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Introduction of Space Science in Higher Education: Space Science in BSc Engineering

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ABSTRACT

Space science is a fascinating and powerful field in which our country has now become an important part. From an educational point of view, several universities now offer some kind of specialised training in space science, and there are already master's degrees in space engineering. Under the UniSpace programme, 17 Hungarian universities are cooperating to offer advanced training in space science at four universities. However, at bachelor's level, a prospective engineer is unlikely to encounter a subject related to space science outside of basic physics, or it may only be offered in a few specialised programs. Future professionals should be introduced to this discipline as soon as possible. This is why universities should consider offering undergraduate-level space science courses, to better prepare students interested in pursuing careers in this field. The Széchenyi István University of Győr has already taken several steps to promote space technologies, including the SZESAT student group, where students can work on space telecommunications, the Mobilis summer children's camps, where SZESAT gives lectures on the topic every year, and the University of Győr is also a member of the UniSpace Hungary consortium.

The study seeks to answer two questions: first, how interested students are in a similar subject that introduces them to space science and the basic space technology opportunities. The second is what majors are interested in the new subject, and which segments of the discipline might be the most interesting to them. In addition to the two main orientations, another important consideration is how students might integrate it into their studies and what prior learning would be required to start such a new subject.

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Introduction

Today, space technology is such an important field that is why space science courses have already appeared in higher education in Hungary. Currently, UniSpace has launched four postgraduate courses in cooperation with 17 Hungarian universities in the country, as well as two MSc courses in Space Engineering. Being a space engineer has been a common profession abroad for some time. However, it is already possible to apply for a BSc in aerospace engineering, which suggests that it is not only an MSc course, but it is worth to start laying the foundations during the undergraduate level. The research at Széchenyi István University in Gyor investigated the needs of students for the introduction of space science and technology courses. Among other things, it looked at the demand for these subjects and how well they could be integrated into the current engineering curriculum.

Teaching space science at the University of Gyor is important because it gives students the opportunity to take part in space science projects even while they are still students, collaborating with peers who are geographically distant from them. The UK Open University (UKOU) operates a distance learning model to support geographically dispersed students. Development of team-working skills is particularly challenging within such a model, but is considered a necessary part of the higher education experience of space scientists and astronomers [1]. This also shows that it is worth teaching space sciences in Bachelor of engineering courses, as geographical distances are no longer a barrier to learning and working. Worldwide, workshops are being organised by communities that agree on the need to introduce or develop basic space science at the university level [2]. The most promising step in this direction was made with the project ‘‘Astrophysics for University Physics Courses’’ [3].

Space Engineering Training

Space science courses already exist both in Hungary and abroad. The first step of the study is to examine the extent to which space science subjects can be integrated into engineering education. Based on the curricula of the engineering courses in Gyor, the study compares the subjects with those of space engineering courses. The comparison is based on the Hungarian postgraduate and space engineering courses and the Lassonde School of engineering bachelor of engineering (BEng): space engineering.

Space Engineering Courses

The curriculum of the aerospace engineering course is shown in Table 1. These are only the basic subjects, they are complemented by optional subjects. They are marked in blue in the table and are taught by all engineers. The subjects that are specific to aerospace engineering are highlighted in green. Those not highlighted are

general subjects taken by students in either mechatronics and mechanical engineering or electrical engineering.

As you can see from the subjects covered, aerospace engineering is a multidisciplinary discipline that is an intersection of several engineering disciplines. Fortunately, engineers can find a topic in space research that is directly related to their area of expertise. Therefore, in conclusion, most of the space science subjects can be easily integrated into the undergraduate curriculum as an optional subject.

Table 1: The subjects of the Aerospace Engineering course. In Blue are the General Engineering subjects, which all Engineering students at the Szechenyi Istvan University of Gyor study in some subject. In green are the specific Aerospace Engineering subjects.

1. year – fall • Applied Calculus I • Applied Linear Algebra • Engineering Mechanics • Renaissance Engineer 1: Ethics, Communication and Problem Solving • Computational Thinking Through Mechatronics	1. year – spring • Applied Calculus II • Chemistry and Materials Science for Engineers • Electricity, Magnetism and Optics for Engineers • Renaissance Engineer 2 Engineering Design Principles • Object Oriented Programming from Sensors to Actuators • The Earth Environment
2. year – fall • Applied Multivariate and Vector Calculus • Intorduction to Probability and Statistics • Engineering Graphics & CAD Modelling • Dynamics • Engineering Projects: Management, Economics & Saft	2. year – spring • Differential Equations for Scientists and Engineers • Effective Engineering Communication • Geophysics and Space Science • Algorithmic and Computational methods for Geomatics and Space Engineering • Space System Engineering • Space Engineering • Introduction to Continuum Mechanics
3. year – fall • Professional Engineering Practice • Engineering and the Environment • Heat Transfer and Thermal Design • Electronics I • Introduction to Space Communications	3. year – spring • Materials for Space Applications • Physics of the Space Environment • Dynamics of Space Vehicles • Mechanisms for Mechanical Systems • Computational Methods for Engineers • Electronics II
4. year – fall • Engineering Project • Time Series and Spectral Analysis • Space Hardware • Payload Design • Introduction to Control Systems	4. year – spring • Engineering Project • Space Mission Design • Finite Element Methods in Engineering Design

Survey among Students in Gyor

Once it became clear that space science subjects could be well integrated into the undergraduate engineering curriculum, the second question was whether there was a demand for such subjects from students. An attitudinal survey was carried out among students at the University of Győr, asking whether they would like to take space science courses, and how many credits and how many semesters they could imagine taking them. The survey was conducted among BSc engineering students and 79 students completed the questionnaire. Figure 1. shows how old the respondents are, and it also shows distribution of ages. The average age is 22.43, whose scope is 13. Age standard deviation of respondents is 2.198, moreover Age empirical standard deviation of respondents is 2.213. Figure 2. clearly shows that the majority of students are interested in space science. This is approximately 80% of the students.

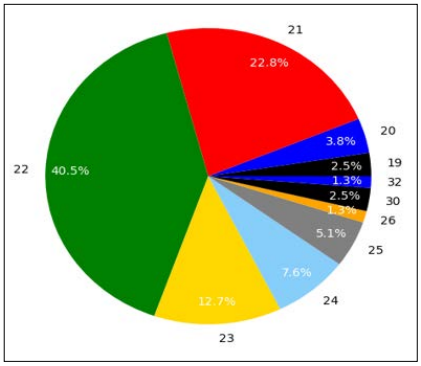

Figure 1: Age of Respondents and Distribution of Ages

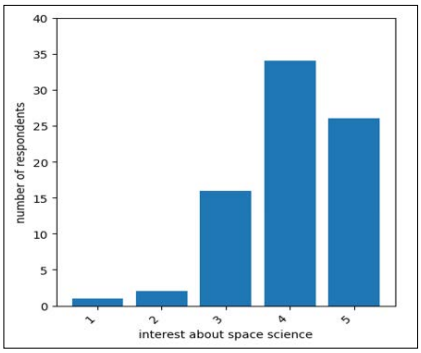

Figure 2: Students give Feedback on a Scale of 1 to 5 on How Interested they are in Space Science

The respondents study at the "Faculty of Mechanical, Computer and Electrical Engineering" and "Faculty of Automotive Engineering". This means that the respondents are: automotive engineer, logistics engineer, electrical engineer, mechatronics engineer, mechanical engineer and computer scientist. The responses are skewed by the fact that the majority of respondents were mechatronics engineers and electrical engineers, 78.4% to be precise. The responses show that only 18% of respondents currently have the opportunity to take a space science course. This follows from the fact that even within a degree course, this is only possible in one of the degree courses. Nevertheless, 62% think that it would be necessary to teach space science subjects in Bachelor of Engineering.

In the rest of the survey, students could choose between introductory and specialised subjects. After selecting the subjects, students had the opportunity to specify the credit value they would like to receive, whether they would like to have it as an optional or compulsory subject in their curriculum, or whether they would like to have it in the first or second half of their studies. In terms of the integrability of the subjects, it was apparent that they could be very easily integrated into any engineering curriculum as optional subjects. The unanimous response was also evident from the

responses. 95.8% of the respondents could imagine space science as an optional subject in their curriculum.

Introductory Courses in Space Science

Survey respondents could choose from the subjects shown in Figure 3. These subjects are: Basics of space technology; Basics of space science; Basics of astronomy and astrophysics; Materials for space instruments; Space weather, physics of the solar system, planetology; space and astrochemistry; The history of space exploration; Space industry and history of space industry; Quality and standards in the space industry; Domestic space activities and the international environment. Only those subjects are shown for which more than 10 respondents applied. Subjects with more than 20 respondents are shown in dark color. These are worth mentioning because it is likely that these are the subjects that could be regularly offered on an annual basis at the university, as they would be of great interest. Courses with more than 50 enrolments are highlighted in maroon. Based on these figures, basics of space technology and basics of space science are the two most popular courses.

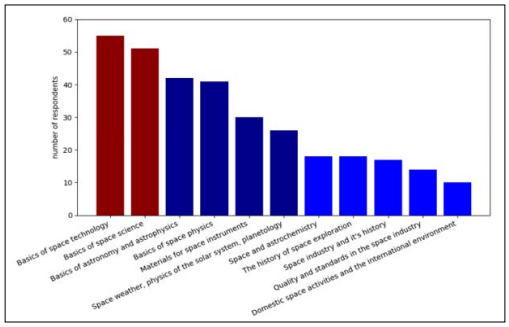

Figure 3: Subjects chosen by the Completers. Subjects marked in dark are those taken by more than 20 people. Subjects selected by more than 50 Respondents are marked in Red

79.7% of students thought that these could be added to their curriculum after the 4th semester. The majority of students would take it as 4 credit courses. Based on the answers the weighted average of the responses is 4.17. Therefore, the optimal credit value is 4. Students had the opportunity to tick whether they thought these introductory courses should start from the basics or be a continuation of some other course, i.e. build on it. Based on the responses, engineering physics and calculus could be required as prerequisites for some optional subjects. The figure 5. shows what prerequisites did respondents imagine for introductory space science courses. After the survey, it was found that physics and calculus are the most important prerequisites subjects. Modern physics is also an important subject, however few have chosen it as a prerequisite. This may have happened because this subject is only for electrical engineers.

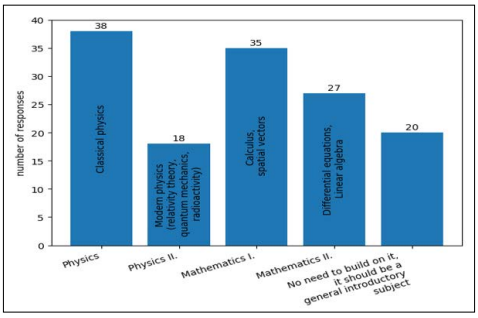

Figure 4: According to Respondents, Introductory Courses should be based on these Subjects

Specialised Subjects in Space Science

Professional subjects are those that can be related to a specific engineering degree or specialization within the degree. Figure 5. shows the specialised subjects. These subjects are: Design of space system; Implementation of space equipment; Satellite instruments, measurements and experiments; Space equipment testing; Application of artificial intelligence is space activities; Space communications; Movement of artificial moons, space debris; Space navigation; Spacecraft orbits and ground stations; Coordinating the development of complex space equipment. The chart shows only the items chosen by more than 20 people. Items selected by more than 40 people are highlighted in dark. This is important because it is essential to have a sufficient number of people interested in the subjects in order to launch them regularly. Based on these, the two most popular subjects are Design of space system and implementation of space equipment. Based on the responses to the credit value, the weighted average was also 4.1 credits, so it can be said that the optimum number of credits for the professional subjects would be 4.

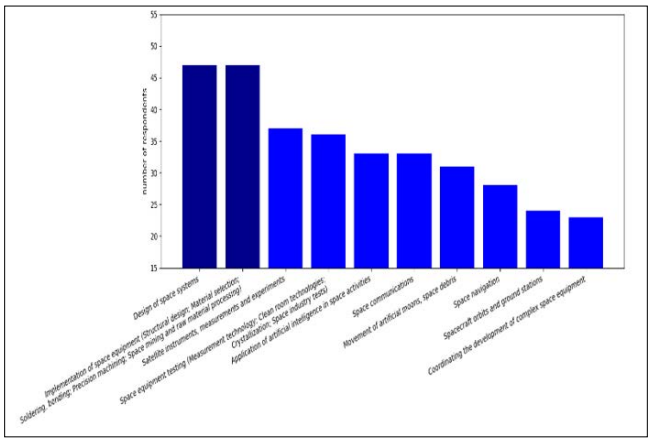

Figure 5: The Specialised Subjects chosen by more than 20 of the Respondents. Highlighted in Dark are the Subjects chosen by more than 40 Respondents

Conclusion

Space engineering is a multidisciplinary branch of science that is an intersection of many engineering disciplines. That is why if you compare their curriculum with any other engineering curriculum, you may get very large overlaps. In addition, space science is a highly researched field that attracts a lot of people. Furthermore, there are many career opportunities for engineers in the space technology field. For these reasons, a survey was carried out among the engineering Bachelor students in Győr to assess their interest in space science and technology and the feasibility of integrating these subjects into their current curriculum. After comparing the curricula, it can be stated that space engineering can be included as an optional subject in any engineering degree. Furthermore, the survey shows that 80% of students in Győr are interested in space science. In addition, 62% think that it would be important to teach space science subjects in basic engineering courses.

In conclusion, space science is a highly researched field that should be integrated into basic engineering education in Hungary. Fortunately, engineers can find a topic in space research that is directly related to their area of expertise. Therefore, it is easy to integrate it into any engineering course as an optional subject. 80% of students are interested in it and 62% consider it a necessary subject. They would like to take the subjects as an elective in

the order of 4 credits. Several of the subjects offered were ones that more than 50% of respondents would like to take, so they could be regular subjects at the university. These are the basics of space science and technology, design of space systems and implementation of space equipment.

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