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Experience in teaching analytical chemistry in a joint English-language educational project of Chinese and Ukrainian universities

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Abstract. The paper was aimed to study the problems that may arise when Chinese students learn an analytical chemistry course in English, read by teachers from Ukraine. In particular, the reasons for the possible excessive increase in cognitive load were investigated. The comparative analysis of the existing learning styles was carried out to achieve the goal of the study. For this purpose, the indicators were compared for respondents studying in similar chemical specialities at the Kyiv College of the Qilu University of Technology in China and Kyiv National University of Technologies and Design in Ukraine. Some students from China demonstrate more pronounced reflective, verbal and intuitive learning styles. In contrast, a decisive advantage towards active, visual and sensing styles is characteristic of Ukraine students. The structure of the lecture course was analysed from the viewpoint of e-resources used. The optimal application of different electronic resources for students with varying learning preferences was established based on the results of experiments by the method of dual-task. The difference in educational priorities should be reflected in the various forms and methods used in the teaching of chemical disciplines. Recommendations for the development of appropriate learning resources are given.

1. Introduction

Introducing information and communication technologies (ICT) into the educational process has led to the emergence of many electronic resources (e-resources) for teachers that were previously unknown and inaccessible [1–3]. These tools cover entirely different areas of educational activities. For example, it can be electronic resources to assess student knowledge, such as testing programs and test shells [4–6]. Other resources are informational [7, 8]. They help informally fill the course being read. Among them, there are static and dynamic visualisations, e-books, media libraries, educational software, simulators, tutorials and academic databases [9–12]. Also, resources can be used to organise communication and data retrieval. Another class of e-resources is software for computer modelling and packages of professional applied programs [13–18].

Lectures remain the dominant form of organising training, especially for teaching basic disciplines. Conservative by nature, however, the lectures did not remain unchanged [19–22]. Now it is almost impossible to imagine lecture talks without multimedia support. The most common example is lectures accompanied by a slide deck. When preparing presentations, electronic resources can also be used, which are very diverse.

It should be noted that the widespread use of ICT does not automatically benefit training [23, 24]. Using e-resources can be effective only if several conditions are met. Probably two aspects are critical [25, 26]. They select teaching methods and educational e-resources, considering the audience's characteristics and the cognitive load that these resources cause.

Individual perception of educational e-resources, materials and information is often described in terms of "learning styles" or "preferences of learning styles" [27–31]. This aspect concerns both teachers and students. Also, a conflict of styles can emerge between teachers and students. On the one hand, the knowledge of student preferences is essential to avoid a possible conflict of styles. On the other hand, it is imperative and advisable to study the preferred learning styles for student groups. Based on this knowledge, it is possible to optimise various aspects of the presentation of materials, including optimising the e-resources used [25, 32, 33].

For successful learning, one needs to control students' level of cognitive load [34–38]. Overloading often causes a misunderstanding, while underloading leads to a loss of attention. In both cases, the perception of the material can deteriorate

Optimising cognitive load is exacerbated when teaching is not in the native language [39, 40]. The cognitive load increases as students need additional time and mental efforts to translate/understand words and compare them with illustrations and actions. The presence of too complicated effects in presentations, the use of a wide range of techniques and e-resources can easily overload a student when teaching in a foreign language [41, 42].

Suppose a foreign teacher conducts teaching in a foreign language. An additional problem may arise that affects both the effectiveness of e-resources and the cognitive load. Evidently, foreign teachers use the same styles and formats that are accepted in their country. The question remains open and unexplored to what extent the approaches used are acceptable and understandable for international students. Do they create additional difficulties, both at the cognitive level and the level of mere perception?

The work aimed to study the problems that may arise when Chinese students learn an analytical chemistry course in English, read by teachers from Ukraine. Analytical chemistry is one of the key disciplines for future specialists in chemical engineering. It involves the separation, identification, and quantification of matter. Analytical chemistry plays a crucial role in various chemical industry branches, such as in the production of synthetic and herbal medicines, industrial process control, environmental monitoring, medical diagnostics, food production, etc. [43–45]. A comparative analysis of Chinese students' learning styles and students from Ukraine of similar specialities was carried out to achieve the study's goal. The structure of the lecture course is analysed from the viewpoint of e-resources used. Some estimates are made of possible correlations between English language proficiency and student achievement.

2. Experimental

The experiment was carried out while teaching a course in analytical chemistry at the Qilu University of Technology, Jinan, Shandong province, People's Republic of China.

The indicators of a group of first-year students of the Kyiv College at the Qilu University of Technology (KCQUT) were studied. Methods of polling and testing were used, and the results of surveys, tests and exams of a student group were analysed. The group comprised 75 people majoring in light chemical engineering. The students in this college are Chinese. Teaching is conducted in English. Teaching in various disciplines is undertaken by both Chinese and Ukrainian teachers. In particular, analytical chemistry is read by Kyiv National University of Technologies and Design (KNUTD) teachers.

The course of analytical chemistry consisted of 32 lecture hours, namely 16 lectures of 90 minutes each. There were two midterm tests, an oral and written final exam. Besides chemical knowledge, the oral exam allowed one to assess the students' ability to understand, interpret, and use spoken English to solve professionally-oriented problems (terminology, classification of chemical compounds, fundamental laws, etc.). Students completed three independent homework assignments and individually performed laboratory work using computer modelling.

The ChemLab English-language program was used for modelling [46]. Before completing the assignments, the teacher explained the technology of work in ChemLab for 45 minutes. Students recorded their work on video and sent them for verification, which the teacher carried out offline.

During independent work with ChemLab, the cognitive load was reduced. The students worked each at their own pace and had sufficient time to comprehend each performed action. This type of work was considered a first step of testing the influence of cognitive load on student learning effectiveness.

The ChemLab program has an intuitive, user-friendly interface and tools for adapting work to each user's requirements. It includes:

- the ability to turn on and off the hint mode and labels on each object,
- the text of instructions for performing work,
- changing the design of the working window of the program, and
- at least three possible options for manipulating modelling objects using the mouse or the context menu.

A similar course of analytical chemistry was also read to first-third-year students of KNUTD. The experiment involved 161 people. The students majored in chemical and pharmaceutical technology at the Faculty of Chemical and Biopharmaceutical Technologies. Lectures were delivered in their native Ukrainian language.

The content of the lecture course was identical for both QUT and KNUTD universities. A comparison was made between the learning styles of Ukrainian and Chinese students who participated in the experiment.

In both cases, profiles of student learning preferences were identified by R. Felder-B. Soloman method. The instrument, known as the Index of Learning Style [47, 48], was used. All respondents answered 44 questions. The processing of responses allowed one to estimate available preferences in four complementary dimensions. Perception of information was studied through the prism of either sensing (sen in short) or intuition (int). The input of information occurred via visual (vis) or verbal (vrb) channels. Either active (act) action or reflexive (ref) reflection determined the type of data processing. Understanding of information took place by using a sequential (seq) or global (glo) approach. In other words, each of the four dimensions consists of a pair of a style and antistyle or two contrasting styles. An 11-point scale was used to quantify students' preferences for each of four dimensions.

An individual style was predominant when the calculated score in the person's answers ranged from 6 to 11 points. The preferred learning styles for a group of students were assessed in two ways. In the first case, the shares of students that scored 6 to 11 and 0 to 5 points were calculated. The learning preference was expressed as the percentage of students who scored from 6 to 11 points. Such an approach (Method 1) illustrated the distribution of student preferences between style and antistyle for each of the four dimensions.

The first approach did not reflect the strength of the existing preference within a pair of styles. Another approach (Method 2) implies calculating the average score of learning preferences in a group instead of the relative number of students in a group. The average score reflected the relative number of students with individual preferences and depended on the preference strength. If the average score was 0-3 points for a style, it was considered that there was no preference. The style preference was weak if the average score was 4-7 points and strong for 8-9 points. The preference was rated as very strong, with an average between 10 and 11 points.

The level of cognitive load of students was measured by the method of dual-task using the developed software. Students mastered the study material prepared with the help of various multimedia resources. The secondary task was to press the button on the screen when the button colour had changed. The time between changing the colour and pressing the button was fixed. It allowed an experimenter to record the change in students' reaction time (t) to the visual signal. It was believed that the response time increases with increasing cognitive load.

In total, 34 Ukrainian students took part in the experiment. Each of them performed six tasks. Each task was repeated 5-6 times to get statistically significant results. When performing the tasks, respondents read the text of two levels of difficulty (tasks 1 and 2), animated text (3), watched videos with audio (4), as well as videos with audio, which contained intense distractions (5). For example, such distraction effects were explosions or flashes. The reaction time (t_n, where n is the number of the experiment) was measured for all five experiments.

A blank experiment was conducted to consider the individuality of the respondents. In such cases, the response time to colour change (t_0) was measured in the absence of a learning task. The periods spent in experiments 1-5 were normalised to the blank investigation time in the future. All calculations and comparisons were made for the relative values $R_n \equiv t_n/t_0$.

As the Kolmogorov-Smirnov test showed [49], the obtained results are subject to normal distribution. Therefore, statistical processing of the obtained results was performed using the T-test for paired dependent samples. First, the differences between the results of the two experiments under comparison were calculated for each respondent. Then, it was checked whether the average of these differences differs from zero. The level of significance was taken as $\alpha \equiv 0.05$.

The materials of the published course for analytical chemistry were used to analyse a slide deck structure. The slide deck is divided into 18 parts, delivered in 16 lectures, and contains 1275 slides. Except for slides with titles and lecture contents (49 slides), an analysis of the content was carried out for the remaining informational 1226 slides. Twelve key elements, which compose slides, were defined. They are titles and contents of sections, flowcharts, classification schemes, stage schemes of a process, procedure schemes, tables, graphs and tasks to solve. Besides, some slides were 100% covered by text, while text coverage varied between 25% and 75% in other transparencies. Also, illustrations for displaying chemical processes at the micro, macro and symbolic levels are highlighted. The analysis carried out included the frequency of using certain elements combined with varying degrees of student preferences for specific resources.

3. Results

3.1. Preferred learning styles

Preferences in learning styles for students of KCQUT and KNUTD calculated by Method 1 are presented in figure 1.

The results represent the proportion of students from the total number, and qualitatively they look similar. In both cases, students are prone to act, sen, vis and seq learning styles. Both experimental curves are shifted to the right and compared to the circular balance curve (50%).

However, a significant difference is seen between Ukrainian and Chinese students in the degree of existing preferences in three of the four dimensions. Both teams show virtually the same results only in the seq-glo dimension. For all other styles, a relatively more significant imbalance between style and antistyle characterises Ukraine students. Conversely, China student preferences look relatively more balanced. For example, almost 87% of Ukraine students show a tendency to the sen style. In comparison, this figure is only 64% among students from China.

The difference in the proportion of students between a particular style and antistyle is not statistically significant. However, this is primarily because individual indicators range from 0 to 11 points. Accordingly, the average data for the group as a whole gives only a qualitative picture.

The learning preferences were assessed according to Method 2 to obtain additional information on the differences between students from different educational institutions. As already mentioned, Method 2 estimates the relative number of students who exhibit preferences

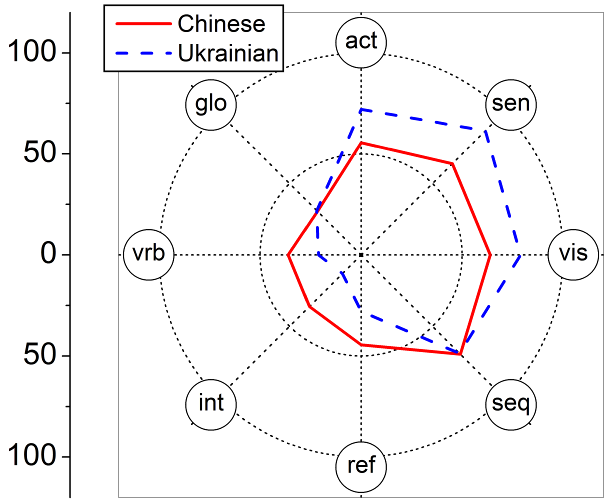

Figure 1. The relative number of students of KNUTD (dotted line) and KCQUT (solid) with different learning preferences.

of different strengths relative to a particular learning style. Relative values, normalised to the total number of students in the sample, were used to level the impact of different numbers of students in the samples. According to the strength of preference, the division of all students into four groups was considered: group 1 – where there is no preference for a particular style or style and antistyle are balanced; group 2 – style has an advantage over antistyle of moderate strength; group 3 – there is a strong advantage; group 0 represents students with the benefit of antistyle of any power over style.

As can be seen from figure 1, the difference in educational preferences can be expected in three dimensions: act-ref, sen-int, and vis-vrb. The results of calculations by Method 2 are shown in figure 2 for these dimensions. In figure 2, the values of act, sen and vis antistyles are shown in addition to the styles of ref, int and vrb. For them, the picture is significantly different.

For each of the dimensions ref, int, vrb, groups of maximum number (up to 50-60% of the total number of students) demonstrate moderate strength. Groups with a balanced style and antistyle occupy 25-40% in number. Groups with other types of learning preferences (groups 0 and 3) are the smallest in number. Together they number from 5 to 10%. The advantage of the respective antistyle or the balance between style and antistyle is typical for 90-100% of Ukrainian students.

Ukrainian students primarily demonstrate either a moderate propensity for these styles or a balance of styles and antistyles. The moderate tendency to these styles of Chinese students is less pronounced. The largest group consists of students with balanced preferences. A relatively large (about 17%) group comprises Chinese students with a strong preference for the styles of act, vis and sen. To some extent, this is abnormal behaviour, as groups with strong preferences are usually small.

3.2. Cognitive load

One can assume that a foreign language increases cognitive load and thus complicates learning. The workload of Chinese students studying in English was increased compared to the workload of, for example, Ukrainian students studying in their native language. After the course of analytical chemistry, the final exam was divided into parts, oral and written, to confirm the assumption about the influence of the language of instruction. The written exam was organised

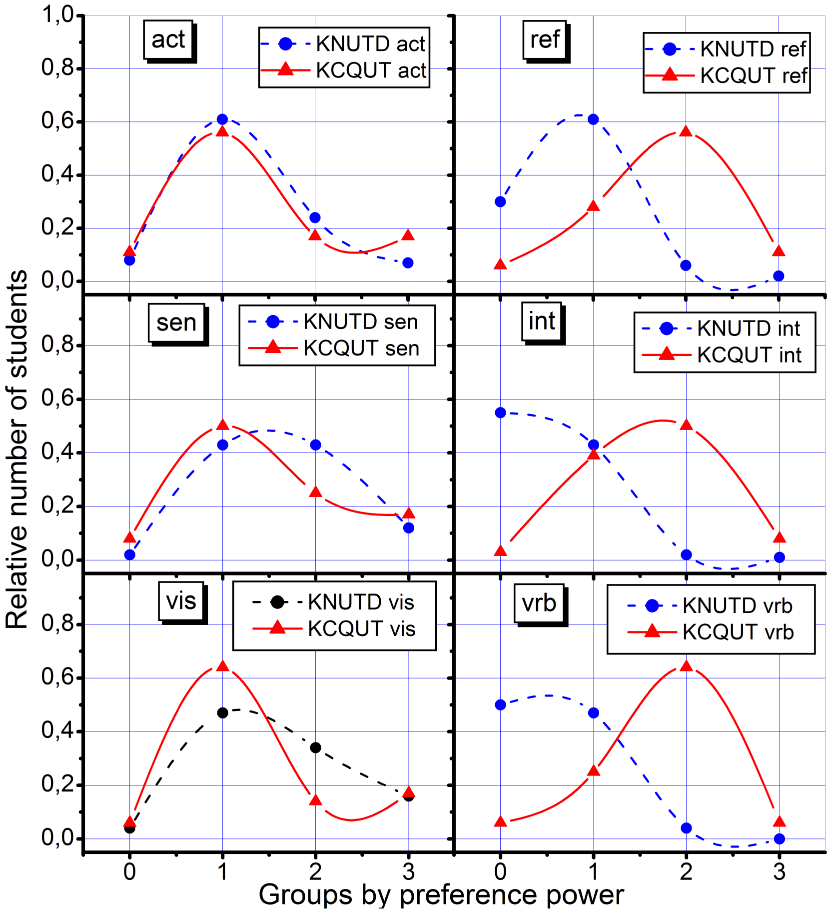

Figure 2. The relative number of students in groups 0-3 who have a learning preference of a particular style: 0 – antistyle prevails, 1 – the balance between style and antistyle, 2 – moderate style advantage, 3 – strong style advantage.

traditionally, and its primary purpose was to test the gained chemical knowledge. During the oral exam, an attempt was made to assess students' necessary level of understanding in English simultaneously with fundamental chemical knowledge. During the exam, students were asked simple questions about chemical terminology and basic chemical laws. They were forced to understand quickly and then answer questions impromptu, demonstrating the level of basic knowledge in both Chemistry and English. The answers were scored on a 10-point scale.

Figure 3 shows a strong linear correlation ($R^2 \equiv 0.89$) between the final mark in analytical chemistry and the language exam mark. The final mark was based on the results of two intermediate tests, the completion of three homework assignments, laboratory work on computer simulations, and the final written exam results. The most straightforward and most logical explanation for the invented fact is that the lack of knowledge of the language of instruction significantly increases students' cognitive load. The increased load thus critically increases the time required to understand and perform tasks.

Suppose students can choose the pace, which is acceptable for performing tasks and understanding the results. Such conditions will help to reduce cognitive load and improve the level of mastery of educational material. ChemLab software provides such an opportunity. This program contains tools for slower or faster execution of the experiment. Also, work is possible with or without prompts. By performing their laboratory works with the help of

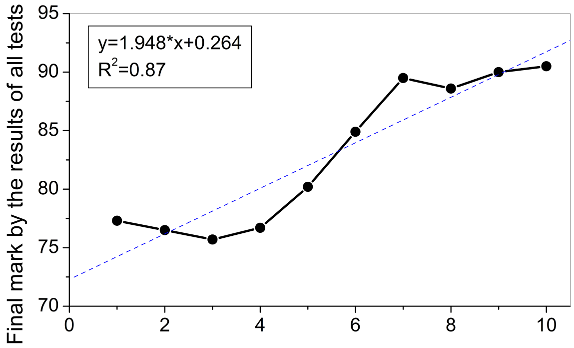

Figure 3. Correlation between the final mark in analytical chemistry, based on all home and laboratory works, exams and tests, and the oral language exam mark. The oral exam used to test students' ability to understand and use chemical nomenclature.

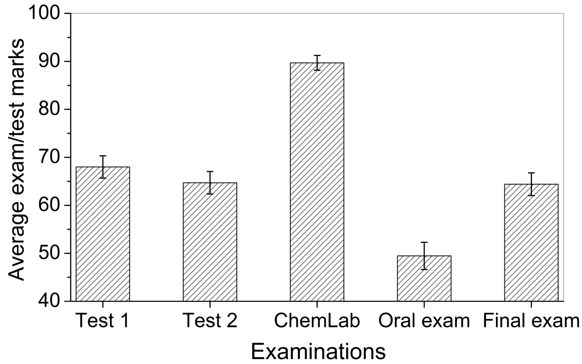

Figure 4. The average results of all exams of the group of students KCQUT in studying analytical chemistry. For comparison, the results are reduced to values on a 100-point scale.

ChemLab, students could create the most favourable environment, thereby reducing cognitive load. As a result, the average score of the group according to the results of laboratory work in ChemLab significantly exceeded the figures obtained by the same students in passing tests or exams (figure 4). Only 2 out of 75 students failed this lab.

Thus, the increased cognitive load when learning a foreign language is an essential factor that must be taken into account when developing a lecture course. On the one hand, the development of multimedia technologies creates a wide range of e-resources that can be implemented in the lecture course. The simultaneous use of many resources can increase the cognitive load in the learning process. To clarify this issue, the influence of using different educational resources, including simultaneous, on the level of a cognitive load of KNUTD students was studied using the dual-task method. The cognitive load level was assessed by measuring the time required to perform a secondary task in the learning process using different multimedia resources. The results of the study are given in table 1.

Table 1. The results of the measurement of cognitive load by secondary task method.

Task No	Respondent reaction rates were measured under the following conditions:	t_n, ms	R_n=t_n/t_0
0	The absence of an educational task (blank run)	530.4	1
1	Simple text reading	777.2	1.41
2	Complex text reading	904.1	1.81
3	Text reading concurrently with animation viewing	835.8	1.70
4	Video viewing together with audio listening	658.9	1.38
5	Video viewing together with audio listening, if demonstration contains distracting effects (explosions, flashes etc.)	1511.3	3.21

The statistical analysis shows that the difference in the relative time R_n is observed for five pairs of experiments out of 10. For example, the differences between the response time R_1 when reading plain text and the values of R_2 (complex text) and R_3 (text with animation) are statistically significant at $\alpha_{12} \equiv 0.011$ and $\alpha_{13} \equiv 0.049$. For experiment 4, the time differences are substantial for experiments 2, 3 and 5 ($\alpha_{24} \equiv 0.038$, $\alpha_{34} \equiv 0.01$, $\alpha_{45} \equiv 0.028$).

For each of these cases, the addition of a second, more sophisticated resource significantly increases the cognitive load. The obtained results show the potential danger of increasing cognitive load when using many different e-resources. As already mentioned, teaching in a foreign language exacerbates the problem of student overload. Therefore, when preparing lecture material, an excessive complication of illustrations should be avoided. Care should be taken to ensure that the slides used are simple in content and stuffing various multimedia resources.

3.3. Lecture structure

As mentioned above, the lecture course has 1275 slides distributed between 18 sections. Of these, 49 slides contain only the names and contents of sections and their subsections. Therefore, they are excluded from further analysis. The remaining 1226 slides are informative.

All 18 sections of the course were combined into five parts according to their content to simplify the analysis. Table 2 illustrates the main characteristics of parts of the course, namely the number of parts and slides in them and the saturation of slides with multimedia elements.

Table 2. The number of slides per lecture part and the average number of multimedia elements per slide.

Lecture parts	Section No	No of informational slides	No of slides with titles	No of multimedia elements per slide
Introductory	1-3	228	23	1.44
Equations & equilibrium	4-5	128	2	1.68
Classic methods	6-9	167	4	1.67
Instrumental methods	10-17	598	19	1.78
Chromatography	18	105	1	2.13
Total	1-18	1226	49	1.72

As is seen, the density of multimedia elements increases from the first lectures to the last one. Typically, each slide contains only two elements and less than 1.5 elements at the beginning of the lecture course. This approach seems appropriate because students are gradually getting used to the methods of conveying the material.

About a third of the total number of informative slides consists of full-text slides. This indicator is maximum in the introductory part because introductory lectures contain many definitions, wording, etc.

It gradually decreases with the transition to other parts of the lecture course. Schemes for various purposes can be seen on average on 20% of slides. On the contrary, this figure increases from the beginning of the lecture course to its completion. Information as graphs and tables is typical of about 22% of informative slides.

Table 3 contains more detailed information on the distribution of multimedia elements between different parts of the course.

About 50% of the total number of informative slides contain illustrations of chemical processes at different representation levels. Such illustrations are hardly appropriate on slides with tasks, full-text slides, and slides containing classification schemes. Excluding such unappropriated slides, there are 816 slides left throughout the course. More than 70% have illustrations of chemical processes at different representation levels (table 4).

The most challenging task is to form an understanding of the transitions between different levels of representation of chemical knowledge [50–52]. However, according to the analysis, there are very few slides (less than 10%) with such illustrations.

Table 3. The number of lecture slides with distinct elements.

Lecture parts	Total	Text 25-75%	Text 100%	Classification	Flow chart	Stage scheme	Procedure scheme	Table	Graph	Task
Introductory	251	92	99	22	3		2	12	28	6
Equations, equilibrium	130	77	27	1				7	2	12
Classic methods	171	74	48	3	1	3	5	20	17	7
Instrumental	617	307	175	18	133	18	10	47	95	11
Chromatography	106	85	14		19			16	33	2
Total	1275	635	363	44	156	21	17	102	175	38

Table 4. The number of slides with illustrations of chemical knowledge at different levels of representation, transitions between these levels and the share of such slides in the slide deck.

Number of slides	Symbol	Micro	Macro	Macro-symbol	Symbol-micro	Micro-macro	Ternary micro-macro-symbol
816	304	94	193	33	14	19	2
Part, %	37.3%	11.5%	23.7%	4.0%	1.7%	2.3%	0.2%

4. Discussion

As is known [25, 53, 54], learning styles can significantly differ for students of different fields of study. Students of related specialities have similar learning profiles. This paper compares the learning styles of students of similar specialities. However, students of distinct groups received secondary education in different countries; higher education was conducted in their native and foreign languages. The obtained results (figure 1) indicate a significant difference in learning preferences between students of KNUTD and KCQUT.

Students from Ukraine demonstrate a clear advantage in the act, vis and sen styles of study. In each dimension, 72% to 89% of students have the benefits mentioned above. In contrast, Chinese students are significantly more verbal (36% verbal students versus 64% visual) than Ukrainian students (21% verbal vs 79% visual). They are good at perceiving linguistic and textual elements, getting more information from words in both written and oral explanations.

They are also a bit more reflective and intuitive: 44% and 36% of Chinese students at Kyiv College are reflective and intuitive, respectively. The same results for Ukrainian students are 28% for reflective and 13% for intuitive style. Almost half of Chinese students prefer reflection and observation. They like to work alone and work well with the text. A third of Chinese students are innovators, being more resourceful and intuitive in information perception. They like to work with abstract problems, concept formulations and mathematical dependencies and readily accept complications. In contrast, they hate monotonous work and repetition, are bored studying the details and do not like courses that contain much material for memorisation and routine calculations,

In dimension seq-glo, the measured difference between Chinese and Ukrainian students is minimal; it never exceeds 1%. Convergent thinking prevails in all students who participated in the survey. They achieve understanding in the step-by-step study when each new step logically follows from the previous one. Traditional technical education is mostly sequential. The coincidence of the characteristics of students from different countries in this aspect possibly results from the influence of the chosen field, namely technical education.

In general, students who studied at KCQUT exhibit a more balanced profile of learning preferences compared to students of KNUTD. However, as shown in figure 2, Chinese students are characterised by a limited group of students who have pronounced learning advantages, often simultaneously for three styles – act, sen and vis. The relative number of such students (up to 17% of the total) is even higher than among KNUTD students (usually 7-12%). The learning advantages of the other 80-83% of students from China show even more balanced profiles than follows from the averages in figure 1. From a practical point of view, the identified difference in learning preferences must be taken into account, particularly when developing educational materials and organising the English-language training for students of China.

The effectiveness of learning is influenced by both the quantitative and qualitative composition of the learning preferences. All four available dimensions are essential for a complete description of the student's learning profiles. Therefore, the analysis is ineffective if the impact of some individual styles on the progress in studies is considered [25, 53].

Students who have different combinations of learning styles experience cognitive loads differently when using e-resources. A detailed analysis of the impact of the qualitative composition of a mix of styles on academic progress has shown that active or sequential styles are necessarily present in learning profiles of well-progressing Ukrainian students. In a broader sense, it is possible to say that the best progress is made by students who have typical advantages for this field of study [53]. In contrast, atypical advantages are undesirable. One can assume that the content of the disciplines being taught, the teaching methods used, and the teaching resources, including e-resources, create a more comfortable learning environment for students with typical learning preferences. Thus, all these factors contribute to a better understanding of chemical knowledge. Therefore, to increase the effectiveness of educational activities, lecturers must analyse the composition of groups and optimise methods, forms and resources for teaching in concord with established groups' profiles.

For both universities, the combination of act-sen-vis-seq styles prevails, but the degree of preference differs significantly. The number of Ukrainian students with the above mix of styles (group A) is approximately 72-89% of the total number. Among Chinese students, only 55-64% belong to group A. In other words, 36% to 45% of students from China have learning preferences (group B) that contrast with the dominant combination in three of the four dimensions. Only the structure of priorities in the seq-glo dimension remains unchanged for groups A and B. Group B contains much less Ukrainian students (11-28% of students).

The vast majority of Ukrainian students receive educational material taught using optimal teaching methods. Therefore, the focus on the specific learning preferences of group A is reasonable and appropriate when teaching students in Ukraine. With KCQUT students, this approach may be one-sided, as it does not consider the existing preferences of 36-45% of Chinese students. For students with different learning profiles, the ways of mastering and assimilating information, as well as the information channels involved, significantly differ. As a result, the perception, as well as the effectiveness of different teaching methods, diverges.

Table 5 illustrates the perception of teaching methods by students of groups A and B separately. A plus marks optimal teaching methods for a particular learning style. Four teaching methods fit nicely with three of four learning preferences in group A. Another five methods are agreed only with two of four learning preferences. Such procedures should be used with caution, as a significant proportion of students do not perceive them.

For group B, the situation looks worse. None of the methods is simultaneously acceptable for all four available preferences. Only one method fits with three of the four available student benefits. The other eight methods are only proper for two learning styles at a time. The obtained result formulates the problem of finding optimal teaching methods for students of group B, which currently has no solution and needs further study. It is also apparent that this problem is acute primarily for KCQUT students, as it may affect 36-45% of existing students.

A separate factor of academic success is language proficiency in learning in a foreign language environment. According to all tests and exams, students with limited language proficiency

Table 5. Optimal teaching methods for students with different learning profiles: a) - profile act-sen-vis-seq and b) - profile ref-int-vrb-seq. Suitable methods for a given learning style are marked with a plus. (* PBL and PjBL – problem-based learning and project-based learning)

a) Teaching methods – profile	act	sen	vis	seq	b) Teaching methods – profile	ref	int	vrb	seq
PBL and PjBL*	+	+	+	+	Question-answer method	+		+	+
Modelling	+	+	+	+	Modelling		+		+
Practical	+	+	+		Verbal			+	+
Visual		+	+	+	Visual			+	+
Experiment		+	+		Independ.work with text	+		+	
Games & simulations	+		+		Case method	+	+		
Verbal	+		+		PBL and PjBL*			+	+
Question-answer method		+		+	Discussion panel		+	+	
Performing exercises		+		+	Performing exercises			+	+

showed worse outcomes than those who speak a foreign language better. On average, for students who received 1-5 points in the language exam, the results of their progress in the study of analytical chemistry are 77.3 points. Those who took 6-10 points in English had an average of 88.7 in analytical chemistry in all exams. The reasons for different levels of English proficiency may be various. As evidenced by the literature [55, 56], one of them may be the difference in learning styles, using teaching methods that are not optimal for some learning styles. It affects the effectiveness of foreign language learning.

Students with limited language skills experience an additional mental workload. If they use favourable resources and reduce the load to some extent, the results improve. Such a statement is evidenced by the results of laboratory work using ChemLab. This program's extensive capabilities to adapt the interface and tools to individual needs (enable/disable hint mode, additional labels on objects, use of online instructions, etc.) led to an increase in the average score obtained by the group for laboratory work. The laboratory work results are by 31- 38% better than the results of other tests of the same students (figure 4).

As proven in dual-task experiments, the simultaneous use of multiple e-resources can complicate learning. The negative effect of distraction can outweigh the positive impact of using simultaneous multiple communication channels. Conversely, the selection of optimal e-resources, both in quantity and quality, reduces cognitive load and promotes learning (table 1). The importance of the optimal choice of educational resources determines the approach to creating lecture presentations for international students. On the one hand, such presentations should be relatively simple and do not contain many e-resources. However, simplifying slides can have negative consequences.

The slide deck analysis showed that insufficient attention was paid to the formation and assimilation of transitions between different levels of representation of chemical knowledge. A serious problem is the inability of many students to create virtual connections between different expression levels of chemical knowledge. As is known, these levels are microscopic (atomic-molecular world, including ideas about the structure of the atom), macroscopic (phenomena of the material world) and symbolic (apparatus of mathematical methods and symbolic description of chemical processes). The inability to establish and use links between the different levels is a severe obstacle to students' development of chemical knowledge [57, 58].

Chemical knowledge is formed in the correct conceptual structures when all the above levels of understanding of processes and phenomena are included. Students quickly make imaginary transitions from one level of knowledge to another. Ideally, such changes should proceed between three levels - micro, macro and symbolic [51].

Unfortunately, virtually no slides illustrating transitions between representations levels are present in the slide deck. As follows from table 4, 11% to 37% of the slides contain illustrations of chemical processes at one of the three mentioned representation levels. Examples of transitions between levels are ten times less. The number of slides with double transitions does not exceed 4% at best, and the figure is only 0.2% for triple links. As a result, teachers are forced to stretch their visualisation in time and space, e.g., by using different neighbouring slides to realise the need to master the triple transitions. Under such conditions, students are forced to combine knowledge at different levels independently. For example, recall information from a previous slide and integrate data with current or subsequent images.

Obviously, when preparing each illustration in the educational presentation, it is necessary not to forget about forming chemical knowledge. If this goal, e. g., is understanding the triple transitions between levels of chemical knowledge, it needs to place all the essential elements on a single slide. In this case, the design of slides should follow Mayer's multimedia principles [19,20] and not overload them, creating conditions for an optimal cognitive load of students.

5. Conclusions

(i) Chinese and Ukrainian students of related specialities demonstrate qualitatively similar preferences in learning styles. Following the Felder - Soloman method, the dominance of act, sen, vis and seq is characteristic of both student groups. However, a significant quantitative difference is observed in learning profiles. Thus, 36% to 44% of students from China demonstrate reflective, verbal and intuitive learning styles. A decisive advantage in the opposite direction, namely act, vis and sen, is characteristic of Ukraine students. From 72% to 87% of Ukrainian students have such advantages. The difference in these learning preferences should be reflected in the different forms and methods used in teaching academic disciplines.

(ii) The influence of the simultaneous use of different e-resources on students' cognitive load was investigated by the method of dual-task. Concurrent use of over two resources can lead to students' mental overload and impair their perception of information. Simultaneous use of different e-resources can activate the simultaneous exchange of information through several channels of perception. However, the danger of mental overload concurrently increases. Then the negative effect of overload outweighs the positive impact of using several channels of information perception. Teaching in a foreign language enhances the mental load on students. It is evidenced by the data obtained on the correlation between students' knowledge of the language of instruction and their academic achievements. If learning conditions help reduce cognitive load, academic achievements increase even among students with poor language skills.

(iii) Studies of the structure of the presentations accompanying analytical chemistry have shown that a slide deck's design cannot be overly complicated. Virtually all course slides involve 1.5 to 2.4 e-resources per slide. However, attempts to simplify the structure of slides have led to a lack of attention to the formation of mental transitions between microscopic, macroscopic and symbolic levels of representation of chemical knowledge. The construction of such transitions is one of the most important and, at the same time, the most challenging task in teaching chemistry courses. An insufficient number of slides (up to 4% of the total) with illustrations of transitions between different levels reduces the teacher's ability to explain these issues.

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