Teaching the Subject of Operations Research at Military Universities (Not Only) of NATO Countries

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Abstract

The guarantor of military higher education in the Czech Republic is the University of Defense in Brno. The student must successfully complete a demanding five-year course of study. Individual subjects develop the relevant competences necessary for mastering military service and the requirements placed on future commanding officers. Operations research (OR) belongs to the theoretical subjects. It teaches students logical thinking and helps solve optimization problems.
The authors of the article focused their attention on the subject of OR. The aim was to find out in which military universities (mainly in NATO countries) OR is taught, what is its content and some other characteristics of the teaching of this subject. A questionnaire was created for this purpose. That questionnaire was distributed to selected military schools. A comparison was made based on the information obtained. The examined data are entered into the appropriate tables. Some conclusions are obtained.

KEY WORDS: *operations research; operational analysis; military student; operations research topics, comparison across countries, questionnaire.*

1. Introduction

In recent decades, there have been significant changes in the economic and political situation in the world. It is crucial that commanding officers are properly educated. The only military college that educates military professionals for the Army of the Czech Republic is the University of Defence based in Brno.

The university training of future officers of the Army of the Czech Republic takes place in accredited study programs in the field of management and resource management applied to the sphere of defence and security. Military study programs combine a broadly oriented theoretical foundation with more narrowly focused study subjects. In our contribution, we will focus on Operations Research (OR), which is taught by the Department of Quantitative Methods at the Faculty of Military Leadership. As part of completing the course, students learn to solve optimization problems, improve their logical thinking and correct judgment.

Operations research is intended for all students of the faculty. The teaching takes place in the second semester of the first year, with a time allocation of 56 hours (28 hours of lectures and 28 hours of exercises). The subject is completed with a credit and an exam. The content of the subject is an introduction to linear programming (production planning problem, mixing problem, distribution problem, graphical method, simplex method, artificial base method, duality), transportation problems, multi-criteria evaluation of variants, multi-criteria linear programming, matrix games. This information is available on the website of our university, see [1]. For more detailed information about the topics and the scope of OR teaching at the University of Defense in the Czech Republic, the reader can be referred to the teaching text [8]. For examples of our work in the area of operations research, see, for example, [9, 10].

The aim of the article is
1) to compare the teaching of OR at military universities, mainly in other European countries and especially in NATO countries;
2) to find out if the OR is taught, and if so, the way how the OR is taught at these universities, i.e. what topics, in which year/semester, the size of the teaching time allocation, number of credits, method of completion of the subject, for which specialization OR teaching is intended, whether the subject is compulsory and whether OR is a part of the final state examination.

2. Data and methods

It is not easy to obtain the necessary information (whether OR is taught at a given school, in which year, subject plan, time allowance for OR teaching, etc.). First of all, we searched on the websites of the selected universities. We started with the university addresses from the document Partner Institutions of the University of Defence in Brno, see [2]. From the selected 26 universities, we found the necessary data for only four of them. At the same time, we approached 26 students who studied at our faculty within the ERASMUS+ program in 2020–2023. We received answers (and other information) only from two Slovak students. We obtained information from Ukraine using our personal contacts. We have already provided information from these six countries (Bulgaria, Czech Republic, Slovakia, Slovenia, Ukraine, USA) in the abstract (mid-February 2024). The websites of these universities are listed in [1, 3, 4, 5, 6, 7].

We created the necessary questionnaire and then sent it to another 84 e-mail addresses and at least 24 countries with a request for completion. Only three of them responded (Austria, Belgium, Romania). We also obtained incomplete data from Georgia (southeast Europe, west Asia) through our personal contacts.

The questionnaire had two parts, a cover letter and a table (excel file) that just had to be filled out. The key part of the cover letter is:

… we need to get information. That is why we ask for your cooperation.

We need to find out at which schools Operational Research (OR) is taught and some other information:

14. In which semester/year?
15. Is it intended for students of which specialization?
16. What is the time allocation for the course/subject? How many lessons/hours?
17. What topics are taught? Ideally, get the Study Plan of the subject.
18. Is OR taught in bachelor's degree, Master's degree, or doctoral study?
19. Is the subject of OR obligatory or optional?
20. Is the subject of OR completed with credit, graded credit or an exam?
21. Is the subject a part of the final state exam?

And there was a large table in the attachment of the email, where the respondents should fill their answers. Here, we devided it into three tables (Tab. 1 – Tab. 3) for better readability.

Table 1.

Operations Research (OR) - information about OR teaching in your country on your university/faculty, part 1.

Country	University	Faculty	Name of subject
Czech Republic	University of Defence	Faculty of military leadership	Operations Research
. . .	. . .	. . .	. . .

Table 2.

Operations Research (OR) - information about OR teaching in your country on your university/faculty, part 2 (Topics of Operations Research).

LP	TP	Duality	MEV	MP	MG	NA	Queue	other topics
Y	Y	Y	Y	Y	Y	N	N	-
. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .	. . .

Table 3.

Operations Research (OR) - information about OR teaching in your country on your university/faculty, part 3 (Characteristics of Operations Research).

Year	Semester	Hours	End	ECTS	For	Obligatory	Notes:
1.	S	56	exam	4	All	Y	5-years study

Notation used in the tables:

Name of Subject   Operations Research, Operational Research, Operational Analysis, Optimization Methods, ...

Topics of OR

LP	Linear Programing
TP	Transportation Problems
MEV	Multicriteria Evaluation of Variants
MP	Multicriteria Programing
MG	Matrix Games, Theory of Games
NA	Network Analysis, Graph Theory

Queue	Queue Theory, Models of Mass Service
other topics	write other topics of OR if you have
Year	In which year of study is OR teaching
Semester	S = summer, W = winter
Hours	number of teaching hours
End	exam, cr = only credit
ECTS	number of credits
For	All students or Which specialization?
Obligatory	Y/N = Yes or No
Notes:	write what you think is important to say about the topic.

The "Czech Republic" line is a sample.

3. Results

We obtained information from 10 universities in total. There are the names of states, the names of universities where OR is taught and names of the subject in Table 4. The symbol * means that there are more schools (or faculties or branches) in the given state (school) where OR is taught. We always chose one school, one faculty or one field of study for each country. In such cases, the data were mostly similar.

Table 4.

Countries, university names and subject names

Country	University	Name of subject
Austria	Theresan Military Academy	No OR
Belgium	Royal Military Academy*	Operations Research
Bulgaria	Vasil Levski National Military University*	Operations Research
Czech Rep.	University of Defence	Operations Research
Georgia	Batumi Shota Rustaveli State University	Operations Research
Romania	"Nicolae Balcescu" Land Forces Academy*	Theory of Decision and OR
Slovakia	Armed Forces Academy of General Milan Rastislav Štefánik*	Operations Research
Slovenia	University of Ljubljana	Operations Research
Ukraine*	Kharkiv National University of the Air Force named after Ivan Kozhedub*	Mathematical problems of operations research in electrical engineering
USA	University of Michigan	Operations Research

Table 5 contains the OR topics (LP = Linear Programming, TP = Transportation Problems, Dual = Duality, MEV = Multicriteria Evaluation of Variants, MP = Multicriteria Programming, MG = Matrix Games/Theory of Games, NA = Network Analysis/Graph Theory, Que = Queue Theory, MS = Mathematical Modelling and Simulations), type of study, year, semester, and teaching hours. Symbol Y means yes, i.e. the topic is taught at the school.

Table 5.

Information about the teaching of OR, i.e. topics, year, semester, and hours. Y=yes, i.e. the topic is taught at the school

Country	Topics of Operations Research									Type of study	Year	Semester	Hours
	LP	TP	Dual	MEV	MP	MG	NA	Que	MS				
Austria				Y		Y							
Belgium*									Y	Bc.	3.	S	
Bulgaria*	Y	Y						Y				W or S	30
Czech Rep.	Y	Y	Y	Y	Y	Y				Mgr.	1.	S	56
Georgia						Y					2.	S	60
Romania*	Y	Y			Y	Y				Mgr.	1.	W or S	36
Slovakia*	Y	Y					Y	Y			1.	W	42
Slovenia	Y		Y	Y	Y			Y			2.	S	45
Ukraine*													
USA													

Table 6.

Information about the teaching of OR, other characteristics of the subject

Country	End	ECTS	For	Compulsory	Final state exam	Notes
Austria						
Belgium*	exam	4	All	Y	Y	
Bulgaria*		3				
Czech Rep.	exam	4	All	Y	N	5-year master's degree
Georgia			Computer science			
Romania*	exam	6		Y	Y	4-year master's degree
Slovakia*		4				
Slovenia						
Ukraine*		4				
USA						

Table 6 shows other characteristics of the OR subject, i.e. the way the subject is completed, the number of credits (ECTS), for which specialization OR teaching is intended, whether the subject is compulsory and whether OR is part of the state final exam. The last column serves as a space for entering additional important data. In our table, it was only an indication of the level of study and its length.

4. Conclusions

Obviously, there is little data. For an explanation, see the Limitations paragraph. Data for Ukraine and the USA are almost completely missing, not available on the Internet; we did not find them. We can only base it on the subject name, see Tab. 4. It is likely that many of the mentioned OR research topics are also taught at the respective universities of Ukraine and the USA.

We simply do not have such information. The same is true with the university in Georgia. We have information that at the Theresan Military Academy in Austria, the OR subject is not taught in our sense there, they only have the multicriteria evaluation of variants and wargames topics.

Linear programming is the most fundamental area of Operations Research. From our data, it can be seen that linear programming is also taught at almost all the mentioned universities. The issue of transportation problems is also a classic discipline of Operations Research, and is also almost always taught. The topic of duality is a relatively theoretical matter, the consequences of duality are applied in matrix games, for example. However, duality is only taught in the Czech Republic

and Slovenia (according to the data obtained). We see the reason in the theoretical character. Matrix games, for their rich application use, are studied at several universities. Similarly, the issues of multicriteria optimization (Multicriteria Evaluation of Variants, Multicriteria Programming), Matrix Games and Queue Theory are taught at several universities.

In contrast, the topics Network Analysis/Graph Theory and Mathematical Modeling and Simulations appeared only once in Table 2. Perhaps this area of operations research is not taught as often, or perhaps it is taught in another subject or under a different name. For example, at the University of Defense in the Czech Republic, we taught Graph Theory and Network Analysis until 2014, later no longer (due to a reduction in the time allocation for the subject). Or we were just unlucky with the data obtained - again, we can point out the small amount of data.

In general, it can be said that some schools teach some topics, other schools teach other topics of Operations Research. Very often OR is taught in the first year and usually the subject is valued at four credits. Considering the teaching of the OR subject in one semester, the time allowance is similar, mostly from 42 to 56 hours. At universities where we have information, the subject OR is compulsory and ends with an exam.

5. Limitations

The lack of information available from public websites is a big problem. When we do get some information, it is often not complete, it is a different type of information than that of another school.

We tried to obtain additional data by contacting the schools at the e-mail addresses available from the schools' websites and also obtained through the ERASMUS+ coordinators. Unfortunately, the efficiency of the reactions was only very low, approximately 5 %. The authors are aware that it is not possible to draw large conclusions from a small amount of data and that the outputs have low validity.

Also, in this way, we ask representatives of schools, other teachers, to share information about the teaching of the subject Operations research at their university. If you contribute to further research and reach out to us, we will be very happy.

Acknowledgements

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