Scientific schools of universities and character-building work

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Abstract. Scientific schools shape the image of universities, while the activity of the scientific schools enables sustainable and dynamic development of the universities. This paper is devoted to the role of scientific schools in character-building work in the context of leading aerospace engineering universities of Russia. The paper stresses the value of building the students' character based on the example of the older senior counterparts capable of transferring their experience and teaching the cutting-edge methods of educational and scientific work. Among these methods, the paper highlights a historical approach in the description of the logic and evolution of design and manufacturing solutions and the method of size effect, allowing in-depth comprehension of the true scale and composition of complex aerospace equipment. Aerospace universities of Russia implement these methods with special study laboratories called demonstration halls. Having unique specimens of spacecrafts in these laboratories helps preserve the historical memory of the forefront research of Russian scientists and engineers. Practical classes in such laboratories are a fine example of transferring the scientific legacy and positively affecting the motivation for professional growth.

1 Introduction

Character building work is an integral part of the university experience [1]. Besides regular activities within the framework of character-building work in line with the current state policy, universities play a proactive role in the character-building of the youth. The activity of these scientific schools manifested in educational programs is embodied in lecture courses and practical classes and equipping study laboratories and research centers. Also, individual student-teacher work is just as important. It can be especially fruitful when traditions are fused with new methods and means of scientific and study work [2–10].

2 The role of scientific schools in the character-building work

In the light of the ongoing discussions about new approaches to training specialists for dynamically developing industries, such as aerospace [1–6], the question of the role of scientific schools in the life of universities is relevant.

Universities have always been set apart by an intrinsic (almost invisible under the veil of routine) process of the transfer of knowledge of and experience from the elders (teachers) to

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the minors (students) via various forms of communication: classes, personal consultations, scientific clubs, conferences and so on. Vocational and business competencies, moral and civil stance of the universities' graduates are formed mainly within the framework of the scientific schools led by the role models of the older counterparts, the Teachers.

A scientific school is a cohesive group of one-minded researchers united by the common research topic maintaining the research continuity and having the leader well-acknowledged in the research community, as well as having significant scientific achievements, both novel and practically relevant. Thus, the quality of educational and mentoring work is directly influenced by the "health" of a scientific school and by a unique set of features setting this school apart from a regular group of teachers. Scientific schools preserve and pass over the legacy of the creative mindset, the spirit of collaborative effort, and respect for their research field and to the Motherland.

In technical universities, many scientific schools are a fine example of a caring approach to the historical memory and the transfer of the best engineering practices to the new generations of researchers and designers. The evolution of scientific schools was immortalized in literature [11–22].

For example, the scientific school of the department E-1 "Rocket engines" of the Bauman State Technical University led by professor D.A. Yagodnikov regularly hosts scientific conferences devoted to the memory of founders of two schools of research, professors V.N. Kudryavtsev and V.N. Polyaev. In addition, the department E-1 re-published tried and tested, yet still relevant, study books, for example, the study book on liquid rocket engines written by M.V. Dobrovolsky.

The department SM-1 "Spacecrafts and launch vehicles" of the Bauman Moscow State Technical University is one of the first departments making engineers specializing in the design and manufacture of guided long-range ballistic missiles. The SM-1 department has a scientific school of dynamics and strength of thin-walled and spatial structures led by Professor V.N. Zimin. The founders of this scientific school, V.I. Feodosiev, K.S. Kolesnikov, N.A. Alfutov, L.I. Balabuh, S.A. Alekseev and V.I. Usyukin had made a significant contribution to developing methods for designing and testing shell and truss structures. The SM-1 department regularly hosts conferences and workshops in memory of famous teachers and scientists and published many books preserving the memory of the pioneers of rocketry and cosmonautics [19–22].

Table 1. Comparison of heat loads in modern aviation, rocketry, and space industry

Parameters/Loads	Aviation	Rockets	Spacecrafts
Flight density, m/s	Up to 1000	7000	7900–60000
Heat flux density, kW/m^2	Up to 2	$5 \cdot 10^3$	$< 2 \cdot 10^4$
Pressure, MPa	< 0.7	< 20	< 10
Duration of the atmospheric stage, hours	< 24 and over that value with re-fueling	0.01	0.5

In Bauman Moscow State Technical University, a scientific school of composite materials' science had started taking shape in the mid-1950s influenced by the roaring development of rocketry and cosmonautics. The unique difference affecting the choice of design and manufacturing solutions for aviation and rocket-space structures was based on a significant difference in in-flight heat and force loads acting on planes, missiles, and spacecrafts (table 1).

It was only the use of composite materials for thermal protection that helped overcome so-called "thermal barriers" that haunted designers of the guided long-range ballistic missiles, crewed spacecrafts, and automatic interplanetary stations. The adoption of composite technologies has paved the way towards solving the tough problem of creating mixed solid-fuel missiles with composite bodies and transport and launch containers. Without new carbon-based composites, there would be no reusable "Buran" orbiter, light and precise reflectors of onboard space antennas, and the load-bearing meshed space structures having the top weight-to-strength ratio.

In the framework of the study course “The history of the scientific school of composite materials”, the students of the department SM-13 “Rocket and space composite structures” get to know the names of the authors of pioneering solutions in the area of design, manufacture, and testing of composite structures of aircraft and spacecrafts. Many of these authors are Bauman Moscow State Technical University graduates. Among them are the chief designers of the industry’s leading enterprises: S.P. Korolyov (OKB-1), P.A. Tyurin (TsKB-7—KB “Arsenal”), B.N. Lagutin (NII-1—MIT), V.D. Protasov (KBM—TsNIISM), designers K. P. Feoktistov (OKB-1), A.B. Mitkevich (KBM—TsNIISM), V.V. Vengerskii (NII-125—LNPO “Soyuz”), material scientists G.G. Konradi and V.N. Iordanskii (NII-88) and many others. Also, a significant contribution in new research and study courses was made by professors E.A. Satel, V.I. Feodosiev, N.A. Alfutov, I.M. Bulanov, A.K. Dobrovolsky, E.F. Kharchenko, M.A. Komkov, V.M. Kuznetsov, G.E. Nekhoroshikh, V.A. Shishatsky, A.A. Smerdov, G.B. Sinyarev, V.A. Tarasov, V.I. Usyukin, V.S. Zarubin, P.A. Zinoviev and others.

In Russia, the creation of technically complex composite structures, perfect both in terms of weight and functionality, demonstrates a high level of Russian science and engineering serves as a motivational example and boosts the students’ confidence that they chose the right “vocational trajectory”.

In acquiring professional competencies, practical classes solidifying the student’s memory of pioneering engineering solutions for complicated structures are essential.

3 The size effect of studying real specimens of equipment

The classes devoted to studying the hardware of rockets and spacecrafts in special laboratories (demonstration halls) are some of the effective forms of professional training. It should be noted that these classes are based on the organic synthesis of the historical approach and the size effect in training.

The demonstration hall of the department SM-1 of the Bauman Moscow State Technical University has been operational for more than 70 years. It was equipped under the supervision of the associate member of the USSR Academy of Sciences V.I. Feodosiev assisted by the industry and the department’s teachers (B.K. Kovalev, V.I. Vorotnikov, I.P. Medov, N.I. Popkov, N.A. Suratov, and others). As early as in the mid-1950s, the hall had been equipped with a then-novel rocket R-2 (8Zh38). Over time, the hall had become too small for new equipment specimens, so the demonstration hall was moved to a new building in the suburban base (currently the Dmitrov branch of the BMSTU) in the settlement Orevo of the Dmitrov district of the Moscow Region (figure 1).

Within the framework of a legacy-based approach, the students can face the journey of creative discoveries of the primary designers of long-range ballistic missiles, S.P. Korolyov, V.N. Chelomei, and M.K. Yangel. Evidently, reading books, studying interactive materials, and even going on excursions is nowhere near this hands-on experience of the study materials relevant to the engineering specialty. The possibility of having a close look on a real rocket fuel tank, touching the rocket fixtures and thermal protection coatings gives one an insight into the designers’ logic, then-innovative material science, and manufacturing innovations and helps form one’s judgment of how proper those designs were.

Figure 1. Laboratory of the department SM-1 “Spacecrafts and carrier rockets” in the Dmitrov branch of the Bauman Moscow State Technical University

Figure 2. Laboratory of the department 601 “Space systems and rocketry” of the Moscow Aviation Institute

The Moscow Aviation Institute (national technical university) department 601 “Space systems and rocketry” founded in 1959 with the participation of the academician V.P. Mishin boasts a rich experience and wide capabilities for training specialists. alleviate the formation of vocational competencies.

This department, led by the academician O.M. Alifanon for more than 30 years, has a demonstration hall and study classes with unique specimens of Russian space equipment, including the lunar spacecrafts 7K-LK, the “Soyuz” type descent modules (figure 2). Due to the size effect, the laboratory practice and the study of real equipment specimens actively.

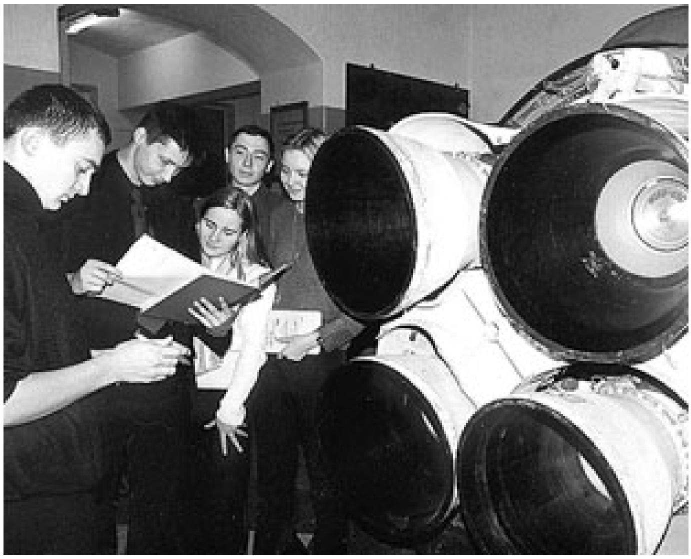

Figure 3. Laboratory of the department A-1 “Rocket building” of Baltic State Technical University “Voenmeh” n.a. D.F. Ustinov

Figure 4. A ballistic missile Polaris A3 in the Royal Air Force Museum Cosford, UK

This year, the department A-1 “Rocket Building” of the Baltic State Technical University “Voenmeh” n.a. D.F. Ustinov led by professor V.A. Borodavkin celebrated its 75th anniversary. The demonstration hall of the department is in an exemplary state, and it is also used for implementing the historical approach and the size effect in training (figure 3).

There is a long list of universities with an excellent space equipment collection. However, Samara National Research University named after S.P. Korolyov, South Ural State University, Peter the Great Military Academy of the Strategic Missile Forces, A.F. Mozhaysky’s Military-Space Academy deserve special attention for their collections.

It should be noted that Western universities, as a rule, use state or enterprise museums for that purpose, for example, the Boeing Museum in Seattle, the Royal Air Force Museum in London and in Cosford, the Museum of Science and Industry in Manchester having unique specimens of planes, rockets and jet engines, the ESA exposition in the European Space & Technology Centre (ESTEC), Noordwijk and so on figure 4.

Museums of equipment are a necessary thing. However, one should bear in mind the main rule of a museum: do not touch the items! In this case, the size effect is quite different.

4 Conclusion

The prospects for the development of rocket science and cosmonautics (new reusable manned spacecraft, small and ultra-small spacecraft, the construction of orbital and planetary structures, space tourism, etc.) serve as an incentive to improve the forms and methods of teaching students of technical universities. Scientific schools of aerospace universities in Russia have a powerful potential in educational work. It is advisable to preserve time-tested effective forms of education that combine a historical approach and a size method. Reasonable conservatism along with the development of advanced scientific methods and tools will serve as a guarantee of high quality training of a new generation of specialists.

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