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Course Articulations Among Establishment Subjects for the R.O.K Naval Academy Based on the Grade Correlation

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Abstract **– Interdisciplinary studies are conducted vigorously in various fields nowadays. To keep place with this trend, it is necessary to educate an integrated study in universities. Thus the analysis of course articulations among the establishment subjects for achieving the educational goal. In order to analyze the articulations, we used the Pearson and Spearman correlation methods among 240 opened subjects in the R.O.K naval academy. We investigated 44,145 grades of total 691 students from the class of 2006 to 2013. We especially focused on correlations among subject of liberal arts, military science (common major) and other majors (selective one). As a result, we derived the articulation ratios are discriminated by each major. Also, there are high articulations between science subjects of liberal arts and science majors, and between science majors and military science. Besides, English subjects of liberal arts are closely relevant only to the English subjects of foreign language major. In addition, we obtained some of the other characteristic results.**

Keywords **– Course Articulation, Curriculum, Grade Correlation, Pearson Correlation Coefficient, R.O.K Naval Academy, Spearman Correlation Coefficient.**

I. INTRODUCTION

A. Purpose

Nowadays, interdisciplinary study is prosperous in most fields such as natural science, engineering, and humanities, and so on. In order to accord the contemporary trend, university educations also need to develop new curriculums in consideration of cross-discipline. For this educational purpose, we are required to investigate articulations among university courses. At present, the curriculums of ROK naval academy allocates that the freshman take courses uniformly regardless of their departments such as sciences or humanities. These freshmen's curriculums consist of Military science (Study of North Korea), Social science & humanities (Korean writing, Korean history, Philosophy, Psychology), Natural science (Calculus, Linear algebra, General physics & experiment, General chemistry & experiment and Introduction of computer science & experiment), foreign language (English translation) and Physical education. These curriculums have a merit that students could experience various area, while they could lose self-confidence and abandon their studies [10]. However, uniform curriculums for the freshmen have the advantage of providing the opportunity to choose a wide variety of majors. In educational psychology, we can verify that the proper prerequisite learning is essential in high level of achievement for the following learning [15]. Nevertheless, the problems mentioned the above could cause excessive stress and psychological anxiety, and it could lead to maladjustment in daily life as well as academic slump [3][14]. In this regard, the difficulties of studying at the beginning of campus life are influential in the whole areas of university life, and it is easy to take a leave of absence or leave school in the majority of cases [4]. This is another reason that we should investigate the course articulations among established subjects of naval academy. In this research, we inferred the articulations among subjects by Pearson and Spearman correlation analysis of grades. This analysis might give information for advancement of the other universities.

B. Major Preceding Research

When we look at previous researches about articulations among subjects in university, there is a research that investigated the articulations among MSC (Mathematics, Science, and Computer) subjects and major subjects [12]. This research has restrictions since the analysis was carried only by the top class students, so the raw data have a little biased.

In addition, there are many researches about relationship between high school and university [2][8]. In this research, they looked forward to which high school subjects are required to effective education in major courses of universities. [8] conducted a survey and calculated the result by focusing frequency count, and checked the perspective difference between groups by F-test. [2] investigated subjects in high school which have a positive effect on successful studies in college, and argued that this requirement should be reflected on high school curriculum.

As narrowing down the field, we can find a research about the academic achievement of science subjects in university depending on completion of elective science subjects in high school [1][7]. [1] required the reconsideration of present uniform science education and the necessity of systematic complement of high school science curriculum. Also, [7] investigated the effect of completion of elective science subject on sense of accomplishment in university science education.

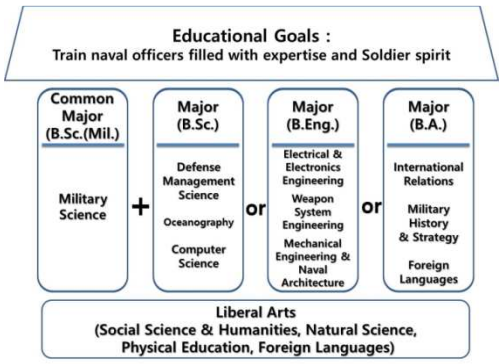

Fig. 1. Conceptual diagram of ROK naval academy Cadet's degree seeking process

Moreover, [11] made an interesting study about the achievement of science subject in university according to depth and breadth of high school science education. This article considered various control variables such as social-economic circumstance, efficiency of English, mathematical ability, prerequisite learning level, and conducted large-scale survey for 8,310 students, in 55 randomly chosen U.S. colleges and universities.

[13] analyzed the effect of course-taking, early academic performance, educational attitudes and behavior in high school on the selection of mathematics or science major in university. This result is helpful to teacher and career advisor.

For readability facilitation of the paper, the list of abbreviations used in this paper is as follows: List of abbreviations.

- Bachelor of Science in Military Science [B.Sc.(Mil.)]
- Bachelor of Science [B.Sc.]
- Bachelor of Engineering [B.Eng.]
- Bachelor of Arts [B.A.]
- Natural Science [Sci.]
- Social Science & Humanities [S&H]
- Foreign Language (Liberal Arts) [F.L.(LA)]
- Physical Education [P.E.]
- Military Science [Mil.]
- Electrical & Electronics Engineering [E&E]
- Mechanical Engineering & Naval Architecture [M&NA]
- Weapon System Engineering [W.S.]
- Defense Management Science [D.M.]
- Oceanography [Oce.]
- Computer Science [Com.]
- International Relations [I.R.]
- Military History & Strategy [MH&S]
- Foreign Language (Major) [F.L.(M)]

II. METHODOLOGY

A. Data Properties

The course articulation is inferred from the grade correlation analysis. In order to analyze the correlation of academic achievement among subjects of the naval academy, we investigated 44,145 grades of total 691 students from the class of 2006 to 2013. The students take essentially military science as the 1st major and choose one of nine general academic majors as the 2nd major.Since the 1st major is the common for every student, the 2nd major functions as the major in other universities. Each major has different number of people as Table 1. Since the number of students for each department is about 10 to 30 in each year, we accumulated the data of the entire 5 year grades (64th to 68th) by subject to extract meaningful statistics. We picked any 2 subjects from the total 240 subjects, and got the correlation of grades between the above 2 subjects. Repeatedly, we calculated every combination of 240 subjects, i.e., 28,680 cases.

To facilitate the analysis of course articulations, we especially focused on the correlation among subjects of liberal arts, military science (common major) and each major. And then, we analyzed the following six results:

- The number of major subjects articulated on each liberal arts subject: Show 22 higher rank subjects per 64 total liberal arts subjects.(Table 4).
- The number of military science major subjects articulated on each liberal art subject: Show 4 higher rank subjects per 64 total liberal arts subjects(Table 5).
- The number of liberal arts subjects articulated on each major subject: Show 19 higher rank subjects per 140 total subjects(Table 6).
- The number of military science subjects articulated on each major subject: Show 20 higher rank subjects per 140 total majors subjects.(Table 7).
- The number of liberal arts subjects articulated on each military science subject: Show 7 higher rank subjects per 36 total military science subjects.(Table 8).
- The number of major subjects articulated on each military science subject: Show 22 higher rank subjects per 36 total military science subjects(Table 9).

Meanwhile, the curriculum of ROK naval academy has the following features:

- The number of students is hardly changed from their admission to graduation. Moreover, almost equivalent information about their courses are provided to them because every student lives in the same dormitory and has virtually the same personal connection and has little time to use internet, and so on. Therefore, almost pure correlation analysis is possible without external factors in ROK naval academy.
- Students are impossible to register the subject that was registered in the past. Also, they could not drop their course during the semester. Eventually, everyone completes a four-year course of study.
- Students are difficult to register subjects of other majors. Thus, indirect factors are excluded to utmost on the correlation between any two subjects.
- Every student should register the courses of military science and liberal arts, and majority of them are requisite.

Table 1 Basic statistical data about majors and opened subjects

Field		The number of opened subject	The number of naval academy students attending class						
			People in all[a]	Constraint number of analysis	64th group	65th group	66th group	67th group	68th group
Liberal Arts (common)	Natural Science	22	-	25[b]	-	-	-		
	Social Science & Humanities	22	-	25[b]	-	-	-	-	-
	Foreign Language (liberal arts)	13	-	25[b]	-	-	-	-	-
	Physical Education	7	-	25[b]	-	-	-	-	-
Major (common)	Military Science	36	691	25[b]	131	139	135	141	145
Major (choose one)	Electrical & Electronic Engineering	24	67	10	14	16	14	13	10
	Weapon System Engineering	11	42	9	-[d]	9	11	11	11
	Mechanical Engineering & Naval Architecture	16	58	9	11	12	9	13	13
	Defense Management Science	18	74	13	13	13	13	18	17
	Oceanography	13	72	12	13	14	14	18	12
	Computer Science	12	75	10	22[e]	14	10	13	16
	International Relations	13	90	16	16	18	19	17	20
	Military History & strategy	11	89	15	20	17	20	15	17
	Foreign Language	22	125	21[c]	22	26	25	23	29
Total		240	691	-	131	139	135	141	145

[a] The total number of students from the class of 2006 to 2013.
[b] Liberal arts and military science(common) set 25 constraint of students for the statistical significance.
[c] The minimum number of foreign language students is 22 for all groups. But for the reason of a studying abroad, the constraint number of students in 21.
[d] The department of weapon system engineering was not existed in the 64th group curriculum.
[e] Department of computing science and that of information & communication science existed in the 64th group curriculum. We combine them to the major of computer science for data analysis since they had similar curriculum.

- Except for little optional courses, the curriculum of every student is fixed every semester. Thus, we can infer the articulations as causal relation between any two courses. In the other universities, since the registration is free depending on personal choice. However, it is difficult to estimate the causal relation of the courses taken.

In calculating correlations, we use grade points to ensure improving the accessibility of data, getting almost identically grade points distributed for each course, and increasing the reliability of grade points. Here, grade points mean numerical values of grades. For example, A+ is 4.3, D- is 0.7, F is 0.0, and so on.

B. Correlation Analysis

During the 8 years of 2006-2013, we used the Pearson correlation coefficient and Spearman correlation coefficient to obtain the articulations among 240 subjects that have been established in the naval academy. Pearson correlation analysis is one of the most widely used methods to measure the linear correlation between two variables X and Y. Spearman correlation coefficient of X′ and Y′ is the Pearson correlation coefficient of X′ and Y′, where X′ and Y′ are the rank of X and Y, respectively.

Pearson correlation coefficient is

$$r_p = \frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{\sqrt{\sum_{i=1}^{n}(X_i - \overline{X})^2}\sqrt{\sum_{i=1}^{n}(Y_i - \overline{Y})^2}} = \frac{1}{n-1}\frac{\sum_{i=1}^{n}(X_i - \overline{X})(Y_i - \overline{Y})}{s_X s_Y}$$

where $\overline{X}, \overline{Y}$ are the sample mean of X and Y, and s_X, s_Y are the sample standard deviation of X and Y.

Note that the coefficient does not stand for whether any one of two variables is caused by the other explicitly. For example, even if there is the positive correlation between the grade of calculus and that of general physics in the first semester, we cannot interpret high grade of calculus causes that of general physics vice versa. In other words, the correlation coefficient between some two courses in an inter-semester does not guarantee their causal relation. On the other hand, the positive correlation coefficient between some two courses in an inter-semester can be regarded as their causal relation. It is reasonable because almost all courses taken are similar sequences in the same major for the naval academy.

Now, Spearman correlation has the following characteristics compared with Pearson correlation.

- While Pearson correlation requires the assumption that the pair of two data X and Y is a bivariate normal distribution, Spearman correlation is a non-parametric statistics irrelevant to the distribution of the pair (Xand Y)[6].
- Spearman correlation coefficient measures the rank correlation between two series data, without requiring the linearity relationship between two data. For instance, while the Pearson correlation coefficient is diversified by the raw data distributions, Spearman correlation coefficient maintains uniform values if the ranks are not changed.

Correlation is an effect magnitude and so we can describe the strength of the correlation using the guidelines that Evans suggests for the absolute value of r [5].

In addition, we require the precondition that correlation coefficient r between each population is not zero to discuss the strength of correlation significantly. Therefore, we implemented the statistical hypothesis test with null hypothesis$\rho = 0$.

Hypothesis test

$$H_0: \rho = 0, H_1: \rho \neq 0$$

Test statistic

$$t_{n-2} = r\sqrt{\frac{n-2}{1-r^2}}$$

which is distributed approximately as Student's t distribution with $n-2$ degrees of freedom under the null hypothesis.

III. RESULT

In ROK naval academy, every student takes all military science courses, while there is no student taking plural major except for the military science. Hence, there is no correlation between any two different major subjects except for some special cases. Therefore, we aimed to analyze the course articulation among liberal arts, military science and each major. In advance, we calculated Pearson and Spearman correlation coefficients of pairs among subjects. In order to ensure the statistical significance of the correlation analysis, we applied the following criterions.

1. The constraint number of students N for analysis: We excluded the pair of subjects if the number of students who took the both subjects is less than some$N$. Therefore, for each major course, N is set to the minimum number among the numbers of each department students during among 64^{th} to 68^{th} groups. The minimum numbers can be found in Table 1.
2. $p\text{-}value \leq 0.05$: We set the 95% significant level to verify the alternative hypothesis $\rho \neq 0$. Here, to easily distinguish, we represented as * in case of $\rho \leq 0.05$, as ** in case of $\rho \leq 0.01$, as *** in case of $\rho \leq 0.001$.
3. $r \geq 0.6$: We considered our analysis object to the cases of $r \geq 0.6$, i.e., "strong correlation" on the standard of Evans[5].

Now, we calculated the Pearson and Spearman correlations for all pairs of 240 subjects, i.e., 28,680 cases. And then, we arranged and partitioned the correlation matrix based on the standard of subject classification. Table 2 is sub-part of the analysis for the liberal arts versus each major subject. We tried to display the pairs that have high correlation coefficients. The numbers displayed at the top of each cell are the Pearson correlation coefficients, and the number displayed in parentheses indicates the Spearman correlation coefficients. Natural science subjects of liberal arts are generally relevant to science & engineering major, and social science & humanities subjects of liberal arts seem to be closely related to social science & humanities majors. However, there are high correlation coefficient between social science & humanities subject of liberal arts and science & engineering majors or science subject of liberal arts and social science & humanities major in some cases. It can be inferred that many competent students got high grades in the most categories of subjects regardless of the course articulations.

Table 3 is another sub-part of the correlation analysis of military science versus each major. Subjects of military science show generally higher relationship with science & engineering majors than social science & humanities majors. Especially, these subjects seem to be related to subjects of electrical electronics engineering, oceanography, and computer science. This result matches well with the educational goal of the naval academy that trains advanced scientific technology officer. When we piece the results together, we can guess the transitive relations like basic science of liberal arts – science & engineering majors – military science (common major).

On the other hand, some pairs show strong correlations in both the Pearson and Spearman coefficients, but others show that only in one coefficient. For instance, the coefficient is high in Pearson's view, but not in the Spearman's view between modern weapon system and Introduction of English literature. For these cases, we guess that some grade data has not normal distributions. In other words, it may not be reliable to draw out the articulation among subjects only by the Pearson's method.

Meanwhile, the Spearman method is not affected by the population distribution, because it converts grade points into the ranks. Thus, as a non-parametric estimating method, the Spearman's method can remedy a distortion by outliers [9]. Therefore, we considered the following for three kinds of correlations: only the Pearson's, only the Spearman's, and both the Pearson's and Spearman's. In this paper, we prefer considering the both correlations.

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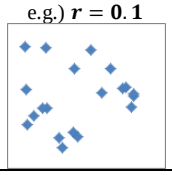
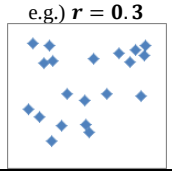
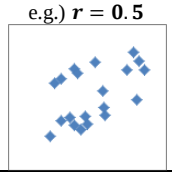
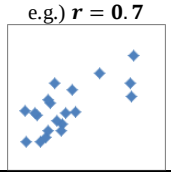
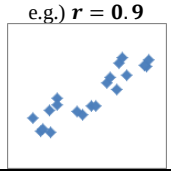
$0 \le \lvert r \rvert < 0.2$	$0.2 \le \lvert r \rvert < 0.4$	$0.4 \le \lvert r \rvert < 0.6$	$0.6 \le \lvert r \rvert < 0.8$	$0.8 \le \lvert r \rvert \le 1$
very weak	weak	moderate	strong	very strong
e.g.) $r = 0.1$ 	e.g.) $r = 0.3$ 	e.g.) $r = 0.5$ 	e.g.) $r = 0.7$ 	e.g.) $r = 0.9$ 

Fig. 2. Strength of relations between two data as the ranges of the Pearson correlation numbers.

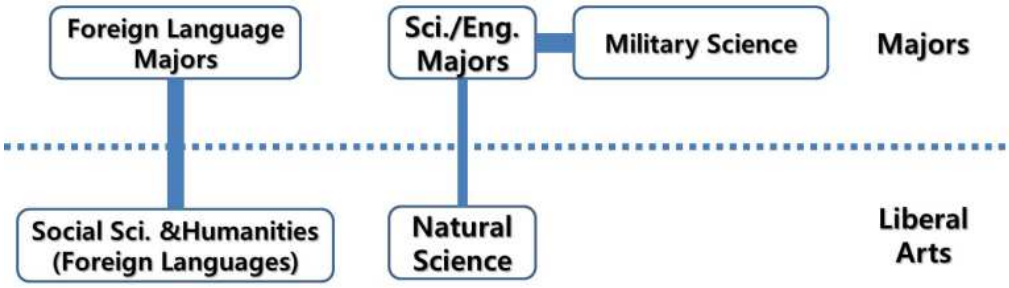


Fig. 3. Correlation analysis result between subject field: The width of lines shows the strength of articulations.

Now, we counted the number of correlated pairs for all subjects that satisfy the three criterions: the necessity number of students for our analyses are given in Table 1, *p-value* ≤ 0.05, and$r \ge 0.6$. As a result, we obtained 265 correlated pairs for Pearson, 267 pairs for Spearman, and 202 pairs for the both methods. Note that the numbers of correlated pairs derived by each method are almost same and highly synchronized (202/265 and 202/267).

Looking into the results closely from Table 4 to Table 9, we can derive some important results. To begin with, a series of English subjects are highly correlated to other subjects. However, most pairs are only formed among English subjects. That is, getting a high grade in English series does not significantly affect the performance of other subjects.

Also, there are high correlations between natural science of liberal arts and science majors, and between science majors subjects and military science courses while the correlations between subjects of military science and liberal arts or social science & humanities are not high as shown in Table 4 to Table 9. In the Table 7, we verified the top 20 subjects in majors that are correlated to military science. Most highly ranks subjects are on the science & engineering majors. If we exclude the series of English subjects because English subjects are closely relevant only to each other, we can verify the above transitive relation again. We can visualize the correlation diagrams between the categories of subjects as in the Fig. 3.

Now, we would like to estimate, so to speak, articulation ratio of each major. For this, we define the articulation ratio as follow.

Definition:

$$r\text{atio of connectivity}(\%) = \frac{n\text{umber of connectable subjects}}{\text{number of opening subjects}} \times 100(\%)$$

The articulation ratio can be the determinant for the following two things: How helpful is a major for the study of military science? Also, how helpful is the liberal arts study for the academic achievement of each major?

The numbers of opened subjects for each major are given in Table 1. Using these values, the course articulation ratio for each major can be obtained as Fig. 4 and Fig. 5.

Here, the ratios are larger than 100% if the number of correlated pairs is larger than that of the opened subjects for each major. In Fig. 4, the department of foreign language has the highest ratio with liberal arts. This result can be expected from high correlation coefficient between subjects for the department of foreign language and the English series of liberal arts. Also, we can find that only the department has the articulation ratio with the liberal arts more than 100%. In Fig. 5, departments of oceanography (269%) and computer science (133%) show the highest articulation ratios with the military science. This result accords with the purpose of the naval academy: trains the marine expertise and the cyber war responsiveness. On the contrary, the articulation ratios of the other departments are less than around 50%. Therefore, it is required to adjust the curriculum, for instance open the new subjects or modify the old subjects. However, note that the higher ratios are not always desirable. This is because an articulation ratio will be high if the contents of two subjects are considerably overlapped with each other.

Thus, a detailed investigation will be required before the adjustment of recent curriculum.

IV. Conclusion and Discussion

In this research, we conducted a comprehensive analysis for every grade of every student from the class of 2006 to 2013. We can implement to analyze the pure data due to the characteristics of the naval academy: no withdrawal, no transference, seldom information flow

and almost fixed curriculum by each department. We analyzed the correlations of all grades by conducting complete enumeration survey for 44,145 grades of 691 students. The purpose of this research is to demonstrate whether the articulations exist among courses of ROK

Table 2 Correlation matrix among the subjects of liberal arts and major courses (one part): The numbers out of parentheses are the Pearson correlation coefficient, the number of the inside are the Spearman correlation coefficient. Blank shows the case that does not satisfy the 3 criterions. In addition, we drew thick border lines between courses of Science & Engineering majors and Social Science & Humanities majors, and also between any two large categories.

	Major	E&E	W.S.	M&NA	D.M	Oce.	Com.	I.R.	MH&S	F.L.(M)
Field in liberal Arts	Subject	Electric Circuit	Rader System	Num'al Analysis	IT &Org. Mgmt.	Marine Fluid Mech.	OS	Intn'al Laws Study	Intn'al Politics & Strt.	English Novels
Natural Science	Introduction to Mechanics		0.68*** (0.71***)							
	Calculus Ⅰ					(0.68***)				
	Calculus Ⅱ	0.60*** (0.61***)				(0.67***)				
	Applied Mathematics				(0.80*)	0.82** (0.90*)				
	General Physics Ⅰ		0.80** (0.82**)							
	General Physics Ⅱ	0.67** (0.69**)	0.79** (0.80**)					0.70** (0.80**)	0.63** (0.62**)	
	General Chemistry Ⅰ		0.70*** (0.69***)		0.76**					
	General Chemistry Ⅱ		0.63*** (0.68***)							
	Introduction to Electrical Eng.		0.66*** (0.72***)							
	Introduction to Computer Sci.			0.67*** (0.66***)						
	Oceanography & Meteorology					0.80** (0.83[a])	0.73*** (0.69***)			
	Introduction to Oceanology			0.74** (0.82**)						
Social Science & Humanities	Introduction to Economics				(0.71**)					
	International Laws					0.65*** (0.80**)				
	Psychology				(0.78**)	0.78** (0.85*)				0.63** (0.61**)
	Language & Writing		0.66*** (0.62***)		0.72**					
	Study on ADM. Yi & Jang						0.62*** (0.69**)			
	Speech Communication					0.60***				
Foreign Language (Liberal Arts)	English Reader Ⅰ	0.66***								0.72* (0.74*)
	English Reader Ⅱ	0.62***								0.80* (0.73*)
	English Conversation Ⅰ	0.68** (0.63***)								0.62** (0.66***)
	English Conversation Ⅱ		(0.61***)							0.70* (0.61*)
	English ConversationⅢ	0.71*** (0.66***)	0.61***							0.61**
	English ConversationⅣ									0.79* (0.80*)
	English Writing					0.62*** (0.72**)				0.78* (0.73*)
Physical Education	Physical Education Ⅳ			0.68*** (0.68**)						

* p-value≤0.05, ** p-value≤0.01, *** p-value≤0.001

In this research, we conducted a comprehensive analysis for every grade of every student from the class of 2006 to 2013. We can implement to analyze the pure data due to the characteristics of the naval academy: no withdrawal, no transference, seldom information flow and almost fixed curriculum by each department. We analyzed the

correlations of all grades by conducting complete enumeration survey for 44,145 grades of 691 students. The purpose of this research is to demonstrate whether the articulations exist among courses of ROK naval academy. We used the Pearson and Spearman correlation methods to measure the course articulations. The Pearson correlation method is used in common. However we can analyze the course articulation more reliably by using two methods all together. If the correlations are high enough between some two.

Table 3 Correlation matrix among the subjects of military science (common) and major courses (one part): The numbers out of parentheses are the Pearson correlation coefficient, the number of the inside are the Spearman correlation coefficient. Blanks show the case that does not satisfy the 3 criterions. In addition, we drew thick border lines between courses of Science & Engineering majors and Social Science & Humanities majors.

Major	Subject	E&E	W.S.	M&NA	D.M	Oce.	Com.	I.R.	MH&S	F.L.(M)
		Electric Circuit	Network System	Solid Mech.	IT & Org. Mgmt.	Military Oceanography	OS	Intn'al Laws Study	Korean War	Intro. to English Lit.
Military Science (common)	NCW & EBO						0.65* (0.63*)			
	Military English							0.61*		
	Military Innovation		(0.66*)							0.62*
	Introduction to Leadership		0.64*							
	Intro. to Wpn. Sys. Engineering	0.68** (0.62***)	0.61*				0.63* (0.62*)			
	Future Info-War								0.67** (0.63**)	
	Ship Control						0.62* (0.63*)			
	Military Action					0.66*** (0.73**)				
	Basic of Operation									0.73* (0.63*)
	Introduction to Strategy				(0.69**)					
	Electronic Navigation					(0.62***)	0.61***			
	Propulsion System							0.71* (0.69*)		
	Marine Laws	0.62*** (0.69**)				0.60*** (0.67***)				
	Intro. to Naval Ship Eng.	(0.62***)								
	Marine Engine Ⅱ				0.76** (0.74**)	0.64*** (0.75**)		(0.62***)		
	Ship Handling					0.67*** (0.73**)	0.75** (0.62***)			
	Introduction to Navigation	0.75** (0.74**)								
	Naval Weapon System	0.64***								
	Naval Operation Tactics					0.61*** (0.72**)	0.65*** (0.69***)	0.63** (0.68**)		
	Marine Corps Operation			0.71*** (0.63***)			(0.61***)			
	Modern Weapon Systems						0.64* (0.63*)			0.62*
	Landing Force Tactics						0.72*** (0.65***)			
	Introduction to Aviation Eng.			0.64***						

* p-value≤0.05, ** p-value≤0.01, *** p-value≤0.001

subjects in an inter-semester, we can assume that the two courses have a causal relation from the course in the previous semester to the course in the next semester.

Through the result of the analysis, we can derive some important facts as follows.

First, the course articulation ratios are diversified by each major as Fig. 4 and Fig. 5. The major of foreign language shows high articulation ratio with liberal arts (168%), but low with military science(32%).The major of oceanography and computer science show high articulation ratio with liberal arts (100%, 100%,

respectively) and military science (269%, 133%, respectively). High articulation of oceanography and computer science accords with the purpose of the naval academy: trains elite officer with marine expertise and cyber war responsiveness. However, it should note that high articulations could be caused from the overlapped contents of subjects. Therefore, low articulated majors have to adjust their curriculum through modifications such as reduction of overlapped contents, increasing course articulations between subjects.

Second, there are strong correlations between science subjects of liberal arts and science major subjects, and very strong correlations between science major subjects and military science subjects as shown in Figure 3. In contrast, English subjects of liberal arts are closely relevant only to the English subjects for the major of foreign language. However, there are weak articulations between major subjects and social science & humanities subjects of liberal arts. Therefore, we can conclude that science education have to be enhanced in order to reinforce the academic achievement of military science. Besides, social science & humanities subjects of liberal arts need to increase the course articulations with the other social science & humanities major subjects.

Third, the academic achievements of major courses have strong correlation with basic mathematics and science courses except for the English course in liberal arts as shown in Table 4: calculus 2, general physics 2, general chemistry 2, applied mathematics, and so on. Even if the result is restricted to the naval academy, this result implies that recent university education should be developed to increase the proportion of basic science course. Moreover, when we look into Table 5, it is noticeable that the social science methodology is strong correlated with military science. It is in opposite that liberal arts might not directly correlated to military science. The enhancements of education, for these subjects contribute to the reinforcement of capacity for military science directly. Thus, the naval academy may prefer to develop this kind of subjects in the field of social science & humanities.

We conducted the whole population analysis for all subjects and grades for all students from the class of 8 years in the ROK naval academy as an isolated system that is rarely affected by social environment. Hence, this study might be evaluated reliable and valuable. Since the goal of education for the naval academy is restricted to train the naval specialist and there is no major of natural science like mathematics, physics, chemistry, we could not study the course articulations more profoundly. However, we can suggest the following things, despite that we mentioned above.

Some major courses, like military oceanography and operating system, need to be common course because they are strongly correlated to the subjects of military science. Moreover, natural science education has to enhance in order to reinforce the academic achievement of military science. Besides, social science & humanities subjects of liberal arts need to increase the course articulations with social science & humanities major subjects.

National defense is one of the most costly areas in the state budget. It is required to develop the curriculums, of ROK naval academy because these changes could contribute to the reinforcement of national defense power with lower cost. We look forward to more detailed research being done in the future.

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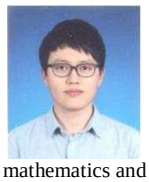

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Table 4 The number of major subjects articulated on each liberal arts subject: Show 22 higher rank subjects per 64 total liberal arts subjects.

Field in Liberal Arts	Subject	The number of articulate subjects									Total		
		E&E (24)	W.S. (11)	M&NA (16)	D.M (18)	Oce. (13)	Com. (12)	I.R. (13)	MH&S (11)	F.L.(M) (22)	P&S[a]	P[b]	S[c]
Sci.	Oceanography & Meteorology	0	0	1	0	6	3	0	0	1	11	13	13
Sci.	Intro. to Basic Mechanical Eng.	0	1	0	0	1	0	0	0	4	6	8	6
S&H	Introduction to Political Science	0	0	1	0	0	1	0	0	4	6	8	6
F.L.(LA)	English Reader Ⅰ	2	0	0	0	0	0	0	0	4	6	7	6
F.L.(LA)	English Reader Ⅱ	1	0	0	0	0	0	0	0	5	6	10	7
F.L.(LA)	English Writing	2	0	0	0	1	0	0	0	3	6	6	7
Sci.	General Physics Ⅱ	1	1	0	0	0	0	1	2	0	5	7	6
Sci.	General Chemistry Ⅱ	0	1	0	0	0	0	4	0	0	5	5	8
Sci.	Applied Mathematics	1	0	0	1	2	0	0	0	0	4	5	6
Sci.	Introduction to Electrical Eng.	1	1	0	0	1	1	0	0	0	4	5	4
S&H	Psychology	0	0	0	0	1	0	0	0	3	4	4	4
F.L.(LA)	English Conversation Ⅰ	2	0	0	0	0	0	0	0	2	4	4	5
F.L.(LA)	English Conversation Ⅳ	1	0	0	0	0	0	0	0	3	4	6	5
Sci.	Web Design Programming	0	0	0	0	0	3	0	0	0	3	3	3
Sci.	Calculus Ⅱ	2	0	0	0	0	1	0	0	0	3	4	6
P.E.	Physical Education Ⅳ	0	1	1	0	0	0	0	0	1	3	3	3
Sci.	General Chemistry Ⅰ	0	1	1	0	0	0	0	0	0	2	2	2
S&H	Introduction to Economics	0	0	0	1	0	1	0	0	0	2	2	3
S&H	Korean History	0	0	0	0	0	0	0	0	2	2	3	3
S&H	International Law	0	0	0	0	1	0	1	0	0	2	3	4
S&H	Language & Writing	0	1	0	0	0	0	0	0	1	2	3	3
F.L.(LA)	English Conversation Ⅱ	0	0	0	0	0	0	0	0	2	2	5	3
Total		13	7	4	2	13	10	6	2	35	92	117	115

[a] The number of correlated in Pearson & Spearman's methods
[b] The number of correlated in Pearson's methods
[c] The number of correlated in Spearman's methods

Table 5 The number of military science major subjects articulated on each liberal art subjects: Show 4 higher rank subjects per 64 total liberal arts subjects.

Field in Liberal Art	Subjects	The number of articulated subjects		
		P&S[a]	P[b]	S[c]
S&H	Social Science Methodology	4	5	4
Sci.	Environment Chemistry	2	2	4
Sci.	Web Design Programming	1	1	1
S&H	The Understanding of Music	1	1	1
Total		**8**	**9**	**10**

[a] The number of correlated in Pearson & Spearman's methods
[b] The number of correlated in Pearson's methods
[c] The number of correlated in Spearman's methods

Table 6 The number of liberal arts subjects articulated on each major subject: Show 19 higher rank subjects per 140 total subjects.

Major	Subject	The number of articulated subjects				Total		
		Liberal Arts				P&S[a]	P[b]	S[c]
		Sci.	S&H	F.L.(LA)	P.L			
F.L.(M)	Applied Linguistics	0	4	5	0	9	11	10
W.S.	Rader System	6	1	0	0	7	8	8
F.L.(M)	English Novels	0	1	6	0	7	8	7
F.L.(M)	Modern English Grammar	0	1	5	0	6	7	6
Oce.	Marine Fluid Mechanics	2	2	1	0	5	6	7
F.L.(M)	English Essays	0	3	2	0	5	6	9
E&E	Application of Microprocessor	0	0	4	0	4	4	4
E&E	Electric Circuit	2	0	2	0	4	6	4
E&E	Theory of Electric Energy Conversion	1	0	2	0	3	4	4
E&E	Circuitry Analysis	1	0	1	1	3	5	5
M&NA	Numerical Analysis	2	0	0	1	3	3	3
Com.	Computer Programming	2	1	0	0	3	4	3
D.M.	IT & Organization Management	1	1	0	0	2	2	3
Oce.	Marine Mechanics	2	0	0	0	2	3	2
Com.	Database	2	0	0	0	2	2	2
Com.	Operating System	1	1	0	0	2	2	3
Com.	Discrete Mathematics	1	1	0	0	2	2	3
I.R.	International Conflicts Theory	1	1	0	0	2	2	2
F.L.(M)	Intermediate 2nd Foreign Language	2	0	0	0	2	2	5
Total		26	17	28	2	73	87	90

[a] The number of correlated in Pearson & Spearman's methods
[b] The number of correlated in Pearson's methods
[c] The number of correlated in Spearman's methods

Table 7 The number of military science subjects articulated on each major subject: Show 20 higher rank subjects per 140 total majors subjects.

Major	Subject	The number of articulated subjects		
		P&S[a]	P[b]	S[c]
Com.	Operating System	7	8	8
Oce.	Chemical Oceanography	6	7	7
Oce.	Military Oceanography	5	5	6
Oce.	Marine Fluid Mechanics	5	7	9
E&E	Application of Microprocessor	4	4	5
Oce.	Underwater Acoustics	4	4	5
Oce.	Coastal Oceanography	4	4	4
Oce.	Marine Pollution	4	4	4
E&E	Electric Circuit	3	4	4
Oce.	Oceanographic Data Analysis	3	3	3
Com.	Database	3	6	3
Com.	Data Structure	3	3	3
F.L.(M)	Modern English Grammar	3	3	4
E&E	Circuitry Analysis	2	3	2
M&MA.	Analysis of Mechanical Engineering	2	2	2
M&MA.	Numerical Analysis	2	2	2
Oce.	Physical Oceanography	2	2	2
Com.	Computer Network	2	2	3
I.R.	International Laws Study	2	3	3
F.L.(M)	Spanish History & Culture	2	2	2
Total		68	78	81

[a] The number of correlated in Pearson & Spearman's methods
[b] The number of correlated in Pearson's methods
[c] The number of correlated in Spearman's methods

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Table 8 The number of liberal arts subjects articulated on each military science subject: Show 7 higher rank subjects per 36 total military science subjects.

Major	Subject	The number of articulated subjects				Total		
		Liberal Arts				P&S[a]	P[b]	S[c]
		Sci.	S&H	F.L.(LA)	P.L.			
Military Science	Marine Laws	1	1	0	0	2	2	2
	Propulsion System	1	0	0	0	1	1	1
	Marine Engine I	0	1	0	0	1	1	1
	Marine Engine II	1	0	0	0	1	2	1
	Ship Handling	0	1	0	0	1	1	2
	Naval Operation Tactics	0	1	0	0	1	1	1
	Marine Corps Operation	0	1	0	0	1	1	1
Total		3	5	0	0	8	9	9

[a] The number of correlated in Pearson & Spearman's methods
[b] The number of correlated in Pearson's methods
[c] The number of correlated in Spearman's methods

Table 9 The number of major subjects articulated on each military science subject: Show 22 higher rank subjects per 36 total military science Subjects.

Major	Subject	The number of articulated subjects									Total		
		E&E (24)	W.S. (11)	M&NA (16)	D.M (18)	Oce. (13)	Com. (12)	I.R. (13)	MH&S (11)	F.L.(M) (22)	P&S[a]	P[b]	S[c]
Military Science	Ship Handling	1	0	0	1	6	3	0	0	0	11	13	12
	Marine Laws	3	0	0	1	2	1	0	0	0	7	9	9
	Introduction to Weapon System Engineering	2	1	1	0	1	1	0	0	0	6	8	7
	Electronic Navigation	0	0	1	0	4	0	0	0	1	6	7	7
	Naval Weapon System	0	0	1	0	3	1	0	0	1	6	7	8
	Naval Operation Tactics	1	0	0	0	2	2	1	0	0	6	6	9
	Military Action	0	0	0	0	4	0	0	0	0	4	5	5
	Propulsion System	0	0	0	1	1	0	1	0	1	4	5	4
	Marine Engine Ⅱ	0	0	0	1	2	1	0	0	0	4	5	5
	Marine Corps Operation	0	0	1	0	2	1	0	0	0	4	5	8
	Modern Weapon Systems	0	0	1	0	1	1	0	0	1	3	5	4
	Military English	2	0	0	0	0	0	0	0	1	3	5	4
	Introduction to Leadership	0	1	2	0	0	0	0	0	0	3	3	3
	Future Info-War	1	0	0	0	1	0	0	1	0	3	4	4
	Introduction to War	0	0	0	1	2	0	0	0	0	3	3	7
	Introduction to Navigation	2	0	0	0	1	0	0	0	0	3	4	6
	NCW & EBO	0	0	0	0	0	2	0	0	0	2	3	2
	Military Culture & Ethics	1	0	0	0	0	0	0	0	1	2	2	3
	Introduction to Military Science	0	0	0	0	1	0	1	0	0	2	2	2
	Ship Control	0	0	1	0	0	1	0	0	0	2	4	2
	Introduction to Naval Ship Eng.	0	0	0	1	1	0	0	0	0	2	4	2
	Landing Force Tactics	0	0	0	0	0	1	1	0	0	2	2	3
Total		13	2	8	6	34	15	4	1	6	89	110	118

[a] The number of correlated in Pearson & Spearman's methods
[b] The number of correlated in Pearson's methods
[c] The number of correlated in Spearman's methods