

Mentorship as a way of developing primary research skills

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Abstract — The paper describes the organization of undergraduate student research activities based on the model of mentorship. The authors explain how the mentoring model can be used for developing primary research skills and competencies. The range of skills required for effective participation in scientific research is determined. The authors propose some principles of constructing the model of mentorship. The functions of main participants of the scientific research – junior students, students-mentors, and teachers – are discussed. The paper describes the mentor training programme offered at the Ural State University of Economics (Ekaterinburg, Russia). The efficiency of the mentoring model is exemplified by the interdisciplinary research project combining analytical chemistry and IT. The conclusion is made that the mentoring model could be adopted for planning and organizing scientific research in different areas of studies and in various educational institutions.

Keywords — *research skills, mentoring model, project-based learning (PBL), interdisciplinary project design.*

I. INTRODUCTION

Fundamental science has always been one of the most formidable achievements of Russia. In the 20th century the Russian science was in an extremely strong position, meeting international standards and leading in some industries. Special emphasis was given to the development of the academic elite and enablement of continuing research. Special “research” classes existed in secondary schools, “research schools” were established in universities and research centres. From the beginning of their university studies, students were involved in the activities of Student Research Societies, Student Development Laboratories and other organizations that were making a significant contribution into developing student creativity, research skills, and project work experience. In their work on research and development projects, which was an essential part of the university studies, students were guided by

professionals - teachers, scientists, industry specialists. A diploma project was an important constituent of the final evaluation procedure that followed an extremely academic pattern and did not leave space for simulation and game formats.

During and after perestroika the continuing radical reforms of the education system resulted in serious changes in the status of science in Russia, which was breaking with many established traditions. New priorities of the market economy did not contribute to engaging young people in scientific studies: research activities required a lot of efforts but were not financially rewarding. The most talented young researchers realized their potential overseas. At the same time, the educational background in fundamental disciplines - mathematics and natural science - and even basic literacy in these fields decreased sharply. Since these subjects played an important role in gathering intelligence, the decrease affected development of creative abilities. To a certain extent, technical progress has had a negative impact on these processes. Massive use of information technology, open access to information and solutions to a variety of issues that previously required intensive studies and training of relevant skills, have significantly reduced the need for this intensive work. The educational paradigm which justifies the redistribution of the roles of educational process participants and gives students rights to choose their own trajectory of educational activity has also changed. Quite often, students’ choice is in favour of an easy, but low-effective way, not demanding thorough preparation for scientific activities. Currently, research projects are excluded as an evaluation method for the Bachelor’s degree programme, but they are used for Master’s degree and at the graduate level. Under these conditions, the issue of developing young people’s understanding of the importance of science and the purposeful development of students’ scientific and research potential at all levels, particularly in higher school, is becoming critical.

Today, a variety of methods and techniques are used in order to engage students in research activities. Project-based learning (PBL) is the most popular among them. PBL perfectly fits the modern educational paradigm. Forms of PBL organization and implementation are numerous. It develops creativity and independent learning in students, fulfil students' need for competence, enhances their academic engagement and, in general, increases the effectiveness of the educational process [1,2]. This is especially significant against the background of contemporary youth's low interest and even apathy toward science and general education, their perception and attitudes toward science [3-5]. In fact, project design is the essence of any scientific activity. Projects may vary in terms of content (subject-specific [6,7], interdisciplinary [8-10], industry, inter-industry [11,12], etc.), a number of participants (individual, pair, group [13,14]), completion time, models of work administration and task distribution among participants, etc.

The modern educational paradigm and changes in the functionality of the educational process offer new opportunities through mentored experience. Mentorship has generated considerable recent research interest [15-17]. Mentoring models are extremely diverse [18-21], but their application is not always systematized. Quite often, the modelling character prevails: project themes relate to the issues that have already been discussed and solved. The only new element is the students' experience of their first exposure to research under the guidance of mentors. This is especially relevant with regard to project work at the secondary school level and during the first year of the university studies. However, these projects are typically research-led and research-oriented where students frequently are an audience rather than participants, and the degree of real scientific activity is low. This is especially true of natural science projects. In view of the aforesaid, the purpose of this study is to develop the concept of organizing PBL with the use of mentorship at the university level. Thus, the objectives of the paper are to develop the organizational principles of this activity; define functions of its participants – students, mentors, experts; and generalize the experience of using the mentoring model in PBL of analytical chemistry and physics in the Ural State University of Economics (USUE) (Russia).

II. METHODS AND MATERIALS

The methodology of this study includes two main aspects: structural-functional and programme-targeted. Viewed from the selected methodological bases, the model of organizing and running research project activities is considered as structurally differentiated integrity of the specific functions of each model component and each process participant. The programme-targeted aspect is ensured by programmed coherence of interaction, where each component uses its own tools, thereby implementing the emergent process of developing students' research skills.

Thus, the object of the study was the system of students' research project organization and administration in accordance with the model discussed in this paper.

The participants of the research were USUE bachelor's degree students majoring in Food Technology; Biotechnology;

Commodity Science and Expertise; Mathematical Provision and Administration of Information Systems.

III. RESULTS AND DISCUSSION

The initial basis for the development of students' research skills was their knowledge, understanding and skills acquired at earlier stages of learning. However, as mentioned above, this basis was characterized by a number of problems that should be solved before further work could be done. A significant role in solving the existing problems can be played by mentors – senior students, who have recently experienced overcoming similar difficulties and started their academic career.

The mentoring model is based on the following principles:

- consistency, which implies, on the one hand, relative autonomy of the model components, freedom and initiative of the participants performing their functions, on the other, harmonization of participant actions and tasks to achieve a common goal;
- complementarity, a harmonious combination of hierarchical and partnership relations, ensuring each participant's awareness of their role, degree of experience and responsibility; constructive interaction, and individual contribution;
- continuity, or effective translation of the experience “from top to bottom” and teachers' willingness to perceive the patterns of behaviour and attitudes existing among young people;
- individualization, which implies an individual trajectory of work for each student, taking into account their competence, psychological characteristics, and external factors affecting student's learning and research activities;
- problematicity that requires the dominance of truly scientific and practical objectives rather than duplication of already resolved issues;
- innovation, or building interaction and all activities towards a constantly changing goal that meets the challenges of the present and the future;
- encouragement of competitiveness, which involves taking into account the existing competition and translating this model of competitive behaviour into the project work;
- self-diagnosis and self-development, consisting of regular mutual monitoring of each participant actions and correlation of the actions and achievements with the criteria used in research studies.

Students' research activities are inextricably linked with the learning process: students are engaged in scientific work that is looked upon as an essential element of their university studies rather than as an additional component of learning. By being involved in studying and solving scientific problems, students are aided to adopt the philosophy of “learning by doing” [22], thus practising the basic research skills. Research activities are based on individual creative qualities that are quite difficult to

measure. Nevertheless, there are some universal skills, required for quality research work, which might include:

- an ability to experience cognitive interest as an effective motivator for research activities;
- an ability to see knowledge gaps, identify possible problems and assess their importance in order to set research objectives;
- an ability to search relevant scientific data, choose reliable sources of information;
- critical analysis of the data collected from various sources;
- an ability to carry out calculations and quantify the numerical values obtained;
- an ability to think logically, understand the cause-and-effect relations;
- an ability to apply a range of research methods and approaches, both general and subject-specific;
- an ability to rationally organize and combine learning and research activities;
- an ability to adequately perceive the routine nature of research, make reasonable conclusions and adjust the research process;
- an ability to analyze findings of the study, see the possible directions of further research;
- an ability to make general and specific conclusions, give recommendations for the use of research results;
- an ability to hold their ground, further their ideas and findings, facilitate scientific communication at different levels.

All these skills should be possessed by mentors who, then, share them with novice young researchers. As mentioned before, today's secondary school leavers have a low level of background knowledge and cognitive interest. To advance this interest is the first step towards gaining new knowledge and pursuing an academic career, hence the importance of mentorship. Senior students are ideally positioned as mentors of junior students: they are peers, but senior students are more experienced with regard to conducting research projects. Mentors can easily and effectively contribute to junior students' revision of their views on the need for knowledge and skills. In addition to teaching scientific skills, senior students can provide guidance to, model appropriate behaviours for, and provide encouragement and motivation to new researchers.

An essential aspect of any activity, including learning and research, is its rational organization. For first-year students, this aspect is associated with numerous psychological problems caused by big changes in their social environment. These changes such as interaction with a new heterogeneous environment, lack of parents' control, inability to cope with freedom of choices, the need for independent decision-making, lack of knowledge about the organization, working principles and requirements existing in the university, different living conditions, inevitably lead

to stress. Mentors could help first-year students to overcome these difficulties and adapt to the new environment. In fulfilling these tasks, mentors have to:

- get to know each student: learn about their personal qualities and psychological characteristics, their family, place of previous residence and education, living conditions;
- pinpoint the problems and difficulties caused by relationships with fellow students and joining the student community;
- identify possible psychological barriers in relations with university teachers, difficulties related to the learning process;
- advise first-year students how to overcome the existing difficulties;
- communicate with teachers, informing them about student problems, if appropriate;
- introduce new students to the future profession, various aspects of the studied disciplines;
- explain assessment methods employed at the university and give strategies for good grading;
- consider opportunities for developing student's initiative and leadership qualities;
- identify student's interests in extra-curricular activities.

In order to be able to complete these numerous tasks, mentors should get special mentorship training. At the USUE the mentorship training programme is run by the student activist group. This group includes the most initiative students, both junior and senior, with good academic performance and impressive portfolios. The student activist group is in charge of all university student events: contests and competitions, exhibitions and conferences. The mentorship training programme involves a variety of seminars and workshops where mentors share their experience. Teachers are also invited to participate in the discussions and are welcome to give professional advice on how to work with junior students. One of the most discussed issues is students' research activities. The Eurasian Youth Economic Forum (EYEF) held annually at the USUE, offers students a unique opportunity to get involved in scientific enquiry. Students participate in research contests and master classes, present their scientific works at conferences.

The involvement of university teachers in the mentorship training programme is not limited to the communication with the student activist group. This is an on-going process where teachers have to cope with the following tasks:

- select potential candidates for mentors;
- identify their strengths and develop a range of interpersonal skills and the contexts within which they are displayed;
- conduct in-class and out-of-class individual work;

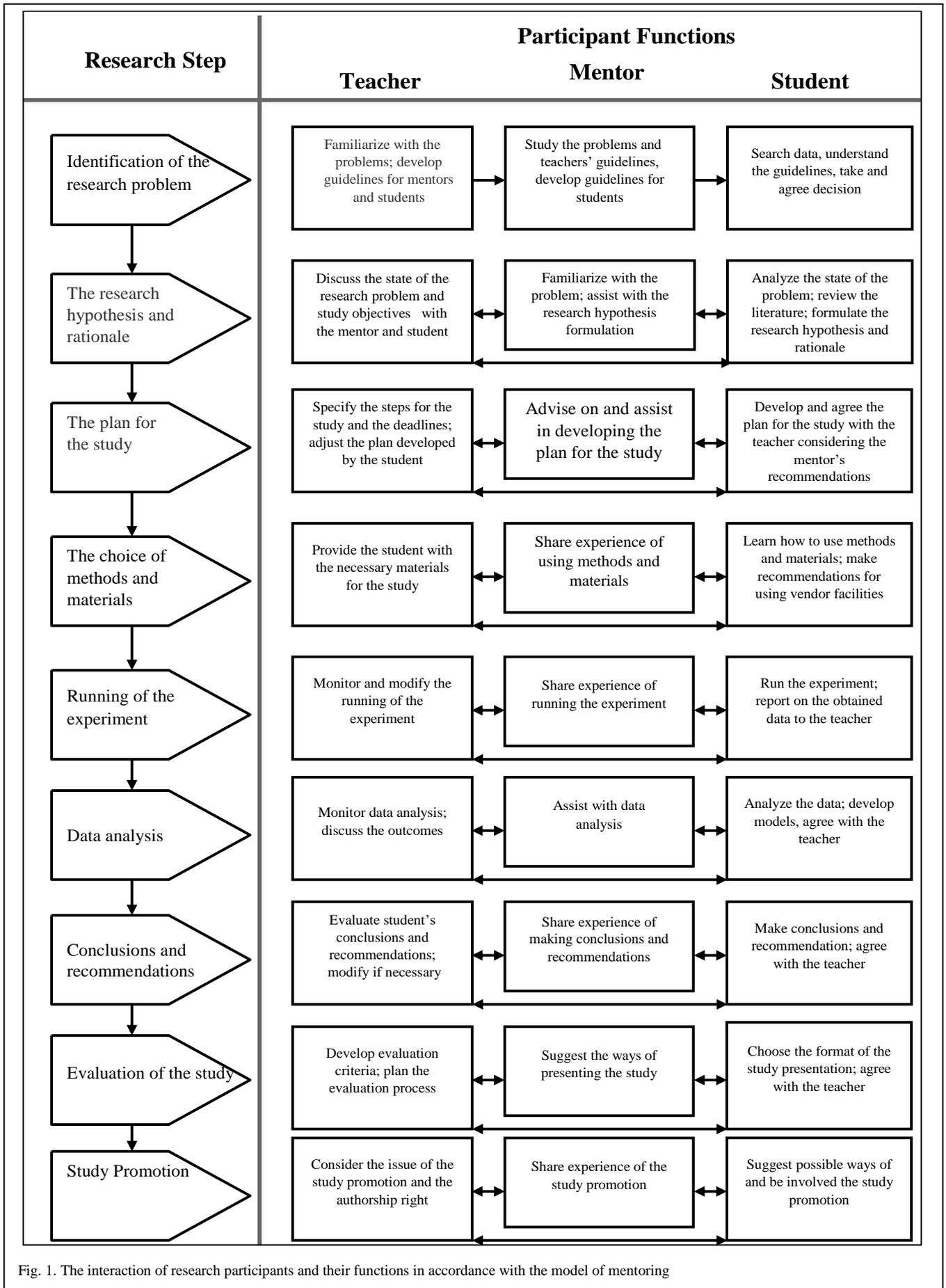


Fig. 1. The interaction of research participants and their functions in accordance with the model of mentoring

- engage potential mentors in methodological work in order to help them learn more about the subject taught and existing pedagogical approaches, methods and techniques;
- introduce potential mentors to the general and subject-specific methodology of science;
- engage potential mentors in scientific activities, including presentation and publication of research papers.

As mentioned earlier, one of the most popular and effective techniques for developing research skills is PBL. At the USUE students may work on a variety of scientific projects: subject-specific, covering the current issues of one subject area; meta-subject, investigating problems that require knowledge of different disciplines; and interdisciplinary. The term “interdisciplinary” may be interpreted in different ways. We understand an “interdisciplinary project” as an activity when students studying a specific subject area design projects that can be used by students specializing in a different subject area [23,24]. In our case, the USUE students majoring in IT developed software that can be used for research in Physics and Chemistry by students majoring in Food Technology, Biotechnology, and Commodity Science and Expertise. This type of project requires deeper knowledge and understanding of the core subject from the developers, while the users gain relevant skills and experience, which makes the project work mutually beneficial for all students.

The model of mentorship used in PBL calls for specific functions for each project participant: junior students, students-mentors, and teachers. These functions are shown in Figure. As can be seen from Figure 1, to a certain extent, mentors are intermediaries between students and teachers. Although their functions are auxiliary, they effectively contribute to the successful implementation of the study at all stages. True, the mentor is not a partner and, as a rule, does not claim to co-authorship. But when senior students mentor their junior peers, there is more direct interaction between the mentor and the student than between the teacher and the student. Junior students feel more comfortable to communicate with the mentor and ask for some assistance. To illustrate the mentoring model, we present the interdisciplinary project under the title “Development of Digital Tools for Determining Hydrocarbonate Alkalinity in Mineral Waters with the Use of Indirect Potentiometry”.

The project was commissioned by the Department of Physics and Chemistry and was carried out by a first-year IT student. The interdisciplinary nature of the project necessitated the involvement of two teachers as project leaders. An analytical chemistry teacher was responsible for providing the equipment and administering a chemical experiment. An IT teacher was in charge of software design. The mentor was a third-year student who had experienced similar project work. He knew a first-year student who showed interest in natural sciences and recommended him to the teachers of the Department of Physics and Chemistry. The mentor helped the student understand the key theoretical concepts of analytical chemistry and their practical application, in particular, the features of chemical

and analytical methods (namely, potentiometry), which aided the student in software design.

The mentor's help was beneficial at all stages of the project, but the most valuable it was at the stages of information search, statement of uniqueness and relevance of the project, planning and coordination with the academic schedule, and the presentation of the project. Scientific novelty and practical application of the project were confirmed by the certificate of state registration of intellectual property rights.

Similar projects both subject-specific and interdisciplinary, designed within the framework of the mentoring model, have been implemented at the USUE Department of Physics and Chemistry for the last few years. Their results have been successfully presented at various conferences and contests.

IV. CONCLUSION

Mentorship is widely used in the organization of various activities. It effectively contributes to achieving good results due to the direct interaction and transfer of experience from more experienced to less experienced participants. The model of mentorship described in the paper seems to be quite effective in the organization of student scientific research. The role of the mentor is not limited by the intermediary functions. The mentor is a relatively independent, but important participant of the learning process. The use of the mentoring model may ensure the acquisition of research skills. The case of project design implemented at the USUE seems to illustrate the common experience that can be gained by educational institutions while planning and administering student research in various fields of science.

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