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The Effects of Safety Training Involving Non-Destructive Testing Among Students at Specialized Vocational High Schools

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ABSTRACT

Background: By examining the safety issues involved in on-site training sessions conducted at specialized vocational high schools, and by analyzing the effects of non-destructive testing (NDT) safety training, this study aims to contribute to ensuring the general safety of high school students.

Materials and Methods: Students who expressed an interest in participation were surveyed regarding current NDT training practices, as well as NDT safety training. A total of 361 students from 4 schools participated in this study; 37.7% (136 students) were from the Seoul metropolitan area and 62.3% (225 students) were from other areas.

Results and Discussion: Of the respondents, 2.2% (8 students) reported having engaged in NDT. As a result of safety training, statistically significant improvements were observed in most areas, except for individuals with previous NDT experience. The areas of improvement included safety awareness, acquisition of knowledge, subjective knowledge levels, objective knowledge levels, and adjustments to existing personal attitudes.

Conclusion: Even at absolutely necessary observation-only training sessions, it is crucial that sufficient safety training and additional safety measures be adequately provided.

Keywords: Safety, Radiation, Student, Non-destructive-testing, Specialized vocational high school, Education

Original Research

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Introduction

Specialized vocational high schools (SVHS) have legal standing as technical high schools (Article 54, Elementary and Secondary Education Act) and were established for vocational skill training purposes. The vocational training offered by SVHS is focused on employment opportunities and provides a space for schools, companies, and society to mutually grow by efficiently distributing manpower.[1)] In the 2010 report, "Learning for Jobs," the Organization for Economic Cooperation and Development emphasized that workplace learning needs to be actively implemented in vocational education and training [1].

According to Van der Veldem et al. (2001), European countries that offer apprenticeship programs show higher youth employment rates [2]. Likewise, workplace learning

[1)] Lee YS. A study on the revision of curriculum of elementary and secondary schools for strengthening professional education of specialized high school. 2013;1-209.

increases one's motivation to learn by linking the content taught at school to hands-on experiences [3]. Moreover, combining learning and working is very effective in streamlining the early stage of the transition from school to the labor market[2].[2)] Thus, workplace learning is a process that provides chances to equip oneself with professional skills and talents required on-site while applying these same skills and talents to real-life situations [4].

Workplace learning programs in Korea usually take place under the premise that students are tentatively hired by their prospective employers after graduation. Therefore, SVHS teachers understand that such programs are effective in improving the employment rate of the school.[3)] Likewise, the workplace learning that occurs when students are dispatched to industrial companies is linked with the students' employment.

Workplace learning is categorized as a subset of industry-academia cooperation that occurs by mutually harmonizing interaction between industry and educational institutions such as SVHS.[4)] Moreover, the content of the job may differ according to the characteristics of the school or region, as well as by the understanding of the relevant personnel connected to the workplace learning program. Moreover, the diverse characteristics of school staff and their experiences can pose a variety of challenges.[5)]

Therefore, a strategy to improve high school workplace learning programs must involve insuring that the work conditions of students are protected and that the connection between the program and employers is reinforced through improving the quality of the program. Moreover, on-site experience and learning in industrial contexts are subject to the legal framework established by the Vocational Education and Training Promotion Act and the Industrial Accident Compensation Insurance Act.

Nonetheless, issues have been consistently raised regarding the adverse effects and fundamental limitations of workplace learning programs. Students are at times exploited as cheap labor, rather than gaining education and knowledge via work experience through such programs. Being students and workers at the same time, students are excluded from various other institutional benefits.[6)] In particular, despite the advantages of workplace learning, additional education programs for managing and protecting the safety of students who are put to work for the purpose of training are currently lacking.

Among various areas of workplace learning, those which involve high radiation exposure, such as non-destructive testing (NDT) areas in the field of radiation use, are regulated under the Nuclear Safety Act (NSA), and participation by students under 18 years old is prohibited. Nonetheless, due to limitations in the management systems of workplace learning programs, students face the risk of being exposed to diverse dangers.

Therefore, in this study, we conducted a survey on the basic state of on-site training relating to NDT in the workplace learning programs implemented at SVHS. To date, such data have been exclusively made available in reports by the Nuclear Safety and Security Commission. In addition, we provided safety education related to NDT as an intervention strategy to improve students' own safety management capabilities. We then analyzed the effects of the intervention in order to take steps towards obtaining evidence supporting the necessity of safe workplace learning.

Materials and Methods

We conducted a survey about the current state of workplace learning programs on NDT and provided safety education on NDT for students in four SVHS that desired to implement safety education with regards to NDT.

The research instruments included lecture materials on NDT safety and a questionnaire. The content of the educational program included the principles of NDT, the necessity of NDT, safety management for NDT, and the NSA. Prior to the educational intervention, students were asked about their awareness of NDT and safety (necessity, safety, information acquisition, and subjective knowledge), objective

[2)] Choi SJ, et al. A study on supporting work and learning in industrial field. Korea Research Institute for Vocational Education and Training. 2013;1-354. http://www.ndsl.kr/ndsl/search/detail/report/reportSearchResultDetail.do?cn=TRKO201600013790.

[3)] Kim ST, et al. Seeking the direction of the training program of functional manpower utilizing the industry-university cooperative education of specialization high school. 2010. 1-325.

[4)] Kang JH, et al. The Strategies for effective management of work-based experience. 1998;1-250. http://www.riss.kr/search/detail/DetailView.do?p_mat_type=d7345961987b50bf&control_no=cdc4bc873f0e4dc5.

[5)] Byun JH, Lee JK, Park YH. Needs analysis of career consultants' job competency in specialized high school. Journal of Employment and Skills Development. 2012;15(3):27-51.

[6)] Korea Research Institute for Vocational Education and Training. Manual for operation of industrial site experience and on-site practice of specialized high schools. KRIVET 2011-53. 2012;1-23. http://www.krivet.re.kr/ku/da/kuBBAVw.jsp?gn=E1-E120130527.

knowledge, and personal attitudes. After the educational intervention, the same students were asked identical questions. Changes in the students' overall awareness, knowledge, and attitudes were analyzed.

The study subjects were 361 students attending SVHS. The schools of 136 students were in the Seoul metropolitan area (37.7%) and the schools of 225 students were outside the Seoul metropolitan area (62.3%). Based on sex, 334 were male (92.5%) and 27 were female (7.5%). According to grade, 89 students were in the 10th grade (24.7%), 210 were in the 11th grade (58.2%), and 62 were in the 12th grade (17.2%).

In the statistical analysis, the frequency and percentage, mean, standard deviation, correlation analysis, *t* test, and regression analysis were utilized.

Results and Discussion

1. Characteristics of SVHS students' choices regarding work and NDT education

What the students of SVHS considered most important when choosing a job (part-time) was: wage (319 respondents, 31.6%), followed by safety (234 respondents, 23.2%), schedule (217 respondents, 21.5%), and enjoyment (204 respondents, 20.2%). Regarding safety checks, 185 students (51.2%) did safety checks on their own, regardless of job type (part-time or full-time), while 71 students (19.7%) did not, and 105 students (29.1%) were uninterested in doing safety checks. Regarding the degree of helpfulness of education after it was provided, more students reported that "it [was] likely to be helpful" (275 respondents, 76.2%) than those who stated that "it [was] not likely to be helpful." (75 respondents, 20.8%).

To examine students' hands-on experience with radiation, they were asked if they had used medical radiation in the past: 41.3% (150 students) had done so, while 25.9% (94 students) had not, and 32.8% (119 students) did not know. Eight students (2.2%) had experience with radiation work (NDT), whereas 259 students (71.7%) did not have such experience and 94 students (26.0%) did not know.

Six students (1.7%) had received an offer of a radiation (NDT)-related job (part-time), while 277 students (76.9%) had not, and 77 students (21.4%) were not sure. When asked if they had been offered a job (part-time) they were not familiar with, 19 students (5.2%) answered yes, 268 students (74.0%) answered no, and 75 students (20.7%) answered that they were not sure.

When asked about their own experiences with regards to medical radiation, experience with NDT work, and the experience of being offered an NDT-related job, 119 students (32.8%), 94 students (26.0%), and 77 students (21.4%), respectively, answered "I am not sure." Based on this finding, it is necessary to provide systems to record or check the specific state of workplace learning to ensure students' safe participation in future programs (Table 1).

2. Changes in awareness, knowledge, and attitudes after NDT safety education

Prior to educational exposure, the level of information acquisition on NDT had the lowest score, and the level of awareness of the necessity of NDT was highest among all other variables. Following educational exposure, scores regarding awareness, knowledge, and attitudes all increased. In particular, the score for attitudes about compliance with the NSA was the highest (4.06 ± 0.97). Levels of awareness regarding the necessity of NDT, safety, information acquisition, and subjective knowledge, all increased following education on the topic in comparison to the pre-education levels.

Van der Linden (2014) reported that not only cognitive factors, but also experiential factors (i.e., emotions and personal experience) and sociocultural factors (i.e., social norms and value orientation) play a role in the recognition of danger [5]. Viewed through the subjects' level of information acquisition, awareness, knowledge, and attitudes toward NDT before education, we can conjecture that students of SVHS may have participated in workplace learning without recognizing the dangers associated with NDT.

Subjects' scores on the 5 items pertaining to objective knowledge (100 full points) all increased after education in comparison to the pre-education level: from 48 ± 0.50 to 73 ± 0.45 on "essence of radiation," from 49 ± 0.50 to 59 ± 0.49 on "characteristics of radiation," from 30 ± 0.46 to 48 ± 0.50 on "radiation safety management," from 41 ± 0.49 to 51 ± 0.50 on "characteristics of NDT," and from 31 ± 0.46 to 37 ± 0.48 on "compliance with the Nuclear Safety Act."

Regarding each of the 5 items pertaining to attitudes (5 full points), answers in agreement with the use of radiation and in agreement with the use of radiation in non-NDT areas both increased after education in comparison to the pre-education level. Regarding the willingness to choose a NDT-related job after graduation, there was no significant change (2.52 ± 1.07 and 2.85 ± 1.13 before and after education, respectively). Regarding compliance with the NSA on the topics of completion of legally mandated safety education,

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Table 1. Respondents' Work Experiences and Attitudes

Item	Response	n (%)
Expectations regarding NDT safety training	Helpful	275 (76.2)
	Not helpful	75 (20.8)
	Other	11 (3.0)
Experience with medical radiation exposure	Yes	150 (41.3)
	No	94 (25.9)
	Unknown	119 (32.8)
Prior NDT work experience	Yes	8 (2.2)
	No	259 (71.7)
	Unknown	94 (26.0)
Potential employment opportunities in NDT-related fields	Yes	6 (1.7)
	No	277 (76.9)
	Unknown	77 (21.4)
Experience with work offers of an unfamiliar nature	Yes	19 (5.2)
	No	268 (74.0)
	Unknown	75 (20.7)
Personality safety check practice	Yes	185 (51.2)
	No	71 (19.7)
	Unknown	105 (29.1)
Priorities at work (multiple choices possible)	Salary	319 (31.6)
	Safety	234 (23.2)
	Work schedule	217 (21.5)
	General interest	204 (20.2)
	Relationships with co-workers	22 (2.2)
	Other	12 (1.2)

NDT, non-destructive testing.

Table 2. Changes in NDT Awareness, Knowledge, and Attitudes after Training

Item		Before training (mean ± SD)	After training (mean ± SD)	[t](p-value)
Awareness	Necessity	3.59 ± 0.99	3.62 ± 1.05	-0.442 (.658)
	Safety	3.02 ± 0.91	3.47 ± 0.91	-6.701 (.000)
	Acquisition of knowledge	2.12 ± 1.04	3.03 ± 0.89	-12.726 (.000)
	Subjective knowledge	2.28 ± 0.94	3.02 ± 0.94	-10.640 (.000)
Objective knowledge		2.24 ± 1.76	2.83 ± 1.82	-4.483 (.000)
Attitudes		3.02 ± 0.76	3.23 ± 0.84	-3.503 (.000)
Attitudes toward regulation compliance		-	4.06 ± 0.97	

SD, standard deviation.

health examinations, and the wearing of a personal dosimeter mandated for radiation hazard protection, the attitude scores were highest (4.06 ± 0.97) (Table 2).

3. Correlation coefficients among main variables

Correlation analysis was conducted on the awareness of NDT regarding necessity, safety, information acquisition, subjective knowledge, objective knowledge, and attitudes before education, and it was found that all variables except for objective knowledge showed positive correlations. Students with a higher level of information acquisition about NDT showed higher subjective knowledge scores (0.643). Students who had work experience in the NDT area and had high attitude scores also showed a high level of awareness of the necessity of NDT (0.366). All variables after education showed positive correlations (Table 3).

With regards to workplace training in areas such as NDT, the mere provision of general information can cause changes in students' attitudes. Therefore, information needs to be provided. In the Theory of Planned Behavior (1991), Ajzen asserted that people make use of their information as much as possible before carrying out an action, considering the profits and losses that may be realized considering the consequences of the action [6]. Therefore, as all variables related

Table 3. Correlations between Key Variables

Item		Necessity	Safety	Acquisition of knowledge	Subjective knowledge	Objective knowledge	Attitudes
Before training	Necessity	1					
	Safety	0.363**	1				
	Acquisition of knowledge	0.158**	0.333**	1			
	Subjective knowledge	0.225**	0.316**	0.643**	1		
	Objective knowledge	0.351**	0.077	0.051	0.101	1	
	Attitudes	0.366**	0.330**	0.162**	0.191**	0.253**	1
After training	Necessity	1					
	Safety	0.546**	1				
	Acquisition of knowledge	0.534**	0.340**	1			
	Subjective knowledge	0.540**	0.455**	0.611**	1		
	Objective knowledge	0.466**	0.312**	0.401**	0.404**	1	
	Attitudes	0.598**	0.535**	0.473**	0.522**	0.386**	1

**$p < 0.001$.

to NDT, such as information acquisition, awareness, knowledge, and attitude are correlated, it is necessary to adopt a strategy to improve the levels of all these variables.

4. Differences in awareness, knowledge, and attitudes regarding NDT by subject characteristics

Students who were interested in radiation (NDT) education showed statistically significantly higher scores regarding the necessity of NDT, safety of NDT, objective knowledge, and attitudes compared to students who had no interest in the topic. Students who had experience with medical radiation showed statistically significantly higher scores regarding the necessity of NDT and objective knowledge. Students who had work experience involving radiation (NDT) showed higher levels of NDT information acquisition than those who did not have such experience.

After educational intervention, cluster analysis was conducted to assess subjects' attitudes on compliance with the NSA: students with higher scores regarding attitudes toward compliance with the law showed statistically significantly higher results for all items—the necessity of NDT, the safety of NDT, information acquisition, subjective knowledge, attitudes, and objective knowledge—compared to students with poorer attitudes. Moreover, students with lower scores regarding attitudes toward legal compliance showed low levels of awareness, knowledge, and attitude on all items. Therefore, it is necessary to adopt a strategy to improve students' attitudes towards legal compliance in educational programs (Table 4).

5. Variables influencing attitudes towards NDT

Regression analysis was conducted. The dependent variables were attitudes towards NDT jobs before and after education. The independent variables were the necessity of NDT, the safety of NDT, information acquisition, subjective knowledge, and objective knowledge. The results showed that prior to education, attitudes were most strongly influenced by the perceived safety of NDT, followed by the perceived necessity of NDT and objective knowledge. After the educational intervention, attitudes were most strongly influenced by the perceived necessity of NDT, followed by the safety of NDT and subjective knowledge. In other words, the most dominant influencing factor on the subjects' attitudes changed from awareness of the safety of NDT to awareness of the necessity of NDT after the educational intervention.

Another regression analysis was conducted, in which the dependent variable was attitudes toward compliance with NSA and the independent variables were the necessity of NDT, the safety of NDT, information acquisition, subjective knowledge, objective knowledge, personal attitudes. The results showed that attitudes toward NSA compliance were most strongly influenced by objective knowledge, followed by the perceived necessity of NDT and personal attitudes (Table 5). To improve students' attitudes regarding legal compliance, the provision of basic education to enhance their level of objective knowledge would be highly desirable.

Mere persuasion or communication focusing on providing information will not nurture proper communication avenues on policy issues that are ideological and value-oriented, such as those related to nuclear power [7, 8]. However, awareness about individual risks related to activities such as NDT may be changed through the transfer of knowledge. This is because individuals in general do not have sufficient knowl-

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Table 4. Differences in Levels of NDT Awareness, Knowledge, and Attitudes based on Respondent Characteristics

Item		Mean±SD	t(p)	Mean±SD	t(p)
		Necessity		Safety	
Interest in training	Yes	3.80±0.88	7.662 (0.000)**	3.10±0.88	2.845 (0.005)**
	No	2.93±1.02		2.78±0.95	
Medical experience	Yes	3.77±0.98	2.907 (0.004)**	3.05±0.85	0.288 (0.773)
	No	3.46±0.99		3.02±0.94	
NDT experience	Yes	3.63±1.77	0.062 (0.952)	3.75±1.49	1.387 (0.207)
	No	3.59±0.97		3.02±0.88	
Attitudes toward regulation compliance	High-level group	3.69±0.99	7.303 (0.000)**	3.51±0.87	4.487 (0.000)**
	Low-level group	1.58±0.67		2.33±1.37	
Item		Acquisition of knowledge		Subjective knowledge	
Interest in training	Yes	2.07±1.05	-1.235 (0.219)	2.28±0.95	0.107 (0.915)
	No	2.23±1.00		2.27±0.93	
Medical experience	Yes	2.01±1.07	-1.455 (0.147)	2.31±1.00	0.458 (0.647)
	No	2.18±1.01		2.26±0.90	
NDT Experience	Yes	3.75±1.58	2.991 (0.020)*	3.38±1.60	1.98 (0.088)
	No	2.07±0.99		2.25±0.91	
Attitudes toward regulation compliance	High-level group	3.07±0.86	4.873 (0.000)**	3.07±0.90	5.57 (0.000)**
	Low-level group	1.83±0.94		1.58±1.24	
Item		Objective Knowledge		Attitudes	
Interest in training	Yes	2.52±1.76	6.147 (0.000)**	3.11±0.72	4.596 (0.000)**
	No	1.35±1.42		2.68±0.78	
Medical experience	Yes	2.93±1.63	6.743 (0.000)**	3.10±0.79	1.89 (0.060)
	No	1.72±1.67		2.94±0.72	
NDT Experience	Yes	2.14±2.41	-0.145 (0.885)	3.40±1.48	0.763 (0.470)
	No	2.24±1.75		3.00±0.73	
Attitudes toward regulation compliance	High-level group	2.90±1.80	4.15 (0.000)**	3.27±0.80	5.952 (0.000)**
	Low-level group	0.64±1.03		1.80±0.98	

*p<0.05. **p<0.001.
NDT, non-destructive testing; SD, standard deviation.

edge about science and technology; instead, they depend on emotional awareness based on personal experiences rather than on rational judgments [9].

Conclusion

In this study, a survey on the current state of subjects' NDT work experience was conducted, and education on NDT was provided to 361 students in 4 SVHS. Changes in the subjects' understanding of the necessity of NDT and the safety of NDT, information acquisition, subjective knowledge, objective knowledge, and attitudes toward NDT were analyzed. According to the NSA, those under the age of 18 cannot work in NDT, which involves radiation exposure. However, 2.2% of subjects (8 students) had experience with NDT.

Regarding the job possibilities given to students in SVHS, students considered the wage to be most important, followed by safety and scheduling. Following educational awareness, all variables except for the necessity of NDT—that is, awareness of safety, information acquisition, subjective knowledge, objective knowledge, and attitude—increased to a measureable statistically significant level. Such a finding suggests that even for high school students, education on NDT will be effective.

Students with NDT work experience showed a higher level of information acquisition regarding NDT. Prior to education, there was no correlation among awareness of safety, knowledge, and information. In contrast, following education awareness, the necessity of NDT, the safety of NDT, information acquisition, and knowledge were all correlated.

Among the variables that influence attitudes toward legal compliance—a primary condition for conducting safe actions—objective knowledge on NDT was most influential. Therefore, as some SVHS students had worked in areas of NDT, violating the NSA, there is a need to create educational

Table 5. Variables Affecting Attitudes towards the Safety of NDT

Item	Independent variables	Non-standardized coefficient		Standardized coefficient	*t*	p-value
		B	s.e.	beta		
Safety attitudes before training	(constant)	1.613	0.169		9.559	0.000**
	Necessity	0.157	0.043	0.205	3.693	0.000**
	Safety	0.207	0.046	0.245	4.525	0.000**
	Acquisition of knowledge	-0.003	0.046	-0.004	-0.067	0.947
	Subjective knowledge	0.028	0.051	0.035	0.546	0.585
	Objective knowledge	0.061	0.022	0.145	2.771	0.006**
					F=16.222(.000), R^2=0.193	
Safety attitudes after training	(constant)	0.774	0.150		5.156	0.000**
	Necessity	0.231	0.043	0.288	5.393	0.000**
	Safety	0.227	0.044	0.244	5.183	0.000**
	Acquisition of knowledge	0.104	0.049	0.109	2.133	0.034*
	Subjective knowledge	0.137	0.048	0.155	2.888	0.004**
	Objective knowledge	0.031	0.021	0.067	1.510	0.132
					F=62.281(.000), R^2=0.460	
Attitudes toward regulation compliance after training	(constant)	2.210	0.175		12.632	0.000**
	Necessity	0.240	0.050	0.271	4.779	0.000**
	Safety	-0.039	0.051	-0.038	-0.768	0.443
	Acquisition of knowledge	0.033	0.055	0.031	0.597	0.551
	Subjective knowledge	0.000	0.054	0.000	0.007	0.994
	Objective knowledge	0.210	0.023	0.414	9.053	0.000**
	Attitudes	0.132	0.059	0.120	2.248	0.025*
					F=47.399(.000), R^2=0.439	

Note: The Cronbach alpha for attitude was high before and after safety training surveys. The before-survey value was 0.805 and the after-survey value was 0.887.
s.e., standard error.

environments supportive of NSA compliance. Additionally, schools should provide education or information to improve students' objective knowledge acquisition methods.

Tyler et al. [10] asserted that various circumstances need to be considered in selecting and organizing educational curricula and activities upon developing education programs. Likewise, educational courses which consider the characteristics of workplace learning of SVHS students should be developed. The SVHS workplace learning program manual states that the purpose of the program is for students to adapt knowledge and skills learned at school in the industry worksite and to develop their ability to adjust to the worksite through various work experiences.[7] However, in reality, teachers in these schools emphasize that the program is for students to find jobs before graduation.

This may cause situations in which students cannot be guaranteed either the rights of workers or the rights of students. In particular, when it comes to NDT, due to lack of knowledge, it is possible that students violate the NSA and cannot ensure their own personal safety. Schools naturally prefer workplace education; as such programs are the main mechanism through which they can increase their employment rates. Moreover, despite diverse challenges, the areas where schools can intervene in this process are extremely limited.

Therefore, it is high time to consider how to operate workplace learning programs with concrete checks related to the educational environment. It is necessary to adopt educational intervention strategies that protect students by enabling them to voice their attitudes regarding compliance with the NSA.[8] In doing so, the interpretation of scientific materials may differ in terms of which portion of the material is more heavily weighted or with regards to how individual materials are compiled, although the same materials are used [11, 12]. Thus, it is necessary to design educational programs based on the content relevant to workplace learning, which focuses on students' safety.

[7] Korea Research Institute for Vocational Education and Training. Manual for operation of industrial site experience and on-site practice of specialized high schools. KRIVET 2011-53. 2012;1-23. http://www.krivet.re.kr/ku/da/kuBBAVw.jsp?gn=E1-E120130527.
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