

DEVELOPMENT OF ENGINEERING WORKSPACES FOR HANDS-ON AND PROJECT-BASED LEARNING

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ABSTRACT

Surgut State University joined the CDIO initiative in June 2017. Since then 1-5 CDIO standards have been implemented in Bachelor's program on Chemistry. In March 2018 the process of sixth standard (Engineering Workspaces) implementation was initiated. Traditional learning spaces have been created in Surgut State University (SurGU) since 1998. They support the learning of chemical substances, processes, systems and technologies. The creation of new workspaces or remodeling of existing laboratories, in which students are directly engaged in their own learning, as well as providing them with opportunities for social learning and settings where students can learn from each other and interact with several groups is needed to encourage hands-on learning. For these purposes three research laboratories at the Department of Chemistry have been remodeled since 2016, in which several projects, aimed at the investigation of oil composition, source rocks organic matter and biologically active substances from plant materials of Western Siberia, are being realized for last three years. Two laboratories have been created as new workspaces for students' project activity in the ongoing projects since 2018, namely Local Farm, focusing on the chemical monitoring of plants grown in hydroponic sets under agrophotonic conditions, and Drilling Fluids, aiming at the optimization of drilling fluid compositions under the geological conditions of formation. Moreover, university halls have been furnished with individual and co-working spaces and recreation areas. Also a Boiling Point was established in 2019 as a public space convenient for both students and teachers to develop future projects, to organize educational events or participate in ones. Everyone can organize an educational event here or take part in it. Thus new or existing workspaces have been created (or remodeled) at Surgut University for the last 4 years to emphasize hands-on learning and project activity of students in Bachelor's program on Chemistry.

KEYWORDS

Engineering workspaces, project activity, hands-on learning, Standards: 3, 5, 6

INTRODUCTION

Surgut State University joined the CDIO initiative in June 2017. Since then 1-5 CDIO standards were implemented in Bachelor's program on Chemistry (Petrova, et.al, 2018; Petrova, et al.,

2019). In March 2018 the process of sixth standard (Engineering workspaces – CDIO workspaces and laboratories that support and encourage hands-on learning of product and system building, disciplinary knowledge, and social learning) implementation was initiated. The workspace, or learning environment, includes traditional learning spaces, such as classrooms, lecture halls, and seminar rooms, as well as engineering workspaces and laboratories (Crawley, 2013). Workspaces and laboratories support the learning of product and system building skills concurrently with disciplinary knowledge. They emphasize hands-on learning in which students are directly engaged in their own learning, and provide opportunities for social learning, that is, settings where students can learn from each other and interact with several groups. Students who have access to modern engineering tools, software and laboratories have opportunities to develop the knowledge, skills and attitudes that support product and system building competencies (Crawley, 2001). These competencies are best developed in workspaces that are student-centered, user-friendly, accessible and interactive. Consequently, workspaces and other learning environments that support hands-on learning are fundamental resources for learning the process of designing, building, and testing products and systems. The creation of new workspaces, or remodeling of existing laboratories, will vary with the size of the program and resources of the university. The purpose of this work was the CDIO standard 6 implementation by remodeling and creating of the workspaces and laboratories for chemistry students.

WORKSPACE REMODELING IN SURGUT UNIVERSITY

The traditional learning environment has been developed at Surgut State University since 1998. Over 15 years, a sufficient number of workspaces tooled up with modern engineering equipment has been created in the university, including classrooms, lecture and sport halls, located in four campus buildings, as well as seven research laboratories of the Chemistry department. The latter ones encourage students of Chemistry Bachelor's program to study chemical substances, processes, systems and technologies aimed at the development of professional skills in the field of inorganic, organic, analytical, physical, oil chemistry and other disciplines.

The creation of new workspaces and remodeling of existing laboratories, in which students are directly engaged in their own learning, as well as providing them with opportunities for social learning and interaction is needed to encourage hands-on learning and support student project activities. For these purposes three research laboratories of the Chemistry Department have been remodeled since 2016, namely: (1) thermal methods of analysis; (2) spectral methods of analysis and (3) sample preparation and petrochemical synthesis. The laboratory of thermal analysis methods (20 m²), for instance, may be used for simultaneous lectures, seminars, as well as a teamwork experimental research, conducted by a student group of 6-8 people under the supervision of 1-2 teachers. In particular, several projects, aimed at the investigation of oil composition, source rocks organic matter and biologically active substances from plant materials of Western Siberia, have been realized in the mentioned workspaces over the last three years. Furthermore, university halls have been furnished with a number of co-working and recreation areas.

Thus, all the mentioned workspaces, appeared at the university, are affordable, interactive, convenient and student-friendly. In three remodeled laboratories, students of 1-2 courses on Chemistry (~30 per year) are engaged in project activities, and students of 3-5 courses (~50 per year) carry out coursework projects and theses, and also conduct research.

NEW WORKSPACE CREATING IN SURGUT UNIVERSITY

To ensure high levels of faculty, staff, and student satisfaction with the workspaces new workspaces, namely Surgut State University Boiling Point (BP SurGU), Local Farm and Drilling Fluids laboratories, have been created in the university since 2018.

The university Boiling Point is a developing space, convenient for students and teachers to work together on the future projects, regularly organize educational events or take part in them. The involvement of leaders and talents enable participants to quickly test breakthrough ideas, assemble project teams, find like-minded people, learn, teach, bring a positive impact on the life of a university, city, region or country – make the world a better place. On October 19, 2019, during the Autumn Navigator session, 41 university co-working spaces (Boiling Points) were opened in 33 Russian cities, including Surgut in Surgut State University. The total number of Boiling Points in the network of the Agency for Strategic Initiatives (ASI) now reaches 82.

A lot of events: conferences, round tables, workshops, master classes, project and pitch sessions took place in the BP SurGU with the participation of more than 200 people, including staff, scientists and university chemical students. On October 24, 2019 a pitch session for bachelors, undergraduate and graduate students in the areas of natural sciences was organized in BP SurGU during the conference «Save North – clean Arctic», with the time limit (no more than 5 minutes) and the presentation template (no more than 3 slides) announced. In total, more than 30 reports were recorded, but only 18 were selected for speeches. As the outcomes of the event showed that the pitch session helped students to develop cross-cutting competencies, such as the ability to present their own research and teamwork results, answer the questions and lead discussions.

In July 2018 the university in a business partnership with REATONIKA company established a new learning space for the project activities of undergraduate Biology and Chemistry students – the Local Farm Laboratory. REATONIKA company is manufacturer of hydroponic systems, including for the cultivation of green and essential oil crops, in the North-West of the European part of Russia and in Western Siberia. The company operates in the field of biotechnology.

The purpose of the created laboratory is to implement a joint project between SurGU and REATONIKA, aimed at developing a Local Farm – an affordable technology for growing crops in closed ground under artificial lighting and introducing an intelligent management system of the local farm resource. Students' involvement in this case includes course works and theses performance; academic, industrial and research practices, making a learning process fully integrated into university's scientific and business projects.

The laboratory consists of three small rooms: (1) for preparing fertilizer solutions; (2) for seed germination; (3) for growing green crops in hydroponic installations with LED lighting systems. All necessary equipment, seeds, fertilizers, substrates for hydroponic sets and other supplies were provided by a business partner. Chemistry program students participate in the project by chemical monitoring source water and fertilizer solutions, used in hydroponic installations and grown products. For chemical analysis the equipment of Chemistry Department and University Collective Center is used (Figure 1). The Local Farm Lab is practically used for practical, active student and project learning in Analytical and Organic Chemistry courses and Project Activity of 1-3 year students. Chemistry students are actively involved in the preparation of recommendations for fertilizer solutions by order of the REATONIKA company. They regularly participate in working meetings with company management and present research results.

In May 2018, on the 25th anniversary of the Surgut State University, it was decided to establish the university Competence Center of Drilling Fluids research (CC LDF), with the financial support of PJSC Surgutneftegaz – a major oil company in Western Siberia. According to the company governance, the establishment of such laboratory is to improve the learning process and chemists training quality. More than 40% graduates of Bachelor's program in Chemistry and integrated Magister's program in Fundamental and Applied Chemistry are traditionally employed in the chemical laboratories of Surgutneftegaz. In addition, the creation of Drilling

Fluid Laboratory would bring an ongoing research to a higher level, increase the commercialization of scientific results and the development of university innovative activity. The laboratory is planned to be used as an R&D center, where new reagents based on surfactants, nanocomposites and layered materials would be developed. Another objective of the CC LDF lies in optimization of drilling fluid formulation under the geological conditions of hard-to-recover reserve fields.

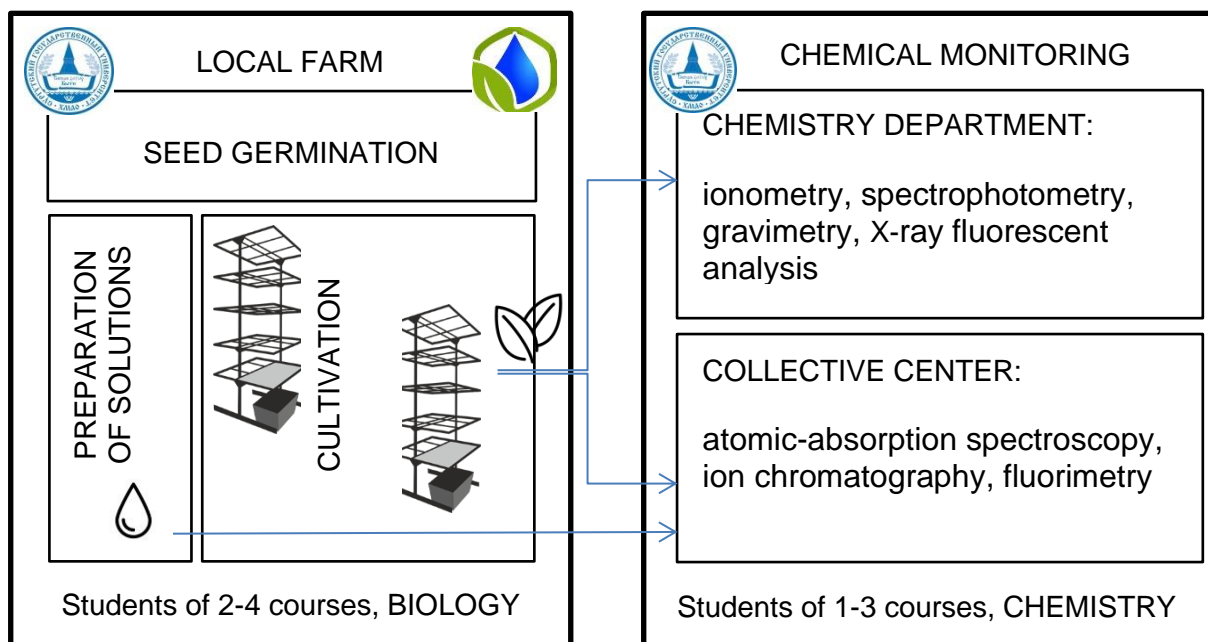


Figure 1. Scheme of student project activities at the Local Farm

Surgutneftegaz has provided funding for the purchase of laboratory equipment, such as a rotational viscometer, a high-pressure filter press and a temperature laboratory blender, and furniture. The laboratory design was completed with the creation of a space for student project work (Figure 2). In the center of the laboratory, there are island tables for teamwork, which may include planning and discussing the experimental processes, project tasks assignment, results recording and presentation, consultations of a supervisor and etc. Specialized equipment is planned to be placed on tables near the walls, in the cabinet between windows – reagents and laboratory glassware. Altogether such workplace is capable of simultaneously accommodating no more than 12 students, working individually or as team members. In the future the database of CC LDF laboratory studies, based on the accumulated historical data and real-time data, will allow to develop domestic visualization tools and predictive analytics, to solve the priority tasks of the Ugra oil and gas cluster with the assistance of the Competence Centers of National Technological Initiative (CC NTI) «New Production Technologies» (Peter the Great St. Petersburg Polytechnic University) and «Technology for Storage and Analysis of Big Data» (M.V.Lomonosov Moscow State University), as well as other partners.

a)

b)

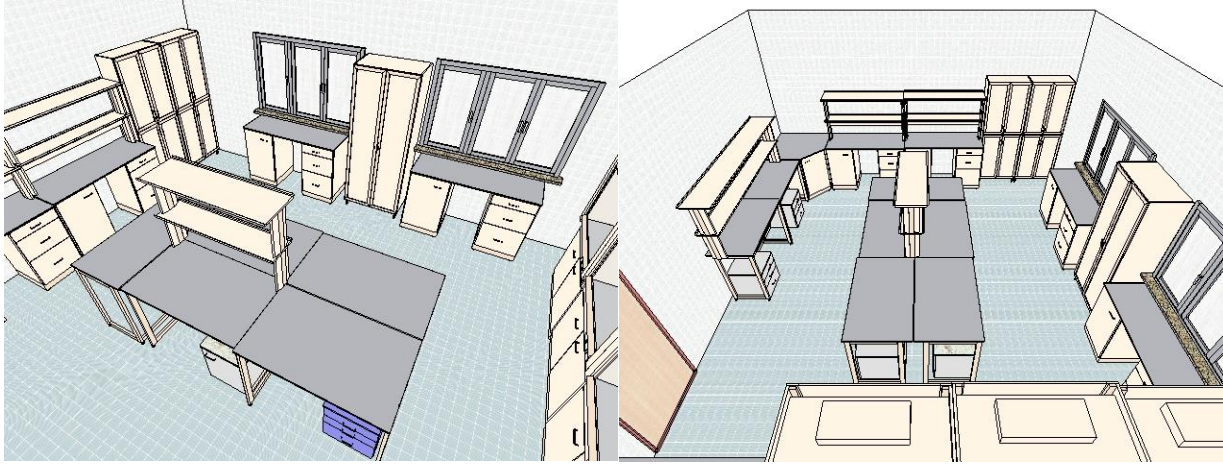


Figure 2. The laboratory design of Drilling Fluid Laboratory:
a) direct view; b) side view

In 2020 the Mirror Engineering Center of CC NTI «New Production Technologies» (Peter the Great St. Petersburg Polytechnic University) on the basis of Surgut State University was created. The aims of this Center in project learning activity are:

- the development of approaches to digital certification based on virtual tests, which will replace some expensive laboratory tests with virtual ones;
- the development of application software and a virtual test bench “Drilling fluid”, which is supposed to be used for virtual optimization of recipes and training for students.

In 2021-2023 the project «Digital Twin of Drilling Fluid» (Figure 3) is planned for implementation with the participation of chemistry students.

Mirror Engineering Center of St. Petersburg Polytechnic University at Surgut State University will be a regional center of competence in the direction of «New Production Technologies» (NTI), which will contribute to:

- enhancing the competencies of digital modeling and digital design based on digital twins and providing student projects in the field of digital engineering;
- the development of cooperation with industrial partners (expanding the portfolio of customers and expanding the list of proposals for industrial partners);
- raising the competence level of staff and students in the field of «New production technologies», including due to the development of project-oriented learning methods;
- increasing the attractiveness of the university and the demand of graduates in the labor market.

PROJECT «DIGITAL TWIN OF DRILLING FLUID»

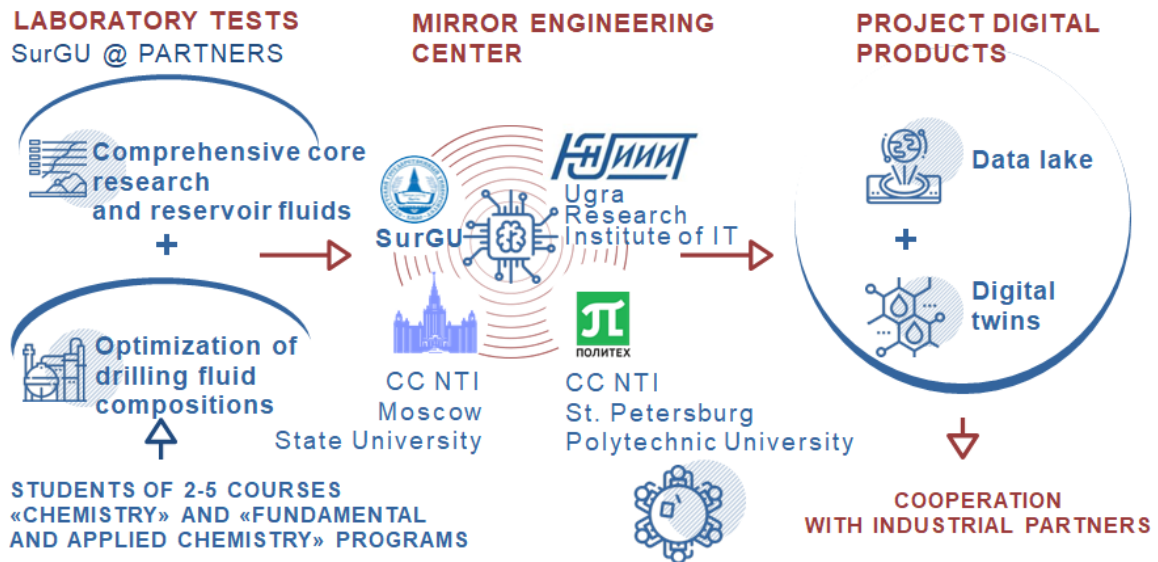


Figure 3. Project structure «Digital twin of drilling fluid»

CONCLUSION

Thus, in accordance with the standard 6: CDIO workspaces and laboratories that support and encourage hands-on learning of product and system building, disciplinary knowledge, and social learning were remodeled and created in Surgut University since 2018. At the university the student-friendly workspaces have been appeared for project activity, co-working and recreation. New learning spaces – laboratories Local Farm and Laboratory of Drilling Fluids were organized at the university for students in Chemistry with support business and industrial partners.

The implementation of redesigned laboratory workspace had allowed us to improve such learning outcomes as teamwork; design process; verification, validation, and certification; implementation management, and had also improved communications; experimentation, research and knowledge discovery; ethics, equity and other responsibilities. The student satisfactions of remodeled and created workspace were assessed before and after implementation using common indicators of learning process satisfaction. A survey of students in February 2020 showed that more than 36% of respondents considered SurGU graduates as competitive (earlier in 2018 it was difficult to answer), more than 54% were satisfied with acquired skills level (up to 40% before implementation). More than 69% of respondents in 2020 said they did not have enough practical skills (in 2018 there were more than 75%), and 29% - the life and career planning skills (40% previously).

Boiling Point was opened in Surgut at Surgut State University on October 19, 2019 as a developing space convenient for students and teachers to work together on the future projects.

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