The Learning-style-based Approach and Optimal Use of e-Resources in Teaching Ecological Disciplines

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Abstract: The paper aims to optimise electronic resources used in teaching ecological chemistry following the educational preferences of students. An approach is used to select e-resources in accordance with the available individual learning preferences of students, teaching styles of teachers and the content of the discipline. The R. Felder and B. Soloman model studied the learning preferences of students of Kryvyi Rih State Pedagogical University majoring in chemistry and informatics and students of Kyiv National University of Technologies and Design majoring in industrial pharmacy. Most students in both groups study visually, sensitively, actively and sequentially. Didactic materials on the theme "Ecological chemistry of the lithosphere" of the content module "Ecological chemistry of environmental objects" were elaborated according to student groups' learning profiles. Expanding the content of the course of ecological chemistry is proposed by including an additional topic on the problems of environmental pollution of medicinal plants. The new topics' content is considered to better match the educational material with the prevailing sensitive learning style in most students and simultaneously strengthen the ecological component and form the necessary competencies in future professionals. Forms of work that involve the use of different cognitive functions are described and therefore contribute to their balanced development. It allows a person to be flexible in the unrestrained development of technological progress, be open to different ways of obtaining information, and perceive it without resistance and stress.

1 INTRODUCTION

Sustainable development of society implies the development of the economy, which provides natural systems' ability to recover and exist stably. Under such conditions, resources are used to meet human needs without erosion of natural systems' integrity and stability. The goals in sustainable development, formulated at the UN level, aim to solve global problems. One such global goal is to make people aware of their responsibility for the results of their activities.

Education for sustainable development is defined as education that guarantees knowledge, skills, values and views to ensure a more sustainable and fair society. Education should train professionals to address the growing and changing environmental challenges facing the planet (Ashford, 2004). Accordingly, education must change to provide knowledge and attitudes that will enable students to contribute to sustainable development. At the same time, education should be strengthened in all programs and activities that promote sustainable development. Sustainable development must be integrated into education, and education must be integrated into sustainable development.

The educational process organisation needs to be changed because each individual's development must become "sustainable". Student understanding of the ecological consequences of people's activities in every day and productive spheres of their lives should also become deep and internal. During the integration of appropriate approaches into training, the authors tried to move in two directions. The first is to improve or change the forms and methods of learning, creating conditions for individuals' sustainable development. The second direction changes the content of

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academic disciplines by filling academic programmes with factual data. Such data should reflect the actual state of things in the real world. They should illustrate the relationships in the chain of human activities – the state of the environment (controlled or uncontrolled changes) – result (risks and dangers for people).

Concerning the first approach, teachers should pay more attention to students' learning styles. Education for sustainable development provides an exciting vision of an interdisciplinary and learner-centred way to empower students to advance a pro-social and environmental agenda in their organisations, communities and personal lives. Introducing a student-centred higher education model requires considering the subject's preferences regarding study methods (Saarinen et al., 2020; Damsa and de Lange, 2019; Gao, 2014). Such an approach will allow students to use their available cognitive functions and improve their gnostic functions to develop rapidly.

Students differ significantly in the speed and manner in which they master new information and the confidence they process and use it (Lee et al., 2010; Coffield et al., 2004). With the development of information and communication technologies (ICT), the range of electronic resources (e-resources) and tools that are used or can be used in the educational process significantly expands (Osadcha et al., 2020; Kholoshyn et al., 2020). Such a statement is especially true of teaching natural sciences (Nechypurenko et al., 2020b; Modlo et al., 2020). Accordingly, the problem of individual perception of students of different resources is becoming increasingly important.

The modern education paradigm also promotes interest in learning preferences to develop the necessary attitudes and skills of lifelong learning, especially in the context of the need to "learning to learn." The logic of lifelong learning assumes that students gain more motivation to learn if they know their strengths and weaknesses in the learning process. In turn, if teachers can respond to people's strengths and weaknesses, student achievements are likely to increase.

Learning to learn skills can be the basis for lifelong learning. Students become independent in their learning if they know their strengths and weaknesses. The adverse effects of reduced contact between lecturers and students with introducing new ICTs will be balanced by a more effective learning strategy that students can use outside the classroom.

Attempts have long been known to take the problem of academic achievement beyond simple solutions, such as the connection with intelligence or previous academic achievements (Childs-Kean et al., 2020; Cassidy, 2004; Pashler et al., 2008). One such concept used in determining the factors influencing the effectiveness of learning is learning style. Since learning styles were investigated in a massive amount of research, there are many definitions, theoretical positions, models, interpretations, and construction dimensions. For example, the review (Coffield et al., 2004) lists 71 models of learning styles with different applications – from pedagogy to commercial use for testing propensity to professions, particularly on-service training, the management or professional development courses and more.

At the same time, there is criticism of the very concept of learning styles (An and Carr, 2017; Newton, 2015; Wininger et al., 2019). The very idea of a variety of approaches to learning among students is usually not criticised. The concept of correlation between learning styles, teaching methods and academic performance is more often criticised. A large number of model ideas about learning styles is a natural consequence of extensive empirical research. This situation can be expected for any continually evolving concept. However, the level of ambiguity and discussion is so high that even the task of choosing the appropriate tool or model to use is burdensome.

Teachers in all fields are increasingly aware of the critical importance of understanding how people learn. It is equally important that any attempts to integrate learning style into educational programs are made from an informed position. According to (Coffield et al., 2004), the vast majority of models of learning styles can be divided into five groups. This distribution covers more than 50 different models. Each group is characterised by the presence of several well-developed and popular theories. Some of them, which are decisive in the distribution of five groups, are listed below.

1. Constitutionally-based learning styles and preferences including the four modalities: visual, auditory, kinaesthetic, tactile (Dunn and Dunn, 1992; Gregorc, 1984);
2. Cognitive structures which are reflected in learning styles (Riding, 2002);
3. Learning styles are one component of a relatively stable personality type (Apter, 2001; Jackson and Lawty-Jones, 1996; Myers and McCaulley, 1998);
4. Learning approaches, strategies, orientations and conceptions are considered instead of learning styles (Entwistle, 2018; Sternberg, 1999; Vermunt, 1996);
5. Flexibly stable learning preferences (Allinson and Hayes, 1996; Mayer, 1993; Herrmann, 1996; Honey and Mumford, 2000; Kolb, 2000).

Each group is based on different assumptions. Some theories are based on studies of brain function. Accordingly, specific nerve activity associated with learning can be detected in different areas of the brain. Other influential ideas come from established psychological theories. Learning styles are believed to be formed based on the fixed traits and intellectual abilities of individuals. Therefore, styles can be accurately identified and then reliably measured using psychological tests. Test results predict behaviour and learning achievements.

In contrast to the above models, other theories avoid all notions of individual features. Attention is focused on the contextual and situational nature of learning. Such models prefer to study the biography of an individual rather than styles or approaches.

Very popular are models that present learning styles as "flexibly stable". Previous learning experiences and other environmental factors may create preferences, approaches, or strategies rather than styles. Therefore, styles can vary from context to context or even from task to task. Sufficiently reliable tools for diagnosis and predictions can be created and used to improve student's learning level. In this approach, learning style is not a fixed feature but a diverse differential advantage in learning, which varies slightly from situation to situation. At the same time, there is some long-term stability in the learning style. Models of learning styles as flexibly stable preferences, which are usually well adapted for teaching natural and technical disciplines (Felder and Silverman, 1988; Felder and Spurlin, 2005), will be used in this paper. According to this approach, one should first understand the learning preferences of individual students and the preferred learning style of a whole student group (Alzain et al., 2018, 2016).

Previous research corroborated the existence of correlations between student learning styles and their preferences in choosing e-learning resources. The use of e-resources, which can be called sensitive to learning style, is widespread in natural sciences, such as chemistry, biology, physics, ecology, engineering (Derkach and Starova, 2017; Derkach, 2018, 2019; Nechypurenko et al., 2018, 2020a). This fact must be taken into account when organising training.

Regarding the course content changes, a clear and essential from a practical viewpoint is the introduction into the curriculum of data on environmental pollution of wild medicinal plants. In Ukraine, industrial pollution of rivers, soils, and consequently plants is a serious problem. By some estimates, about 25% of the drugs used worldwide are directly obtained from medicinal plants. In Ukraine, approximately 50% of the bulk medicinal herb feedstock are cultivated under controlled conditions. At the same time, the rest belongs to wild plants.

However, the number of certain types of medicinal plants is decreasing, and the natural reserves of some wild species are entirely or partially depleted. About 200 species are listed in the Red Book of Ukraine, and more than 70 are regionally rare (Minarchenko, 2014). Many wild medicinal plants have limited resources. More than 50% of them are significantly distributed but grow scattered or sporadically. Harvesting of such plants in natural places of growth is unprofitable. The shortage of plant raw materials is due to the ecological load, changing climatic conditions, and anthropogenic factors. In addition to reducing plants' natural habitat, damaged ecology also deteriorates their quality due to contamination with various pollutants.

In summary, the optimal organisation of the educational process ensures the acquisition by future professionals of the competencies necessary for the work and organisation of production and technology in a sustainable society. Optimisation of the educational process concerns both the methods and educational resources and the studied disciplines' content. Considering the learning styles inherent in individual students provides individualisation of education while increasing the effectiveness of learning.

This work aims to identify ways to modernise the educational environment of universities to implement the philosophy of sustainable development in the competence of future graduates of the Faculty of Natural Sciences. First, the prevailing learning styles of student groups majoring in chemistry and informatics will be determined. Then the acquired knowledge will be used in optimising teaching methods in studying ecological chemistry.

2 EXPERIMENTAL

2.1 General Scheme of Experiment

The central part of the experiments was performed at Kryvyi Rih State Pedagogical University (KSPU). Totally 61 persons, including ten male and 51 female, participated in the experiment. They were virtually all first- to fifth-year students of the Faculty of Natural Science of two admission years. They took undergraduate or graduate courses majoring in chemistry and informatics. Senior students studied the integrated course "Ecochemistry and Environmental Monitoring" in the 4th year of study. Junior students have not yet begun to study it.

The experiment consists of three stages. At first, the dominant learning styles were studied for all students who participated in the experiment at the KSPU. The variability of learning styles was studied depending on students' gender, age and study year. Based on the results of measuring the preferences of individuals, educational profiles were developed for student groups.

The course "Ecochemistry and Environmental Monitoring" consisted of 18 lecture hours and 72 hours of laboratory works. This course fruitfully links theoretical knowledge of chemistry and its practical application. It included three content modules devoted to various aspects of ecology. The second stage of the experiment aims to correct teaching methods for the module "Ecological chemistry of environmental objects". For this purpose, didactic materials have been developed that best meet the existing educational preferences of student groups.

At the next stage of the experiment, correcting the course content was proposed by including a new topic, "Ecological pollution of plants", in the module "Ecological chemistry of environmental objects". The new topic's content strengthens students' environmental competencies, expanding their knowledge to the food and pharmaceutical industries.

Some aspects of the new content were improved by one of the co-authors using the same experimental stages 1 and 2 at the Kyiv National University of Technology and Design (KNUTD). A total of 178 students majoring in industrial pharmacy at the Faculty of Chemical and Biopharmaceutical Technologies participated in the experiment to determine educational profiles.

Students from both universities specialised in related, albeit different areas of education. As is well known, educational benefits strongly correlate with the field of study. For this reason, the stylistic educational characteristics of students of both universities were analysed separately. In both cases, the sample size was limited by the available number of students because almost all students participated in the experiment.

Some environmentally-oriented educational elements were introduced in an analytical chemistry program at the bachelor's level and a pharmaceutical quality system curricula within a master's program at KNUTD. Accordingly, 164 undergraduate students and 14 masters took part in the testing of learning preferences. Such a change in the curricula forms a student understanding of the need to continuously acquire new knowledge about plant raw materials and continuously improve the production process.

The obtained results and research methods used at KNUTD are described in this article. They complement the experiment results at KSPU and can be further used to improve the course "Ecochemistry and Environmental Monitoring".

2.2 Index of Learning Style Instrument

The instrument, known as Index of Learning Style and developed by R. Felder and B. Soloman (thereinafter Felder-Soloman's model), was used to study students' learning preferences (Felder and Brent, 2016; Felder and Soloman, 2020). All respondents were interviewed to respond to 44 questions.

The instrument categorises individuals in line with their preferences in four complementary dimensions. These dimensions are as follows: perception – sensing (sns in a clipped form) or intuitive (int), information input – visual (vis) or verbal (vrb), data processing – active (act) or reflective (ref) and understanding of information – sequential (seq) or global (glo).

In other words, each of the four dimension consists of two opposite styles or a pair of style and antistyle. An 11-point scale scores them. The advantage of one of two opposite styles is estimated based on the distribution of 11 points between them. In this paper, the results related to preferred learning styles will be given percentages indicating the relative number of students in the sample with a particular style. Therefore, the number of students will always be 100% for a given style and anti-style pair.

2.3 Style-induced Preferences in Learning

Consider in detail aspects of the R. Felder and B. Soloman model's learning styles, namely the main characteristics of cognitive functions, if one of the styles prevails.

Sensing-type students prefer to learn the facts. They should solve problems using known methods. They do not like difficulties and surprises. So, they will be upset if they receive a question on educational material that has not been covered in detail in a lecture room. Sensing students are also attentive to detail, well-remembered, and do laboratory works, more practical and careful.

Intuitive students prefer theories and hypotheses, love innovation, and do not like repetition. They have a better understanding of new concepts and tend to feel more confident with abstractions and formulas. They work faster and more inventive (Felder and Silverman, 1988; Felder and Spurlin, 2005). Students with a pronounced sensing learning style do not like courses that are not relevant to reality. Intuitive students do not like instructional courses that require a lot of memorisation and tedious calculations.

The benefits of one or the other way of learning can be strong, medium or weak. Students should be able to act in both ways to be effective in teaching and solving problems. If they favour intuition too much, they may lose important details and make mistakes in calculations and lab work due to inattention. If they rely solely on sensing learning, they will reduce learning to cramming and repetition of known methods, refusing to live experiment and develop creative thinking (Felder and Soloman, 2020).

Sensing-type students remember and understand information better when they see how it relates to real life. When they study a discipline that contains much material in the form of theories and abstractions, difficulties may arise. The teacher should be given specific examples for each concept and methodology and show how these concepts are practically used to prevent obstacles in learning theoretical problems. Suppose the teacher does not provide sufficient specific data. In that case, sensing students should find it on their own or in a textbook, or other texts, or using a joint brainstorming session with their learning colleagues (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Usually, intuitive type students take most lectures without problems. However, suppose such students find themselves in classes where they are primarily required to memorise and mechanically use formulas. In that case, they may have problems and boredom. Therefore, the teacher should be provided with interpretations and theories related to the facts studied. If this does not happen, students of intuitive type should try to find regular connections independently (Felder and Soloman, 2020).

Students who have a distinct visual learning style better remember what they see – pictures, diagrams, flowcharts, graphs, movies and visual demonstrations. Verbal students are more likely to receive information in the form of words – written and oral explanations. Both types absorb more when the information is presented both visually and verbally (Felder and Soloman, 2020).

Most classes use very little visual information: students mainly listen to lectures, read materials written on blackboard and textbooks, and manipulate materials. The facts indicate that most students are people with a visual type of perception. In other words, they do not get as much as they could if the visual presentation of data were used more in the class (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Suppose the student has a visual type of perception. In that case, he/she must independently find diagrams, sketches, diagrams, photographs, graphs, or any other visual representation of course materials, which is predominantly verbal. References to videos, videos of the course will be helpful. Students should use maps or flowcharts. Such materials depict critical points of a theme in the middle of squares or other figures, with demonstrations of connections between concepts (in the form of a line with arrows between blocks) (Felder and Silverman, 1988; Felder and Spurlin, 2005). It is helpful for students of the visual type to use colour markings of records. Each colour has its meaning in such markings, highlighting concepts related to the same topic, class, type, etc. (Felder and Soloman, 2020).

Students of verbal type should write short summaries or translations, of course, materials in their own words. Group work can be beneficial to them. They understand the material better by listening to classmates' explanations and learning even more when explaining the content to others (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Students who have the advantage of an active learning style can better understand and acquire new knowledge by doing something with them. Reflective students should first calmly reflect on the information received and then begin working with it (Felder and Silverman, 1988; Felder and Spurlin, 2005).

It is desired to have a balance of both styles. If the student always does and then thinks, at first, he or she may take up the case too hastily, which will create problems. If he spends too much time thinking, he can never do anything about it.

As a rule, active students are more comfortable working in a group than reflective students who prefer to study alone. Attending lectures without any movement and physical activity, apart from giving notes, is not easy for both types, but especially tricky for active students (Felder and Soloman, 2020).

Suppose there is little classroom time when discussing discipline or discussing it together. In that case, students with an active type of perception should make up for that. To do this, they need to prepare for a class together with a group of friends to take turns explaining topics to each other. It is helpful to imagine that they can be asked the next presentation and represent how they will respond (Felder and Silverman, 1988; Felder and Spurlin, 2005).

When students have a little time in the lecture room to reflect on new knowledge, persons with an intuitive perception should try to make up for the lack of that. To do this, they need to read and memorise the educational material and stop from time to time to repeat what they have read, think about possible questions and apply their knowledge. It is also helpful for them to write small summaries based on what they have read or taken notes in the audience, presenting the material in their own words. Such an approach requires additional time but will allow better study of information (Felder and Soloman, 2020).

Students with a predominant sequential learning style gain understanding through successive steps, each of which is a logical continuation of the previous one. Global-type students tend to learn giant leaps, gathering information almost haphazardly and then suddenly grasping the essence (Felder and Soloman, 2020).

Students with sequential perceptions tend to follow a logical step-by-step search. Students with global perceptions can solve problems quickly and put the pieces together once they have understood the big picture (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Many people may mistakenly qualify as "global" because everyone felt astonished by the "illumination" (Felder and Soloman, 2020). However, what makes the perception global or sequential happens before the outbreak. Students with a very pronounced global perception who cannot think sequentially may experience severe difficulties until they understand the overall picture (Felder and Silverman, 1988; Felder and Spurlin, 2005). Even when received, they may have a vague idea of the details of the subject. Simultaneously, sequential students may know a great deal about specific aspects of the subject under study but not understand how they relate to its other components or other matters (Felder and Soloman, 2020).

Most courses in higher education are taught sequentially. Suppose a student has a sequential type of perception. Suppose also a teacher moves from one topic to another and misses the logical steps. In that case, it may be difficult for the student to keep track of his or her reflections and remember something. One needs to complete the missing steps with the teacher's answers or yourself, referring to the directories. Students should logically arrange the lecture material. To develop global thinking, one must try to relate each new topic to one studied before. The more a student does this, the deeper the problem will be understanding (Felder and Silverman, 1988; Felder and Spurlin, 2005)].

Suppose students have a global type of learning style. In that case, it will be useful for them to understand their need for a general picture of the subject under study before mastering the details. If a teacher starts a new topic without explaining how it relates to what has been learned before, it can cause problems. However, there are steps a student can take to get a total picture faster (Felder and Soloman, 2020).

Before beginning the first paragraph of the next section of the text, a student with a global learning style needs to review the section completely to understand a general idea. Initially, this will take extra time and subsequently avoid multiple revisions of individual parts (Felder and Soloman, 2020). Instead of spending time reviewing each subject for a short time each day, it may be more beneficial for such students to study topics in large blocks (Felder and Silverman, 1988; Felder and Spurlin, 2005).

Students of this type should try to relate the subject under study to what they already know. For example, they can ask a teacher to help them see the links or find them in the additional literature independently. At one time, a global student suddenly understands new material and understands its relation to other topics or disciplines. Then, he/she will be able to apply new knowledge very effectively. The student can use acquired information in a particular way that most sequential students do not dream of (Felder and Soloman, 2020).

2.4 Structure of Ecological Chemistry Course

Ecology is a scientific matrix on which the sustainable development of society is built. Sustainable development, in essence, is the inclusion of environmental knowledge in development activities in general. The course of ecological chemistry continues the cycle of chemical disciplines focusing on analysing chemical processes and objects in nature. Mastering the course will contribute to the formation of professional competencies of the future chemist, teacher of chemistry and ecology, or laboratory assistant of chemical-ecological laboratories.

The task of the course of ecological chemistry is to provide students with knowledge about: a) the chemical composition of natural objects; b) natural processes that occur with the participation of natural compounds in the presence of pollutants; c) systems of monitoring control over the condition of natural objects; d) indicators that determine the quality of the environment; e) features of chemical control of natural objects. The structure of the discipline "Ecochemistry and Environmental Monitoring" is given in table 1. The content of the discipline consists of three modules. One of the four topics of module 2, namely the topic "Environmental chemistry of the lithosphere", was chosen for the study to optimise teaching methods and tools following student groups' educational preferences.

Table 1: Structure of discipline “Ecochemistry and Environmental Monitoring” by topics and hours.

Name of topics	Total	Lectures	Labs	Independent work
Module 1. Introduction to a special course				
1.1 Monitoring & ecochemistry as environmental sciences	7	2	–	5
1.2 Human habitat	15	1	10	4
1.3 Chemical elements of the environment	8	1	4	3
Module 1 subtotal (hours)	30	4	14	12
Module 2. Ecological chemistry of natural objects				
2.1 Scientific aspects of ecological chemistry	14	–	–	14
2.2 Ecology of the atmosphere	30	2	14	14
2.3 Ecological chemistry of the hydrosphere	22	2	6	14
2.4 Ecological chemistry of the lithosphere	24	4	6	14
Module 2 subtotal (hours)	90	8	26	56
Module 3. Monitoring of natural objects				
3.1 Scientific bases of environmental monitoring	15	1	–	14
3.2 Atmospheric monitoring (air and gas mixtures)	24	2	8	14
3.3 Hydrosphere monitoring	24	2	12	10
3.4 Lithosphere monitoring	27	1	12	14
Module 3 subtotal (hours)	90	6	32	52
Total (hours/credits)	**210/7**	**18**	**72**	**120**

2.5 Algorithm of e-Resource Selection

To select educational resources according to students' educational preferences, we used the approach firstly described in (Baldiris et al., 2009). We determined students' preferences with different learning styles for certain types of ICT and e-resources used in the training of students of the Faculty of Natural Sciences. Individual e-resources were evaluated by questioning teachers and students. The assessment was made according to the so-called advantage indicator, determined on a 3-point scale. Points mean:

0 – an indifferent attitude to a resource because the respondent does not believe that this resource can contribute to the learning process;

1 – good attitude, the student considers it appropriate to work with this e-resource but does not give it an advantage over others;

2 – very good attitude; the student likes to learn with this type of resource and prefers it to other resources. The respondent also considers it very important for teaching that the teacher offers e-resources of this type.

According to the student survey results, the average scores of resource assessment were determined for students with different learning preferences. The results show how the type of e-resource is consistent with the type of student learning style. Such assessments became the basis for optimising the choice of teaching materials by the teacher. According to the teacher survey results, tables of expert evaluation of the feasibility of using e-resources in teaching specific topics of various disciplines at the Faculty of Natural Sciences were created.

In the presence of such evaluation data, the procedure for optimising the choice of resources to work in a particular student group can be reduced to the following steps:

1. Defining the types of student learning styles as a combination of four aspects (act / ref, sen / int, vis / vrb, seq / glo). Analysis of the group's composition, construction of its average profile or division into subgroups of students with similar learning preferences.
2. Compilation of a list of e-resources required for teaching a specific topic, based on a table of expert evaluation of the module content.
3. Calculation of the specific indicator for each allocated e-resource as a quantitative measure to justify the feasibility of using the resource in the classroom for groups with a particular combination of learning styles.

An example of the application of the described technique is given in (Derkach, 2018). An approach that implies using several types of e-resources for main learning elements was applied for further work in the group. It was considered that the style of teaching and the use of e-resources might run counter to the preferences of students, encouraging them to grow in less developed areas. However, the level of discomfort for students should not be too great. Therefore, we used e-resources that had an average score of ≥ 1. Duplication of information and inappropriate use of class time was not allowed.

2.6 Methods of Plant Chemistry Study

As argued in previous sections, one of the priorities among teaching methods is to teach sensitive students. It is favourable for them to create an environment where the material's presentation is based on real-life examples with specific information or indicators and their comparison. This feature was one of the arguments favouring the introduction of an in-depth study of the influence of the environment on plant chemistry in the course of ecological chemistry.

The content of metallic and non-metallic impurities in plants and the content of biologically active substances, from a practical viewpoint, is most important for medicinal plants. These plants are the raw material base for the pharmaceutical industry. Besides, they are widely used in the food industry, like spices or dietary supplements.

Plants always contain elemental impurities. Some chemical elements in plants, known as essential ones, take part in biochemical processes. In contrast, others do not contribute to plant development and are the product of plants' interaction with the environment (Kabata-Pendias, 2011). The contents of elemental impurities and biologically active substances are formed under the environment's influence (Derkach and Starikova, 2019). At optimal concentrations, the essential elements are helpful while they can become toxic in excess.

On the contrary, a plant poorly develops in deficiency of essential elements. In the meanwhile, the content of essential microelements is often not controlled in herbal medicines. Both essential and non-essential elements can be toxic to the consumers of herbs. Some non-essential metals (*As*, *Cd*, *Pb* and *Hg*) are very harmful (Chizzola, 2012; Locatelli et al., 2014).

Accordingly, the potential presence of toxic metals and the variability of biologically active substances content largely determines the quality, effectiveness and safety of medicinal plants and herbal medicines (Derkach and Starikova, 2019; Derkach and Khomenko, 2018a). Knowledge of the problems of plants, in general, and medicinal plants, in particular, will significantly strengthen the environmental competence of future chemists. Some of the results obtained, which are essential for the formation of environmental competence, will be presented in the following sections.

The primary experimental method for studying the elemental composition of plants was flame atomic absorption (FAAS). Biologically active substances were investigated by high-performance liquid chromatography (HPLC). The used sample preparation methods, equipment and details of experiments are given elsewhere (Derkach and Starikova, 2019; Derkach and Khomenko, 2018b).

3 RESULTS

3.1 Preferences in Learning Styles

The results obtained in the study of learning preferences are shown in Fig. 1 as the average for all interviewed students. A significant difference was observed in three dimensions: sns (65.7%) / int (34.3%); vis (64.2%) / vrb (33.2%) and act (59.5%) / ref (40.5%). No essential difference was found in the fourth dimension of seq (50.1%) / glo (49.9%). In other words, a style prevails over its anti-style in three dimensions. In the fourth dimension, a balance is observed between style and anti-style.

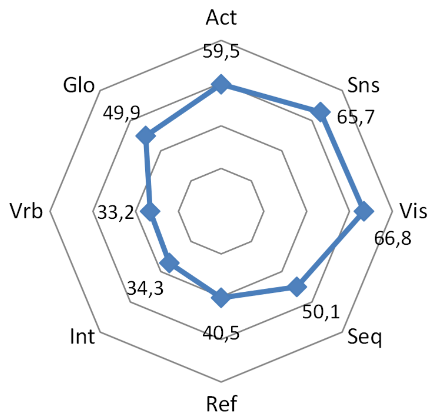

Figure 1: Preferences in learning styles for students of the Faculty of Natural Sciences of KSPU, the speciality 014 Secondary education (chemistry & informatics).

Typically, learning style is a relatively stable and weakly variable characteristic of a person formed under the influence of its psychological and physiological characteristics. For example, it was shown in (Derkach and Starova, 2017) that it is weakly dependent on the year of study for first- to fourth-year undergraduate students.

The opposite view is that dominant learning styles can change under the influence of external circumstances. Such influencing factors may include the field of study and type of material being studied, delivery mode, the age of an individual, motivation and educational level, etc.

It is also commonly believed that learning styles are not sensitive to the student's gender but may vary significantly between students in different fields of study. However, the question of the stability of learning styles and their dependence on students' gender and age can still be considered debatable. The results obtained in the paper allow us to evaluate the influence of the above factors. For this reason, the results of testing the learning styles were divided into groups by gender (figure 2).

Comparing the results of the two studied groups "boys" and "girls", we can see that respondents-boys and respondents-girls have a difference between the two dimensions: "boys" – vis (75.8%) / vrb (24.2%), seq (59.1%) / glo (40.9%); "girls" – vis (62.6%) / vrb (34.0%); seq (46.9%) / glo (53.1%).

In two other characteristics, the difference is almost imperceptible: "boys" – sns (68.2%) / int (31.8%), act (60.6%) / ref (39.4%); "girls" – sns (65.4%) / int (34.6%) and act (59.8%) / ref (40.2%).

Also, testing all students' learning styles was divided into groups by age (figure 3). Comparing the results for ages of 17–20 and 20+ years, we concluded that these groups' respondents had only minor differences. For 17–20 years, the preferred styles are as follows: sns (64.1%) / int (35.9%), vis (66.2%) / vrb (33.8%), act (59.3%) / ref (40.7%), seq (51.1%) / glo (48.9%). For 21+ years, sns (68.2%) / int (31.8%), vis (61.0%) / vrb (39.0%), act (59.7%) / ref (40.3%), seq (48.7%) / glo (51.3%).

In our opinion, there is a slight difference in the respondents' learning styles because all the respondents study in the same speciality. The existing preferences among students-pharmacists of KNUTD compared with the average indicators of students-chemists of KSPU are given in figure 4. Learning preferences are shown for undergraduate and separately for graduate students of KNUTD.

The predominance of the act, vis and sns styles is maintained for all groups of students. KSPU students are balanced in measuring seq-glo. At the same time, pharmacists show a pronounced advantage in favour of a sequential style. The most significant difference is between undergraduate students of KNUTD and all other groups. That is, the difference between students of KSPU and masters of KNUTD is significantly reduced. The measurement of seq-glo is an exception because the existing advantage of a sequential style among pharmacists does not change over years of study.

3.2 Teaching Ecological Chemistry of the Lithosphere

Considering the obtained profiles of educational advantages in groups, we have prepared a didactic material on the topic "Ecological chemistry of the lithosphere" of the content module "Ecological chemistry of environmental objects". Most students in the group are those who study visually, sensitively, actively, and sequentially. That is why we used the methods, forms, and e-resources that are well percept by them in the lecture. Example:

- a large amount of multimedia presentation data was used for visual perception of information during the lecture;
- for sensing data processing, lecture information was provided based on life stories and situations;
- to attract an active component of the training types, several problematic situations on this topic were created. Students worked in small groups for several minutes over their decision;
- a link between current material and everyday life was demonstrated for the sequential component.

For the lecture, information on the following processes was elaborated: soil formation, weathering and its varieties, leaching, gouging, salting and others, and learning about the participation of living organisms in soil formation.

Submission of material on the lithosphere's fundamental processes was also adapted to students' prevailing stylistic characteristics: visual, sensing, active and sequential, but other techniques have already been used. Example:

- a multimedia presentation with various diagrams and photographs illustrating the content of the theme was used for visual stylistic characteristics during the class;
- for the sensing style, the information of the lecture was related to the environment, which is directly an integral part of human life;
- for the active component, lectures specifically made mistakes in the content and provided an opportunity for students in small groups (2–3 people) to consider where the inaccuracy was made;
- for a sequential component, the connection between current material and everyday life was demonstrated.

During the laboratory session, we formed practical knowledge about the soil composition and some of its indicators. For this purpose, the following methods were applied:

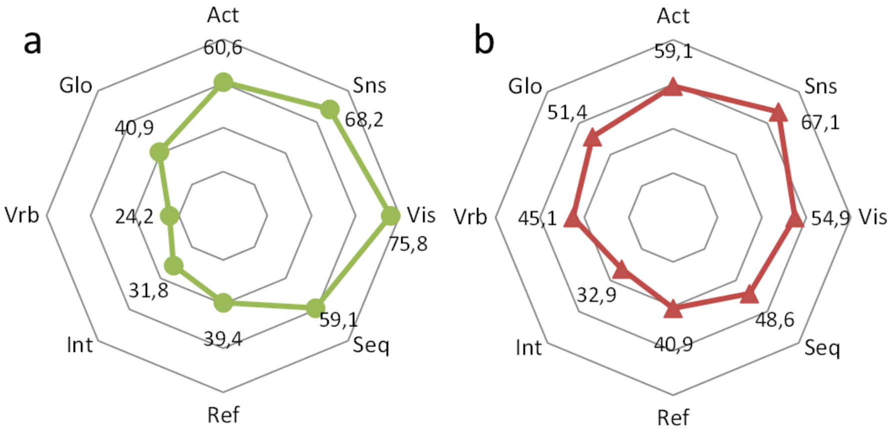

Figure 2: Preferences in learning styles for male (a) and female (b) students.

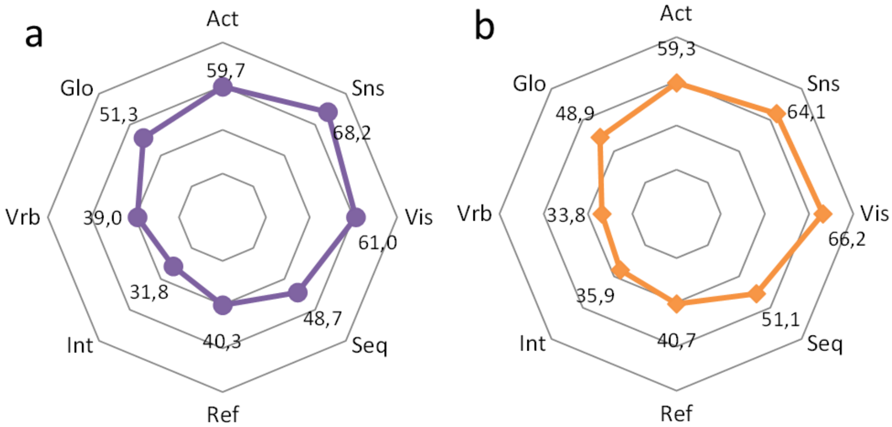

Figure 3: Preferences in learning styles for students of 17–20 (a) and 21+ (b) years old.

- illustrations of the mechanical composition of the soil, video of bean growth, and instructions for planting it in the soil were used simultaneously with the parallel text that described these processes to learn by visual style during the laboratory work;
- for the sensing style, the information related to the fertile surface layer of the lithosphere, which is directly connected with human life, was provided. Students were asked to find signs that determine the quality of the soil and its use in human activity;
- an analysis of soils in which beans grew was used for the students with active style in the laboratory. Students worked in small groups analysing soils.

The content of students' independent work included tasks that, in our opinion, are intended to help develop a global, reflective, verbal, and intuitive styles of learning activity.

Here are examples of the tasks of students' independent work. Students were invited to do the following task to develop a global characteristic of the seq/glo pair of learning styles. "Use the guides, the Internet, and other recommended sources to learn about the content of the ecological chemistry of the lithosphere. Determine the importance of chemical processes in soils for the formation of biogeochemical cycles of chemical elements and their substances in the nature of our planet".

To satisfy the reflective learning style in the act/ref dimension, we asked students to do the following. "Using lecture notes, read the study material, occasionally pausing to repeat what you have read. Write small abstracts based on what you have read. What is the main source of pollution of the lithosphere? Describe the main components of the emissions from such a source and their influence on the fertile soil layer's chemical composition. What are some ways we can deal with the primary and re-contamination of key areas?"

To satisfy the requirements of a verbal style in the vis/vrb pair, we asked students to do the following task: "Using the above text, make a diagram of the

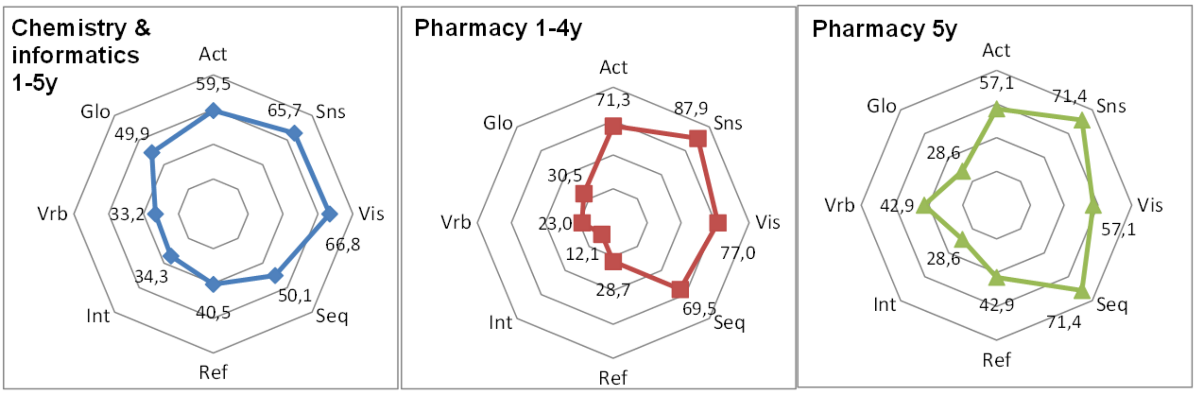

Figure 4: Learning styles of 1-5 years students majoring in chemistry & informatics at KSPU compared to styles of 1–4 years undergraduate and 5-year master students of industrial pharmacy at KNUTD.

biogeochemical cycle of carbon.

Carbon in nature:

The chain of carbon atoms is the basis of all organic matter: proteins, fats, carbohydrates and other compounds that are necessary for the life of all living organisms. The carboniferous circulation between wild and inanimate nature occurs at high speed. The main inorganic compounds of carbon are its oxides (CO_2 and CO) and carbonate, making up carbonate rocks. The most mobile carbon compound in the atmosphere, which plays a significant role in the cycle, is carbon dioxide (CO_2).

Carbon's central reserve is concentrated in carboniferous rocks (carbonates, dolomite, etc.) at the bottom of the ocean and in the Earth's crust, as well as fossil fuels. The carbon reserve in the atmosphere is much smaller. However, it plays a significant role in the cycle due to its mobility. As a result of the relatively small reserves in the atmosphere, the carbon cycle is more vulnerable than the nitrogen cycle.

Recently, the atmosphere's carbon dioxide content has been steadily increasing, indicating that the equilibrium processes in the biosphere are disturbed. The reason is human economic activity: high carbon dioxide emissions from burning fossil fuels, reducing forest area, pollution of the oceans. As a result, photosynthesis intensity and carbon dioxide binding decrease. Increasing carbon dioxide content is the leading cause of the greenhouse effect and an increase in the average temperature on the planet."

We proposed that students do the following task to develop an intuitive style in the subsystem sen/int. "Tailings cause a large amount of dust under the influence of wind flows, which leads to the pollution of atmospheric air and its deposition in large areas of land. Suggest a plan for minimising dust generation".

Thereby in the course of the study, we started to introduce students to different forms of work. These forms involve using the different cognitive functions and therefore contribute to the development of their balance. In turn, the latter allows a person to be flexible in the unrestrained development of technological progress, be open to different ways of receiving information and perceiving it without resistance and tension. As a whole, students evaluated the completed tasks at a high level, which indicates that the student's perception of new tasks is positively fulfilled, without sabotage.

3.3 Teaching Plant Pollution

As shown in the previous section, the sensitive perception of information is characteristic of most KSPU and KNUTD students. Such students perceive the theoretical part more effectively if they can establish a connection between theory and real-life facts. It seems appropriate to strengthen the course of ecological chemistry with new topics, which are essentially based on the consideration of numerous real-life examples. The environmental pollution of plants by human economic activity products looks promising because its teaching can include many real examples. On the one hand, such topics will be well perceived by students with the revealed educational preferences. On the other hand, they will strengthen the environmental component in the education of future professionals. Accordingly, if the previous section considers procedures, methods and approaches to learning ecological chemistry, this section considers the proposed changes in the discipline content.

Previously measured elemental and chemical composition of several widespread medicinal plants growing in different regions of Ukraine (Derkach and Starikova, 2019; Derkach and Khomenko, 2018a,b) were used as environmental education elements in the teaching of analytical chemistry and pharmaceutical quality system. Elemental composition compared to the available recommendations for the content of metals and metalloids in plant foods, medicines, dietary supplements, spices, etc. Authorised organisations use different characteristics to determine the limits of element intake in the human body. Virtually all elements, except for particularly toxic ones (*As*, *Cd*, *Pb*, *Hg*), can play a dual role and become toxic in a particular concentration. As a rule, there is a concentration interval of optimal daily human consumption of a particular element. Various norms regulate either the recommended dose of the element (often per 1 kg of human weight) or the maximum allowable intake.

Two aggregated characteristic exposures, entitled Level of Optimal Consumption (LOC) and Upper Limit of Safe Consumption (ULSC), are constructed based on the universally recognised norms (Derkach and Khomenko, 2018a; WHO, 2007; EC, 2006; www.atsdr.cdc.gov, 2016; Rubio et al., 2018). Ranges of some element concentrations were measured in a few popular medicinal plans (St Jon's wort, chamomile, nettle and sage). The measured concentrations were compared with the LOC and ULSC values, as shown in table 2. The ULSC and LOC ratios to the maximal measured concentrations respectively estimate maximum allowable and safe limits of daily intakes of the most contaminated studied herbs from the viewpoint of possible side effect of the microelements (table 2).

Figure 5 illustrates the variability of biologically active substances in medicinal plants.

As an example, the HPLC were shown for herbal preparations "St. John's wort herb", prepared by four different suppliers and purchased in Kyiv pharmacies. As an example, the HPLC were shown for herbal preparations "St. John's wort herb", prepared by four different suppliers and purchased in Kyiv pharmacies. As is seen, the concentrations of flavonoid rutin and hypericin are the highest in samples of supplier 4. In contrast, the herbs of supplier 3 are most enriched in hyperforin. Herbs of suppliers 1 and 2 are characterised by the highest concentrations of quercetin and hyperoside, respectively. Among flavonoids, the observed concentration fluctuations are relatively moderate for quercetin and hyperoside. For these compounds, the maximum-to-minimum concentration ratios are 1.45 and 1.87, respectively. The variation of rutin concentration is the highest, 13.8 for the maximum-to-minimum ratio. Amid flavonoid fluctuations, the instability of antidepressants (hyperforin and hypericin) appears to be moderate – 3.11 and 4.7 for these compounds, respectively.

4 DISCUSSION

4.1 Learning Preferences in Different Fields of Studies

The study results have shown that the existing preferences in learning styles among students majoring in chemistry and informatics generally persist throughout their studies. They are relatively weakly dependent on gender and age. The students demonstrate solid preferences for sensing, visual and active learning style. In the dimension of seq-glo styles, an approximate balance is observed.

The question arises as to whether the invented behaviour patterns are universal or inherent only to a particular speciality. Learning styles were determined for students of different specialities at the Faculty of Natural Sciences (figure 6) to compare with students majoring in chemistry and informatics (figure 1).

A difference in almost all style dimensions is observed between specialities. For example, most ecology students prefer reflective style (52.7% ref vs 4.3% act). In contrast, all other specialities prefer active learning (51.5–61.6% of active students vs 38.4–40.5% reflective). A discrepancy in the sen-int dimension almost reaches 11% – from 61.1% for physiologists to 71% for chemists. In the vis-vrb dimension, it exceeds 16%. Students majoring in biology and physiology are the most balanced, while visual learning dominates in all other specialities. The speciality "ecology" and "biology + physiology" demonstrate a clear preference for sequential style. In contrast, students of biology + chemistry and chemistry + informatics specialities are well-balanced in this dimension.

Similar to the results obtained, there is much evidence in the scientific literature that students in different study fields often demonstrate different learning styles (Derkach and Starova, 2017; Derkach, 2018; Sahragard et al., 2016). The origin of different learning styles in different environments is not finally evident yet. Instead, one may suppose that learning styles are educational strategies that characterise the individual's actions in response to a particular learning situation. Thus, the learning styles or individually-unique ways of educational activity by their very nature may depend directly on the educational technology used, including the teaching methods, types of educational resources, teacher position, status educational institution, etc.

So, the definition of learning styles as flexibly stable preferences in information processing, instructional technologies, and learning strategies fits the obtained results well. Accordingly, the development

Table 2: LOC and ULSC ranges in comparison with the measured concentration range and safe daily intakes.

Element	Measured concentrations, μg/g	ULSC, mg	LOC, mg	Maximum allowable intake, g/day	Safe intake, g/day
Al	No data	0.5-10	10		
As (in inorganics)	No data	0.021-0.3	0.02		
B	No data	6.2-20	14		
Ba	No data	4.0-14	14		
Be	No data	0.14	0.14		
Ca	No data	2500	1000		
Cd	0.2-0.9	0.02-0.07	0.007	22	8
Co	0.08-0.4		0.02-0.04	1500	50
Cr	0.2-2.0	0.25-21 (CrIII)	0.002-0.003 (CrVI)	125	1
Cu	5.0-12	10.0-12	0.7-0.9	833	58
Fe	25-120	9.7-58.8	8.0-18	81	67
Hg	No data	0.35	0.014		
K	7500-9900		4700		475
Mg	1000-1600	350-2500	310-420	219	194
Mn	40-150	2.0-11	0.35-2.3	13	2
Mo	No data	0.03-2	0.045		
Na	110-160		1500	0	9375
Ni	0.8-2.8	0.2-1		71	0
Pb	0.1-6.2	0.1-0.25	0.14	16	23
Sb	No data	30			
Se	No data	0.3-0.4	0.055-0.35		
Sr	No data	42			
V	No data		0.7		
Zn	19-34	21-50	8.0-21	1	235

of didactic materials based on the identified learning profiles seems appropriate for teaching ecological chemistry.

4.2 Conflict of Styles

Lecturers have their advantages of learning styles (Rahimi et al., 2017). Most lecture courses are aimed at a small number of people who can perceive and process information intuitively, verbally, reflectively and sequentially. Such a situation creates a disadvantage for many students.

Lab work, being inherently sensing, visual, and active, could offset some of the imbalance. However, most laboratory work involves, first and foremost, mechanical exercises. They illustrate only a small part of the concepts discussed at the lectures and rarely provide a robust understanding or development of skills. Thus, sensing, visual, active and global students rarely meet their educational needs when studying at higher education institutions.

The discrepancy between teaching and learning styles has several serious implications. In this case, the students feel that communication is taking place in an unknown foreign language.

These problems can be minimised, and education quality can be significantly improved if teachers consider the particularities of student preferences in teaching styles (Richardson, 2011; Franzoni and Assar, 2009).

It is challenging to create the conditions for the presentation of information that satisfies all possible student learning styles in one audience. There are different approaches to solving this problem.

The works we have done earlier describe the methodology of choosing methods, forms, and teaching aids, taking into account students' peculiarities of learning styles of different specialities (Derkach, 2019; Derkach and Starova, 2017; Derkach, 2018). He has a right to life and another approach that involves applying the techniques of presenting information conveniently to each style for a while.

The development of all cognitive styles is beneficial for students. Therefore, seeking to strike a bal-

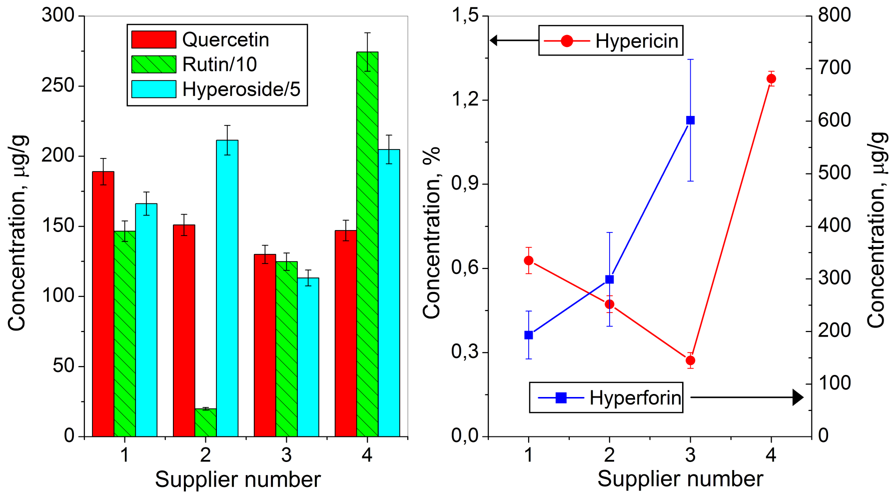

Figure 5: Concentrations of biologically active compounds (hypericin, hyperforin and flavonoids) in herbal medicines St John's wort of different suppliers.

ance for everyone in the learning process can be helpful. Then students will have natural learning activities available to them and create conditions for the development of other learning styles. Such a situation can promote active learning and a positive attitude towards it and lead to the strengthening of less developed abilities (Mayer, 1993).

When developing a global teaching style, it is better to study the material using visual techniques. These techniques should allow students to offer a generalised conclusion from their analysis. To do this, you should first show the schematics of the links of the elements for study, experiments, results, and then allow students to reach the provisions of specific theories independently.

When developing a reflective teaching style, teachers sometimes need to stop during the lecture to allow the audience to think and formulate questions. You should also schedule small group problem-solving sessions. Then group students will have a chance to spend one or several minutes solving any of the many different issues and problems. Some examples of such problems are as follows. "Start solving this problem", "What is wrong with what I wrote on the board?", "Suppose you enter a lab, check the measurement results, and find that the formula we just derived gives incorrect results. How many possible explanations can you come up with?"

Also, to develop a global teaching style, it is necessary to demonstrate the logical connection of particular topics. It is also essential to show the interaction between current material and other topics of the same discipline, other courses and daily life. Encouraging or engaging in self-help in homework is essential. Students who participate in collective learning, both in and out of the classroom, receive better grades and show tremendous enthusiasm (Mayer, 1993).

4.3 Environmentally-induced Variation of the Chemical Composition of Medicinal Plants

The data in the previous section provide several examples of the impact of the environment on the elemental and chemical composition of a number of medicinal plants. The introduction of this type of material in the curriculum creates a favourable environment for sensitive students. Among undergraduate pharmacy students, up to 88% of students have a sensitive learning style.

These examples clearly illustrate the fact of variation in plant composition depending on growing conditions. For example, the content of some biologically active substances, which determine the effectiveness of herbal medicines, varies by 1.5–14 times. Accordingly, the quality of herbal medicines of various origins varies within these broad limits. It should be emphasised that these examples are herbal medicines that are purchased legally in pharmacies. The obvious conclusion is that the existing quality control system does not fully ensure consistent and uniform herbal medicine quality.

The analysis of the given data on the elemental composition also shows high variability in plants' composition in different areas. The content of toxic impurities and excessive contamination with essential elements that are not toxic in moderation directly affects herbal medicines' safety. Besides, the presence of ions of some metals in plants can affect their ef-

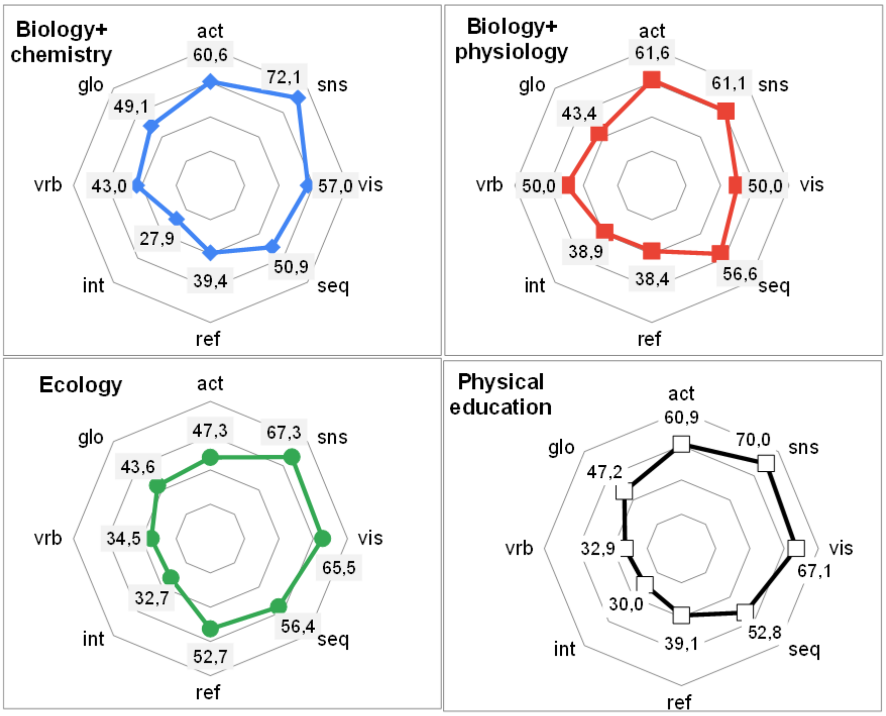

Figure 6: Learning styles of 1–4 years KSPU students majoring in biology & chemistry, biology & physiology, ecology and physical education.

fectiveness. Many free ions can form metal-organic complexes, bind biologically active substances into complexes and reduce their activity.

Draws attention to the fact that the plants available in pharmacies in terms of the content of the most toxic metals generally meet the standards (table 2). The most unfavourable situation is concerning cadmium. Daily safe internal consumption of the most contaminated grass should not exceed 8 g. Even worse is the consumption of plants with high *Cr* and *Mn* contents; no more than 1 and 2 g, respectively, are safe for daily intake.

As is known, Ukraine has rich deposits of manganese (about 10% of world resources). The explored reserves of mining companies are 140 million tons or about 21% of world reserves (Sun et al., 2020). The country is a prominent producer of manganese ore. The primary deposits are concentrated in the Dnipropetrovsk region. The chain of manganese circulation, from its extraction, further processing and end-use in various industries, is illustrated in figure 7. The initial data for illustration are taken from (Sun et al., 2020). According to the results of 2017, the total manganese in the world is 23.9 million tons.

The source of manganese supply is manganese and iron ores, as well as manganese-containing scrap. When processing ore and scrap, they are converted into various intermediate products by smelting, electrolysis or other technological processes. They are various ferroalloys and other manganese compounds. As a final consumption, manganese is used to produce steel and aluminium alloys, various galvanic cells, fertilisers, animal feed components, and other products.

Sooner or later, the lifespan of manganese products expires and such products are discarded. If the spent elements are collected, their secondary use begins in the form of scrap. Unfortunately, most of the discarded products are not efficiently collected and processed. They are classified as waste. Currently, there are almost no well-established systems (except for steel metallurgy) of manganese regeneration.

Accordingly, waste manganese products and emissions from the metallurgical and mining industries are environmental pollution sources. The scale of pollution from human activities is huge. As already mentioned, the primary manganese deposits, ferroalloy and metallurgical plants are concentrated in the Dnipropetrovsk region. Accordingly, the impact of these enterprises on the environment focuses on this region. Simultaneously, heavy manganese pollution of small rivers is registered even in the Ternopil region (Prokopchuk and Hrubinko, 2016). This paper presents data on manganese contamination of

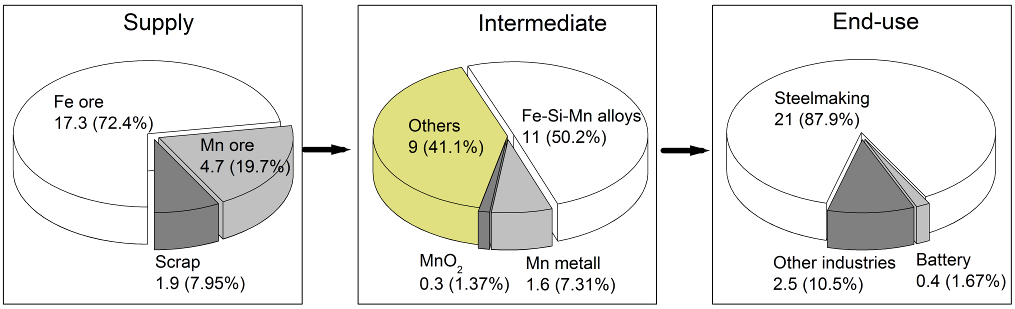

Figure 7: Supply and intermediate products and end-use of *Mn* in the world (million ton and %).

medicinal plants collected in four different regions of Ukraine. For example, manganese and iron are known to be antagonists in plants (Alejandro et al., 2020; Zaitsev et al., 2020). In many countries, iron concentration in tissues of most plants is usually higher than *Mn* content. Ukraine is an exception in this sense, as the concentration of manganese has been shown to exceed typically iron concentration (Derkach and Khomenko, 2018a,b). Obviously, the source of such pollution is the spread of manganese waste.

Mn is the fifth most abundant metal on the Earth. *Mn* does not occur naturally in a pure state (Schmidt and Husted, 2019; Huang and Zhang, 2020). It exists in both inorganic and organic compounds — the inorganic form being the most common. However, *Mn* also exists in organic forms, particularly as an additive to fertilisers and fuels. In principle, *Mn* can occur in 11 different oxidation states, varying from -3 to +7 because of 7 electrons in the outer electron shell. In living tissue, *Mn* has been found as Mn^{2+}, Mn^{3+}, and possibly as Mn^{4+}. Higher oxides and other complexes of *Mn* at lower oxidation states are not observed in biological materials. This element is essential for normal biochemical and physiological functions in plants and serves as a co-factor for some enzymes.

The most common toxicity is manganese in a professional environment. However, there are known cases of adverse health effects of this element due to environmental impact. Poisoning by this element is referred to as manganism (Lange and Condelo III, 2016). The suggested dietary intake of *Mn* is about 2 mg/day (table 2). Organ systems most affected are the liver, heart and nervous system.

4.4 Optimisation of Teaching Methods and Forms to Study Ecological Chemistry

The article attempts to modify future specialists' ecological training in chemical specialities, integrating sustainable development ideas. Teaching technologies have been improved in several areas to prepare future professionals to work in a sustainable production environment.

To ensure the sustainable development of the student's personality, they tried to promote a conscious attitude to their cognitive activity and create conditions for the most practical knowledge acquisition. Determining the profiles of groups allowed the authors to use the technology of integration of methods, forms and means of teaching, including ICTs, taking into account the peculiarities of the formed educational preferences of students. The use of quantitative criteria for assessing the feasibility of using e-resources on this technology can prevent the emergence of "conflict of styles" of teaching and learning.

The content of educational components was filled with factual material that reflects the current state of environmental ecology. The primary purpose of this was to form students' understanding of the connection between changes occurring in nature due to human-made impact and elements of their future professional activity. It was also important to better align the developed teaching material with the requirements, which dictate the presence in groups of the vast majority of active and sensitive students.

To ensure the organisation of training using ICT, dedicated educational and methodological support was developed. It includes instructions for the self-facilitated execution of computer simulations and sets of multimedia presentations. The developed methodical recommendations for teachers reveal a technique of using the described e-resources in the real educational process.

5 THE PROSPECTS FOR FUTURE RESEARCH

Preliminary diagnosis of students styles in the group allows the teacher to create conditions for enriching students' stylistic behaviour, which will increase the productivity of their intellectual actions.

The use of the educational resources created in this work will help prevent the "conflict of learning styles" of teachers and students.

The paper's findings can be used in higher education institutions' educational process to teach the pedagogical cycle disciplines. For example, "Methods of teaching chemistry in a specialised school and vocational education institutions", as well as professional disciplines "Organic chemistry", "Computer statistical processing results" and others.

Continuing experiments to establish links between students' academic performance and the development of their cognitive styles is a promising area of research. Summarising their results will help to formulate principles for the organisation of efficient training of future chemical specialists.

6 CONCLUSIONS

1. The paper proposes changes in teaching methods and the discipline's content in ecological chemistry teaching. The change in teaching methods and content is focused on optimising e-resources according to students' educational preferences. Individuals' educational preferences were studied for 1-5 year students majoring in chemistry and informatics at KSPU and 1-5 year students majoring in industrial pharmacy at KNUTD.
2. The Index of Learning Style instrument by R. Felder – B. Soloman was used. Most future chemists learn visually, sensitively, actively and sequentially. The styles of undergraduate students majoring in industrial pharmacy are qualitatively similar and show even more pronounced preferences in 3 dimensions. In the glo-seq dimension, pharmacists have a clear advantage in the sequential style, while chemists' styles are relatively balanced.
3. Learning preferences are relatively stable during undergraduate study and vary very little depending on gender or age. Detailed comparisons of undergraduate and graduate students among the future pharmacists show an increase in the number of masters with ref and vrb preferences. So, student profiles in these dimensions become more balanced in passing from undergraduate to graduate studies.
4. Based on individual students' learning preferences, the group profiles are calculated using the previously developed methodology. It considers the rating of e-resources by the average score of student preferences and the difference between the ratings of experts and scores of students with different learning styles.
5. Developed didactic materials, which correspond to the group's educational preferences, were used to teach the topic "Ecological chemistry of the lithosphere".
6. The topic "environmental pollution of plants" contains a large number of concrete examples. The possible introduction of this topic into the syllabus of ecological chemistry aims to improve the correspondence between the content of the discipline and students' educational preferences with a sensitive learning style.
7. In the study, we started introducing students to different work forms that involve different cognitive functions and contribute to their balance. In turn, the latter allows a person to be flexible in the unrestrained development of technological progress, be open to different ways of receiving information and perceiving it without resistance and tension.

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