Higher engineering education: traditions, regular and forced innovations

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Abstract. This paper focuses on the study of the features of distance learning at a university in light of modern requirements for higher engineering education and the traditions of the education in Russia. Education in Russia has always been understood not only as learning but also as enlightenment when the lecturer's mission was not limited to teaching goals – it involved the moral and intellectual development of students. This research formulates and analyses a contradiction of the need to combine traditions of Russian education with a strengthening of the professional component of engineering education. The concept of «intelligence» is actualized as a desire for knowledge, humanism, selfless attitude to work and professionalism, high culture and moral qualities, developed sense of duty, social responsibility. Diversified personality development correlates with the concept of intelligence. In this regard, it is natural to turn to the transdisciplinary approach in the educational process in its expanded understanding as integration of not only the content and methods but also the forms of learning organization, as well as obligatory establishment of working contacts between lecturers of different disciplines. The paper formulates proposals for semi-formalized tests in force majeure conditions of distance learning. The authors of the paper conducted a questionnaire survey of students with different majors on the effectiveness of forced full distance learning caused by COVID-19 and analyzed its results. This provides the necessary grounds for predicting the possibilities and prospects of distance learning in the higher education.

1. Introduction and historical overview

In the history of Russia, the education has always occupied one of the main places in the internal policy of the state and public life. The humanitarian component was viewed as the key one in the development of a specialist and a professional. At the same time, the dominant idea was to combine learning and enlightenment [1]. Nowadays, in engineering universities, humanitarian and general culture training is carried out, rather «per a leftover principle». In these circumstances, rationalism and pragmatism dominate. This is one of the reasons why students demonstrate weaker visual thinking and, therefore, lower personal creative potential. Moreover, they show some difficulties with knowledge summarizing and its application in allied disciplines and treat their academic achievements with indifference, which results in lower cognitive activity [2]. All this is at variance with the traditions of Russian education and damages socialization of an engineering university graduate, the development of his personal and communication qualities [3]. Thereupon, the problem lies in need to combine the traditions of Russian education, in which humanitarian knowledge has always played a leading role, with challenges of the time dictating the need to strengthen the professional component. It is necessary to clarify the place and
role of humanitarian knowledge as a basis for mastering the non-humanitarian disciplines, development of creative abilities and formation of personal qualities of the future technical intelligentsia.

The objective of the paper is to give suggestions on the effective use of modern strategies for teaching engineering students at universities, with due regard to the traditions of Russian education. This objective involves not only the study and analysis of the current state of the issue but also a short overview of the history of Russian education. The history of education in Russia dates back to the times of Ancient Rus – after the adoption of Christianity at the end of the 10th century, on the basis of the Byzantine tradition, schooling began to form first at monasteries, and then at princely courts. The vector in the development of Russian school was immediately determined – education is not a private business, but a state institution, since the entity that is most interested in education is the state. In the history of Russia, there are many vivid examples of elaborate and purposeful state policies in the field of education. In this regard, special attention should be paid to the 18th century [4].

Thus, one of the turning points in the formation of Russian education was the reign of Peter I (1689–1725), when, fundamentally, specialized training developed – the artillery, engineering, medical, navigation, cannon and other schools were opened under the authority of the state. Thanks to these schools, skilled workers appeared in Russia in such fields as army, navy, engineering and medicine. No less significant was the large-scale educational reform during the reign of Catherine II (1762–1796), which gave rise to the formation of school education systems and training of teachers in the country. It is interesting that in the history of Russia, even the establishment of individual educational institutions became a national affair, the expression of certain political views. So, for example, first, the opening of the Slavic Greek Latin Academy (1687), which set the task of reconciling the Greek and Latin philosophy followers [5], and then the opening of noble educational institutions such as the Land Gentry Corps and Smolny School for Noble Maidens were of great significance in the cultural life of the country. A separate chapter in the history of Russian education is M.V. Lomonosov and Moscow University (1755), which laid the foundations of university education and academic research in Russia. In 1811, the Tsarskoie Selo Lyceum was opened – an educational institution for noble children who, after graduating from the Lyceum, were to enter the public service and carry out the policy of the new monarch Alexander I (1801–1825) at the local level.

It should be noted, that education in Russia has always been understood not only as learning but also as enlightenment, in the broad sense, when the teacher’s mission was not limited to teaching goals but involved the moral, intellectual and spiritual development of students. With regard to this, Starodum's final remark from the famous comedy by D.I. Fonvizin The Minor (1781) «Here are the worthy fruits of malice!» was more than just relevant and consistent with the spirit of the times – it became an expression of a certain ideological position on the problems of upbringing and education as a negative example of teaching without character building.

In the first years of Soviet government (1917–1920s), education issues were considered on a par with acute political issues, and the idea of patriotism became one of the main ones in education for many years to come. The history of the new Russia began with reforms not only in the economy and production but also in education. Thus, during the years of Perestroika, starting from the mid-1980s, the problem of humanisation and humanitarization of the education system began to be actively discussed. The absence of systemic connections between the natural science, technical and humanitarian parts of higher education was noted, which resulted in degradation of the humanitarian potential of science and production, and decrease in the creative and cultural level of a specialist. A number of studies emphasised the importance of education humanitarization tasks as an essential condition for achieving success in a new social environment [6]. However, these ideas generally remained unfulfilled. Utilitarianism became central in the acquisition of knowledge.

2. The phenomenon of intelligence
When it comes to traditions of classical Russian education, one cannot ignore such a phenomenon as the intelligentsia and intelligence. The understanding of «intelligentsia» as a social group was formed in Russian society by the 1870s, and starting from that time, a new concept appeared in dictionaries – the
intelligentsia. Thus, V.I. Dahl places this word in the second edition of his Explanatory Dictionary (1880–1882), explaining it as follows: «a reasonable, educated, mentally developed part of citizens». Derivative words "intelligent" and «intelligence» did not appear in the Russian lexicon at once. But, the idea of intelligence had already taken shape in Russia by the end of the 19th century.

At the end of the 19th century, the concept of «intelligence» becomes a measure of spirituality and moral consistency of society, consisting of desire for knowledge and enlightenment, selfless service and humanism, selfless attitude to labour and professionalism, high moral qualities, developed sense of duty and social responsibility, but first of all – high level of culture. It should be noted that in modern Russian science, there is a branch of knowledge called intellectual studies. In particular, it preserves the traditional opposition of Western intellectuals and the Russian intelligentsia, for which the spiritual and moral component has always been crucial. Distinguishing feature of the Russian intelligentsia is a heightened sense of justice, the so-called special Russian soul open to other people's suffering and pain. The difference between the scientific and technical intelligentsia from its other varieties is that, being non-humanitarian by the nature of its occupation, it is designed to combine both technical and humanitarian orientations in its professional activities and public position.

3. Transdisciplinarity and distance learning
Diversified personality development correlates with the concept of intelligence. In this regard, in our opinion, it is productive to turn to a transdisciplinary approach aimed at combining knowledge heterogeneous in content and methods, and correlating with ideas of integrity, integration of the laws of nature, society and mental activity [7]. We proposed an extended understanding of the transdisciplinarity idea in the educational process, including the integration of all educational components (i.e., attendance form, foundation of more effective contact (formal and informal) between lecturers of different disciplines). Such integration demands increased attention to independent and research work, ensuring the dominance of actual activity, a combination of logical and figurative perception of information, self-organization of a student and external control over him/her. There is a publication of an example of how we use the ideas of transdisciplinarity to form students' comprehensive knowledge and competence. Transdisciplinary ties between the disciplines of humanitarian and technical cycles work to achieve the most important result – the development of a specialist who has domain-specific knowledge, narrow professional competence, and also has trans-professional skills that contribute to more productive work in socio-technical systems.

On the way to distance learning systems (DLS), among the milestones are programmed control and training, technical means of control and training, computer control and training programs, electronic textbooks. Capabilities of modern electronic and distance learning tools are very diverse and include, in particular, multimedia (sound, video, animation), computing, modelling programs (conducting experiments, play classes), interactivity (including informing students about their educational activity), hypertext (for quick information search) and means of orientation in educational information, means of knowledge testing with an automatic assessment of learning outcomes, generation of reports on student progress with a rating. Systematic presentation of educational, methodological, reference materials creates conditions for an individual pace of work, a manifestation of constructive activity, independence and self-control for students. In general, it increases the student's academic motivation. There also is blended learning as a combination of traditional and distance learning. But under the force majeure of COVID-19, it was impossible to implement it in the usual format. We have to focus on improving control tests. Without due attention to means of assessing the results of learning, distance forms are depreciated, since the transformation of information into knowledge requires serious independent work of students. Under the conditions of distance learning, the results of such work can only be effectively assessed by a lecturer by the quality of control tests done rather than in an interactive oral dialogue. DLS like Moodle uses multiple-choice questions, numeric and calculated questions, matching questions, short answer questions, etc. to compose tests. In the force majeure of COVID-19, when more remote controls were required, we used semi-formalised control tests, the answers to which have not been fully formalised and therefore are checked by the lecturer himself. For example, two alternative schematics
are presented, and you need to answer what each of them is called, what the designations on the schematics mean, when it is preferable to use each of these. Or a schematic is given, the work of which needs to be described in two or three phrases (no way to cheat). The lecturer gets more work when checking such tests, but the reliability of the learning outcome assessment is significantly increased. With this approach to the use of DLS, lecturer’s functions become more intellectual in general. However, as a result, the lecturer is required to spend much time and improve professional and methodological qualification.

4. Results and their analysis

The purpose of the survey was to confirm or refute the assumptions that appeared after several months of working in conditions of one hundred per cent distance learning due to COVID-19. Firstly, lecturers do not have enough remote control tools (tests). Therefore, there is often just a broadcast of information instead of a discussion of results of painstaking independent work of students. Secondly, many students, starting from school days, do not have enough general preparation to really study independently and complete control tests of various levels of difficulty. Thirdly, the sudden need for an exclusively distance communication that suddenly overtook us is often reduced to a simplified version of traditional education. At the same time, the quality of education decreases, although distance learning should be introduced to improve the quality of education.

Table 1. Questionnaire. Abbreviations: DL – distance learning, TL – traditional learning.

| Part 1 | | | |
|---|---|---|---|
| 1 Have you ever taken distance learning courses before? | Yes/No | | |
| 2 What device do you use during DL? | Respondent’s answer | | |
| 3 Have you had problems with your Internet connection? | Yes/No | | |
| 4 What types of classes were held in distance format? | Respondent’s answer | | |
| 5 What platforms have you used during distance learning? | Respondent’s answer | | |
| 6 Which platform, in your opinion, was more convenient? | Respondent’s answer | | |
| 7 Do you find that DL is suitable for you? | Yes/No | | |

| Part 2 | | | |
|---|---|---|---|
| 1 Can you agree with the thesis that «distance learning is an independent student's work»? | Yes/No | | |
| 2 How do you see your independent work under DL conditions? | Respondent’s answer | | |
| 3 What is the lecturer's role in ensuring effective independent work of students? | Respondent’s answer | | |
| 4 What has become more difficult in DL for you, and what is easier compared to TL? | Respondent’s answer | | |
| 5 Has your interest (positive emotions) in learning changed under the new conditions? | Yes/No | | |
| 6 Has your motivation (responsibility) to study changed under the new conditions? | Yes/No | | |
| 7 From your point of view, what is the appropriate ratio between DL and TL (in percentage)? | Respondent’s answer | | |
| 8 Do you think that you are ready to switch to DL completely and at the same time gain profound professional knowledge? | Yes/No | | |

| Part 3 | | | |
|---|---|---|---|
| 1 Which type of learning is psychologically more comfortable for you (DL, TL)? | DL/TL | | |
| 2 Which type of learning helps you get higher grades? | DL/TL | | |
| 3 In which learning do you spend more time studying? | DL/TL | | |
| 4 When do you understand the educational material better? | Respondent’s answer | | |
| 5 Indicate the ratio of information received (in percentage) from the lecturer in the form of oral speech during DL and TL. | | | |
| 6 Have there been more tests and other written control assignments with DL? | Significantly more; Slightly more; Did not see the change. | | |
| 7 What are the reasons the DL is difficult for you (several answers acceptable)? | - I can’t bring myself to study; - no help from strong students; - there is no possibility to get help from a lecturer orally; - tests are too difficult for me; | | |
The questionnaire was posted on Google Forms on-line service. The survey was participated by 153 students of the Chuvash State University: 63 students of the 1st, 2nd and 3rd years at the Faculty of Radioelectronics and Automation (REA); 31 freshman students of the Faculty of Informatics and Computer Engineering (ICE); 18 students in their 3rd year at the Faculty of Management and Social Technologies (MST); 41 students from 1st to 4th years from the training direction «Philology».

Commentary on Part 1. In total, 85 first-year students (55%), 35 second-year students (23% respondents), 27 third-year students (18%) and 6 fourth-year students (4%) were surveyed. Previously, on-line courses were used only by 29% of students. Quite often students used more than one device for distance learning, but used them in various combinations: personal computer + smartphone (42%), personal computer + tablet (7%), personal computer + smartphone + tablet (7%). Further, 21% students had no problems with the Internet connection, 14% students constantly experienced difficulties. Types of classes that were held in an on-line format: only lectures (10% of respondents), lectures + practical classes (43%), lectures + laboratory practicals + practical classes (43%). The following platforms were used: Zoom, Webinar.ru, DLS Moodle and Discord. The easiest applications are Zoom (63% students) and Webinar.ru (37% students). To the question «Do you find that DL is suitable for you?» 41% students answered «Yes», 28% – «No», 31% – «I don't know».

Commentary on Part 2. Students understand that DL focuses on their independent work (100%). Here are the students' answers to question 4: theory is good, but practice began to lag behind (i.e. practice-oriented forms of education, which were far from fully used in conditions of forced innovations); it got easier to answer questions; it is difficult to keep track of the subject and what is required for it; it is more difficult to master new things; it is easier to defend laboratory research and pass the exams; there is not enough time to complete written tests; lectures have become easier and practical classes have become more difficult.

Interest, positive emotions, as well as motivation (responsibility) did not change significantly (questions 5,6).

Students point out that when using distance learning, learning in the traditional form should still prevail. The overwhelming majority of respondents, firstly, are not ready to switch to 100% distance learning, and secondly, they believe that in its current state it does not form profound knowledge (question 8).

Commentary on Part 3. In all four faculties, traditional TL is psychologically more comfortable for a noticeable majority of students (from 61% to 78% at different faculties). But the situation with grades is different (with the exception of REA faculty); in DL, the grades are higher, as indicated by 55–63% of students (at the REA faculty, only 38% of students think so), although in fact, students dedicate less time to studying with distance learning! (answers of 32% of REA faculty students, 41% – ICE, 44% – MST). Students-Philologists, on the other hand, as noted above, do not even have enough time to study in a distance learning environment. Thus, 63% of humanities students work more than in TL. The contrariety of answers is also based on the fact that in distance learning the material is less clear – this is indicated by 65 to 85% of students.

Answers to question 6 clearly depend on the training direction (figure 1). At the Faculty of ICE and among students of Philology, there are certainly more tests, unlike in the other two cases.

Answers to the question about the ratio of oral information from lecturers in distance and traditional learning correlate with these results (table 2). The answers are surprisingly similar, despite the different majors. Thus, we can conclude that lecturers abuse the use of information and communication technologies for verbal communication. The situation is aggravated by the fact that more often such
communication is a monologue («well, it's a lecture»), since the last question 7 in the Part 3, with an overwhelming preponderance, is answered with a reason «there is no possibility to receive timely oral help from the lecturer». That said, at second place with a margin from the rest of the options is «I can't bring myself to study».

Table 2. The ratio of verbal information from lecturers in distance and traditional learning.

| Type of learning | REA  | ICE  | MST  | Philology |
|------------------|------|------|------|-----------|
| Distance         | 46%  | 55%  | 56%  | 46%       |
| Traditional      | 54%  | 45%  | 44%  | 54%       |

Conclusions on Questionnaire Survey Results. Lecturers do not have enough remote controls (tests), and therefore, lectures often prevailed over discussions and analysis of results of students' independent work on tests and other control assignments. As a result, distance communication was often reduced to a poor version of traditional learning. Students did not manage to switch to independent work on control tests of different levels of complexity. Under the conditions of a sudden unprepared transition to exclusively distance learning forms, the quality of learning became a problem that cannot but worry both the lecturer and the student.

5. Conclusion
Forms and methods of learning in the context of distance education clearly convince us that traditions of Russian education are still relevant – the lecturer's mission cannot be limited to teaching goals only. Moral and intellectual development of students is one of the main tasks of education. This is what we clearly lack now. Another regularity of today is the need to combine the traditions of Russian education with the strengthening of the professional component of engineering education. Here, in our opinion, such a quality as intelligence, which is traditionally inherent in a Russian university, should play a decisive role. In this regard, the use of the transdisciplinary approach in its expanded understanding as the integration of the content, methods and forms of training organization, as well as working contacts between lecturers of different disciplines, becomes inevitable. The results showed that in force majeure conditions, when the general distance learning was introduced not in a natural, evolutionary way but due to reasonable necessity, regional universities faced a number of problems, overcoming which is only possible if the ratio of learning forms would be in favor of practice.

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