# Educational Requirement Analysis for Information Security Professionals in Korea

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**ABSTRACT**

The IT industry in Korea, having recognized the importance of Information Security (IS), is in pressing need of IS Managers (ISMs) and IS System Developers (ISSDs). Many educational institutions, both universities and training organizations, are developing IS courses to meet this demand. For these educational programs to be successful, their design should address the specific knowledge required by IS professionals. In this paper, the authors first identify and rank the knowledge requirements of IS professionals using a simplified Delphi technique. They then, through refined analysis, come up with two sets of 15 specific educational requirements, one each for ISMs and ISSDs.

**Keywords**: Educational requirement, information security manager, information security system developer, Delphi approach.

## 1. INTRODUCTION

Due to exponentially growing threats of cyber attacks, many organizations in Korea have begun to recognize the importance of information security (Jung 2001). To securely protect assets, many organizations have adopted information security applications and have begun to establish a department specialized in the management of the organization's information security. Since there is an explosion in demand for information security experts, there is a shortage of experienced Information Security personnel (Gil 2001). Specifically, there is a need for ISMs (Information Security Managers), ISSDs (Information Security System Developers), security system operators, and information security system evaluators. In this paper, we consider only ISMs and ISSDs, arguably the most important positions in the information security field.

Due to the inter-disciplinary nature of the information security field, various kinds of related educational fields like computer science, telecommunication systems, mathematics, e-business, management, and law should be included in the curriculum of an information security program (MIC 2001). Identifying the specific educational requirements for information security professionals is critical. However, no analysis of the educational requirements for ISSD professionals in Korea has been undertaken as of yet.

The purpose of this research is to identify the proper educational requirements for information security professionals. In this paper, we define educational requirements as the necessary knowledge and skills required by information security professionals to accomplish their job-related tasks. The results of this research could be used in determining what kinds of knowledge and skills should be included in the curriculum of information security programs. The results could also be used in designing a systematic educational program for information security professionals.

In many organizations, the role of ISMs and that of ISSDs are quite different. ISMs establish the organization's information security programs, as well as the goals, objectives and priorities that support the program and the mission of the organization. ISMs also direct the day-to-day management of the organization's information security program. ISSDs implement technical security on information systems by being familiar with security technology that relates to information systems (Wilson 1998; Wood 1995).

Due to these different job duties, we expect that the educational requirements for these two groups could be different and hence, in this study, the requirements for both ISM and ISSD are considered.

To identify the most important educational requirements for ISMs and ISSDs, we first prepared a full list of 40 requirements that were suggested by a group of information security professionals. Then we followed a simplified Delphi procedure to determine which of these 40 requirements are perceived as most important for the education and training of ISMs or ISSDs. The Delphi approach is a survey technique, widely used in the field of information systems when it is desirable to collect and combine the opinions of many experts, such as information security professionals (Buckley 1995; Niederman 1991; Palvis 1995; Wetherbe 1996). The following three issues are analyzed in this study:

1. What are the fifteen most important educational requirements for ISMs?

2. What are the fifteen most important educational requirements for ISSDs?

3. What are the differences and similarities in the educational requirements for ISMs and ISSDs?

## 2. PREVIOUS RESEARCH

There is little reported research about information security education in Korean research journals. In 2001, C. Kim published "Development of Information Security Educational Courses in Universities" which analyzes the current situation of information security education in a qualitative way and suggests an information security educational curriculum for Korea (Kim 2001). Also in 2001, the government of Korea published a report on the development and utilization of information security professionals (KISA 1999). These studies provided valuable information pertaining to information security education. However, they did not adequately analyze the educational requirement of information security education and did not reflect on the needs of the organizations that will utilize the information security professionals.

## 3. THE CURRENT SITUATION OF INFORMATION SECURITY EDUCATION IN KOREA

To identify the current situation of information security education in Korea, we first surveyed the curricula of information security programs in 11

**Table 1: Curricula Offered by Universities and Industrial educational Centers**

| Courses | Undergraduate School | Graduate School | Industry |
|---|---|---|---|
| Introduction to Information Security | 3 | 4 | 3 |
| Introduction to Cryptography | 3 | 5 | 2 |
| Mathematics for Cryptography | | 6 | |
| Cryptographic Algorithms | | 3 | 1 |
| Information Security Protocols | | 3 | 1 |
| Modern Cryptography | | 3 | |
| Block Cipher Analysis | | 2 | |
| Stream Cipher Analysis | | 2 | |
| PKI (Public Key Infrastructure) | | 3 | 3 |
| Key Management Systems | | 1 | |
| Information Security Theory | | 2 | |
| Hacking and Computer Virus | | 2 | 3 |
| Computer and Network Security | 2 | 7 | 3 |
| Electronic Commerce Security | | 4 | 1 |
| Mobile Telecommunication Security | | 1 | 1 |
| Internet Security | | 3 | 3 |
| Smart Card Security | | 2 | |
| Operating System Security | | 1 | 2 |
| Design of Cipher Chips | | 1 | |
| DB Security | | 1 | |
| Information Security Practice | | 1 | |
| Special Issues in Information Security | | 2 | |
| Information Security Standards | | 2 | |
| Information Security Evaluation | | | 1 |
| Information Security Policy | | 2 | 1 |
| Privacy and Ethics | | | 1 |
| Risk Analysis | | | 1 |
| Information Security Consulting | | | 2 |

graduate schools, 3 undergraduate schools and 3 industrial educational centers (Table 1). At the graduate school level, the information security programs are mainly offered in the schools of information security, information and communications, or computer science. These schools have Ph.D. programs also. At the undergraduate school level, it is mainly the computer science departments that offer information security courses. Among the three industrial education centers, two are private centers, which train system developers and system administrators; and the third, operated by the Korean government, trains its own information security managers and system administrators and the sponsors of information systems evaluation programs.

The aforementioned eleven graduate schools and three undergraduate schools offer a total of seventy-one information security courses. The three industrial education centers offer twenty-nine information security courses. Among these courses, thirty-three of the seventy-one IS courses offered by universities and seven of the twenty-nine IS courses offered by industrial education centers are related to cryptography. The information security education programs in undergraduate schools mainly focus on courses in "cryptography" and "computer and network security". This suggests that information security courses in schools are not offered in a systematic way, but perhaps, depending on the interests of the faculty members of these universities (Kim 2001). The industrial education programs, however, seem to include practical courses like "Introduction to Information Security", "Public Key Infrastructure" and "Application Security".

Through our survey of the curricula of information security programs, we found that independent information security departments do not exist in undergraduate schools. The main reason for this is that there is a lack of faculty members with proper professional backgrounds (Kim 2001). Specialized graduate schools of information security also have few full time faculty members and most of these consist of adjunct faculty.

## 4. RESEARCH METHODOLOGY

Information security professionals may have different individual opinions about the key educational requirements for information security professionals. Obtaining a general consensus from a leading group of information security professionals would help to identify the key educational requirements. The simplified Delphi approach used in the study had four steps:

1. Create a full list of educational requirements.
2. Prepare a questionnaire with a list of 40 requirements.
3. Conduct the survey (ask participants to select top 15 requirements).
4. Analyze survey results.

To identify important educational requirements for information security professionals, we first asked a group of Korean information security professionals (senior researchers in the National Security Research Institute and prominent scholars in Korean universities) to contribute to the creation of a full list of educational requirements. Then a simplified Delphi procedure was used to determine the most important requirements for ISMs or ISSDs. The simplified Delphi approach used in this study followed the steps below:

1) To create a full list of educational requirements, each participant in the professional group was asked to identify and briefly describe ten major educational requirements. Each participant was also asked to contribute a rationale for including each requirement. Ten responses were returned and consolidated into a combined list of requirements and rationales.
2) Based on the list compiled from participants in the professional group, a questionnaire with a list of 40 requirements was prepared. Appendix A shows the full list of requirements. Since researchers and practitioners could have significantly different views, we divided the participants into two respondents' groups. The first one is a researcher group, which is composed of university faculty and researchers

**Table 2: Breakdown of Respondents by Job**

| Position | Number | Percentage (%) |
|---|---|---|
| Faculty in University | 5 | 8.06 |
| Research Manager in Security Institute | 9 | 14.5 |
| Researcher in Security Institute | 14 | 25.5 |
| Security Consultant | 6 | 20.9 |
| Director in Security System Development Company | 5 | 8.06 |
| Developer in Security System Development Company | 7 | 12.7 |
| Security Manager in Government | 9 | 14.5 |
| Total | 55 | 100.0% |

whose interests mainly focus on the theoretical aspects of IS rather than practice. The second one is a practitioner group, which is made up of security consultants, directors, and system developers in information security companies and information security managers in government, whose job duties involve the practical application of IS technology. The breakdown of the respondents by job is given in Table 2. The purpose of dividing the respondents into two respondents' groups is to improve the validity of our survey results.

3) Participants were asked to check fifteen important requirements for ISMs and ISSDs. After checking the requirements, they were asked to rank the requirement from 15 (highest) to 1 (lowest) indicating the importance of each item. The questionnaire was sent to 70 professionals in Korea; 55 professionals returned their answers. The return rate was 78 %.
4) The returned questionnaires were analyzed using the following procedure. First, we selected 25 requirements for ISMs that appeared most frequently in the returned questionnaires. Similarly, we selected 27 requirements for ISSDs. The lists of requirements were sorted by frequency. The scores obtained for each requirement were summed. Based on summed scores and frequency, we obtained 15 requirements for each group of ISMs and ISSDs. By using the summed score, the requirements were ranked. If the summed scores tied, the frequency number was used as the next criterion.

## 5. DISCUSSIONS ON THE EDUCATIONAL REQUIREMENTS FOR ISMS

Table 3 shows the combined opinions of both groups of respondents on the identification and ranking of educational requirements for ISMs. Table 3(a) is the survey result of the researcher group. Table 3(b) is the survey result of the practitioner group. The two tables show that identical items were highly ranked by both groups except for two on each list. The researcher group included "Security audit controls" and "Internet technologies", while the practitioner group added "Coping with hacking" and "Knowledge of information security standards". The collective opinions of the two respondent groups are almost identical, suggesting that the results of our study have relatively high reliability.

There are no surprises in the survey results on the educational requirements for ISMs. The first two requirements, "Establishing information security policy" and "Establishing managerial security measures", are closely related to the roles of senior management and computer security managers in Wilson's research (Wilson 1998). These two requirements reflect the roles and responsibilities of ISMs. The information security manager establishes the organization's computer security program and its overall program goals, objectives and priorities in order to support the mission of the organization (Na 2000; Wilson 1998; Wood 1995, 1993). Ultimately, the responsibility for the success of information security in an organization lies with the information security managers.

The importance of education on system protection, specifically protection from unauthorized hacking, is becoming increasingly recognized. According to the CERTCC-KR (Computer Emergency Response Team Coordination Center – Korea)'s official report, the number of institutions, which were attacked by hackers, reached 5,334 in Korea last year (CERTCC-KR 2001). The educational requirements concerning hacking incidents are "Testing vulnerabilities in information security systems (rank 3$^{rd}$)", "Managing intrusion check and detection (rank 13$^{th}$)", "Handling computer viruses (ranks 15$^{th}$)" in the results of the survey of the researcher group. In the practitioner group, the above-mentioned educational requirements were ranked 7$^{th}$, 10$^{th}$ and 12$^{th}$, respectively.

As the implementation of information security measures increases, the assurance concept of information security system should be stressed (DoD 1996). Three educational requirements for ISMs concerning this concept in this survey -- "Analyzing security environments (6$^{th}$, 3$^{rd}$)", "Risk analysis and assessment (5$^{th}$, 4$^{th}$)" and "Knowledge of security system evaluation (8$^{th}$, 15$^{th}$)" – are ranked in the top 15 requirements suggested by both groups.

Besides the above-mentioned educational requirements, others ranked by both groups include "Acknowledging laws and regulations," "Security audit controls,", and "Designing physical security measures". The survey also shows that ISMs need to be able to understand the basic principles of cryptography.

The rankings of importance of each educational requirement based on the results of the two respondent groups are compared in Figure 1. Although the two respondent groups selected very similar sets of educational requirements, the order in which the items are ranked differs slightly. The researcher group scored the educational requirements related to managerial security more highly; the practitioner group scored educational requirements related to intrusion detection technology more highly.

## 6. DISCUSSIONS ON THE EDUCATIONAL REQUIREMENTS FOR ISSDS

The combined opinion of both groups of respondents on the educational requirements for ISSDs is given in Table 4. The survey results in Table 4(a) and 4(b) show that both researchers and practitioners think "Designing information security systems" and "Analyzing system structures" are the most important items. These two tables also show that identical items have been ranked in the top 15 except for two in each list. The researcher group included "Analyzing security environments" and "Testing vulnerabilities in information security systems", while the practitioner group added "Design and management of the

**Table 3: List of Educational Requirements for Information Security Managers**
**(a) Survey Results of Researcher Group**

| Rank | Educational Requirements | Total Value | No | Percentage (%) |
|---|---|---|---|---|
| 1 | Establishing managerial security measures | 321 | 26 | 93 |
| 2 | Establishing information security policy | 295 | 26 | 93 |
| 3 | Testing vulnerabilities in information security systems | 229 | 22 | 79 |
| 4 | Understanding basic cryptography | 217 | 24 | 86 |
| 5 | Risk analysis and assessment | 214 | 22 | 79 |
| 6 | Analyzing security environments | 205 | 26 | 93 |
| 7 | Acknowledging laws and regulations | 192 | 25 | 89 |
| 8 | Knowledge of security system evaluation | 164 | 18 | 64 |
| 9 | Security audit controls | 157 | 17 | 61 |
| 10 | Designing physical security measures | 156 | 20 | 71 |
| 11 | Managing security education program | 149 | 24 | 86 |
| 12 | Privacy and ethics | 124 | 15 | 54 |
| 13 | Managing intrusion check and detection | 99 | 17 | 53 |
| 14 | Internet technologies | 98 | 17 | 53 |
| 15 | Handling computer viruses | 97 | 14 | 50 |

(Number of total respondents = 28, Total Value = Score Sum, The Highest Score = 15, The Lowest Score = 1, No = Number of respondents who selected the requirement.)

**(b) Survey Results of Practitioner Group**

| Rank | Educational Requirements | Total Value | No | Percentage (%) |
|---|---|---|---|---|
| 1 | Establishing information security policy | 271 | 26 | 96 |
| 2 | Establishing managerial security measures | 246 | 26 | 96 |
| 3 | Analyzing security environments | 238 | 27 | 100 |
| 4 | Risk analysis and assessment | 193 | 21 | 78 |
| 5 | Understanding basic cryptography | 192 | 19 | 85 |
| 6 | Acknowledging laws and regulations | 192 | 23 | 70 |
| 7 | Testing vulnerabilities in information security systems | 170 | 19 | 70 |
| 8 | Designing physical security measures | 163 | 19 | 70 |
| 9 | Coping with hacking | 143 | 22 | 81 |
| 10 | Managing intrusion check and detection | 138 | 18 | 67 |
| 11 | Privacy and ethics | 137 | 17 | 63 |
| 12 | Handling computer viruses | 133 | 18 | 67 |
| 13 | Knowledge of information security standards | 115 | 13 | 48 |
| 14 | Managing security education program | 114 | 20 | 74 |
| 15 | Knowledge of security system evaluation | 111 | 18 | 67 |

(Number of total respondents = 27, Total Value = Score Sum, The Highest Score = 15, The Lowest Score = 1, No = Number of respondents who selected the requirement.)

**Table 4: List of Educational Requirements for Information Security System Developers**
**(a) Survey Result of Researcher Group**

| Rank | Educational Requirements | Total Value | No | Percentage (%) |
|---|---|---|---|---|
| 1 | Designing information security systems | 309 | 27 | 96 |
| 2 | Analyzing system structures | 254 | 25 | 89 |
| 3 | Understanding basic cryptography | 244 | 21 | 75 |
| 4 | Understanding network security protocols | 214 | 26 | 93 |
| 5 | Design and management of key protocols | 187 | 21 | 75 |
| 6 | Understanding network protocols | 182 | 22 | 79 |
| 7 | Testing information security systems | 179 | 22 | 79 |
| 8 | System programming | 178 | 21 | 75 |
| 9 | Designing cipher protocols | 170 | 19 | 68 |
| 10 | Understanding O.S. structure | 170 | 19 | 68 |
| 11 | Ability to apply cryptography | 154 | 17 | 61 |
| 12 | Analyzing security environments | 151 | 19 | 54 |
| 13 | Internet technologies | 117 | 17 | 57 |
| 14 | Testing vulnerabilities in information security systems | 97 | 15 | 43 |
| 15 | Managing intrusion check and detection | 89 | 16 | 46 |

(Number of total respondents = 28, Total Value = Score Sum, The Highest Score = 15, The Lowest Score = 1, No = Number of respondents who selected the requirement.)

**(b) Survey Result of Practitioner Group**

| Rank | Educational Requirements | Total Value | No | Percentage (%) |
|---|---|---|---|---|
| 1 | Analyzing system structures | 264 | 26 | 96 |
| 2 | Designing information security systems | 258 | 26 | 96 |
| 3 | System programming | 251 | 24 | 88 |
| 4 | Understanding basic cryptography | 236 | 22 | 81 |
| 5 | Understanding network protocols | 228 | 25 | 92 |
| 6 | Understanding O.S. structure | 198 | 23 | 85 |
| 7 | Understanding network security protocols | 186 | 22 | 81 |
| 8 | Designing cipher protocols | 179 | 20 | 74 |
| 9 | Ability to apply cryptography | 178 | 21 | 77 |
| 10 | Design of key management protocols | 173 | 23 | 85 |
| 11 | Design and management of cryptography APIs | 154 | 21 | 77 |
| 12 | Testing information security systems | 143 | 21 | 77 |
| 13 | Design and management of cipher chips | 117 | 16 | 59 |
| 14 | Internet technologies | 112 | 14 | 51 |
| 15 | Managing intrusion check and detection | 107 | 18 | 61 |

(Number of total respondents = 27, Total Value = Score Sum, The Highest Score = 15, The Lowest Score = 1, No = Number of respondents who selected the requirement.)

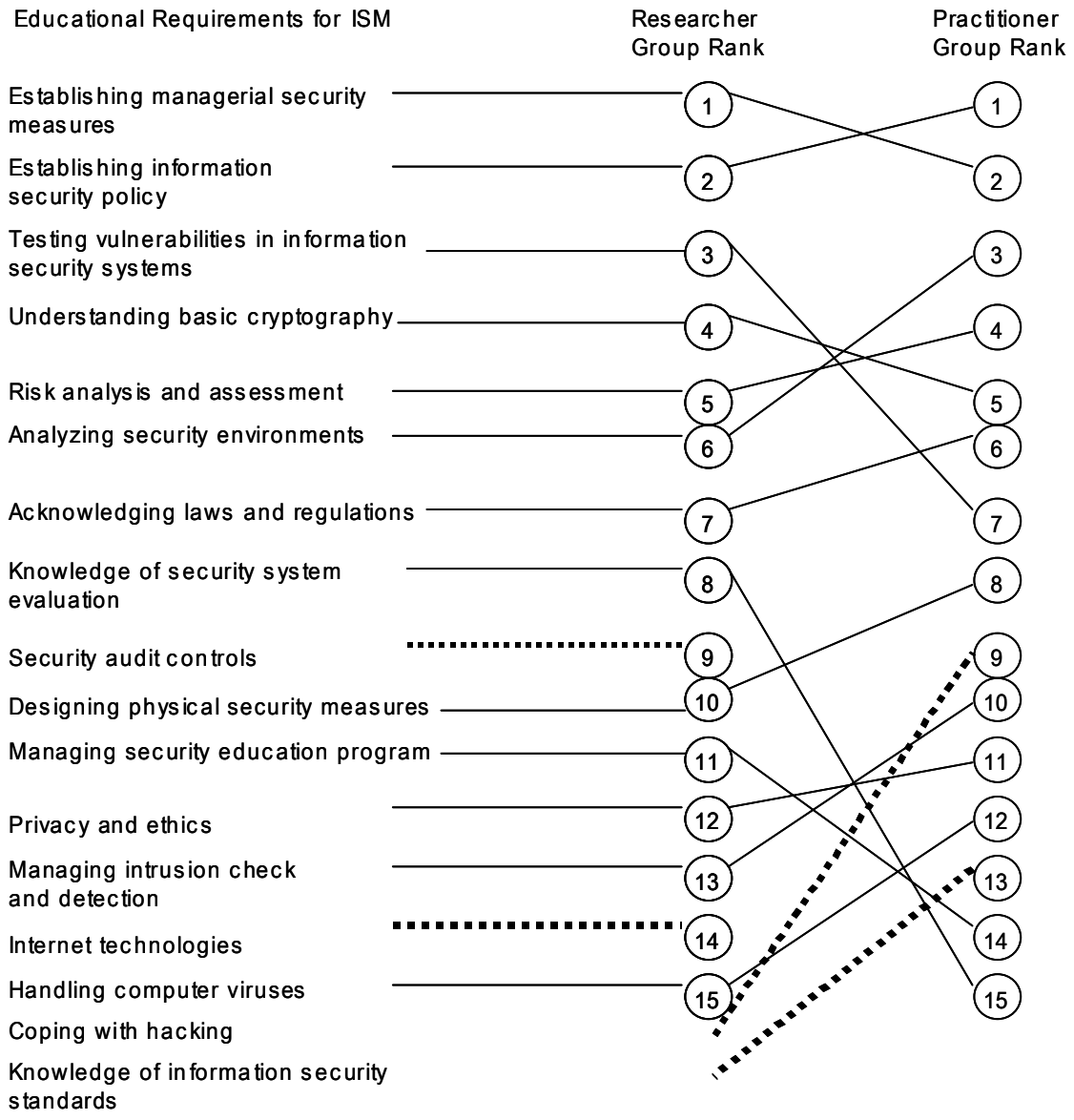


Figure 1. The Rank Differences Between Researcher Group and Practitioner Group for ISM Requirements

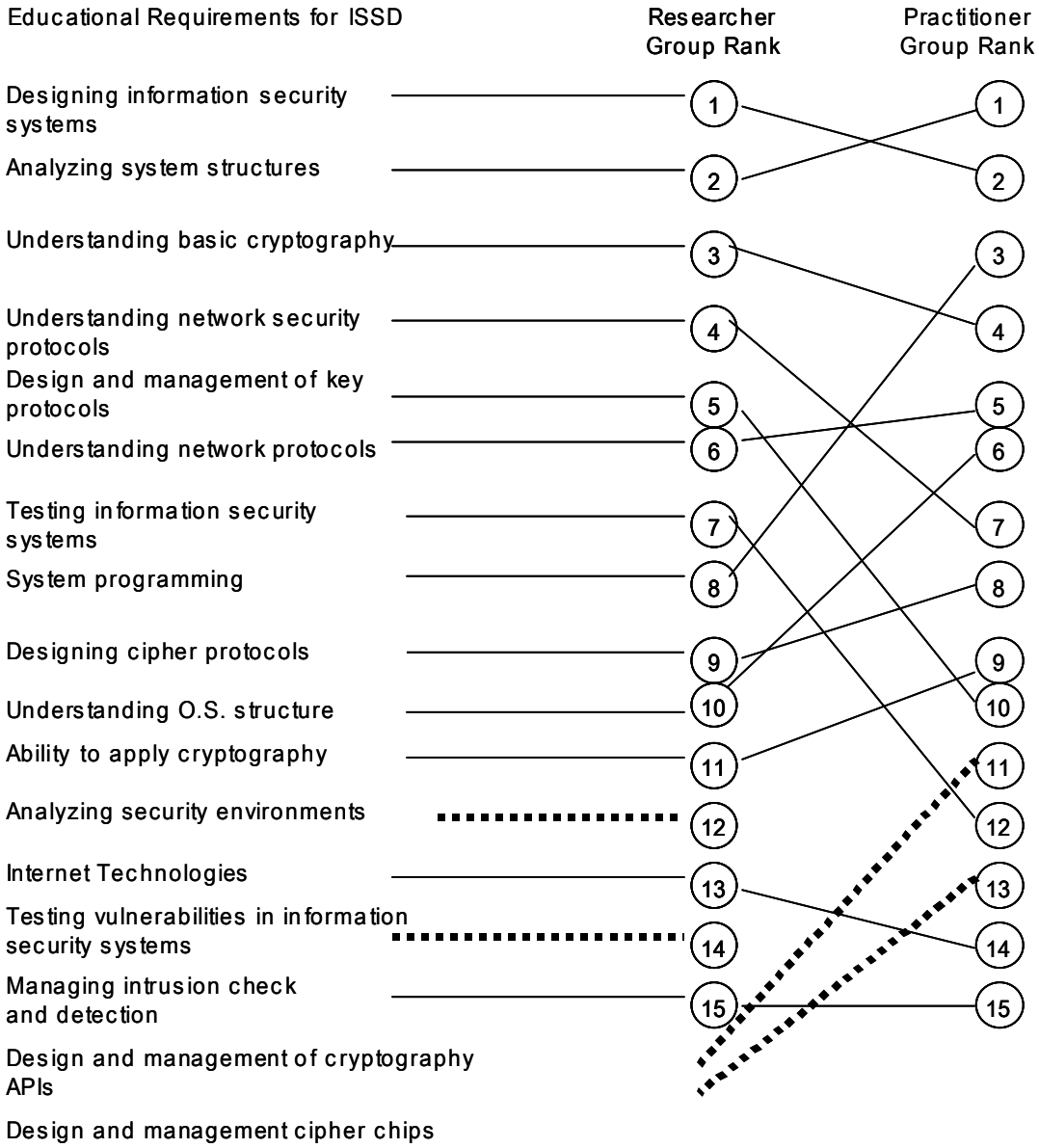


Figure 2. The Rank Difference Between Researcher Group and Practitioner Group for ISSD requirements

cryptography APIs (Application Interfaces)" and "Design and management of cipher chips".

The survey results show that knowledge of the following three kinds of technologies are needed by ISSDs: security technology, information technology, and hacking technology. "Designing information security systems" is ranked as the most important item by the researchers' group and the second most important item by the practitioners' group. Overall, it is the most highly ranked item. Other educational requirements related to security technology, including "Understanding basic cryptography", "Design and management of key protocols" and "Designing cipher protocols," are identified as essential items and ranked highly by both groups of respondents.

Although the importance of "Ability to apply cryptography" is less stressed in this survey, participants pointed out its importance in the rationale section of the questionnaire. The ability to apply cryptography is an essential technology that integrates applications with cryptography (Cooper 1989, Schneier 1993). For the successful development of a crypto system, ISSDs should know the properties of each of application and cryptography and be able to choose the kind of cryptography according to the application.

The practitioners' group pointed out the importance of the cryptography API (Application Interface) and cipher chips. They were ranked 11th and 13th, respectively, in the results of the practitioners' group. These educational requirements reflect current trends in the development of information security systems. An information security system is generally composed of hardware based cipher chips providing security services, application systems, and a cryptography API which bridges the cipher chips and application systems (Baskerville 1993; NIST 1994; Tryfonas 2001). In the information security system development process, an ISSD tends to use cipher chips made by others. Therefore, for the effective development of a security system, the developers should be able to properly manage a cryptography API which bridges cipher chips and application systems.

As with the results pertaining to ISMs, both groups of respondents selected similar sets of requirements for ISSDs but their rankings were quite different. The difference is depicted in Figure 2. While the researchers' group considered the security technologies to be important educational requirements for ISSDs, the practitioners' group considered the information technologies to be more important.

## 7. DIFFERENCES AND SIMILARITIES IN THE EDUCATIONAL REQUIREMENTS FOR ISMS AND ISSDS

If we compare Tables 3 and 4, we can easily recognize that the curricular goals for ISMs and ISSDs are very different in the collective opinions of the two respondent groups. Table 3(a) and 4(a) have only four common items and Tables 3(b) and 4(b) have only two. This indicates that education programs should be structured differently for ISMs and ISSDs. The educational program for ISMs should be designed with an overall understanding of information security technologies and managerial issues. The program for ISSDs should include more basic and technical skills. Based on these findings, we find that current information security education programs in Korea are created mainly to educate ISSDs.

## 8. CONCLUSIONS

The determination of key educational requirements for information security professionals by information security experts is an important contribution to the improvement of information security program development. To reflect professionals' opinions on necessary educational requirements for information security professionals, we identified the educational requirements of information security professionals and asked professionals in the information security industry to rank them. We then divided the respondents into two groups and compared the survey results -- a process which we feel helps to validate the results. We hope these findings can help individuals and organizations educate information security professionals, employ qualified people, and identify essential information security technology.

This research outlined the main differences in the educational requirements for ISMs and ISSDs. As mentioned above, the current information security education in Korea is in some sense biased to a special area within the information security field. The results of this research should prove useful in directing information security education programs in Korea.

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**Appendix A – <Survey Forms for the Educational Requirements>**

Please review items in the table and check 15 important educational requirements for **Information Security Managers, Information Security System Developers**, respectively. In order to validate the result of the survey, the persons asked to respond are divided into two groups, the Research Group, the Practitioner Group. After completing questionnaire, please check your job among the following: Faculty, Research Manager, Researcher, Security Consultant, Director, Developer, and Security Manager in Government. After checking items, score each item in order of importance from 15 to 1 and write down the rationale for checking the item. Remember that **the highest score is 15** and **the lowest score is 1.**

| Educational Requirement | Check | Score | Rationale |
|---|---|---|---|
| Ability to apply cryptography | | | |
| Acknowledging laws and regulations | | | |
| Analyzing security environments | | | |
| Analyzing system structures | | | |
| Coping with hacking | | | |
| Design and management of Cryptography APIs | | | |
| Design and management of key protocols | | | |
| Design and management of cipher chips | | | |
| Designing cipher protocols | | | |
| Designing information security systems | | | |
| Designing physical security measures | | | |
| Establishing information security policy | | | |
| Establishing managerial security measures | | | |
| Handling computer viruses | | | |
| Information security consulting | | | |
| Internet technologies | | | |
| Interpersonal communication skills | | | |
| Knowledge of information security standards | | | |
| Knowledge of security system evaluation | | | |
| Managing certifying agents | | | |
| Managing intrusion check and detection | | | |
| Managing security education program | | | |
| Mobile security technologies | | | |
| Privacy and ethics | | | |
| Risk analysis and assessment | | | |
| Security audit controls | | | |
| Skill to backup, recovery data | | | |
| System programming | | | |
| Telecommunication security | | | |
| Testing vulnerabilities information security systems | | | |
| Testing information security systems | | | |
| Understanding electronic commerce security | | | |
| Understanding mechanisms of DB security | | | |
| Understanding network protocols | | | |
| Understanding O.S. structure | | | |
| Understanding smart card technologies | | | |
| Understanding basic cryptography | | | |
| Understanding cryptography mathematics | | | |
| Understanding network security protocols | | | |
| Understanding information warfare | | | |


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