

Analysis of the Curriculum of Departments of Information Security in Universities and Comparison with Industrial Needs in Korea

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Abstract—These days cyber attacks are increasing all over the world, and the national critical infrastructure and information network protection have become important. For this reason, the concentrated investment in information security and bringing-up professional human resource are essential, but there is a shortage of information security workforce in Korea. Currently, departments of information security in Universities make efforts to bring up human resource of information security. On the other hand they have an increasing interest in the curriculum design of information security. So this paper investigates the curriculum of information security in Universities of Korea, and then compare with industrial needs of information security. Through this analysis, we will get implications about curriculum design of information security.

Index Terms—information security, curriculum of information security, industrial needs of information security

I. INTRODUCTION

Last March 20, computer networks of the key broadcasters and banks in Korea were completely paralyzed in what appears to be cyber attacks. And June 25, the websites modulation of South Korea's presidential office, the ruling party and major media companies DDoS attack was turned out to be the work of North Korea. Cyber attacks are becoming larger security threats in the country while the national critical infrastructure and information depending on network. The type of information breach is becoming advanced and diversification. Due to these things cybercrime such as Hacking, Malware Code, DDoS is directly related to national security. For this reason, the concentrated investment in information security and professional human resource are urgent.

However, according to 'Korea Internet & Security Agency (KISA)' conducted in 'The 2012 Survey and Analysis of Information Security Workforce Supply and Demand Outlook', lacking human resource of information security industry is 1,767 in 2013, as many as 3,660 people will be shortage in 2017 [1]. Training institutions for lack of manpower are Universities and Graduate Schools, ITRC (Information Technology

Research Center), private educational institution, KISA etc.

So this paper investigates the curriculum of information security in Universities of Korea and then compare with Industrial needs of information security by using SPSS. Through this analysis, we will be discussed a way to compensate for the lack of the curriculum.

II. RELATED WORKS

Information security curriculum related study began in earnest in the late 1990s. Starting with Chul Kim (2001) [2]'s study about information security curriculum development of Universities, Jeong-Mo Yang (2003) [3], Tae Sung Kim *et al.* (2004) [4], Hyeon-Mi Rha (2003) [5], Jung-Duk Kim and Tae-suk Baek (2011) [6] are representative.

Chul Kim (2001) studied that dealt with general methodology of curriculum development in the field of education, characteristics of Korea and international information security curriculum. Also Undergraduate and graduate information security education curriculum model is proposed [2]. And major in undergraduates ① Law, Management, Administration ② Computer science, Engineering ③ Electrical Engineering ④ Communication Engineering ⑤ Mathematics, Physics suggested by classified [2].

Jeong-Mo Yang (2003), the new and expanded information security-related departments in four-year major Universities and the curriculum are classified to ① Mathematics group ② Electronic Communications group ③ Computer Engineering group ④ Security related field combined ⑤ others [3]. And based on this, he suggested the curriculum model of the future for the field of information security [3].

Tae Sung Kim *et al.* (2004) analyzed the information security education institution with The Korea Education Development Institute for Statistical Yearbook of Education, and classified with Colleges, four-year University, Master Degree, and Doctor Degree [4]. Then expected to supply the information security workforce after graduation using the students data of related department [4].

Hyeon-Mi Rha (2005), in case of Korea, each University professors are leading curriculum development and operation [5]. So she pointed out exist

not information security curriculum organization and operating [5]. In addition, she found that these curriculum of Korea and America curriculum developed in National level collaboration with industry are difference [5].

Jung-Duk Kim and Tae-suk Baek (2011) say that information security professional supply of Universities is regional disparity, and information security professional new supply is not enough to new demand [6].

III. ANALYSIS OF INFORMATION SECURITY CURRICULUM

Currently, departments of information security have been established in College, University, Cyber University and Graduate School or in computer engineering department.

A. Analysis based on the Curriculum

According to status of manpower by the regular curriculum in ‘2012 National Information Security White Paper(KISA)’, as of 2011, 20 departments of information security have been established in Universities [7].

Universities surveyed based on ‘2012 National Information Security White Paper (KISA)’ and new departments of 2013 were selected. Finally Universities that public can read the curriculum were surveyed.

B. Analysis of the Curriculum in Universities

The target of analysis is 18 Universities (Konyang Univ. [8], Kyonggi Univ. [9], Kyungdong Univ. [10], Korea Univ. [11], Gwangju Univ. [12], Far East Univ. [13], Daejeon Univ. [14], Tongmyong Univ. [15], SoonChunHyang Univ. [16], Youngdong Univ. [17], Joongbu Univ. [18], Hoseo Univ. [19], Howon Univ. [20], Seoul Women’s Univ. [21], Seonam Univ. [22], Baekseok Univ. [23], Ajou Univ. [24], Mokpo Univ. [25]) 18 departments and 697 Subject.

- Subject Categorization: This paper divided the curriculum of each University into 12 category with reference Min-Jeong Kim *et al.* (2013) [26] - ① Programing and Computing Security ② Communication Network Security ③ Database Security ④ Attack(Hacking, Malware, etc.) ⑤ Security Control ⑥ Cyber War ⑦ Forensic ⑧ Information Security Theory ⑨ Mathematics and Cryptograph ⑩ Security Management ⑪ Security Law and Policy ⑫ Other.
- And re-classified into four groups - ① Technology and Engineering ② Technical Theory ③ Management and Institution ④ Other [26].
- The ‘Programming and Computing Security’ of entire University information security department curriculum were the highest proportion (42.2%) Table I. In addition, the ‘Technology and Engineering’ made up 70.6% of the curriculum, and adding the ‘Technical Theory’ was 85.1% occupied. On the other hand, the ‘Management and Institution’ was lower than ‘Other’, as a result the proportion was lowest.

TABLE I. ANALYSIS OF THE CURRICULUM IN UNIVERSITY

Group	Subject Categorization	Frequency	Rate (%)	
Technology and Engineering	Programing and Computing Security	294	42.2	70.6
	Communication Network Security	103	14.8	
	Database Security	18	2.6	
	Attack (Hacking, Malware, etc.)	26	3.7	
	Security Control	24	3.4	
	Cyber War	2	0.3	
	Forensic	25	3.6	
Technical Theory	Information Security Theory	44	6.3	14.5
	Mathematics and Cryptograph	57	8.2	
Management and Policy	Security Management	15	2.2	5.6
	Security Law and Policy	24	3.4	
Other	Other	65	9.3	9.3
Total		697	100	100

- Position of Universities of Information Security Department: In this paper, position of department of information security in each University was investigated. If position is not clear, separately summarized on the basis of Degree Table II. 83.3% of all is the ‘Engineering’. If adding the ‘Natural Science’, 94.4% of all is in the ‘Science and Engineering’. Only one department is in the ‘Humanities and Social’.

TABLE II. CLASSIFICATION ACCORDING TO POSITION OF THE DEPARTMENT OF INFORMATION SECURITY

Position	Number	Rate (%)
Engineering	15	83.3
Natural Science	2	11.1
Humanities and Social	1	5.6
Total	18	100

IV. SURVEY RESULTS

A. Survey a Information Security Professionals in the Industry

Needs knowledge of industry was investigated targeting currently security personnel. Survey lists were written by reference to Knowledge and Technology presented by Tae Sung Kim (2010) [27] and curriculum of information security departments. It is separated by 25 kind of security-related knowledge and skills, and used a 5-point scale according to the level of needed.

B. Statistical Analysis Using SPSS

This paper analyzed the survey using SPSS. After factor analysis about survey, through computing each classified mean value was calculated and executed non-parametric correlation analysis between Universities curriculum and survey result.

This paper used the ‘Spearman rank-order correlation coefficient’ and the ‘Kendall’s tau’ for non-parametric correlation coefficient. The ‘Spearman rank-order correlation coefficient’ is $-1 \leq r_s \leq 1$, closer to 1 determined the ranking is similarly, closer to -1 determined the ranking method is opposition [28]. So if ranking is matched completely, the value is 1, and if ranking is opposition completely, the value is -1 [28]. ‘Kendall’s tau τ ’ is calculated from statistics, it is showed how is consistence the order in ranking a series [29].

TABLE III. SURVEY SUBJECT

Man	Women	Research	Reply
29	7	36	36

TABLE IV. INDUSTRY NEEDS – 5-POINT SCALE MEAN VALUE

Subject Categorization	Knowledge (Survey list)	5-point scale mean	mean
Programing and Computing Security	1	3.889	4.090
	2	4.000	
	3	4.444	
	4	4.028	
Communication Network Security	5	4.639	4.139
	6	4.361	
	7	3.417	
Database Security	8	4.056	3.625
	9	3.194	
Attack (Hacking, Malware, etc.)	10	4.083	3.944
	11	3.806	
Security Control	12	4.250	4.250
	13	4.250	
Cyber War	14	3.667	3.667
Forensic	15	3.694	3.694
Information Security Theory	16	4.139	4.139
Mathematics and Cryptograph	17	3.167	2.875
	18	2.583	
Security Management	19	3.611	3.833
	20	4.028	
	21	3.861	
Security Law and Policy	22	3.806	3.785
	23	3.722	
	24	3.639	
	25	3.972	

Universities curriculum and needs knowledge of industry rank is in Table V, Table VI.

TABLE V. RANK OF THE CURRICULUM

Rank	Subject Categorization
1	Programing and Computing
2	Communication Network Security
3	Mathematics and Cryptograph
4	Information Security Theory
5	Attack (Hacking, Malware, etc.)
6	Forensic
7	Security Control
8	Security Law and Policy
9	Database Security
10	Security Management
11	Cyber War

TABLE VI. RANK OF THE INDUSTRY NEEDS

Rank	Subject Categorization
1	Security Control
2	Communication Network Security
3	Information Security Theory
4	Programing and Computing
5	Attack (Hacking, Malware, etc.)
6	Security Management
7	Security Law and Policy
8	Forensic
9	Cyber War
10	Database Security
11	Mathematics and Cryptograph

The results of non-parametric correlation analysis, ‘Kendall’s tau’ between Universities curriculum and needs knowledge of industry is

$$\tau = 0.273$$

$$(p\text{-value} = 0.243)$$

And ‘Spearman rank-order correlation coefficient’ is

$$r_s = 0.382$$

$$(p\text{-value} = 0.247)$$

Therefore the correlation between curriculums and Industry Needs is not statistically significant. In other words, there are significant difference between University curriculum and Industry needs.

TABLE VII. COMPARISON UNIVERSITIES CURRICULUM AND NEEDS OF INDUSTRY

Correlation				
			University	Industry
Kendall's tau	University	Correlation Coefficient	.	.273
		p-value	.	.243
		N	11	11
	Industry	Correlation Coefficient	.273	.
		p-value	.243	.
		N	11	11
Spearman's rho	University	Correlation Coefficient	.	.382
		p-value	.	.247
		N	11	11
	Industry	Correlation Coefficient	.382	.
		p-value	.247	.
		N	11	11

V. RESULT AND CONCLUSION

Results and Discussion include the following:

- The curriculums of information security departments in Universities of Korea focus on the ‘Technology and Engineering’.
- There is a big deviation in Universities between subjects related with ‘Technology’ and ‘Management’.

- Most of the departments of information security belong to 'Engineering'.
- There are significant difference between University curriculum and Industry needs.

To show direction for more information security manpower in the future, this work has investigated the following three research issues.

First, administrative process like a management or system of information security is needed to replenish. Due to the fact that most of the departments of information security are part of the 'Engineering', many subjects are weighted 'Technology and Engineering'. We should recognize that information security is very important not only 'Technology' but also 'Management'. Therefore, replenish of curriculum related with technology and management is required. It is necessary to deal with processes policy or law in this connection. Due to the exist of ISMS(Information Security Management System) certification obligation, from now on more demand for manpower are expected to happen in part of information security consulting in Korea. Proper balance of subjects between technology and management system will lead to significant advances for information security professionals. For this reason, enlarge of curriculum related with 'Management and Institution' in Universities is required.

Second, the 'Technology and Engineering' isn't concentrated in several processes. Various method and the attacks of scale are rising with the progress of cyber space. Emphasizing the importance of response to cyber attacks, educational institution to train information security professionals is need to realize that the importance of the curriculum related to cyber attacks. Make curriculum better which weighted in existing 'Programming and Computing', 'Communication Network' is required. And it is necessary to open subjects related with 'Security Control', 'Cyber War', 'Forensic' etc.

Third, it is necessary to replenish curriculums needed in field work. There is a big difference between needs knowledge and skills for information security professionals in field work and curriculum of information security departments in Universities of Korea as shown in correlation analysis. Especially, there is a big difference between 'Mathematics and Cryptograph'. To reduce the adaptation time for work and be immersed in business it is necessary to expand into subjects what correlate with knowledge of industry needed in case information security manpower put into field work.

In this paper we investigated the curriculum of departments of information security in Universities of Korea. As a result, the curriculums of information security in Universities of Korea focus on the 'Technology and Engineering', and most of departments of information security are in the 'Engineering College'. And there is a big deviation related with subjects of management of technology.

And to check that the curriculums of information security departments in Universities of Korea are how much coincide with industrial needs of information

security, non-parametric statistical analysis are conducted by using SPSS. There is a big difference between the curriculum of information security departments in Universities and industrial demand of information security.

So, we should consider not only 'Technology' but also 'Management' and 'Law and Policy' etc., when designing curriculum of information security departments in Universities.

And, we should know 'Technology' subject is too focused to 'Programming' area, so it is need to make various technology subjects. What is important is that it is necessary to expand into subjects of high industrial needs

Based on this research, we will analysis new established curriculum and trace trend of information security curriculum in the future.

In addition to, we will research about availability and satisfaction of information security curriculum and carry out analysis about the subjects of information security additionally needed in the company.

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