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OPTIMISATION OF SELECTION OF ELECTRONIC LEARNING RESOURCES ACCORDING TO STUDENT GROUP COMPOSITION

Abstract. The technology of integration of learning methods, forms and means of information and communication technologies is described with due regards for psychological and pedagogical characteristics of student groups. The results of theoretical and experimental research conducted on the basis of two Ukrainian universities with the participation of 341 students in the "Chemistry" training area and 18 lecturers of basic chemical disciplines are highlighted. Both students and lecturers were polled in a specially designed questionnaire to show their attitude to the use of various electronic learning resources in learning and teaching basic chemical disciplines. Students' preferences in learning styles were estimated on the basis of a self-scoring questionnaire for assessing preferences on four complementary dimensions, such as perception (sensitive or intuitive), input (visual or verbal), processing (active or reflective) and understanding (sequential or global) of chemical information. Such an approach is known as the method of Felder-Soloman, and it allows one to calculate Indices of Learning Style which assess qualitatively available preferences of all respondents in each of the four available directions. The developed technology allows lecturers to qualify an optimal set of electronic learning resources for the teaching of individual sections of chemistry, taking into account preferences in their use of students with different learning styles. The technology under development is based on the calculation of average resource scores as assessed by all students in the group, as well as on the expert evaluation of the feasibility of their application in the teaching of basic chemical disciplines. The taxonomy of the optimal selection of electronic learning resources and teaching methods is developed for each type of students' learning preferences. Advantages and disadvantages of all available variants of the application of the developed technology are discussed for student groups of different compositions. An example of the application is given for studying the discipline "Inorganic Chemistry".

Keywords: higher education; chemistry learning; Felder-Soloman learning styles; information and communication technologies; electronic learning resources; optimisation of e-resource set.

1. INTRODUCTION

The problem setting. Several areas of application of information and communication technologies (ICTs), which are used to solve the problems of training chemistry students, can be currently identified: improving understanding of chemical concepts through the use of visualisations; notation of chemical data at different levels of representations; and establishment of connections between theoretical knowledge and its practical realisation [1] – [8]. Such directions are actively developing, however, the issues of ensuring the effective implementation of ICT in the educational process, still remain unresolved. The existing contradictions mainly concern the following two problems:

– unclear conditions for the efficient use of dynamic visualisations and prevention of situations when cognitive load is significantly increased during training with the use of ICTs; and
– lack of clear guidance for lecturers in the optimal selection of electronic learning resources (e-resources) on the base of learning preferences of individual students and aggregate profiles of student groups.

The analysis of recent studies and publications. The theoretical foundations of teaching chemical disciplines with the use of ICT tools have been recently developed [9] to solve the first aforementioned problem. The most important principles of the established approach are the principles of balance of cognitive load and combination of presentations of educational material at different levels of representation [10]. A set of generalised rules, which should be guided to organise adequate training, is formulated, and it, in particular, includes the following fundamental principles: prevention of attention splitting; taking into account the double effect of the implementation of an action; taking into account the level of preliminary training of students; as well as the principles of the design of dynamic visualisations (semantic accents, colour coding, segmentation and management of dynamic images, and use of different perception modalities) [1], [10].

Taking into account the individual learning styles of students, when organising ICT-based training, involves the appropriate selection of e-resources and the implementation of measures to prevent a "conflict of styles" between the lecturer’s and students’ learning styles. However, methodological recommendations and criteria, according to which the lecturer can deliberately organise the learning process and select the important e-resources to achieve the required balance, are not practically available in the literature. The required balance includes conditions for the development of students’ necessary learning styles in the group and does not lead to cognitive overload, discomfort in learning, overwork, negative emotions, etc. In most cases, choosing teaching methods and resources, lecturers can only rely on their own experience and creative intuition.

The paper goal is to describe the proposed technology of integration of methods, forms and means of ICT learning with due regard to students' cognitive style that allows lecturers to select an optimal set of e-resources for the teaching of chemistry.

2. METHODOLOGY

The research was carried out at Oles Gonchar Dnipropetrovsk National University (DNU) and M.P. Drahomanov National Pedagogical University (Kyiv). The experiment involved 341 students of chemical specialities and 18 lecturers and consisted of an analysis of the characteristics of students, the composition of student groups, and the real preferences of students and lecturers in choosing e-resources.

Students' attitudes towards the use of various e-resources used in chemistry learning were studied using a specially designed questionnaire. The respondents had the opportunity to determine their preferences with a three-point (0-2 points) system. The indicator of 0 points testified that the respondent did not mention the value of the specified type of resource, considering it either unnecessary or not conducive to the process of teaching chemistry. One point evidenced that the respondent liked the resource, appreciated its usage by a lecturer, knowing that this could facilitate the study of the material and the execution of tasks. However, in respondent’s opinion, such a resource did not have significant advantages over others. Two points determine the resources that the student readily used for learning and considered as necessary means for use. Also, such resources have an advantage over other similar tools. The absence of a response testified to the impossibility or reluctance of the respondent to determine their attitude to the resource. Questions without answers were not taken into account when processing the results of the questionnaire. The estimates of all students in a group were then averaged to calculate the values of resource average scores (RASs) for each e-resource under consideration [1], [11] – [13].

Previously, these respondents participated in the tests by R. Felder and B. Soloman (thereinafter – Felder-Soloman) [13] to identify preferred learning styles [14]. Indices of Learning Style (ILS) were calculated in accordance with the method of Felder-Soloman.

Learning styles were evaluated on a scale from 0 to 11 points so that the total score for each of the 4 available directions, characterised by 4 pairs of style / anti-style (active / reflective, sensitive / intuitive, visual / verbal, and sequential / global), was 11 points. This allowed one to show results for only 4 learning styles (act, seq, vis, sen) from 8 possible because indicators for 4 other learning styles (anti-styles) were the same but with the opposite sign.

Preliminary studies allowed identifying 45 individual e-resources which could be used or are already used in teaching various chemical disciplines [1], [13], [15]. By their function, some resources were combined into a few conditional groups. In the process of analysing the results, the compositions of the groups were refined, taking into account the attitude of respondents to them. The positive correlation between respondents' commitment to comparable resources in the group was considered as evidence of a similar position of respondents. If the relationship between the indicators of one resource and other resources in the group was contrary, such a means was excluded from the group, and its characteristics were further analysed separately.

An average resource score obtained in lecturers' questionnaire in the "expediency" column, which reflected the relative number of topics during the course in which this resource should be used in training, was considered as the primary estimate of the resource demand from the lecturers' viewpoint.

3. RESULTS AND DISCUSSION

3.1. The technology of selection of e-resources optimal set

The choice of an optimal kit of e-resources takes into account students' preferences and is based on the calculation of RASs. The values of RASs regarding individual e-resources used for the study of basic chemical disciplines are calculated for students with different preferences in learning styles and shown in Table 1.

The diagrams of the expert assessment of the feasibility of using e-resources in the teaching of basic chemical disciplines, such as inorganic, physical, analytical and organic chemistry, for the training of future specialists in chemical sciences were plotted according to the results of the survey of lecturers[11] – [13].

Table 1

Resource average scores that characterise the preference degree to a specific e-resource for chemistry students with different learning styles

Type of ICT or e-resource			Individual learning styles							
			act	sen	vis	seq	ref	int	vrb	glo
Static images		Pictures, photographs	1,3	1,3	1,5	1,3	1,5	1,5	1,5	1,4
		Graphs	1,2	1,3	1,2	1,1	1,5	1,5	1,5	1,4
		Diagrams	0,9	0,8	1,0	0,7	1,5	1,3	1,3	1,2
		Charts	1,3	1,2	1,2	0,9	1,5	1,3	1,3	1,4
		Tables	1,3	1,0	1,1	0,7	1,5	1,0	1,0	1,2
Dynamic images	Animation:	3D models	0,9	0,9	0,9	0,6	1,3	1,0	0,7	1,2
		Processes and phenomena on microlevel	0,8	0,9	1,0	0,7	1,3	0,7	0,7	1,0
		Processes and phenomena on macrolevel	0,6	0,7	0,9	0,6	1,3	0,7	0,7	0,8
	Video of:	experiment	0,9	0,9	1,0	0,7	1,0	0,7	0,7	0,6
		Natural processes	0,7	0,5	0,6	0,3	0,7	0,7	0,3	0,8
		Real-world examples	0,8	0,6	0,8	0,4	0,7	0,7	0,3	1,0
		Excursions	0,7	0,8	0,8	0,7	0,3	1,0	1,0	0,8
Audio recording of text			0,1	0,1	0,1	0,2	0,0	0,0	0,0	0,0

Type of ICT or e-resource		Individual learning styles							
		act	sen	vis	seq	ref	int	vrb	glo
Quantum chemical simulation	Molecule parameters and energy effects	0,3	0,4	0,6	0,3	1,5	1,0	1,0	0,6
	Molecule structure	1,0	1,1	1,1	1,0	1,5	1,5	1,5	1,4
	Spectra	1,5	1,5	1,5	1,5	0	0	0	0
Virtual chemical laboratory to emulate:	Laboratory works	1,0	1,0	1,2	1,0	0,7	1,0	1,0	1,2
	Work with equipment	0,5	0,5	0,9	0,6	0,7	0,7	0,7	0,8
Laboratory complex with measuring sensors		0,7	0,7	0,9	0,6	1,5	1,3	1,3	0,8
Integrated software environment for:	Simulation of chemical system kinetics	0,8	0,8	0,8	0,7	0,7	0,3	0,7	0,6
	Thermodynamic calculations	0,9	0,9	0,8	0,9	1,0	0,7	0,7	0,6
	Modelling of experiments	0,7	0,9	1,1	1,0	1,0	1,0	1,0	1,0
Internet and communication technologies	Webinar	0,1	0,2	0,5	0,4	0,7	0,7	0,3	0,4
	Wiki	0,3	0,4	0,5	0,1	1,3	1,0	0,7	0,6
	Video and audio conferences	0,5	0,7	0,8	0,4	0,7	1,3	1,0	1,4
	Forum	0,3	0,5	0,6	0,6	1,3	1,3	1,0	0,8
	Chat	0,4	0,4	0,7	0,7	1,0	1,3	1,3	0,8
	E-mail	1,4	1,4	1,2	1,4	1,3	1,5	1,3	1,5
	Search engine	1,4	1,5	1,5	1,5	1,5	1,5	1,5	1,5
	Teaching databases	1,5	1,5	1,5	1,5	1,5	1,3	1,3	1,5
Teaching materials	e-textbooks, encyclopaedia	1,5	1,5	1,5	1,5	1,5	1,5	1,5	1,5
	Hypertext	0,7	0,7	0,9	0,4	1,3	1,3	1,0	1,2
Educational software	Teaching programs	1,5	1,5	1,5	1,5	1,5	1,3	1,3	1,5
	Manuals for self-tuition	0,5	0,7	0,8	0,7	0,7	1,0	0,7	0,8
	Training simulators	0,7	0,9	1,4	1,1	0,7	1,0	1,0	1,0
Control of knowledge	Tests ready for use	1,5	1,5	1,5	1,5	1,5	1,0	1,3	1,4
	Test shells	0,6	0,6	1,0	0,4	1,7	0,7	1,0	0,8

Based on the results from Table 1 and the feasibility diagrams mentioned above, the procedure for optimising the selection of e-resources for teaching in a particular group of students can be summarised as follows:

1. Determining students' preferred learning styles as a combination of preferences in four dimensions (act/ref, sen/vent, visa/vrb, seq/glo). Analysis of group composition followed by either construction of average group profile or group division into subgroups of students with similar learning preferences.

2. Creation of a list of e-resources required for teaching a specific topic, based on an expert evaluation table of discipline curriculum.

3. Calculation of specific indicators for each of the selected e-resources by students' preferred learning styles in a group as a quantitative measure to justify the suitability of using the resource in the class.

3.2. Example of e-resource selection for inorganic chemistry teaching

The experts identified the set of e-resources required for teaching inorganic chemistry. The consistency of experts' opinions on the feasibility of using resources was estimated by Kendall's criterion which showed a coefficient of concordance $W = 0.837$ at a significance level of p <0.001.

An example of a possible algorithm for choosing an optimal set of e-resources is given for the study of the topic "Basic Mechanisms of Chemical Reactions". The experts preliminary identified 16 resources that should be used to teach this topic. Among them, only nine e-resources have got RAS values RAS ≥ 1 based on students' responses, and thus they are desirable for the student audience (Fig. 1).

The profile of a student group taken as an example is characterised by the domination of act, sen, vis and seq styles, which is typical for students for chemical specialities [14]. The value of RAS, which characterises the attitude of a group of students as a whole to a particular e-resource, is calculated as the average arithmetic score for the four styles mentioned earlier (Table 1) [11] – [13]. The resulting value of RAS = 1.05 ≥ 1 (Table 2) indicates the positive attitude of most students to this resource.

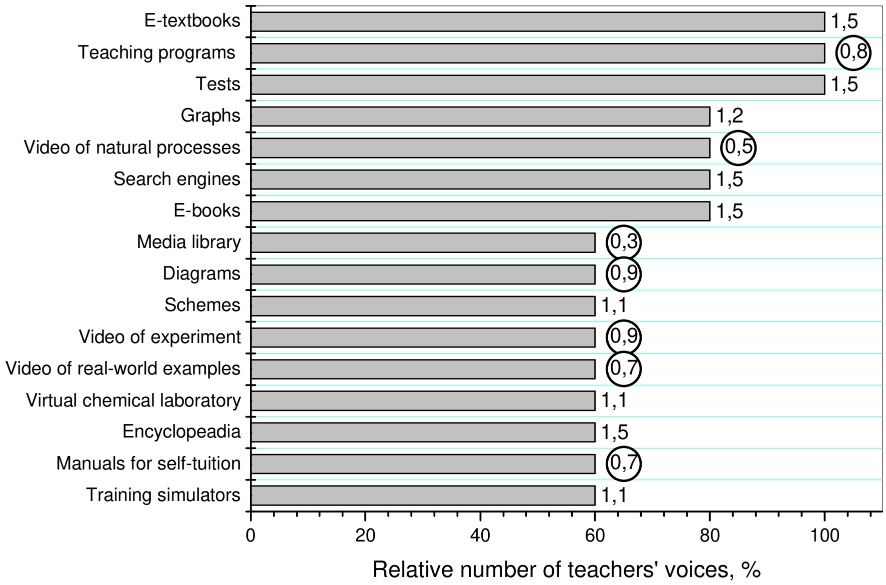

Fig. 1 Diagram illustrating experts' evaluation of the suitability of the use of e-resources in the learning of the topic "Basic Mechanisms of Chemical Reactions". RAS, calculated by students' survey data, are indicated by numbers on the right: for RAS ≥ 1 and RAS < 1 (numbers in the circles)

Table 2

Calculation of the average effective RAS for a student group with specific preferred learning styles on the example of the e-resource "Virtual Chemical Laboratories"

Learning style dimensions	**act**	**ref**	**sen**	**int**	**vis**	**vrb**	**seq**	**glo**
RAS for preferred learning style	1,0	0,7	1,0	1,0	1,2	1,0	1,0	1,0
Profile of a group of students	act + sen + vis + seq							
Average effective RAS for a group:	(1+1+1,2+1)/4 = 1,05 ≥ 1							

Thus, the considered resource may be recommended for use in a lecture room. However, the lecturer needs to explain to students what educational purposes and benefits are behind its usage.

3.3 Integration technology of learning methods and e-resources with due regard for student group composition

3.3.1 Methods for chemical discipline teaching

The real variety of classifications of learning methods and the lack of developed categorical apparatus describing the educational process create the most considerable difficulties in the development of learning technology and its implementation. Various approaches to the systematisation of learning methods in chemistry are analysed in [16]. In our opinion, the use of classifications, which reflect the specific nature of studying at a high school [17] and the specifics of professional training have good prospects in solving the problem of integration of learning methods and e-resources.

For chemistry teaching, the classification proposed by R.G. Ivanova [16] is the most convenient for educational practice. Three essential components are identified as the most important: the nature of the cognitive activity, the source of knowledge and the form of work of both students and lecturers. Despite some disadvantages, this classification is convenient for practical use because, in practice, the chemistry teaching methods are applied in a complex and are mutually integrated. The selection of common, concrete and individual methods allows one to understand the structure of how the techniques are combined and what they are composed of.

It is of importance to define characteristics of the methods that should be used in the teaching of chemical disciplines in professional training. First, it is a convergence of teaching methods with scientific methods. In higher school, not only scientific facts are taught, but the methodology and techniques of chemistry as a scientific field are also revealed. Problem-based, heuristic and research learning takes a large part of educational process.

Second, all possible sources of knowledge, such as verbal, visual and practical, should be combined in all variants of the organisation of students' activities. An important role belongs to demonstrations and research experiments. The design of methods for chemical discipline learning should allow students to observe, analyse, express their opinion, create hypotheses, seek solutions and demonstrate knowledge during the study.

3.3.2. Taxonomy of selection of e-resources and learning methods for each type of students

For the development of methods for chemical discipline teaching, the taxonomy of the selection of appropriate e-resources and teaching methods is compiled for each type of students. Taxonomy is based on four dimensions of learning styles ILS. Based on the accepted notation, the expression can be written as follows:

Combination ILS = {ILS1, ILS2, ILS3, ILS4},

where ILS1 represents data processing and corresponds to dimension active/reflective, ILS2 describes the perception of information in sensitive/intuitive dimension, ILS3 shows preferences in perception channels (visual/verbal), and ILS4 corresponds to learning patterns (sequential/global).

Entirely there are 16 combinations of styles, for example (sen, visa, act, seq), (sen, visa, act, glo), (sen, visa, ref, seq), etc. The choice of optimal learning methods, depending on students' learning styles, is based on the following components: a pedagogical approach to the organisation of learning; most suitable learning methods; and characteristics of the corresponding e-resources.

For each type of student, there are one or more learning methods that can be implemented using one or more e-resources which are most relevant to their preferred learning styles. For example, a student, who has a clear sensitive style of study, prefers teaching material and methods to solve problems. When selecting teaching methods for him, one must pay particular attention to practical work, such as study based on solving problems, practical exercises, etc.). The following e-resources assist in implementing learning methods based on the solving problems: animation, simulation, teamwork in forums, etc.

The integration elements for ILS1 (act/ref dimension) are illustrated in Table 4. The selection of appropriate e-resources is carried out in accordance with [11], [12] and Table 1.

Table 4

Taxonomy of methods and e-resources for active/reflective dimension (ILS1)

	Active	**Reflective**
Characteristics of student style	Prefer experimentation, and active and collective work with learning data with the possibility of practical application of results	Prefer thinking and observation, as well as prefer to work alone. Working with text is well perceived.
A pedagogical approach to the organisation of learning	Students need to take active action: discuss or apply data, and explain the material to others. It is difficult for them to listen to lectures without performing any activities other than annotation. It is better to organize training in groups	During training, it is necessary to arrange periodic stops to understand the material, write short stories, and think about possible applications of the studied. Without such activity, students experience discomfort
Learning methods that are best suited	Problem-searching Practical Modelling Creating game situations Study based on solving problems Expert discussion group (discussion panel) Brainstorm Method of projects	Presentations Case method Method of questions and answers Individual work with text It may be helpful to write a short resume paraphrased with own words. It can take longer, but it will allow students to remember the material more efficiently.
E-resources qualified for use	Static visualisation Program package E-mail Search engines, teaching database E-textbooks Teaching programs Tests ready for use	Static and dynamic visualizations Quantum chemical simulation Lab complex with measuring sensors Wiki, Forum, Chat, E-mail Search engines, teaching database E-textbooks, hypertext Teaching programs Tests ready for use Test shells

For sen-int dimension (ILS2), the integration elements, including pedagogical approach, learning methods and suitable e-resources, are shown in Table 5. The appropriate e-resources were selected in accordance with [11], [12] and Table 1.

Table 5

Taxonomy of methods and e-resources for sensitive/intuitive dimension (ILS2)

	Sensitive	**Intuitive**
Characteristics of student style	Prefer the courses that are directly related to the real world, studying facts and experimenting. Pay attention to the details, work well practically, often solve problems by known methods; they are cautious and do not like surprises and difficulties.	They are innovators, hate tedious work and repetition. It is pleasant to work with abstract problems, formulation of concepts and mathematical dependencies. They do not enjoy courses that contain a lot of material for memorizing and routine calculations, are bored studying details and more inventive
A pedagogical approach to the organisation of learning	Teaching material with specific examples of the implementation of theories and their practical application. Solving tasks with a particular order, implementation of procedures-actions. Work in the laboratory	Teaching material with a guide to the theory and conceptual examination. It is necessary to provide theories that connect the facts being studied. Recommended lectures, exercises, and innovative methods.
Learning methods that are best suited	Verbal, visual, practical Simulation, problem-searching Experiment, execution of exercises; question and answer method; a study based on solving problems	Modelling Role games, games and simulations The case method, project method Discussion panel
E-resources qualified for use	Static visualisation Program package	Static visualisation, 3D models Quantum chemical simulation

	Sensitive	Intuitive
	Virtual labs for laboratory work E-textbooks Teaching programs It is advisable to provide students with resources that allow them to independently find the facts: E-mail, search engines, teaching database Tests ready for use	E-textbooks, Encyclopaedia All types of communications are best suited for learning: forum, video-, audio-conference, chat, e-mail Search engines, teaching database Ready tests are of little use for learning

Table 6 illustrates the results of selection of the integration elements, such as optimal learning methods, pedagogical approach and e-resources, which are qualified for the use in teaching students with preferred visual and verbal learning styles (ILS3). As before, the selection of appropriate e-resources is fulfiled in accordance with [11], [12] and Table 1.

Table 6

Taxonomy of methods and e-resources for visual/verbal dimension (ILS3)

	Visual	Verbal
Characteristics of student style	Well perceived and better-memorized images: drawings, diagrams, charts, graphs, etc.	Well perceived language and text elements, more information is obtained from words - written and oral explanations
A pedagogical approach to the organisation of learning	Both types study better when the teaching material is presented both visually and verbally	
	Students better remember what they see	They quicker perceive spoken or audio information. It is better to remember what they read or hear
Learning methods that are best suited	Visual, practical Problem-searching Modelling Experiment Games and simulations Independent work with training programs and simulators	Verbal, visual Problem-searching Lecture, Exercises Method of questions and answers Discussion panel Brainstorm Individual work with text Work in the group can be particularly useful: students achieve an understanding of the material, hearing the explanations of the groupmates and learn even more when they themselves explain the material
E-resources qualified for use	Static and dynamic visualizations Quantum chemical simulation of spectra Modelling of experiments Virtual labs are best suited for learning Teaching programs Teaching database Tests ready for use	Static visualisation Quantum chemical simulation of spectra Lab complex with measuring sensors E-textbooks Chat, E-mail Teaching programs Search engines,

The methods and e-resources selected with the use of data from Table 1 and results of works [11], [12] are listed for seq-glo dimension (ILS4) in Table 7.

Analysis of the results collected in Tables 1, 4-7 allows lecturers to design the teaching methodology which is best suited to the course material. Different approaches can be used for such a goal. The first approach is to group students into subgroups with similar learning styles and use different teaching methods and materials for each of the subgroups. Typically, the lecturer is not able to implement such an approach because of time constraints, inaccessibility of technical support, etc. Another similar method is based on the identification of a "group average type" and selection of appropriate learning materials. The third alternative approach, perhaps, the most realistic, consists in using learning materials of different types, which take into account the needs of different kinds of students, for particular units of study.

Table 7

Taxonomy of methods and e-resources for sequential/global dimension (ILS 4)

	Sequential	**Global**
Characteristics of student style	Convergent thinking prevails. Achieve an understanding using step-by-step study of the material, when each new step logically follows from the previous	System thinking prevails. Seeing everything in general, studying with high jumps, mastering the material almost by accident, not seeing the connections, and then suddenly "understand them", can combine things in an innovative way.
A pedagogical approach to the organisation of learning	Students learn better through small, orderly, and logically related sequential steps to solve problems. It is necessary to teach the material in a logical order, to try to link each new topic with those studied earlier for a broad and holistic understanding.	Students can study through high jumps, suddenly and almost in any order. Such students may find it more useful to consider subjects in large blocks. Lecturers need to help students to see the links of the material with other topics and disciplines
Learning methods that are best suited	Verbal-dialogical Visible - manuals Reproductive exercises Method of questions and answers Modelling Problem-searching work with reference books	Case method Method of projects Role games Brainstorm Independent work Creative activities on systematisation
E-resources qualified for use	Static and dynamic visualizations are of little use for learning Quantum chemical simulation of spectra E-mail, search engines, teaching database E-textbooks, teaching programs Tests ready for use	Static visualisation, 3D models Quantum chemical simulation of molecule structure The following e-resources are best suited for learning: virtual labs for laboratory work; video-, audio-conferences E-mail, search engines, teaching database E-textbooks, hypertext, teaching programs Tests ready for use

Integrating aspects of styles, and selecting e-resources and teaching methods allow one to change the teaching methodology, focusing on the characteristics of students. The optimal methodology seeks to balance teaching and learning styles rather than to achieve absolute consistency between each lecturer’s action and students’ learning preferences. The discomfort, when students work according to a method that does not fit their learning styles, should not be significant, but it is necessary for the formation of knowledge and qualifications of a future specialist. Completely consistent with student's learning preferences, teaching methods do not create conditions for their progress. Our approach allows one to apply an indicative quantitative characteristic that helps in determining the balance mentioned above. The main stages of the developed approach are as follows (Fig. 2):

- methodological work on the content of a discipline, the development of a training and work program, and the establishment of goals and objectives of the study;
- investigation of the composition of a student group using Felder-Soloman questionnaire. When a lecturer works in a traditional group, it is impossible to make the whole material convenient for all types of students. Therefore, it is necessary to take into account the dominant category of students that will be the basis for selecting methods and means of learning;

– selection of teaching methods and essential electronic resources according to taxonomy illustrated in Tables 1, 4-7.

Not all considered teaching methods with corresponding e-resources should be used for each type of student. You can select the most convenient and affordable.

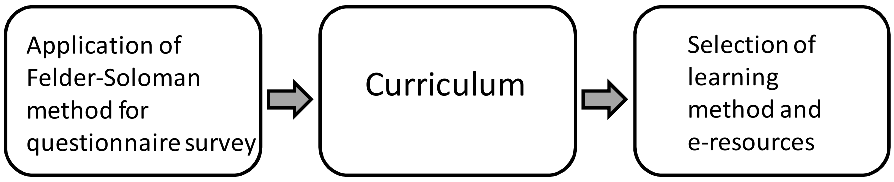

Fig. 2 Stages of integrating learning styles with teaching methods and learning e-resources in the course of development of instructional technology

3.4 Example of application of the developed technology for inorganic chemistry learning

At the first stage, 63 students of the first year of Faculty of Chemistry at DNU completed a questionnaire based on the method of Felder-Soloman. The results are shown in Table 8.

A large average difference was found to connect with the channels of perception where 70% of students pointed out as the prevailing visual style, and only 30% preferred the verbal style. The most significant difference is observed for the aspects of processing and perception of data: most students work actively (77% versus 23% of reflective students) and are more sensitive and practical than intuitive (78.3% and 21.9% respectively). Finally, in the aspect of comprehension, students mainly prefer a consistent style. As a result, the dominant combination of the styles for each dimension in the studied group is {act, sen, vis, seq}.

Table 8

The results of a survey of the first year students of Faculty of Chemistry at DNU by Felder-Soloman method

Subgroup	The relative number of students, %							
	act	**ref**	**sen**	**int**	**vis**	**vrb**	**seq**	**glo**
1	77,8	22,2	88,9	11,1	55,6	44,4	77,8	22,2
2	88,9	11,1	66,7	33,3	66,7	33,3	22,2	77,8
3	63,6	36,4	90,9	9,1	90,9	9,1	54,5	45,5
4	77,8	22,2	66,7	33,3	66,7	33,3	77,8	22,2
Total:	77,0	23,0	78,3	21,7	70,0	30,0	58,1	41,9

Lecture course of the discipline is supplemented by four-hour practice in a laboratory, where the group is divided into subgroups. During the organisation of laboratory classes by subgroups, lecturers will need to take into account the specific characteristics of each subgroup because, e.g., subgroup 1 has more verbal students while subgroup 2 differs from others by higher relative numbers of global and intuitive students (Table 8).

Based on the consideration of general characteristics of this course, students are recommended to carry out the largest number of tasks in the form of possible problems to be solved. Practising and repeating the material, while they are solving problems, is what will allow students to understand the theory entirely.

At the third stage, the selection of optimal teaching methods and e-resources is performed on the basis of the taxonomy of Tables 1, 4-7 and according to the results of the student's educational preferences survey (Table 8). The results of optimisation are shown in Table 9. A lecturer can select a type of e-resources that better matches the content of the material and the category of students. Table 9 allows one to compare learning methods that are better perceived by students of these types, and select the most expedient one.

For example, most students in a group with the profile {act, sen, vis, seq} are better trained in the problem-searching method in its different versions, and quickly comprehend modelling. The computer simulation method, which is rarely currently used, however, shows promise in the development of teaching methods for basic chemical disciplines.

Table 9

Taxonomy of integration of learning methods and e-resources for {act, sen, vis, seq}

	Active	**Sensitive**	**Visual**	**Sequential**
Characteristics of student style	Prefer experimentation, and active and collective work with learning data with the possibility of practical application of results	Prefer the courses that are directly related to the real world, studying facts and experimenting. Pay attention to the details, work well practically, often solve problems by known methods; they are cautious and do not like surprises and difficulties.	Well perceived and better-memorized images: drawings, diagrams, charts, graphs, etc.	Convergent thinking prevails. Achieve an understanding using step-by-step study of the material, when each new step logically follows from the previous
A pedagogical approach to the organisation of learning	Students need to take active action: discuss or apply data, and explain the material to others. It is difficult for them to listen to lectures without performing any activities other than annotation. It is better to organize training in groups	Teaching material with specific examples of the implementation of theories and their practical application. Solving tasks with a particular order, implementation of procedures-actions. Work in the laboratory	Study better when the teaching material is presented both visually and verbally. Students better remember what they see	Students learn better through small, orderly, and logically related sequential steps to solve problems. It is necessary to teach the material in a logical order, to try to link each new topic with those studied earlier for a broad and holistic understanding.
Methods qualified for use	Practical Problem-search (brainstorming, project method) Modelling Creating game situations Study based on solving problems Expert Group Discussion	Verbal, visual Practical Problem-searching Modelling Experiment Method of questions and answers Study based on solving problems Exercise	Visible Practical Problem-Finding Modelling Experiment Games and simulations Independent work with training programs and simulators	Verbal, visual Problem-searching (work with reference books) Modelling Method of questions and answers Reproductive exercises
E-resources qualified for use	Static visualisation Program package E-textbooks	Static visualisation Program package Virtual labs for laboratory work E-textbooks	Static and dynamic visualisations Virtual labs for laboratory work Quantum	Quantum chemical simulation of spectra E-textbooks Teaching programs E-mail, search

	Active	Sensitive	Visual	Sequential
	Teaching programs E-mail, search engines Teaching database Tests ready for use	Teaching programs E-mail , search engines Teaching database Tests ready for use	chemical simulation of spectra Teaching programs Teaching database Tests ready for use	engines Teaching database Tests ready for use

4. CONCLUSIONS AND OUTLOOK FOR FURTHER RESEARCH

When selecting and combining teaching methods, it is necessary to provide the conformity of the chosen methods with the following aspects of the educational process: teaching principles; goals and tasks of training; content of a specific topic; educational characteristics of students, such as age, psychology and qualification level; methods of chemical science; available conditions and time of training; performance of training aids; and capabilities of lecturers themselves. The proposed approach takes into account several of the factors mentioned above and allows one to select the methods in a well thought-out and balanced manner.

Application of the approach described in the article shows promise not only for learning with due account for psychological and pedagogical peculiarities of both students and student groups in traditional education. The proposed technology can be used to organise effective interaction of users with the interface of electronic learning resources when creating adaptive educational products and distance learning platforms [18], which, under conditions of the information society, is one of the critical tasks of educational development.

The outlook of further scientific research is seen in the development of new pedagogical teaching technologies, which take into account different models of student behaviour, and the creation of appropriate educational programs, teaching manuals and instructions, and electronic learning resources.

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ОПТИМІЗАЦІЯ ВИБОРУ ЕЛЕКТРОННИХ ОСВІТНІХ РЕСУРСІВ ВІДПОВІДНО ДО СКЛАДУ СТУДЕНТСЬКИХ ГРУП

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Анотація. Описано технологію інтеграції методів навчання, форм і засобів інформаційно-комунікаційних технологій, що створена з урахуванням психологічних ы педагогічних характеристик студентських груп. Висвітлено результати теоретичних і експериментальних досліджень, проведених на базі двох українських вишів за участю 341 студента напряму підготовки «Хімія» та 18 викладачів базових хімічних дисциплін. Як студенти, так і викладачі були опитані за допомогою спеціально розробленої анкети щодо свого ставлення до використання різних електронних навчальних ресурсів у вивченні та викладанні базових хімічних дисциплін. Переваги студентів у стилях навчання оцінювалися на основі анкети для самооцінки наявних переваг у чотирьох компліментарних вимірах, таких як сприйняття (сенситивне або інтуїтивне), канал входу (візуальний чи вербальний), обробка (активна або рефлексивна) та розуміння (послідовне або глобальне) хімічної інформації. Такий підхід, відомий як метод Фелдера-Соломан, дозволяє розрахувати індекси стилів навчання, які, у свою чергу, оцінюють наявні переваги всіх респондентів у кожному з чотирьох доступних вимірів. Розроблена технологія дозволяє викладачам визначати оптимальний набір електронних навчальних ресурсів для викладання окремих розділів хімії з урахуванням переваг у їх використанні студентами з різними стилями навчання. Розроблена технологія базується на підрахунку середніх значень ресурсів, оцінених усіма студентами групи, а також на експертній оцінці доцільності їх застосування у навчанні базових хімічних дисциплін. Розроблено таксономію оптимального вибору електронних навчальних ресурсів і методів навчання для кожного типу навчальних уподобань студентів. Переваги й недоліки всіх доступних варіантів застосування розробленої технології обговорюються для студентських груп різного складу. Наведено приклад застосування розробленої технології для випадку вивчення дисципліни «Неорганічна хімія».

Ключові слова: вища освіта; навчання хімії; пізнавальні стилі; інформаційно-комунікаційні технології; електронні освітні ресурси.

ОПТИМИЗАЦИЯ ВЫБОРА ЭЛЕКТРОННЫХ ОБРАЗОВАТЕЛЬНЫХ РЕСУРСОВ СОГЛАСНО СОСТАВУ СТУДЕНЧЕСКИХ ГРУПП

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Аннотация. Описана технология интеграции методов обучения, форм и средств информационно-коммуникационных технологий, которая создана с учетом психологических и педагогических характеристик студенческих групп. Представлены результаты теоретических и экспериментальных исследований, проведенных на базе двух украинских вузов с участием 341 студента направления подготовки «Химия» и 18 преподавателей базовых химических дисциплин. С помощью специально разработанной анкеты, как студенты, так и преподаватели были опрошены о своем отношении к использованию различных электронных учебных ресурсов при изучении и преподавании базовых химических дисциплин. Предпочтения студентов в стилях обучения оценивались на основе анкеты для самооценки имеющихся предпочтений в четырех комплиментарных измерениях, таких как восприятие (сенситивное или интуитивное), канал ввода (визуальный или вербальный), обработка (активная или рефлексивная) и понимание (последовательное или глобальное) химической информации. Такой подход, известный как метод Фелдера-Соломан, позволяет рассчитать индексы стилей обучения, которые, в свою очередь, оценивают имеющиеся предпочтения всех респондентов в каждом из четырех доступных измерений. Разработанная технология позволяет преподавателям определять оптимальный набор электронных образовательных ресурсов для преподавания отдельных разделов химии с учетом склонности к их использованию студентов с разными стилями обучения. Разработанная технология базируется на расчете средних показателей ресурсов, оцененных всеми студентами группы, а также на экспертной оценке целесообразности применения ресурса при изучении базовых химических дисциплин. Разработана систематика оптимального выбора электронных учебных ресурсов и методов обучения для каждого типа учебных предпочтений студентов. Преимущества и недостатки всех доступных вариантов применения разработанной технологии обсуждаются для студенческих групп различного состава. Приведен пример применения разработанной технологии для случая изучения дисциплины «Неорганическая химия».

Ключевые слова: высшее образование; обучение химии; познавательный стиль; информационно-коммуникационные технологии; электронные образовательные ресурсы.