Information Capability Evaluation Model of Military Personnel Based on Factor Analysis

Yang Wu[1*], Yi Zhang[2], Zhenyue Zhang[1]

[1]China People's Liberation Army National Defence University, Beijing, 100091, China;
[2]National University of Defense Technology, Wuhan, Hubei, 430035, China

*348023288@qq.com

Abstract. Information capability of military personnel refers to the the comprehensive ability of military personnel to acquire, process and use information. Before the evaluation of the information capability of military personnel, a scientific definition of the system, composition, and evaluation model of information capability is required. Based on literature research and fieldwork, we adopt the suggestions of military personnel and put forward 26 information capabilities that military personnel should possess. After that, with the participation of military personnel, we filter and then determine the weights of the 26 items through several approaches to machine learning, such as statistical analysis and feature selection. Based on this, we obtain the evaluation model of information capability of military personnel. Finally, a scale was designed to collect military personnel's self-assessment for the assessment model, and an analysis of the results show that the model is reliable and practicable.

Keywords: Factor Analysis, Capability Evaluation, Evaluation Model, Evaluation Method

1 Introduction

Information capability of military personnel refers to the the comprehensive ability of military personnel to acquire, process and use information[1]. The architecture of information capability for military personnel reflects the overall structure and composition of various information capabilities of military personnel Based on the research of a large amount of literature and fieldwork related to information competencies, information literacy, information quality, and data literacy, we summarize the information competencies that should be acquired by military personnel into 26 items. Including information needs (X1), information sensitivity (X2), information acquisition (X3), information conversion (X4), information inspection (X5), information selection (X6), information deep mining (X7), metadata (X8), information understanding and interpretation (X9), information classification and preservation (X10), information analysis (X11), information utilization (X12), information modeling (X13), information tracking and updating (X14), information processing and innovation (X15), information creation and production (X16), information transformation (X17), information technology

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tools (X18), information management platform (X19), information analysis software and tools (X20), information exchange and expression (X21), information sharing (X22), information evaluation (X23), information security (X24), information policy and regulations (X25) and information ethics (X26) and other capabilities[2], see Figure 1.

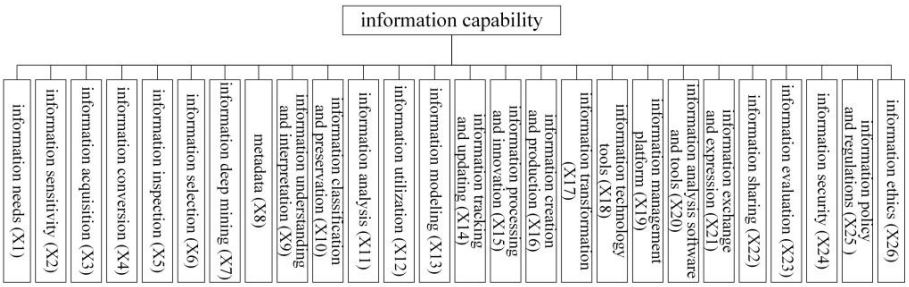

Fig. 1. Military personnel information capability system framework

The meaning of each capability item is shown in Table 1.

Table 1. Composition of military personnel information capabilities

number	Capabilities	Meaning
X1	Information Needs	Capability to identify one's needs and express them correctly
X2	Information Sensitivity	Capability to quickly identify information leads and values
X3	Information Acquisition	Capability to obtain the required information from multiple sources
X4	Information Conversion	Capability to convert the acquired information into the format or content one needs
X5	Information Inspection	Capability to make judgments about the truthfulness of information
X6	Information Selection	Capability to correctly select the information you need when faced with multiple pieces of information
X7	Information Deep mining	Capability to judge, select, and find patterns from the clutter of data, and find valuable information
X8	Metadata	Capability to use metadata to manage and access information resources
X9	Information Understanding and Interpretation	Equipped with the appropriate knowledge or capability to understand and interpret information acquired in the expertise
X10	Information Classification and Preservation	Capability to classify and preserve information using modern techniques and tools

X11	Information Analysis	Capability to process and analyze relevant information at a deep level to form new information that can help solve problems
X12	Information Utilization	Capability to integrate information into the workplace to provide a basis for forecasting, decision-making, and planning activities
X13	Information Modeling	Capability to sample and standardize model the same type of information, providing the basis for the establishment of different information systems and standardized interaction of information
X14	Information Tracking and Updating	Capability to track and update information
X15	Information Processing and Innovation	Capability to create and process scientifically based on existing information
X16	Information Creation and Production	Capability to create and produce new information
X17	Information Transformation	Capability to transform information to generate value or improve efficiency
X18	Information Technology Tools	Capability to work with a variety of information technology tools; Capability to identify problems based on feedback data, design and adjust the work plan
X19	Information Management Platform	Capability to use various information management platforms proficiently
X20	Information Analysis Software and Tools	Capability to use information analysis software and tools for data analysis and mining
X21	Information Exchange and Expression	Capability to spread information and one's understanding to others through communication, expression, elaboration, and reporting
X22	Information Sharing	Awareness of information sharing and the capability to share information through various means
X23	Information Evaluation	Capability to evaluate information comprehensively in terms of information quantity, accuracy, timeliness, relevance, processing, and effectiveness
X24	Information Security	Awareness of information security, capability to protect information from outside influences, not to be damaged, changed, leaked
X25	Information Policy and Regulations	Capability to comply with the relevant policies and regulations on information development, dissemination, management, and utilization imposed and enforced by state agencies
X26	Information Ethics	Capability to comply with ethical requirements, ethical guidelines, and ethical statutes related to information development, information dissemination, and information management and use

2 Military personnel information capability evaluation model

For the 26 information capability items mentioned above, we filtered and weighted them according to their importance . We used the questionnaire to collect data to determine the importance of each item. The questionnaire applies a 5-point Likert scale, which scales each information capability item with 5 grades, “fully agree”, “agree”,

"neutral", "disagree", and "fully disagree", and gives a score of "5, 4, 3, 2, and 1" respectively to facilitate the survey participants' evaluation of the importance of each capability. In this regard, we selected a representative military unit, distributed the questionnaires, and collected 84 valid responses. After the questionnaires were collected, all questionnaires were first checked and 2 invalid responses with incomplete or incorrect answers were removed. After that, we tested the data reliability and validity using statistical analysis[3].

2.1 KMO measure of sampling adequacy and Bartlett's test of sphericity

The KMO measure of sampling adequacy and Bartlett's test of sphericity were performed to determine the suitability of the survey questionnaire for factor analysis [4]. The KMO measure of sampling adequacy examines the partial correlations between variables [5]. The value of KMO is generally between 0 and 1, and the closer the value is to 1, the higher the correlation between variables. The effect of factor analysis is usually judged based on the KMO value. When its value is 0.6 or above, it indicates that the questionnaire is suitable for factor analysis. The larger the value, the better the effect of factor analysis. If its value is below 0.5, or the significance level is greater than 0.05, it indicates that the questionnaire is not suitable for factor analysis.

Bartlett's test of sphericity is a test that examines the degree of correlation between individual variables. The statistic of Bartlett's test of sphericity can be obtained from the determinant of the correlation coefficient matrix. If the value is large and the corresponding companion probability value is less than the significance level in the user's mind (usually less than 0.05), the null hypothesis should be rejected and the correlation coefficient cannot be a unit matrix, i.e., there is a correlation between the original variables. In this case, it is suitable for a factor analysis. If on the contrary, it is not suitable for factor analysis.

Factor analysis was performed on the questionnaire using statistical analysis. From the results, the KMO value reaches 0.835 (usually greater than 0.6), Bartlett's spherical test approximate chi-square value is 1455.265, the degree of freedom is 325 and significance level is 0 (usually less than 0.05) as shown in Table 2. Therefore, factor analys is suitable for the analysis of military personnel information capability.

Table 2. Results of KMO measure of sampling adequacy and Bartlett's test of sphericity

Testing method		Value
KMO measure of sampling adequacy		.835
Bartlett's test of sphericity	Approximate cardinality	1455.265
	Degree of freedom	325
	Significance level	.000

2.2 Principal component analysis

In the questionnaire, 26 questions corresponding to 26 variables are included. Due to the large number of variables, it is not conducive to conducting further analysis. Considering that there is a certain correlation among the variables, which can be interpreted as the existence of some overlap in the information reflected among the variables, principal component analysis can be applied. Principal Component Analysis (PCA), is also known as matrix data analysis [6]. It reduces the dimensionality of the data set by transforming the variables into several uncorrelated composite indicator variables through the method of variable transformation, simplifying the problem.

The results of the questionnaire were extracted using principal component analysis and then used Promax with Kaiser Normalization [7] for rotation. The rotation converged after 10 iterations. The total variance explained and the rotated component matrix obtained are shown in Tables 3 and 4.

Table 3. Total variance explained

Component	Initial Eigenvalue		Extraction t sum of squares of loads		Rotation Sums of Squared Loadings	
	Total	Cumulative %	Total	Cumulative %	Total	Cumulative %
1	11.207	43.104	11.207	43.104	6.711	25.810
2	1.994	50.773	1.994	50.773	2.949	37.153
3	1.669	57.193	1.669	57.193	2.830	48.038
4	1.383	62.510	1.383	62.510	2.791	58.773
5	1.157	66.959	1.157	66.959	2.128	66.959

Table 4. Component matrix after rotation

Capabilities	Component				
	1	2	3	4	5
Information Policy and Regulations	0.771	0.184	0.159	0.234	-0.069
Information Conversion	0.714	0.281	0.051	0.227	0.121
Information Technology Tools	0.706	0.293	0.145	0.173	0.039
Information Acquisition	0.687	0.388	0.077	0.143	0.109
Information exchange and expression	0.684	0.093	0.444	0.099	-0.090
Information Ethics	0.671	0.002	0.262	-0.019	0.209
Information Utilization	0.666	0.387	0.190	0.262	0.104
Information Tracking and Updating	0.644	0.316	0.097	0.287	0.098
Information Sharing	0.644	-0.038	0.093	-0.099	0.522
Information Understanding and Interpretation	0.638	0.220	0.193	0.392	0.091
Information Conversion	0.539	-0.028	-0.020	0.456	0.414
Information Analysis	0.459	0.220	0.360	0.455	0.106
Information Selection	0.296	0.756	0.220	0.156	0.085

Deep information mining	0.411	0.648	-0.045	0.065	0.289
Information Sensitive	0.575	0.631	0.160	0.059	0.073
Information Inspection	0.109	0.575	0.502	0.177	0.190
Information Management Platform	-0.014	0.097	0.720	0.312	0.280
Information Security	0.583	0.185	0.631	0.108	-0.226
Information Analysis Software and Tools	0.400	0.181	0.608	0.001	0.240
Information Evaluation	0.398	0.258	0.511	0.261	-0.041
Information Needs	0.249	0.288	0.035	0.687	0.187
Information Processing and Innovation	0.121	0.295	0.154	0.681	-0.066
Information Creation and Production	0.107	-0.276	0.383	0.621	0.175
Information Classification and Preservation	0.429	-0.125	0.431	0.482	0.167
Information Modeling	0.053	0.134	0.100	0.065	0.833
Metadata	0.065	0.314	0.215	0.308	0.669

From the results of the principal component analysis, a total of five common factors were extracted, and the coefficients of the variables in each common factor were ranked from highest to lowest. Since the coefficients of the sub-variables in each common factor were all greater than 0.4, no variables were excluded and all were retained. The five common factors were named according to the meaning of the variables. The 5th common factor is named information modeling and metadata, the 4th information demand, innovation, creation, and preservation, the 3rd information management, and security, the 2nd information sensitivity, selection, and mining, which covers several core information capabilities, the 1st common factor is the most complex and contains information policy, ethics, access, utilization, communication, sharing, and so on. Its main body is traditional information capability, thus named traditional information synthesis.

The weights of each factor can be assigned using the factor contribution ratio normalization, as shown in Table 5.

Table 5. Variance contributions and weights of the common factors

Common Factor	Contribution rate	Weights
Traditional Information Synthesis	25.810%	0.386
Information Sensitivity, Selection, and Mining	11.343%	0.169
Information Management and Security	10.886%	0.163
Information Demand, Innovation, Creation, and Preservation	10.735%	0.160
Information Modeling and Metadata	8.186%	0.122
Total	66.959%	1

The cumulative variance contribution rate of the extracted common factors over 55% is generally considered to be acceptable. The variance contribution rate of the five common factors obtained from the principal component analysis reached 66.959%, which can be considered that the model reflects the influencing factors of military personnel information capability.

The factor score coefficient matrix was obtained simultaneously using the regression method in machine learning, as shown in Table 6. Using the factor score coefficient matrix, the scores of each common factor can be calculated from the scores of each information capability, and then the common factor scores are multiplied by their respective weights to obtain the total score of information capability.

Table 6. Factor score coefficient matrix

Capabilities	Principal Components				
	1	2	3	4	5
Information Needs	-.060	.073	-.179	.370	-.001
Information Sensitivity	.037	.242	-024	-.096	-.035
Information Acquisition	.122	.076	-.100	-.030	-.007
Information Conversion	.123	-.171	-199	.190	.175
Information Inspection	-.171	.269	.233	-.054	.027
Information Selection	-.099	.361	.026	-024	-.041
Information Deep Mining	.000	.277	-141	-.057	.103
Metadata	-126	.098	.023	.052	.324
Information Understanding and Interpretation	.096	-.029	-.064	.120	-.037
Information Classification and Preservation	.047	-.210	.111	.156	.021
Information Analysis	.006	-.006	.054	.142	-.035
Information Utilization	.086	.069	-.051	.025	-.027
Information Modeling	-.058	-.001	.006	-.088	.466
Information Tracking and Updating	.104	.035	-.109	.067	-024
Information Processing and Innovation	-111	.115	-.076	.384	-149
Information Creation and Production	-.039	-.241	.103	.296	.034
Information Transformation	.146	.004	-.134	.029	-.002
Information Technology Tools	.136	.017	-.059	-.015	-.048
Information Management Platform	-.168	-009	.379	.011	.096
Information Analysis Software and Tools	.003	-.017	.313	-.209	.092
Information Exchange and Expression	.138	-.097	.164	-.099	-111
Information Sharing	.200	-185	-.028	-.212	.296
Information Evaluation	-.017	.041	.203	.007	-.105
Information Security	.064	-.023	.296	-.112	-201
Information Policy and Regulations	.174	-.055	-.064	.031	-113
Information Ethics	.180	-.155	.069	-165	.092

Through regression compute, the five common factors and their weights were obtained, and the score coefficient matrix of the five common factors was also derived to form information capability evaluation model of military personnel, as shown in Table 7.

Table 7. Evaluation criteria for the information capCapability of military personnel

Primary Capability	Secondary Capability	Weights
Traditional Information Synthesis (S1)	X25, X17, X18, X3, X21, X26, X12, X14, X22, X9, X4, X11	0.386
Information Sensitivity, Selection and Mining (S2)	X6, X7, X. X5	0.169
Information Management and Security (S3)	X19, X24 X20,X23	0.163
Information Demand, Innovation, Creation, and Preservation (S4)	X1, X15, X16, X10	0.160
Information Modeling and Metadata (S5)	X13, X8	0.122

3 Applications of Information Capability Evaluation Model for Military Personnel

Based on the information capability evaluation model for military personnel, an information capability assessment scale can be designed to conduct the assessment. The design of the competency evaluation scale was classified according to the five common factors in the factor analysis described above, and the 5-point Likert scale was again used to assess the 26 information capabilities.

We selected a representative military unit and distributed and collected 77 valid responses. The coefficients of the factor score matrix were used to calculate the scores of the five common factors, and the following line graphs of the scores of each of the five common factors were obtained.

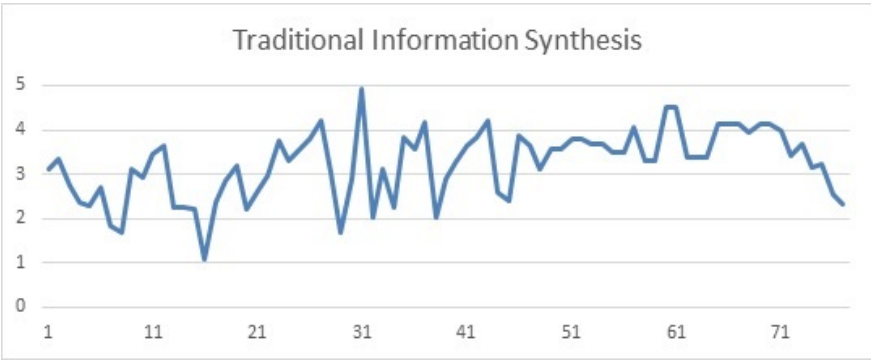

Fig. 2. Traditional information synthesis Capability score line graph

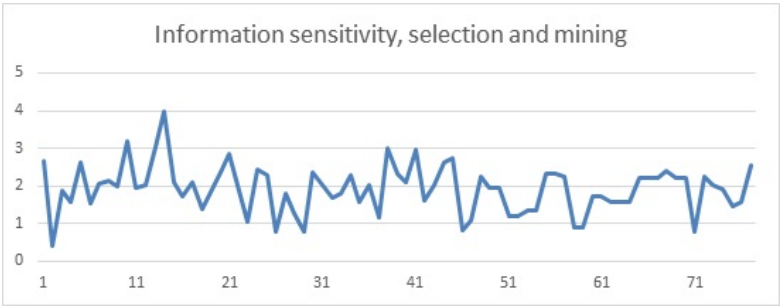

Fig. 3. Information sensitivity, selection, and mining Capability score line graph

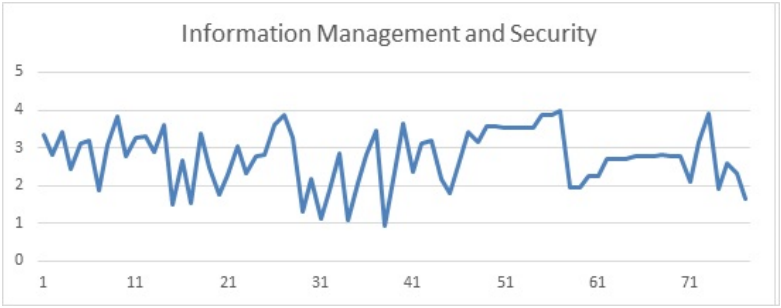

Fig. 4. Information management and security capabilities score line graph

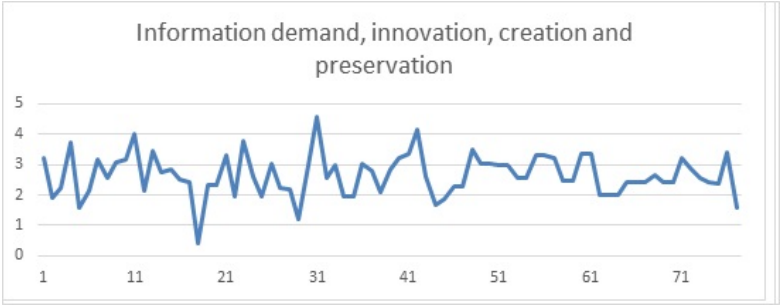

Fig. 5. Information demand, innovation, creation, and preservation Capability score line graph

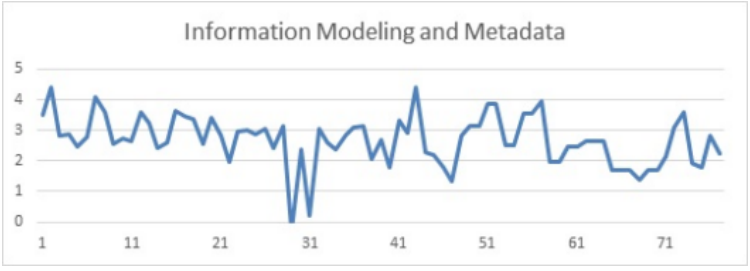

Fig. 6. Information modeling and metadata capability score line graph

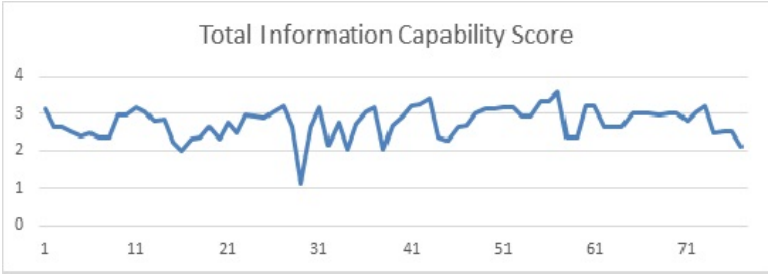

Fig. 7. Line graph of total information capability score

The line graph of the common factor scores shows that this group scores high in the "traditional information synthesis" capability (see Figure 2) and low in the "information sensitivity, selection, and mining" capability (see Figure 3). The scores of "information management and security" (see Figure 4), "information demand, innovation, creation and preservation" (see Figure 5), and "information modeling and metadata" (see Figure 6) fall between the first two competencies, but their degree of dispersion is larger. We multiplied the scores of several common factors with their corresponding weights to calculate the total information capability scores, which are shown in Figure 7.

To analyze the data in more detail, descriptive statistical analysis was conducted using SPSS to calculate the mean, standard deviation, skewness, and kurtosis of the common factors and their total scores. The results are shown in the table below. In terms of the mean, the group scores relatively high in the "traditional information synthesis" and relatively low in the "information sensitivity, selection and mining", while the other three scores are in between, which is consistent with the estimates on the line graph. The standard deviations of several common factors are relatively large, reflecting the wide dispersion among the data, but the standard deviations of the total scores are small. In terms of skewness, all of them are left-skewed, except for "information sensitivity, selection, and mining", which is underestimated to varying degrees, while "information sensitivity, selection, and mining" is overestimated. In terms of kurtosis, "traditional information synthesis" and "information management and security" are flat tops, while the other three are sharp peaks, indicating that the distribution of the data is steeper than the normal distribution. We used Cronbach's α coefficients for the liability test, which are mostly above 0.65, and the coefficient of the whole scale is 0.933. The scale has good content validity, except for "information modeling and metadata" (which has too few options, only 2 items).

Table 8. Analysis of scale data

Common factor	Average value	Standard deviation	Skewness	Kurtosis	Cronbach's Alpha factor
Traditional Information Synthesis	3.22787013	.764962561	-.429	-.174	0.894
Information sensitivity, selection, and mining	1.91892208	.638460500	.142	.631	0.771

Information Management and Security	2.74709091	.740722606	-.439	-.424	0.681
Information demand, innovation creation, and preservation	2.65951948	.682330558	-.093	1.146	0.656
Information Modeling and Metadata	2.68516883	.823836539	-.714	1.929	0.550
Total	2.77114523	.416520610	-.866	1.703	0.933

4 Conclusions

In this paper, based on literature research and fieldwork, we propose 26 information capabilities that military personnel should possess. After that, we filter and then determine the weights of the 26 items through several approaches to machine learning, such as statistical analysis and feature selection. Based on this, we obtain the evaluation system framework and evaluation model of information competencies. Finally, a scale was designed to collect military personnel's self-assessment for the assessment model, and an analysis of the results show that the model is reliable and practicable. However, there are several questions remain in this study. For example, the model's structure is simple, and can be ameliorated in the future.

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