and Practice in Intellectual Disabilities*, *13*(4), 269–276. doi:10.1111/jppi.2016.13.issue-4

Drake, E. K., & Fumia, D. (2016). Evolution of correctional education evaluations and directions for future research. *Criminology and Public Policy*, *16*(2), 14–28.

Duggleby, J., Jennings, D., Pickering, F., Schmoller, S., Bola, F., Stone, R., & Willis, P. (2004). Innovative practice in the use of ICT in education and training: Learning from the winner. *Education and Training*, *46*(5), 269–277. doi:10.1108/00400910410549850

Haas, M. R. (2006). Acquiring and applying knowledge in transnational team: The roles of cosmopolitans and locals. *Organization Science*, *17*(3), 367–384. doi:10.1287/orsc.1060.0187

Higley, K. A. (2017). Education vs. training: Does it matter? *Health Physics*, *112*(2), 165–171. doi:10.1097/HP.0000000000000622

Isba, R., Woolf, K., & Hanneman, R. (2017). Social network analysis in medical education. *Medical Education*, *51*(1), 81–88. doi:10.1111/medu.13152

Jimenez, T. R., Snchez, B., McMahon, S. D., & Viola, J. (2016). A vision for the future of community psychology education and training. *American Journal of Community Psychology*, *58*(3), 339–347. doi:10.1002/ajcp.12079

Keogh, B. K., & Daley, S. E. (1983). Early identification: One component of comprehensive services for at-risk children. *Topics in Early Childhood Special Education*, *3*(3), 7–16. doi:10.1177/027112148300300304

Kohtamäki, V. (2013). Managing teaching and R&D: Diverging views of managers. *International Journal of Educational Managemanet*, *27*(4), 340–355.

Kraiger, K., McLinden, D., & Casper, W. J. (2004). Collaborative planning for training impact. *Human Resource Management*, *43*(4), 337–351. doi:10.1002/(ISSN)1099-050X

Massey, D. S. (1990). Social structure, household strategies, and the cumulative causation of migration. *Population Index*, *56*, 3–26. doi:10.2307/3644186

Miller, G. (1990). The assessment of clinical skills/competence/performance. *Academic Medicine*, *65*(9), 63–67. doi:10.1097/00001888-199009000-00045

Noe, R. A., & Schmitt, N. (1986). The influence of trainee attitudes on training effectiveness: Test of a model. *Personnel Psychology*, *39*(3), 497–523. doi:10.1111/peps.1986.39.issue-3

Rowden, R. W. (2005). Exploring methods to evaluate the return-on-investment from training. *Business Forum*, *27*(1), 31–36.

Toral, S. L., Barrero, F., Martinez-Torres, M. R., Gallardo, S., & Duran, M. J. (2009). Modeling learner satisfaction in an electronic instrumentation and measurement course using structural equation models. *IEEE Transactions on Education*, *52*(1), 190–199. doi:10.1109/TE.2008.924215

Wiethoff, C. (2004). Motivation to learn and diversity training: Application of the theory of planned behavior. *Human Resource Development Quarterly*, *15*(3), 263–278. doi:10.1002/(ISSN)1532-1096