

PREFERRED LEARNING STYLES OF STUDENTS MAJORING IN CHEMISTRY, PHARMACY, TECHNOLOGY AND DESIGN

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Research on students' preferences in learning styles is a topical issue of modern education because understanding the learning styles promotes individualisation of the teaching process. The existing preferences in learning styles of students of four areas of training have been studied by the Felder-Soloman Index of Learning Styles. Technology students have the most balanced learning profile: the preference of any style in all dimensions does not exceed 70%. Future chemists and pharmacists are characterised by the apparent preferences of visual, sensitive and active styles (at the level of 80%), as well as a moderate preference of sequential style (~70%). Design students exhibit distinct domination of visual style (>95%) over verbal one (<5%). In three other dimensions, a moderate preference (60-70%) of active, sensitive and sequential styles over reflective, intuitive and global styles is observed. Relative invariance of learning styles has been proved by the results of the survey for pharmacy students: the dominant styles are poorly changed during four years of undergraduate study. Increasing reflectivity, intuitiveness and verblity becomes significant for the fifth year of study. However, such changes may be related not so much to the transformation of personality characteristics, but are caused by the additional selection of students when they join their graduate school. The problem of optimal choice of electronic resources for teaching chemistry was illustrated for future chemists and pharmacists with different preferences in a sensitive-intuitive dimension. One preferred learning style (more than 90% of students are sensitive) dominates among pharmacy students, while up to 20% of chemists have a pronounced intuitive type of learning. The pedagogical approaches, methods and electronic resources for teaching chemistry, are discussed for students of both specialities.

Keywords: learning style; chemistry; pharmacy; design and technology education; Felder-Soloman Index of Learning Styles.

Introduction

The creation of conditions that help to master the knowledge of various subject fields effectively is an urgent problem of modern education. The development of adaptive learning strategies that take into account both psycho-physiological characteristics of students and changes taking place in their intellectual development is considered as one of the ways that facilitate individualisation of professional training of future specialists and increases the efficiency of the educational process.

The actual problem is the identification of predominant styles of learning, as well as the provision of consistency between the styles of learning and the styles of teaching material. A learning style can be defined as a typical cognitive, emotional and psychological behaviour, serving as a relatively stable indicator of how students feel and interact with the learning environment. This definition accounts for the fact that learning styles are an adaptive strategic response to a situation and depend on different factors (for example, level of interest), and also show themselves as more stable types associated with personal characteristics. A variety of approaches are used to characterise the learning styles of people (Coffield, Moseley, Hall, Ecclestone, 2004; Velusamy, Anouncia, 2013).

There is a lot of evidence that students from different fields of study often demonstrate different preferences in their learning styles (Yaroshenko, Derkach, 2012; Derkach, Starova, 2017). The nature of the emergence of different learning styles in different environments is not finally evident yet. One may suppose that learning styles are, rather, educational strategies that characterise the individual's actions in response to the requirements of 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. (Velusamy, Anouncia, 2013). In turn, individual ways of scholarly activity are formed under the influence of cognitive styles typical of a person (coding and processing styles, staging and solving problems, cognitive attitudes to the world, etc.).

There are rather complex connections between the learning styles and the academic performance of students in various areas of training (Chun Lok, Kuan, 2016; Cetin, 2015; Russo, Mertins, Ray, 2013; Surjono, 2015; Wilson, Narayan, 2014; Ishak, Awang, 2017). Also, the existence of a correlation between the students' success in the study of chemistry and their preferred learning styles, as well as the cognitive load that students experience when working with electronic learning resources, has been established (Derkach, 2011). Understanding the type of preferred learning styles enables teachers of different specialities to design course materials so that they can be equally well-learned by all students. Recognising their own methods of study helps students to master the disciplines by developing a strategy of activity in accordance with their preferences, providing a basis for mastering new patterns of behaviour. Research in

this area is vital for determining the conditions for the effective training of students through the use of modern information and communication technologies (ICTs), since understanding students' learning styles allows one to optimise a set of electronic learning resources (e-resources) (Derkach, 2013; 2016).

The purpose of this work is an experimental determination and a comparative analysis of the learning preferences inherent in students of different fields of study.

Methods

Students of two faculties of the Kyiv National University of Technologies and Design (KNUTD), which get trained in four different areas, took part in the survey during 2017-2018 (Table 1).

Table 1

Students of KNUTD which took part in the survey

Faculty	Field of study	Year of study	Number of respondents
Chemical and Biopharmaceutical Technologies	Pharmacy	1-5	174
Chemical and Biopharmaceutical Technologies	Chemistry	3	48
Fashion Industry	Design	4	9
Fashion Industry	Technology	4	11

The research was based on the model of learning styles of R. Felder and B. Soloman (thereinafter Felder-Soloman's model). This model, also known as the Felder-Soloman Index of Learning Styles, was initially designed to determine the learning styles of engineering students, but later became a favourite questionnaire tool in other areas of education. Its reliability and validity were repeatedly discussed and validated (Felder, Spurlin, 2005). The model is available for free use since the late nineties (Felder, Soloman, 1997) and involves interviewing respondents and analysing their answers to 44 questions. The results obtained by the survey allow one to evaluate the available preferences in four dimensions. Each dimension consists of two opposite styles or a pair of a style and anti-style and is scored by an 11-point scale. The advantage of one of two opposite styles is estimated on the base of distribution of 11 points between them.

The dimensions of Felder-Soloman's model and a list of the available styles with their brief description are shown in Table 2.

Table 2

Learning styles and dimensions of Felder-Soloman's model

Dimension	Style name (in short)	Description
Perception of information	Sensitive (sen)	Awareness of information, facts
	Intuitive (int)	Intuition, forming an abstract concept
Sensors for perception	Visual (vis)	Preference to drawings and diagrams
	Verbal (vrb)	Preference to the written or oral explanation
Understanding information	Active (act)	Activity, experimentation
	Reflective (ref)	Reflections, observations
Learning patterns	Sequential (seq)	Step-by-step understanding, convergent thinking and analysis
	Global (glo)	Understanding by jumps, system thinking and synthesis

For each respondent, style preferences in all four dimensions were determined on the base of the survey results. The total and relative numbers of respondents of a particular preferred style were calculated. The relative numbers in percentage were used to describe preferred learning styles in different groups of students.

Results

The results of the study of preferred learning styles among the students of KNUTD major in different fields of training are shown as solid lines on charts in Fig. 1.

The preferred learning styles of students of some world universities obtained from the literature are marked with dashed lines in Fig. 1. A comparison of the experimental results with literature data will be carried out in the next section of the work.

As is seen from Fig. 1, the preferences of future chemists and pharmacists of the KNUTD look similar, they both are characterised by a substantial (more than 80% of respondents) advantage of styles sen and vis and similar in intensity (~80%) advantage of style act. At the same time, in a seq-glo dimension, they demonstrate a more moderate preference to style seq which is at the level of 70%.

Profiles of technology students look a bit more balanced. For any dimension, the dominant style does not exceed 70%. Thus, the prevalence of styles vis and seq is at the level of 70% of respondents, the advantages of styles act over ref and sen over int are about 60% and 55% respectively.

Despite the extraneous dissimilarity of the profiles of technologists and designers, their teaching profiles are mostly similar in three dimensions, namely, sen-int, act-ref and seq-glo. An essential difference is observed only for a vis-vrb aspect: Designers almost wholly prefer the visual learning style, while about a third of future technologists demonstrate a predominant verbal style.

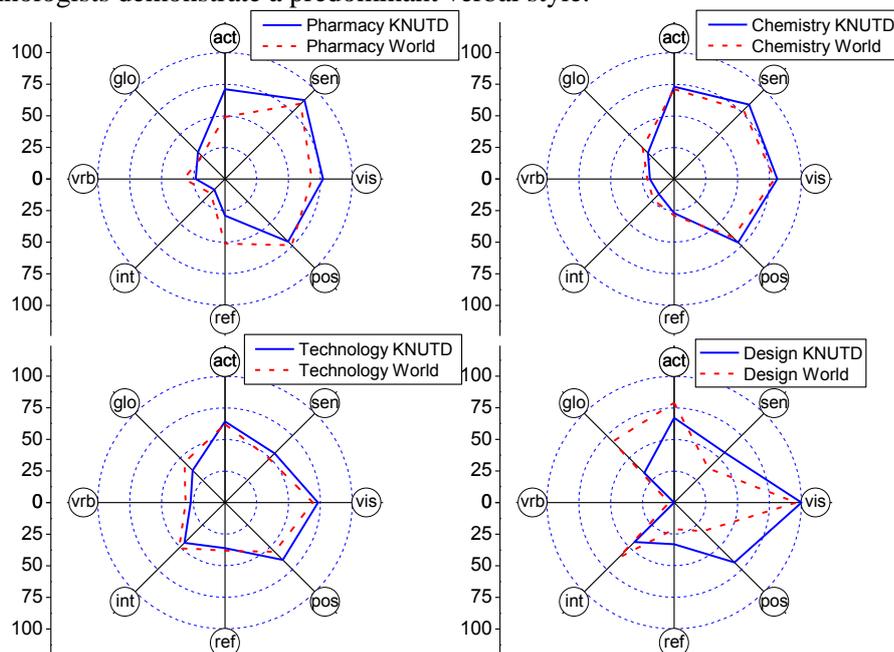


Fig. 1 Preferred learning styles of students of four different fields of study at KNUTD and some world universities

Discussion

The question arises as to whether the invented behaviour patterns are of a universal nature or they are inherent only to students of a particular year of study in a specific university. Information about the preferred learning styles in the areas of training under discussion, which covers 14 universities in 8 countries (Table 3), has been collected from the literature to answer such a question.

Table 3

Characteristics of foreign universities compared to KNUTD

Field of study	Country (Faculty numbers)	Year of study	Number of students	References
Design	Denmark (1)	1	77	Kolmos, Holgaard, 2008
Technology	USA (1), Canada (1), Ireland (1), Brazil (1), Australia (1)	1, 2, 4	1433	Livesay, Dee, Nauman, Hites, Livesay, 2002; Seery, Gaughran, Waldmann, 2003; Kuri, 2004; Rosati, 1996; 1999; Fowler, McGill, Armarego, Allen, 2002
Pharmacy	USA (1), United Kingdom (1)	1-2	299	Laight, 2004; Teevan, Schlesselman, 2011
Chemistry	USA (1), Ukraine (2), Denmark (1), Malaysia (1), Brazil (1)	1-4	1200	Lopes, 2002; Klauk, 2007; Yaroshenko, Derkach, 2012; Derkach, Starova, 2017

As mentioned above, Figure 1 contains both experimental results and literature data. The profiles of KNUTD students major in chemistry almost entirely coincide with the profiles built on the average data of 1200 chemistry students from 5 countries of the world, including 2 Ukrainian universities (Yaroshenko, Derkach, 2012; Derkach, Starova, 2017). Evidently, such a coincidence gives evidence to the typicalness of the revealed learning profiles: future chemists in their majority demonstrate pronounced act, sen, vis and seq styles.

Also, a good coincidence of learning preferences between KNUTD and other world universities is observed for students specialised in technology. They exhibit the most balanced profile of learning preferences: dominant styles have never exceeded 70%, ranging from 51% to 69%.

Comparison of the profiles of students of foreign universities and students of KNUTD in the fields of pharmacy and design reveals a very significant difference between them, although a more careful analysis allows one to explain the nature of such a discrepancy easily.

Pharmacy students at KNUTD are much more active and also moderately more visual than pharmaceutical students from two universities in the US and UK. It is worthy to note that pharmaceutical students at KNUTD are studying in the field of industrial pharmacy, and, therefore, they are future technologists in the field of industrial pharmacy. Foreign students under comparison are studying at medical faculties of universities, and in the future, they will become medical pharmacists. Their training is aimed at work in medical institutions (pharmacies, etc.), and not in manufacturing companies. Thus, in spite of the similarity of the names, curricula, in particular, and educational environment, in general, are quite different for both specialities under comparison that results in the differentiation of student learning profiles.

It can be assumed that the learning profiles of pharmacy students of the above-mentioned foreign universities will be closer to the profiles of medical students. This assumption is consistent with the data of work (Hughes, Fallis, Peel, Murchison, 2009) where the learning preferences of future dentist students from the US and Canada were studied. The most significant discrepancy between KNUTD and foreign pharmaceutical students relates to act-ref and vis-vrb dimensions. For dental students (Hughes, Fallis, Peel, Murchison, 2009), the average preference of style act is equal to 22% compared to 71% and 49% for pharmacy students at KNUTD and foreign universities, respectively. For style vis, the analogous values are 37%, 77% and 68%. Therefore, in both cases, the results of medical pharmacists are expectedly located between the results of future industrial pharmacists and medical students.

A very significant difference also exists between the profiles of design student of the KNUTD and the universities of the world. The domination of style vis over style vrb is typical for both samples, while the students of KNUTD are significantly more consistent, reflective and sensitive. The reason for such a discrepancy is similar to that described for pharmaceutical students. As for pharmacists, given the limited amount of data on universities in other countries, we were forced to compare profiles of similar but, nevertheless, somewhat different specialities. On the one hand, the KNUTD designers study at the Faculty of Fashion Industry and specialise in designing household items, such as clothing, footwear, interior decoration, and so on. On the other hand, international data are available for the students of one university specialised in design and architecture. Thus, these students are specialised primarily in engineering design and architecture in contrast to fashion design typical for KNUTD students.

Knowledge of an individual's learning style is of importance for improving personalised learning, instruction, or educational materials. However, the origin of the revealed differences in learning styles of students in different fields of studies is not entirely clear. Two polar explanations of this phenomenon, each of which has a confirmation in the scientific literature, are as follows.

In some studies, the emphasis is on the fact that the dominant learning styles are relatively stable and weakly variable characteristics of a person, which is formed under the influence of his/her psychological and physiological characteristics (Richardson, 2011; Salter, Evans, Forney, 2006; Gogus, Gunes, 2011).

The opposite view is that the 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, his motivation and educational level, etc. (Bitran, Zuniga, Pedrals, Padilla, Mena, 2012; Mitchell, James, D'Amore, 2015; Gurpinar, Bati, Tetik, 2011). For example, in (Gurpinar, Bati, Tetik, 2011), the variability of learning styles of medical students has been researched during first two years of their study. Depending on the applied pedagogical approaches to teaching, 46 to 56% of students demonstrated the variability of learning profiles, while the rest of the students did not change them.

The current work compares the learning profiles for pharmaceutical students of KNUTD from the 1st to 5th (master) courses inclusively (Fig. 2).

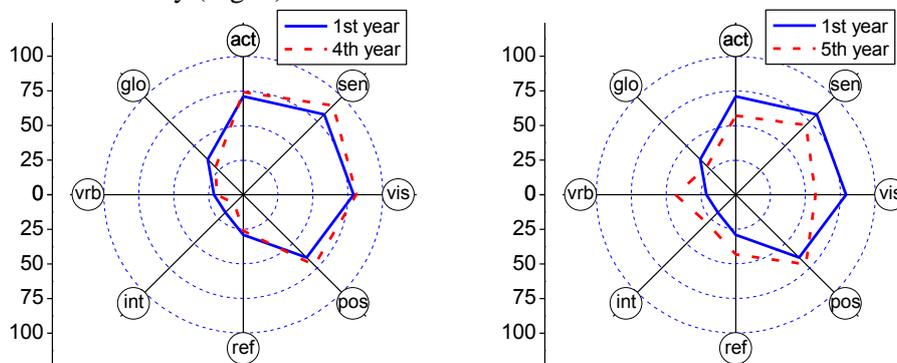


Fig. 2 Preferred learning styles of pharmacy students at KNUTD:
a – 1st and 4th years of study, b – 1st and 5th years of study

The difference in the preferred styles between students of the first and fourth year is minimal, while in going from the first to fifth course, the difference seriously increases in the direction of the growth of reflectivity, verblivity and intuitiveness. In our opinion, the reason for such changes is not so much the natural change of personal styles but is mainly caused by the additional selection of students when they enter the graduate course at the 5th year.

According to data from Fig. 2, a better balance in three of four directions of the learning styles is typical for graduate students. Compared to freshmen, they are more inclined to form abstract concepts (more intuitive), to reflections and observations (more reflective), and also more readily use the verbal channel of information transmission in addition to the visual pathway.

An additional argument in favour of the explanations presented above is the results of comparison of the learning styles of students and faculty members of two technology faculties at two Australian (87 students and 11 lecturers were surveyed in (Fowler, McGill, Armarego, Allen, 2002) and Canadian (858 students and 53 lecturers in (Rosati, 1996; 1999) universities (Fig. 3).

Apparently, among others, a stage of the additional personnel selection passed by former students before achieving professorship distinguishes faculty members and undergraduate students. Such a selection results in the fact that instructors on the average are more reflective and intuitive than their students. It is worthy to note that the direction of changing learning preferences from students to lecturers (Fig. 3) correlates well with changes in the transition from undergraduate to graduate students (Fig. 2).

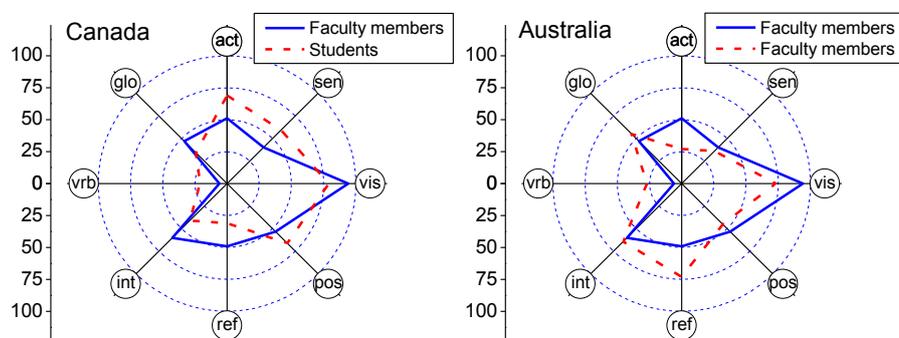


Fig. 3 Preferred learning styles of students and faculty members at Faculties of Technology of two Canadian (Rosati, 1996; 1999) and Australian (Fowler, McGill, Armarego, Allen, 2002) Universities

As is known from previous studies (Derkach, Starova, 2017; Derkach, 2013; 2011), the analysis of learning preferences is a prerequisite for the efficient use of ICTs in education. Therefore, the identified difference in learning preferences must be taken into account when developing educational materials. This statement can be illustrated by the example of teaching basic chemical disciplines to future chemists and pharmacists. As is known, the curricula for these specialities are very similar. However, as seen from Fig. 4, the educational preferences of students vary considerably. Thus, among pharmacists undeniably dominates the sensitive style of learning (more than 90%), while among chemists, almost 20% prefer intuitive style.

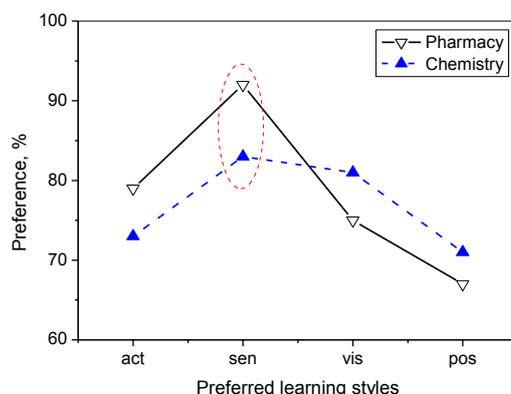


Fig. 4 Preferred learning styles of pharmaceutical and chemistry students (3rd year of study, KNUVD)

Students with sensitive style prefer the courses that are directly related to the real world, studying facts and experimenting. They pay attention readily to the details, work well practically, often solve problems by known methods; they are cautious and do not like surprises and difficulties. Students with intuitive style are innovators, hate tedious work and repetition. It is pleasant for them to work with abstract problems,

formulation of concepts and mathematical dependencies. They do not enjoy courses that contain a lot of material for memorising and routine calculations, are bored studying details and more inventive.

According to the above-described information, the optimal pedagogical approach to the organisation of training, as well as the optimal teaching methods, should be different for students with different preferences (Table 4). Only those e-resources, which are acceptable for this or that learning style, are shown in the generalised form in Table 4. So, students with style *sen* are willing to take part in simulation labs and testing. Intuitive students, on the other hand, do not like testing, and among computer programmes, their preference is given to computer models that illustrate theoretical constructs and do not foresee manual manipulations.

Table 4

Integration of methods and e-resources for sensitive/intuitive dimension

	Sensitive	Intuitive
A pedagogical approach to the organisation of learning	To use teaching material with specific examples of the implementation of theories and their practical application. Solving tasks in a particular order, implementation of procedures-actions. Work in the laboratory	To use teaching material with a guide to the theory and conceptual examination. It is necessary to provide arguments 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.
The difference in attitude to e-resources	It is useful to provide students with resources that allow them to find the facts independently, perform computer simulation of laboratory works and undergo testing	They prefer e-resources which provide communication, computer simulation (3D or quantum mechanics) and do not like to be tested

Conclusions

The preferred learning styles of students of KNUTD of four different educational areas were determined on the base of the results of the survey conducted by the Felder-Soloman's method.

Chemistry and pharmacy students have similar learning profiles that are characterised by intense (70-80%) advantages of styles *act*, *sen*, *vis* and *seq* over styles *ref*, *int*, *vr*b and *glo*, respectively. Learning profiles of future technologists and designers in most cases are better balanced than those of future chemists and pharmacists. The advantage of the above-mentioned styles *act*, *sen*, *vis* and *seq* is held true, but it usually is within the range of 55-70%. The exception and feature of designers' profile is their very high preference for the visual style (more than 95% of respondents) over the verbal style.

The results obtained for pharmacists show the relative stability of learning profiles which have changed little over the years of undergraduate studies. At the same time, the comparison of freshmen with graduate students shows an increase in the number of masters with *ref* and *vr*b preferences. So, student profiles in these dimensions become more balanced in passing from undergraduate to graduate studies. The reasons are discussed with the consideration of data on the learning profiles of students and faculty members of foreign universities and seem to be associated with the availability of additional stages of selection in the career growth process, rather than with the rapid change of acquired learning styles. However, additional research is necessary to address the revealed discrepancies and issues in the field of learning preferences as well as to gain further information required for the implementation of effective teaching methods in a lecture hall.

Examples of optimal chemistry teaching of student groups with different preferences in a sensitivity-intuitiveness direction are illustrated by differences in pedagogical approaches, acceptable learning methods and optimal e-resources that can provide effective learning.

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