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How Can We Teach Our Students if We Do Not Know How they Learn? - Medical students' learning styles and academic performance -

Abstract: *Circumstances arising after the proclamation of the COVID-19 pandemic indicate the need for a permanent change in the access to education in medicine, the use of online tools and flexibility in the application of innovative learning solutions. This study aimed to determine medical students' learning styles and to use this information to improve distance learning platforms in order to promote personalized learning performance.*

A prospective cohort study was conducted among medical students attending the Faculty of Medicine, University of Belgrade, who were enrolled in the obligatory Medical statistics and informatics (MSI) course during 2017–18 school year. The Index of Learning Styles (ILS) questionnaire was used to measure the dimensions of learning styles: Sensing/Intuitive, Visual/Verbal, Active/Reflective, and Sequential/Global. Additional data included demographic information and formal evaluation of student achievements. The existing online teaching approach supported by Moodle LMS was upgraded for upcoming 2020–21 school year to cover all student learning preferences.

Four hundred sixty-two medical students were enrolled. Most students were female (64.5%); average age 21.4±1.1 years. The average problem solving and final statistics scores were 16.8±2.6 and

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82.8±12.4, respectively. The dominant learning styles on the Active/Reflective and Sensing/Intuitive scales were active (74.9%) and sensing (50%). On the Visual/Verbal and Sequential/Global scales main learning preferences were neutral to visual (48.5% and 41.3%, respectively) and neutral to sequential (72.3% and 18.4%, respectively). The strong sensing learning style and age were significant predictors in multivariate regression models, with problem solving and final statistics score as dependent variables. Based on these findings, the existing learning platform has been upgraded to cover all learning preferences and personalize learning for students with learning styles other than sensing.

Students with a strong sensing learning preference have a better academic performance in MSI. Better knowledge and understanding of students learning styles can aid instructors and curriculum designers to adjust teaching methods in order to help students gain their full academic potential during COVID-19 pandemic.

Keywords: learning styles, medical students, academic performance.

Background

Learning styles refer to the notion that people learn in various ways. The capability to learn is one's natural or instinctive ability to achieve and process information (Young, 2010). Students learn in different ways – by hearing and seeing; acting and reflecting; interpreting intuitively and logically (Felder, 1988). There are also various methods of teaching. Some educators lecture, others discuss or demonstrate; some prefer applications rather than principles; some value memorizing over understanding (Ibid). Student's native ability, compatibility of learning style and prior preparation, as well as educator's teaching style dictates how much student will learn in a class (İlçin et al., 2018).

The concept of learning styles has steadily broadened its influence in recent decades (Manojlovic, 2023; Young, 2010; Arthurs, 2007; Coffield et al., 2004). Learning style is defined as a developmentally and biologically established set of features that make the same teaching method excellent for some and unpleasant for others (Dunn et al., 1989). Strong thought is currently aimed at course designers and teachers to pay closer attention at students' learning capabilities and styles – designing learning and teaching methods based on students' ambitions and habits (Coffield et al., 2004).

The need for a more personalized education in the field of medicine has been clearly recognized (DeLuca et al., 2016). Circumstances arising after the proclamation of the COVID-19 pandemic indicate the need for a permanent change in access to education in medicine, the use of online tools and flexibility in the application of innovative information and communication solutions, both to improve the quality of education in normal and emergency condition (Sklar, 2020; Arsenijević, Andevski 2022). Implementing adequate innovations in the way of conducting medical education in the online environment should contribute to reaching the standard of collective knowledge of physicians, necessary to improve the health of individuals and the population as a whole, in the usual mode of work, but especially in emergencies such as the COVID-19 pandemic (Ibid). During the last years, the Department for Medical Statistics and Informatics has been involved in efforts aimed at implementing different learning environments at the Medical Faculty of the University of Belgrade, in order to encourage students to be more involved and left with a choice how to learn, and more importantly, to benefit the most from their learning process (Milic, Masic et al., 2016; Milic, Trajkovic et al., 2016; Milic et al., 2018). This reform was triggered by a growing amount of evidence that insufficient knowledge about statistics is contributing to the presence of erroneous conclu-

sions in published medical literature (Weissgerber et al., 2015; Weissgerber et al., 2016; Weissgerber et al., 2019). In this study we aimed to determine the learning styles among medical students and analyze the association between students' learning styles and their academic performance in medical statistics and informatics. This served as a ground for improving medical statistics and informatics distance learning platform in order to promote the personalized learning performance of students attending medical faculties during COVID-19 pandemic.

Methodology

Study design

A prospective cohort study was conducted among the third-year medical students attending the Faculty of Medicine, University of Belgrade, who were enrolled in the obligatory introductory Medical statistics and informatics course during 2017–18 school year. Briefly, the introductory medical statistics course included, in total, ten lectures, twenty practicals and eight seminars, that covered research methodology and statistical analysis, including data types, descriptive statistics, data distribution, sample size determination, confidence intervals estimation and hypothesis testing, with various statistical software use. Two methods of education were offered: blended and on-site. At the beginning of the school year, students were given the option of choosing the preferred learning method. Course materials and learning objectives were identical for both formats of the course and were taught by the same instructors. The blended teaching approach was supported by the multimedia didactic materials via online Moodle teaching platform, which was in use from 2013/14 school year. More details regarding the content of the course, learning objectives and course materials can be seen in a previous study (Milic, Trajkovic et al., 2016). The formal evaluation of student achievement was identical for both learning modalities and consisted of:

course activities throughout the year and the final exam, which consisted of a written knowledge test and problem-based solving part.

The Index of Learning Styles

To provide further evidence for a continuous improvement of the effectiveness of the Moodle learning platform for Medical statistics classes The Index of Learning Styles (ILS) questionnaire was administered to students. The Index of Learning Styles (ILS) questionnaire was used for the assessment of students learning styles. ILS is a self-scoring instrument that assesses preferences on the four dimensions: Active/Reflective, Sensing/Intuiting, Visual/Verbal, and Sequential/Global (Felder, 1996; Felder and Spurlin, 2005). The first dimension differentiates between an active and a reflective way of processing information. The second dimension defines sensing versus intuitive learning. The third one distinguishes those who learn best from what they have seen, in contrast to learners who remember words (written or spoken). The fourth dimension characterizes learners according to their sequential or global understanding of problems. Each student has an individual preference for each of these dimensions. A questionnaire was originally designed by Felder and Silverman (Felder, 1988) and consists of 44 questions. Preference for each dimension is expressed with values from + 11 to -11, with steps +/- 2. This range comes from the 11 questions that are asked for each dimension. Each question is valued + 1 (when corresponding to the preference for the first pole of each dimension: active, sensing, visual, or sequential) or - 1 (when corresponding to the second pole of each dimension: reflective, intuitive, verbal, or global) (Graf et al., 2007).

Study sample and additional data

Four hundred sixty-two medical students were enrolled. Most students were female (64.5%), and the average age was 21.4 ± 1.1 years (ranged from 19-32) (Table 1). Additional data included the for-

mal evaluation of student achievements. The formal (objective) evaluation of student achievement in medical statistics and informatics was measured by the final score which integrated: course activities throughout the semester (weighted 0.3); a knowledge test (weighted 0.35) and solving problems part, which included four problem-based components (weighted 0.35). The final score ranged from 0 to 100, and was defined as the primary endpoint. As an approximate for student achievement in medical students the GPA was used. The average solving problems and final statistics scores were 16.8 ± 2.6 and 82.8 ± 12.4 , respectively. The current GPA was 8.4 ± 0.9 (Table 1).

Table 1. Demographic characteristics and formal evaluation of the surveyed medical students

Medical students characteristics	n=462
Gender, n (%)	
Male	164 (35.5)
Female	298 (64.5)
Age, mean \pm sd	21.4 ± 1.1
Solving problems, mean \pm sd (0-20)	16.8 ± 2.6
Knowledge test, mean \pm sd (0-50)	41.4 ± 5.4
The final grade, mean \pm sd (0-100)	82.8 ± 12.4
Cumulative GPA, mean \pm sd (6-10)	8.4 ± 0.9

At the beginning of the COVID-19 epidemic in Serbia, in March 2020, all students were redirected to the online courses. The results from learning styles assessment from 2017–18 school year were used to upgrade the existing Moodle learning platform, to cover all learning preferences and provide more personalized learning in Medical statistics and informatics.

Participation was voluntary. Ethical approval was obtained from the Institutional Review Board (IRB) of the Faculty of Medicine, University of Belgrade. As there was no potential harm to the study participants, the IRB approved the use of the oral consent, which was documented in students' records at the beginning of the course.

Statistical analysis

The descriptive statistics, including mean and standard deviation for numerical data, and absolute numbers with percentages for categorical variables, were used to characterize the study population. Linear regression models were used to assess predictors, such as age, gender, learning style and learning delivery method, for solving problem, final statistics score and GPA (as dependent variables). Variables significant in the univariate regression model entered the multivariate model. In all analyses, the significance level was set at 0.05. Statistical analysis was performed using IBM SPSS statistical software (SPSS for Windows, release 25.0, SPSS, Chicago, IL).

Results

According to the Activist-Reflector scale, 74.9% medical students are active learners, which means that they tend to retain and understand information best by being active. Only 1.3% of medical students are reflectors, who prefer to think about things quietly first. The Sensing-Intuitive scale shows that a half of the respondents (50%) are sensing learners. Sensing involves observing, gathering data through the senses. On the Visual/Verbal and Sequential/Global scales the main learning preferences were neutral to visual (48.5% and 41.3%, respectively) and neutral to sequential (72.3% and 18.4%, respectively). The learning preferences of medical students included in this study are presented in Figure 1.

Strong sensing learning style and age were significant independent predictors in multivariate regression models, with solving problem, final statistics score, and GPA as dependent variables. Younger students and students with a strong sensing learning style had better results in solving problems, a higher statistic score and better cumulative GPA (Table 2). Learning delivery method was a significant independent predictor for GPA, indicating that the students who attended the blended learning course had a higher GPA (Table 2).

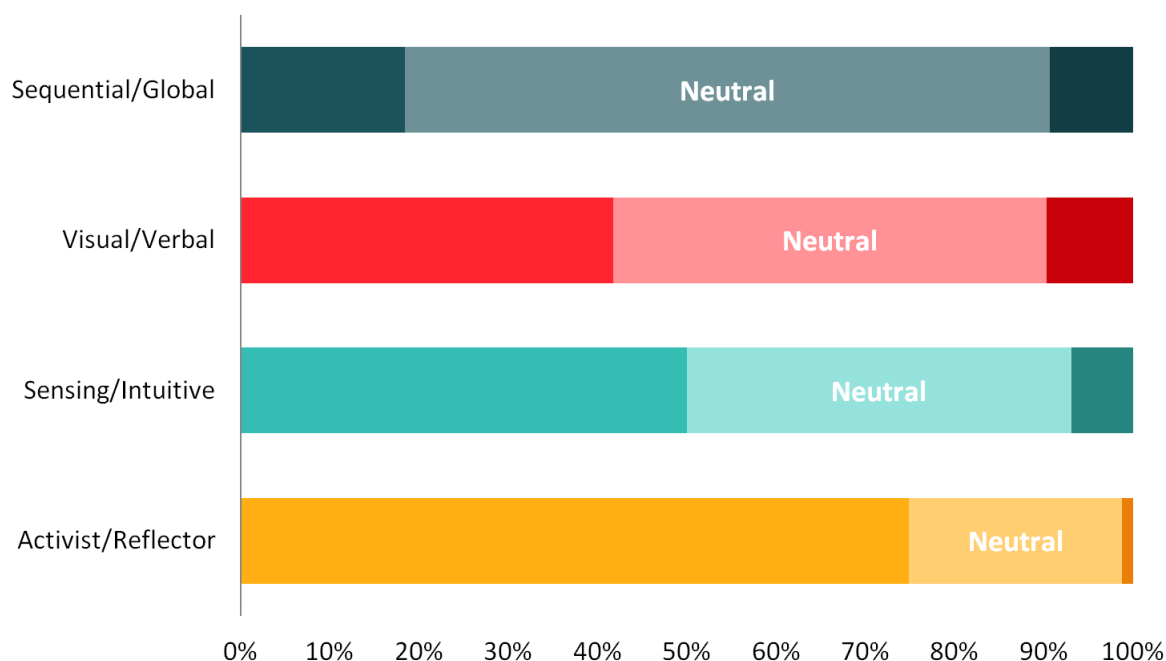


Figure 1. Learning style preferences of third year medical students. Each bar represents the percentage of the cohort's preference for each dimension

Table 2. Linear regression model with solving problems, grade and cumulative GPA as dependent variable

Variables	Solving problems			Grade			Cumulative GPA		
	B	SE	p	B	SE	p	B	SE	p
Gender	-0.287	0.258	0.266	-0.762	1.138	0.504	-0.026	0.084	0.756
Sensing learning scale	0.729	0.356	0.041	3.452	1.588	0.028	0.271	0.116	0.020
Age	-0.638	0.131	<0.001	-4.083	0.505	<0.001	-0.305	0.037	<0.001
Blended delivery method	0.283	0.264	0.285	1.959	1.169	0.094	0.224	0.086	0.010
Global learning scale	-0.376	0.790	0.635	-1.125	3.566	0.752	-0.355	0.260	0.173

Learning delivery method was a significant independent predictor for GPA, indicating that students who attended the blended learning course had higher GPA (Table 2). Based on the findings that all the respective learning style dimensions are present

among medical students, the existing learning platform has been upgraded to cover all learning preferences and personalize learning for students with learning styles other than sensing (Fig 2).

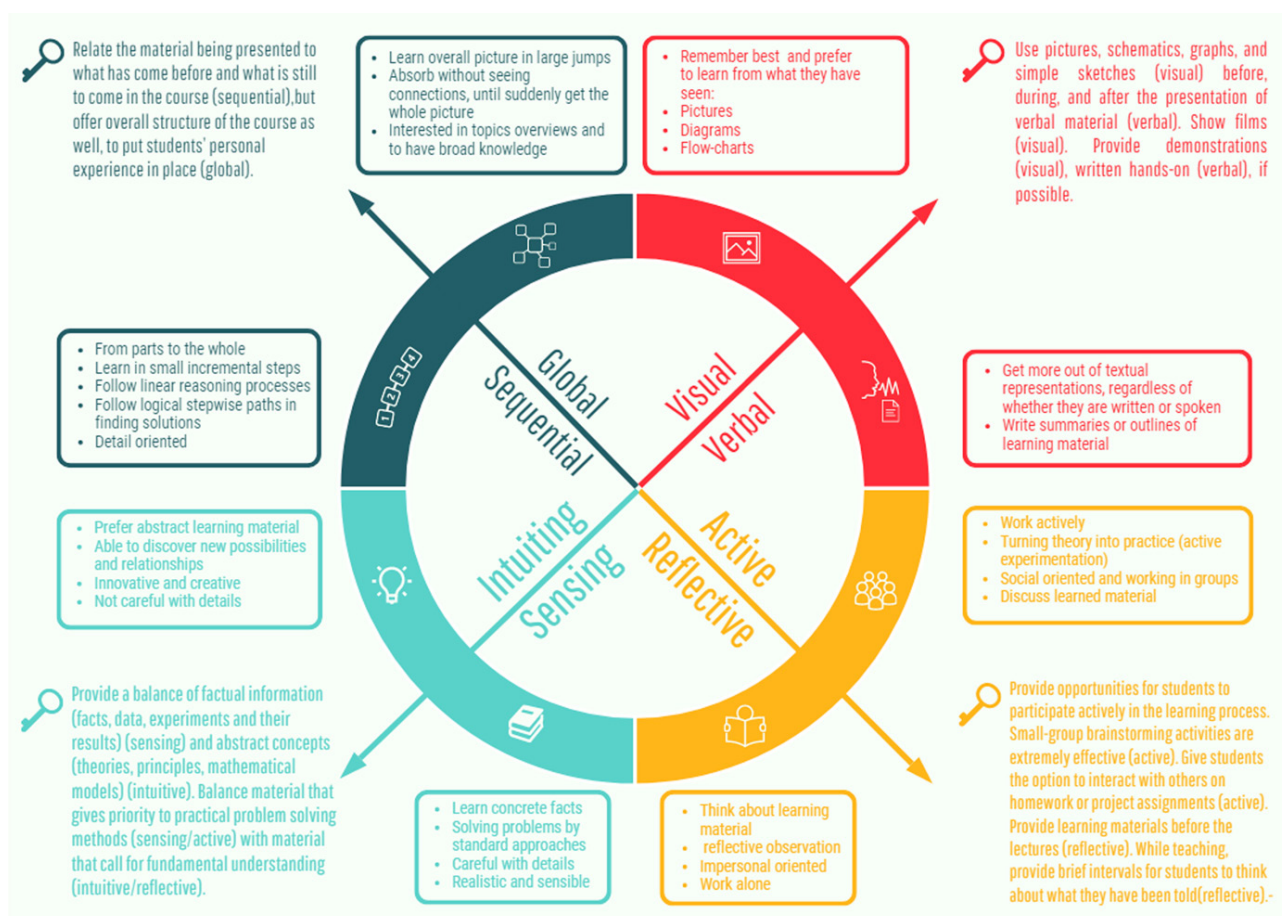


Figure 2. Short overview of learning styles and recommended techniques to facilitate teaching in terms of learning styles

Discussion

In this study, conducted among the medical students at the Medical Faculty of the University of Belgrade, the strong sensing learning style was associated with the better medical statistics and informatics performance. The study revealed the presence of all the respective learning style dimensions among the medical students. The dominant learning styles were active, sensing, neutral to visual, and neutral to sequential.

Similar results were presented by Quinn et al. (Quinn et al., 2018), showing that the anatomy students at The Ohio State University had the same learning preferences. Furthermore, students in other academic fields, such as health sciences (Brown et al., 2009) or mechanical engineering (Kuri et al., 2002), showed results corresponding to ours. In a cross-sectional study examining the learning style preferences of the first-year medical students conducted in Kazakhstan (Hernández-Torrano et al., 2017), the results were similar to ours. Their analy-

sis detected a balanced number of students preferring sensing (54.9%) and intuitive learning (45.1%), while in our study sensing learners accounted for one half of the respondents (50.0%). Regarding the active-reflective preference, in our study more students were activists (74.9%) as compared to the analysis in Kazakhstan, where a small difference in reflective (49.1%) versus active (50.9%) learning styles was found. In the same study, the sequential learning style was more represented in contrast to global, whereas in our study, most of the respondents had neutral preference. Contrary to our results, difference in the preference of the students in visual compared to verbal learning style, was found (Ibid).

Based on our study results, the sensing learning style was the most important preference for gaining competences in medical statistics and informatics. According to Felder (Felder, 1996), a tendency to be patient with details and good at memorizing are the characteristics of the sensors. They tend to learn facts and solve problems by well-established methods (Ibid). This is supported by the same findings in our group, where students with a strong sensing type showed better overall GPA. In the regression model with solving problems, final statistics score and cumulative GPA as dependent variables, significant independent predictors were sensing learning style and age. The association of ability to solve problems in medical statistics and informatics with sensing learning style over intuitive is not unexpected because sensors are prone to remembering a variety of specific facts as well as being able to put them into practice. A study by Dobson (Dobson, 2010) previously showed an association between a learning style and academic achievement, where significant relation between course scores and sensor learning preference was found. Our study results support these findings. On the other hand, some studies have shown that learning styles do not affect academic achievement (Tariq et al., 2016; Alghasham, 2012). Regarding age as a significant predictor, the key findings of a study in Iran (Mohammadi et al., 2015) conducted among medi-

cal students was that learning style is age-dependent, which corresponds to our study results as well.

The key question arises as to how to improve learning and/or learning conditions for the remaining students whose dominant type of learning is not sensitive? How can we reach their maximum potential and the highest possible academic achievement? An adapted and systematic approach is unavoidable, so its inclusion in the education system is an important step forward in assessing effectiveness of the learning environment. Currently, special attention is paid to teaching within the online environment, which contributes to the improvement of the traditional way of education, but becomes indispensable in conditions of emergency in cases of epidemics, pandemics and natural disasters. Such situations bring new challenges, but also unique opportunities for the introduction of technological innovations in teaching for medical students (Rose, 2020). At the time of an epidemic-induced state of emergency, a restriction in physical contact between a teacher, a student, and a patient is introduced. The COVID-19 pandemic posed enormous challenges to health system around the world, with equally severe consequences for the implementation of the health care, but also for the education of physicians (Alvin et al., 2020). Epidemics leave unexpected consequences on the education system, including the suspension of classes, exams and may lead to the closure of medical schools (Miller et al., 2020). Also, these situations could lead to permanent changes in the way physicians are educated (Rose, 2020). For these reasons, medical schools have begun to adapt to the working conditions in the pandemic, strengthening their capacity for consultation, teaching and examinations in digital environments, which have been developing rapidly in recent years (O'Doherty et al., 2018).

Incorporating learning styles in teaching plans may enhance the learning process at medical faculties and lead to the better student achievement in medical statistics and informatics. In this study,

we have focused on The Index of Learning Styles (ILS) (Felder, 1988), that is often used in technology-enhanced learning. Most other (Kolb, 1984; Mumford and Honey, 1992) learning style models classify learners into a few groups, whereas ILS describes the learning styles in more detail, distinguishing between preferences on different learning dimensions. Another main advantage of ILS is that it is based on tendencies, implicating that students with a high preference for certain behavior can also perform sometimes differently. Most authors suggested ILS as the most appropriate tool for the assessment of learning style preferences with respect to the application in e-learning and web-based learning systems (Carver et al., 1999; Kuljis and Liu, 2005).

Such detailed information about students' learning styles is beneficial in many ways. In today's environment of the heightened focus on student diversity, better educators and institutional accountability, a considerable attention to learning preferences may be in order (Lawson, 2011). Determining the learning styles for each person itself is beneficial, since the students are more able to perceive and broaden their academic potentials (Liew et al., 2015). There is a strong impending appeal that different learning environments should be implement-

ed to address all types of learning styles. In Figure 2 we offer detailed information about learning styles, as well as short guidelines for curriculum designers and faculty members on how to adapt teaching strategies in these most challenging times for medical education. The learning material structured to address different learning styles preferences would result in achieving better student academic performance in medical statistics and informatics.

Conclusion

Students with a strong sensing learning preference have better performance in medical statistics and informatics in existing learning platform. Based on the distribution of different learning styles, the existing platform has been upgraded with the aim of including all learning preferences and personalizing curriculum for students with learning styles other than sensing, in order to maximize all students' medical statistics and informatics performance. We postulate that better knowledge and understanding of students' learning styles can aid instructors and curriculum designers to adjust the lessons and teaching methods in order to help students gain their full academic potential.

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КАКО ДА НАУЧИМО НАШЕ СТУДЕНТЕ АКО НЕ ЗНАМО КАКО ОНИ УЧЕ?

– Стилови учења студената медицине и академски успех –

Резиме: Стилови учења односе се на идеју да људи уче на различите начине. Способност учења је природна или инстинктивна способност усвајања и обраде информација. Ученици уче на различите начине – слушањем и читањем; подражавањем и рефлексijом; тумачећи информације интуитивно и логично. Колико ће ученик научити на часу зависи и од усавлашености стила учења са начином рада наставника, односно од прилагодености наставних метода и средстава стила учења доминантним код ученика.

Концепти стилова учења конципирано је ширио свој утицај последњих деценија. Stil учења се дефинише као развојно и диолошки утврђен стилова особина које стилова наставни метод за једне чине одличним, а за друге непријатним. Данас је изражено схватање да наставници треба да обратe посебну пажњу на склоности ученика како би методе подучавања свеобухватно подржале стилове учења.

У области медицине јасно је препознатљива тенденција за индивидуализацијом образовања. Увођење иновативних начина образовања студената медицине у онлајн-окружење требало би да допринесе усвајању стандарда колективне знања лекара, неопходној за унапређење здравља појединаца и становништва у целини, у уобичајеном начину рада, а посебно у ванредним околностима као што је пандемија вируса корона. Последњих година Катедра за медицинску статистику и информатику је иницирала имплементацију различитих окружења за учење на Медицинском факултету Универзитета у Београду како би се студентима омогућио избор у начину учења и подстигло ефикасније усвајање знања. Ову реформу покренула је све јача свест да недовољно познавање статистике допринеси бољем закључивању у медицинској литератури. У овом истраживању циљ је био да се утврде доминантни стилови учења међу студентима медицине и анализира повезаност стилова учења и студентског академског учинка на предмету Медицинска статистика и информатика. Ово истраживање је зајим послужило као основа за унапређење платформе за учење на даљину медицинске статистике ради унапређења академског учинка студената који похађају медицинске факултете.

Проспективна кохортна студија спроведена је међу студентима Медицинског факултета Универзитета у Београду, који су уписани на обавезни предмет Медицинска статистика и информатика током школске 2017/18. Утицај Индекс стилова учења

коришћен је за мерење димензија стилова учења: сензорно/интуитивно, визуелно/вербално, активно/рефлексивно и секвенцијално/глобално. Додатни подаци су укључивали демографске податке и формалну евалуацију ученичких постигнућа. Постојећи истраживачки подаци подржан од стране Мудр платформе за учење на даљину је надограђен за школску 2020/2021. годину како би открио све начине учења студената.

Истраживањем су обухваћена 462 студента медицине. Највише испитаника је било женског пола (64,5%), док је њихова просечна старост $21,4 \pm 1,1$ година. Просечни резултати решавања проблема и коначне оцене на предмету били су $16,8 \pm 2,6$ и $82,8 \pm 12,4$. Доминантни стилови учења на скалама активно/рефлексивно и осећајно/интуитивно били су активни (74,9%) и сензорни (50%). На визуелним/вербалним скалама и секвенцијалним/глобалним скалама главне особности учења биле су неутралне према визуелном (48,5% према 41,3%) и неутралне према секвенцијалним (72,3% према 18,4%). Сензорни стил учења и старост били су значајни предиктори у мултиваријантним регресионим моделима, са решавањем проблема и коначном оценом на предмету као зависним варијаблама. На основу ових налаза постојећа платформа за учење је надограђена да открије све особности учења и да персонализује учење за студенте са стиловима учења који нису сензорни.

Студенти са јаким склоностима према сензорном стилу учења имају боље академске резултате на предмету медицинска статистика и информатика. Боље познавање и разумевање стилова учења може помоћи наставницима и сарадницима у осмишљавању наставног плана и програма и прилагоджавању наставних метода који би помогли студентима да остваре свој потенцијал.

Кључне речи: стилови учења, студенти медицине, академски успех