МАТЕМАТИКА И МАТЕМАТИЧЕСКО ОБРАЗОВАНИЕ, 2014
MATHEMATICS AND EDUCATION IN MATHEMATICS, 2014
Proceedings of the Forty Third Spring Conference
of the Union of Bulgarian Mathematicians
Borovetz, April 2–6, 2014

ON THE SELF-LEARNING ACTIVITIES OF UNIVERSITY STUDENTS

Alexander Rusakov

The paper considers professional competence formation as an important goal in the changing socio-economic life of the society and the deteriorating situation of the labor market. The mathematical education modernization of future specialists turns out to be of special actuality. It requires new organization-methodological tools and technologies for quality improvement of university teaching. Considering the objectives and the results of the education, researchers emphasize the need of building unified motivation-cognitive and behavioral components of the personality structure of university graduates. Most adequately the unification is expressed by the "professional competence" concept, which is related to one of the main qualities of future specialists.

The analysis of the traditional mathematical preparation of future engineers in technical universities shows that the level does not meet modern requirements fully and conditions for personality-professional development of students are not created to reveal creativity and form subject competences. Traditional educational results expressed in terms of knowledge, skills and habits are insufficient in the preparation for life and production problem solving. The stress should be directed to the developmental function of mathematics education, to the transition from "school of memorizing" to "school of understanding", to the transformation of the existing educational system into a sphere of learning methods for cognitive activity, mathematical, communicational and engineer culture, into a system of education in complex practice-orientated multidisciplinary teams using organic inclusion of students in creative activities and ensuring their mass participation in research work in the presence of mathematical modeling and design [1].

The university education includes two practically identical parts in size and mutual influence – teaching and self-learning process. In the organization of self-preparation three groups of factors are determined in relation with its efficiency and success on the essential base of the didactic possibilities implementation of information and communication technologies [2], namely: organization, methodology and management.

1) Planning of all types of training activities during the full school year; advising students to plan their own activities, which are necessary for the execution of current homework and design-graphical projects; providing of instruction-methodological literature (interaction by sources of educational information);

2) Elaboration of individual tasks by lecturers for self-work; teaching of methods and techniques to students for self-work; assistance in the determination of personal learning

paths (accounting for the possibility of self-selection by trainees of modes of subject learning that have been differentiated according to the level of difficulty and the types of training activities);

3) Control of individual work on the part of the lecturer, i. e. the work should be supervised since control is impossible without supervision (implementation of automated supervision by error diagnostics, self-monitoring and self-correction).

In extracurricular self-work (which exercises various kinds of collecting, processing, transmission and production of educational information including activities by distributed information resources of local and global networks, individual design-graphical projects and current homework) students have the opportunity to actualize, accumulate and organize all sorts of methods of training to compare them and to apply the most rational ones in best ratios. Independent work is also carried out in conversations, consultations, tests, colloquiums, additional "problem" classes, math circles, workshops and other forms. An example of consultation content could be "a memory card" since everything new is well forgotten old. The memory card contains the learned material in an "individual package". It is necessary not only to learn the material but also to identify the main concepts; to establish a categorical hierarchy, i. e. to find connections and relationships between key concepts; to invent a visual display of the resulting knowledge "system".

"At the present stage of development of the pedagogical science, improvement of the methodology and the criteria for the selection of educational content is due after all to a need of orientating the educational process not to a certain volume of knowledge, skills and habits to be acquired but to the development of intellectual capacity, to the development of abilities for independent formation of knowledge by means of modern technologies for information interaction like multimedia and telecommunications" [4]. The basis of problem system design is the principle of understanding whose essence is that the transition from one topic to another is not allowed until the first one reaches a certain level of understanding of the corresponding material. The principle of understanding is a methodological component of the management by a self-learning information process [2,3]. The last is realized by the presence of e-textbooks (as multi-purpose information systems [1,8]), the presence of continuous monitoring (possibly automated) of the state of understanding by means of information and communication technologies.

Every discourse is constructed on a definite structure, which builds and sees the subject, while the understanding concerns the structure itself. The main approach is to elaborate a construction, which connects the data and the unknown challenges, also structuring the elements of this construction and its elaboration is based on main approaches of thinking activity like "synthesis" and "analysis".

The next example [6] traces how the subject obtains events and states of understanding in problem solving:

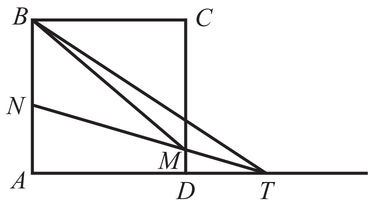
Problem 1. The numbers $1, 2, 3, \ldots, 2917$ are written down along a circle in ascending order. The first step is to delete the numbers on odd places. The second one is to delete the remaining numbers on the new odd places, thus continuing until a unique number remains. Which is the last number?

Solution. After two or three steps, a confusion and chaos occur, which cannot be controlled. It is necessary to structure, organize and understand. A possible structuring is by encoding the initial numbers, the deleting process and the remaining numbers.

Encode the initial numbers by the parameter m, i.e. m takes the consecutive values 1, 2, 3, 4, 5, ..., 2917. After the first step the remaining numbers are of the form $2m$, i. e. 2, 4, 6, 8, ..., 2916. The result of the second step gives the numbers $4m$, i. e. 4, 8, 12, ..., 2916 (every fourth from the initial sequence). After the third step we obtain the numbers $8m$, i. e. 8, 16, 24, ..., 2912. And so on. All the steps are emotional and bring humor to the solver. The successive results are encouraging. At each step the mood improves, because the solver "understands" that the procedure is correct. After the 10^{th} step we obtain 1024, 2048 and the answer is 2048.

The achievement of the understanding state is due to the structuring of the initial number system and the systematization of the solution steps. The encoding itself is the technology of structuring, which optimizes the solving process. Additional examples could be found in [6, 7].

Problem 2. Let N be the midpoint of the side AB of the square $ABCD$ with side 4. A line through N intersects the lines CD and AD in points M and T, respectively. Find the area of the triangle BMT if $\operatorname{tg}\alpha = 3$, where α is the acute angle between the lines AB and NM.



Solution. From the triangle NAT we have $\dfrac{AT}{AN} = \operatorname{tg} \sphericalangle ANT$ and consequently $AT = AN.\operatorname{tg} \sphericalangle ANT = 2.3 = 6$. It follows that $DT = 2$. The similarity of the triangles NAT and MDT gives $\dfrac{MD}{NA} = \dfrac{DT}{AT}$ and we obtain $MD = NA \cdot \dfrac{DT}{AT} = 2 \cdot \dfrac{2}{6} = \dfrac{2}{3}$. Thus, $S_{BMT} = S_{BAT} - (S_{BADM} + S_{MDT}) = \dfrac{6.4}{2} - \left(\dfrac{4+\frac{2}{3}}{2} \cdot 4 + \dfrac{2.\frac{2}{3}}{2}\right) = 12 - \left(8 + \dfrac{4}{3} + \dfrac{2}{3}\right) = 12 - 10 = 2$, which is the answer of the problem.

Here the structuring concerns the representation of the area S_{BMT} by the area S_{BADM} of the trapezoid $BADM$ and the areas of the triangles BAT and MDT. The technology of structuring includes the similarity which helps to find the lengths of the necessary segments. This problem is of testing character aiming at the evaluation of student capability to connect the unknown area with the given data using the structure of the corresponding construction.

The seminars (in Latin "seminarium" means "hotbed of knowledge") are of essential significance in the realization of discussions concerning educational materials. Their goal is an in-depth study of the corresponding discipline, generating habits for independent search and analysis of educational information, forming and developing scientific thinking, skills for active participation in creative discussions, competences to make correct conclusions and to state arguments in defending personal views. Self-study could be implemented in the course of collective work in subgroups (5–7 people), applying individual and differentiated approaches by the inclusion of students in certain kinds of self-organization. Nowadays, the existing dynamic environments help not only to see figures, drawings, images, graphical representations, etc., which illustrate problem conditions, but also to "twist" them, thus notifying some of their peculiarities and essential features. There exist special task designs which define three possible types of self-work. Each type depends on the degree of student responsibility and the level of difficulty of the problem content. The first type refers to designs in which students choose actions that they are able to perform with results not affecting the actions of the others. The results of the second type designs affect the actions of the others. Finally, the third type includes tasks in which no one can get results until a common problem situation has been overcome. In such a case students work together and/or with the support of the lecturer and just after a successful end everybody could pass to his/her individual task. Some examples from various mathematical domains are given below concerning the different design types.

Problem 3. The coordinates of the vertices of a triangular pyramid $ABCD$ are given: $A(4,4,10)$, $B(1,10,2)$, $C(2,8,4)$ and $D(9,6,4)$. Find:

1. The lengths of the edges.
2. The equations of the edges.
3. The equations of the faces.
4. The plane angles at one of the vertices.
5. The angles between the edges AD, BD, CD and the base ABC.
6. The area of the pyramid faces.
7. The volume of the pyramid.
8. The length of the height of the pyramid.
9. The equations of the pyramid heights.
10. The coordinates of the point K, which is symmetric to D with respect to the base ABC.
11. The slope angles between the faces and the base ABC.
12. A description of the interior of the pyramid by a system of inequalities.

Most of the tasks in this problem are independent of each other and students could choose those of them which correspond to their capacities. For this reason the problem is an example giving possibilities for the realization of individual motives and self-assessment.

Problem 4. A set of ten items contains four, which are defective. Five items are chosen randomly. Denote by X the number of the defective ones among the chosen. Determine:

1. the probability distribution of the variable X;
2. the distribution polygon and the probability function;
3. the initial moments, executing all necessary computations;
4. the central moments, executing all necessary computations;
5. the mathematical expectation $M(X)$, the dispersion $D(X)$ and the standard deviation $sd(X)$;
6. the probabilities of the specific events, when the values of the variable X are in the interval: a) (0;3), b) (2;5), c) (1;4); the values of X, which do not affect the calculated ones;
7. the asymmetry $A_s(X)$ and the excess $E_k(X)$;
8. geometric interpretations of $M(X)$, $D(X)$, $sd(X)$, $A_s(X)$ and $E_k(X)$.

This problem is addressed to a collective execution by a distribution of individual tasks for different students. Systematization is needed and a useful tool could be a working table. Obviously, the individual results affect each other. The final one depends on all intermediate actions and computations. The lecturer has the possibility to direct the actions of the sub-groups using criteria in accordance with the level of difficulty. Control of the intermediate results is encouraging.

The third design type is connected with the next problem.

Problem 5. The lateral faces of the tetrahedron $SABC$ belong to the planes $4x + 8y + 5z + 53 = 0$, $10x + 11y - z - 34 = 0$ and $10x + 47y - z + 146 = 0$, respectively. The point $M(3; 2; -4)$ is in the interior of the pyramid, and the lengths of the lateral edges are 2, 10 and 1. Find:

1. the area of the tetrahedron base;
2. the volume of the tetrahedron;
3. the equation of the tetrahedron height;
4. the angles between the lateral faces and the base;
5. the equations of the lateral edges;
6. the coordinates of the circumcenter of the tetrahedron.

To start any manipulation in this problem we need the coordinates of the tetrahedron vertices. A unique determination is impossible without understanding the role of the point M. In fact the last is the problem situation to be overcome. This could be realized by collective attempts from the part of the students or by the support of the lecturer. Afterwards differentiated and individualized actions could be performed, although some additional difficulties may occur.

Composition of problems is also an activity which is classified as a creative one. It is a part of the global goal of education – to learn the art of problem solving and problem statement. Students take active part in such activities, especially in the domain of linear algebra and linear programming, probability theory and statistics. Many of them are included in specific work in connection with their future realization. No matter what is their concrete specialization, mastering of mathematical methods and approaches is of essential significance and this determines the topics of their course projects and diploma researches.

REFERENCES

[1] А. А. Русаков. Методические подходы к совершенствованию математического образования студентов технических специальностей. *Педагогическая информатика*, **6**, 2011, 45–55.

[2] Т. Ф. Сергеева, С. Гроздев. Субектность как методологический принцип. *Математика и информатика*, **3**, 201–207.

[3] S. Grozdev. For High Achievements in Mathematics. Theory and Practice. (The Bulgarian Experience). Sofia, ADE (ISBN 978-954-92139-1-1).

[4] И. В. Роберт. Теория и методика информатизации образования (психолого- педагогический и технологический аспекты). Москва, Институт информатизации образования РАО, 2008.

[5] A. A. Rusakov, K. N. Lungu. Understanding as a pedagogical category (for example, mathematics). Science, Technology and Higher Education, (Materials of the international research and practice conference, Westwood, Canada, December, 11-12 2012), Westwood, Canada, 2012, 34–39, (ISBN 978-1-927480-57-1).

[6] К. Н. Лунгу. Дидактический и методический аспекты понимания. Новые технологии, Москва, Наука, 2007.

[7] К. Н. Лунгу, В. П. Иорин, Д. Т. Письменный, Ю. А. Шевченко. Сборник задач по высшей математике. Части 1 и 2. Москва, Айрис Пресс, 2006.

[8] Е. Князева, С. Гроздев, М. Георгиева, Д. Гълъбова. Синергетичен подход във висшето образование. В. Търново, Слово, 2013, (ISBN 978-954-439-986-3).

Alexander Rusakov
Moscow State University of Instrument Engineering and Informatics (MGUP)
Moscow, Russia
e-mail: vmkafedra@yandex.ru

ВЪРХУ САМОСТОЯТЕЛНИТЕ УЧЕБНИ ДЕЙНОСТИ НА СТУДЕНТИТЕ

Александър Русаков

В статията се разглежда формирането на професионална компетентност като важна цел в условията на променящия се социално-икономически живот и изострящата се ситуация на пазара на труда. Това прави особено актуална модернизацията на математическото образование на бъдещите специалисти. Изискванията касаят нови организационно-методически средства и технологии за качествено подобряване на университетското обучение. Отчитайки целите и резултатите на образованието, изследователите подчертават необходимостта от изграждане на единни мотивационно-когнитивни и поведенчески компоненти в личностната структура на университетските випускници. Най-адекватно това единство се изразява с понятието „професионална компетентност“, което се отнася до едно от главните качества на бъдещите специалисти.