

**GOCE DELCEV UNIVERSITY, STIP, NORTH MACEDONIA
FACULTY OF ELECTRICAL ENGINEERING**

ETIMA 2025
THIRD INTERNATIONAL CONFERENCE
24-25 SEPTEMBER, 2025



**TECHNICAL SCIENCES APPLIED IN ECONOMY,
EDUCATION AND INDUSTRY**



УНИВЕРЗИТЕТ
ГОЦЕ ДЕЛЧЕВ
ЕЛЕКТРОТЕХНИЧКИ
ФАКУЛТЕТ



УНИВЕРЗИТЕТ „ГОЦЕ ДЕЛЧЕВ“, ШТИП
ЕЛЕКТРОТЕХНИЧКИ ФАКУЛТЕТ

GOCE DELCEV UNIVERSITY, STIP
FACULTY OF ELECTRICAL ENGINEERING

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Трета меѓународна конференција ЕТИМА Third International Conference ETIMA

PREFACE

The Third International Conference “Electrical Engineering, Technology, Informatics, Mechanical Engineering and Automation – Technical Sciences in the Service of the Economy, Education and Industry” (ETIMA’25), organized by the Faculty of Electrical Engineering at the “Goce Delchev” University – Shtip, represents a significant scientific event that enables interdisciplinary exchange of knowledge and experience among researchers, professors, and experts in the field of technical sciences. The conference was held in an online format and brought together 78 authors from five different countries.

The ETIMA conference aims to establish a forum for scientific communication, encouraging multidisciplinary collaboration and promoting technological innovations with direct impact on modern life. Through the presentation of scientific papers, participants shared the results of their research and development activities, contributing to the advancement of knowledge and practice in relevant fields. The first ETIMA conference was organized four years ago, featuring 40 scientific papers. The second conference took place in 2023 and included over 30 papers. ETIMA’25 continued this scientific tradition, presenting more than 40 papers that reflect the latest achievements in electrical engineering, technology, informatics, mechanical engineering, and automation.

At ETIMA’25, papers were presented that addressed current topics in technical sciences, with particular emphasis on their application in industry, education, and the economy. The conference facilitated fruitful discussions among participants, encouraging new ideas and initiatives for future research and projects.

ETIMA’25 reaffirmed its role as an important platform for scientific exchange and international cooperation. The organizing committee extends sincere gratitude to all participants for their contribution to the successful realization of the conference and its scientific value.

We extend our sincerest gratitude to all colleagues who, through the presentation of their papers, ideas, and active engagement in discussions, contributed to the success and scientific significance of ETIMA’25.

The Organizing Committee of the Conference

ПРЕДГОВОР

Третата меѓународна конференција „Електротехника, Технологија, Информатика, Машинство и Автоматика – технички науки во служба на економијата, образованието и индустријата“ (ЕТИМА’25), организирана од Електротехничкиот факултет при Универзитетот „Гоце Делчев“ – Штип, претставува значаен научен настан кој овозможува интердисциплинарна размена на знаења и искуства меѓу истражувачи, професори и експерти од техничките науки. Конференцијата се одржа во онлајн формат и обедини 78 автори од пет различни земји.

Конференцијата ЕТИМА има за цел да создаде форум за научна комуникација, поттикнувајќи мултидисциплинарна соработка и промовирајќи технолошки иновации со директно влијание врз современото живеење. Преку презентација на научни трудови, учесниците ги споделуваат резултатите од своите истражувања и развојни активности, придонесувајќи кон унапредување на знаењето и практиката во релевантните области.

Првата конференција ЕТИМА беше организирана пред четири години, при што беа презентирани 40 научни трудови. Втората конференција се одржа во 2023 година и вклучи над 30 трудови. ЕТИМА’25 продолжи со истата научна традиција, презентирајќи повеќе од 40 трудови кои ги отсликуваат најновите достигнувања во областа на електротехниката, технологијата, информатиката, машинството и автоматиката.

На ЕТИМА’25 беа презентирани трудови кои обработуваат актуелни теми од техничките науки, со посебен акцент на нивната примена во индустријата, образованието и економијата. Конференцијата овозможи плодна дискусија меѓу учесниците, поттикнувајќи нови идеи и иницијативи за идни истражувања и проекти.

ЕТИМА’25 ја потврди својата улога како значајна платформа за научна размена и интернационална соработка. Организациониот одбор упатува искрена благодарност до сите учесници за нивниот придонес кон успешната реализација на конференцијата и нејзината научна вредност. Конференцијата се одржа онлајн и обедини седумдесет и осум автори од пет различни земји.

Изразуваме голема благодарност до сите колеги кои со презентирање на своите трудови, идеи и активна вклученост во дискусиите придонесоа за успехот на ЕТИМА’25 и нејзината научна вредност.

Организационен одбор на конференцијата

СОДРЖИНА / TABLE OF CONTENTS:

СОВРЕМЕНО РАНОГРАДИНАРСКО ПРОИЗВОДСТВО СО ПРИМЕНА НА ОБНОВЛИВИ ЕНЕРГЕТСКИ ИЗВОРИ И ТЕХНОЛОГИИ.....	15
ШИРОКОПОЈАСЕН ПРЕНОС НА ПОДАТОЦИ ПРЕКУ ЕЛЕКТРОЕНЕРГЕТСКАТА МРЕЖА	25
TRANSIENT PHENOMENA IN BLACK START	32
OPTIMIZATION OF SURPLUS ELECTRICITY MANAGEMENT FROM MUNICIPAL PHOTOVOLTAIC SYSTEMS: VIRTUAL STORAGE VS BATTERY SYSTEMS.....	43
IMPACT OF LIGHT POLLUTION ON ENERGY EFFICIENCY	53
ПЕРСПЕКТИВИ, ПРЕДИЗВИЦИ И ИНОВАЦИИ ВО ПЕРОВСКИТНИТЕ СОЛАРНИ КЕЛИИ	61
ПРИМЕНА НА НАНОМАТЕРИЈАЛИ КАЈ ФОТОВОЛТАИЧНИ КЕЛИИ ЗА ЗГОЛЕМУВАЊЕ НА НИВНАТА ЕФИКАСНОСТ ПРЕКУ НАМАЛУВАЊЕ НА РАБОТНАТА ТЕМПЕРАТУРА	68
LONG-TERM POWER PURCHASE AGREEMENT FOR PHOTOVOLTAIC ENERGY AS A SOLUTION FOR ENHANCING THE PROFITABILITY OF THE TASHMARUNISHTA PUMPED-STORAGE HYDRO POWER PLANT	75
СПОРЕДБЕНА АНАЛИЗА НА ПОТРОШУВАЧКА, ЕНЕРГЕТСКА ЕФИКАСНОСТ И ТРОШОЦИ КАЈ ВОЗИЛА СО РАЗЛИЧЕН ТИП НА ПОГОН	87
АВТОМАТСКИ СИСТЕМ ЗА НАВОДНУВАЊЕ УПРАВУВАН ОД ARDUINO МИКРОКОНТРОЛЕР	95
ПРИМЕНА НА WAMS И WACS СИСТЕМИ ВО SMART GRID	103
IoT-BASED ENVIRONMENTAL CONTROL IN 3D PRINTER ENCLOSURES FOR OPTIMAL PRINTING CONDITIONS.....	112
BENEFITS OF STUDYING 8086 MICROPROCESSOR FOR UNDERSTANDING CONTEMPORARY MICROPROCESSOR.....	123
ПРАКТИЧНА СИМУЛАЦИЈА НА SCADA СИСТЕМ ЗА СЛЕДЕЊЕ И РЕГУЛАЦИЈА НА НИВО НА ТЕЧНОСТ ВО РЕЗЕРВОАР	130
ADVANCEMENTS IN INDUSTRIAL DIGITAL SENSORS (VERSION 3.0 TO 4.0) AND RADAR SYSTEMS FOR OBJECT DETECTION: A STATE-OF-THE-ART REVIEW.	140
CHALLENGES AND SOLUTIONS FOR ENHANCING DRONE-TO-TOC COMMUNICATION PERFORMANCE IN MILITARY AND CRISIS OPERATIONS..	148
BRIDGING TELECOM AND AVIATION: ENABLING SCALABLE BVLOS DRONE OPERATIONS THROUGH AIRSPACE DIGITIZATION.....	157
MEASURES AND RECOMMENDATIONS FOR EFFICIENCY IMPROVEMENT OF ELECTRICAL MOTORS	167
USE OF MACHINE LEARNING FOR CURRENT DENSITY DISTRIBUTION ESTIMATION OF REBCO COATED CONDUCTORS	180
APPLICATION OF ARTIFICIAL INTELLIGENCE IN DENTAL MEDICINE	186
ИНТЕГРАЦИЈА НА ДИГИТАЛНИОТ СПЕКТРОФОТОМЕТАР ВО ДЕНТАЛНАТА МЕДИЦИНА – НОВИ МОЖНОСТИ ЗА ТОЧНОСТ И КВАЛИТЕТ	194

CORRELATION OF DENTAL MEDICINE STUDENTS' PERFORMANCE IN PRECLINICAL AND CLINICAL COURSES	205
INTRAORAL ELECTROSTIMULATOR FOR RADIATION INDUCED XEROSTOMIA IN PATIENTS WITH HEAD AND NECK CANCER.....	214
ELECTROMAGNETIC INTERFERENCE OF ENDODONTIC EQUIPMENT WITH GASTRIC PACEMAKER	221
DENTAL IMPLANTS ANALYSIS WITH SEM MICROSCOPE	226
ПРЕДНОСТИ И НЕДОСТАТОЦИ ПРИ УПОТРЕБА НА ЛАСЕР ВО РЕСТАВРАТИВНАТА СТОМАТОЛОГИЈА И ЕНДОДОНЦИЈА.....	231
LASERS AND THEIR APPLICATION IN PEDIATRIC DENTISTRY	238
INCREASE OF ENVIRONMENTALLY RESPONSIBLE BEHAVIOUR THROUGH EDUCATION AND TECHNOLOGICAL INNOVATION.....	242
A DATA-DRIVEN APPROACH TO REAL ESTATE PRICE ESTIMATION: THE CASE STUDY SLOVAKIA.....	249
ANALYSIS OF THE BACKWARD IMPACTS OF A PHOTOVOLTAIC POWER PLANT ON THE DISTRIBUTION SYSTEM	261
VARIANT SOLUTIONS FOR A PARKING LOT COVERED WITH PHOTOVOLTAIC PANELS.....	268
COMPARISON OF ENERGY STATUS IN PORTUGAL AND IN SLOVAKIA	279
DESIGN, ANALYSIS AND IMPLEMENTATION OF PHOTOVOLTAIC SYSTEMS ...	286
BATTERY STORAGE IN TRACTION POWER SUPPLY	297
THE ROLE OF CYBERSECURITY AWARENESS TRAINING TO PREVENT PHISHING.....	304
A REVIEW OF RESOURCE OPTIMIZATION TECHNIQUES IN INTRUSION DETECTION SYSTEMS	311
APPLICATION OF A ROBOTIC ARM IN A SIMPLE PICK-AND-DROP OPERATION	321
SIMULATION-BASED PERFORMANCE ANALYSIS OF A SECURE UAV-TO-TOC COMMUNICATION FRAMEWORK IN MILITARY AND EMERGENCY OPERATIONS	328
DIGITALIZATION OF BPM USING THE CAMUNDA SOFTWARE TOOL ON THE EXAMPLE OF THE CENTRAL BANK OF MONTENEGRO	339
DESIGNING A SECURE COMMUNICATION FRAMEWORK FOR UAV-TO-TOC OPERATIONS IN MILITARY AND EMERGENCY ENVIRONMENTS.....	349



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CORRELATION OF DENTAL MEDICINE STUDENTS' PERFORMANCE IN PRECLINICAL AND CLINICAL COURSES

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Abstract

The main aim of this study was to investigate the correlations of final grades among dental students across three academic courses, examining both their pre-clinical and clinical performances, and to determine the relationships between their achievements in pre-clinical practical courses and clinical courses. The final preclinical and clinical grades for 34 graduates from the Faculty of Medical Sciences at Goce Delcev University in Stip, North Macedonia, who studied dental medicine between 2020 and 2022 (appropriate generations), were retrieved. The study examined three courses: one preclinical course, Preclinical Periodontology, and two clinical courses, Periodontology 1 and Periodontology 2. Final grades for these courses were sourced from the students' information system (e-index) and evaluated anonymously. Correlation analysis methods were applied to discover the relationship between two variables/datasets, as well as the strength of that relationship. The data analysis indicates a positive relationship between the grades of students in preclinical courses and their final grades in clinical courses. In particular, it has been found that students with higher final grades in preclinical courses often achieve higher final grades in clinical courses as well. However, it is important to note that many students experience discrepancies in their final grades between the two clinical courses. Our research suggests a potential positive correlation between preclinical and clinical performance, indicating that clinical outcomes may be forecasted based on preclinical final grades. Additionally, students who demonstrate proficiency in the necessary clinical procedures during the ninth semester tend to maintain that proficiency in the tenth semester. However, it is important to acknowledge that the specific factors influencing this relationship were not explored in this study and warrant further investigation.

Key words

preclinical courses, clinical courses, final grades, Students' performance

Introduction

The duration of the dental medicine study program at our university is five years, organized into a total of 10 semesters of learning. The curriculum and study program are defined in line with the standards and principles of the Bologna Declaration, which provides a framework for the integration of our educational system into the European Union. The courses available and the teaching approaches are completely aligned with the practical needs and the educational framework of universities, thus guaranteeing the highest quality in the educational process. The program and plan of the integrated studies from first and second cycles for dental medicine at the faculty of medical sciences at Goce Delcev University, are structured to correspond with the abilities of students in mastering knowledge, aided by modern technical and technological innovations in this area. As a result, students reach an elevated level of proficiency in the dental field.

Recognizing that only highly educated individuals can contribute to the ongoing development of dentistry, the improvement and modernization of work technologies in this sector, which has the primary goal of preserving and enhancing oral and dental health, and thus the general health of the population. By educating these individuals, the faculty of medical sciences at our university simultaneously furthers the objective of increasing the number of citizens with higher education in the nation.

The main objective of the Integrated Academic Graduate Studies in Dentistry is to ensure that the graduates, who become doctors of dentistry / doctors of dental medicine are capable of working independently within dental practices and are proficient in executing all dental procedures typical for general dentistry in everyday dental practice. Furthermore, they have the option to continue their education through specialization studies or doctoral programs in dentistry, with an emphasis on engaging in scientific research. Upon completing their studies and defending their thesis, the student earns the professional academic title of Ph of dental sciences.

In the first year of study, the student acquires knowledge in general education and essential dental courses, thereby gaining the necessary foundation for further education. In the second year of study, the student learns clinical medical and preclinical dental courses, which qualifies him to pursue the teaching of clinical dental courses. In the third year of study, the student gains knowledge from preclinical dental courses, along with basic clinical dental courses. During the fourth year of study, the student acquires knowledge from clinical dental courses, which prepares him for independent patient work and introduces him to scientific and research endeavors. In the fifth year of study, the student gains the necessary knowledge for independent patient work and is trained to engage in scientific and research activities.

Students gain an understanding of the didactic approach through lectures and the process of 'signing off' on student paperwork. Transitioning from a didactic approach to a more problem-centered method that emphasizes independent learning, self-assessment, and reflection poses challenges for students [1].

Effective learning consists of two fundamental aspects: the understanding of the specified standards and criteria, and the skill to correctly assess if one's work meets these expectations. It is only when both aspects are achieved that evidence can confirm that self-assessment methods facilitate the learning of novices [2].

The early preclinical years of dental education mark a transitional phase where students actively move beyond their comfort and control zones to synthesize new knowledge, construct their professional identity, and cultivate the clinical skills and perspectives indispensable for oral health practitioners [3].

Furthermore, the structure and content of the preclinical dental curriculum, especially the hands-on learning experiences, were deemed foreign and stressful for most beginners. While challenges are crucial for keeping students motivated, ongoing and high levels of stress may jeopardize their overall wellbeing [4].

Empirical investigations in dental education have shown that the transition from preclinical to clinical training is accompanied by various challenges, similar to those in other health professions. In addition to the increased workload, the lack of confidence in applying theoretical knowledge and skills to real-world patient issues, ongoing learning, educational expectations, and assessment, these challenges also involve problems with professional socialization and interprofessional collaboration [5].

Regardless of the curriculum structure, evidence indicates that students undergo what is referred to as the "shock of practice" during the transition from preclinical to clinical phases in healthcare.

Periodontology is a field of study that focuses on the periodontium, which refers to the supporting tissues of the tooth. After dental caries, periodontal diseases are the most frequently encountered oral health issues. It is estimated that up to 90% of individuals have some form of periodontal disease. The pathological processes involved in various periodontal diseases lead to a gradual yet progressive loss of teeth.

The dental medicine curriculum includes three courses that address periodontology: preclinical periodontology, which is a course in the 8th semester; periodontology 1 in the 9th semester; and periodontology 2 in the 10th semester of the study program. Each of these courses is designed in line with the curriculum and includes both lectures and practical exercises. In the periodontology 1 and 2 courses, the practical exercises consist of clinical practice, where students work with real patients, engaging in the diagnosis and treatment of periodontal diseases.

The skills that students are expected to gain from studying and passing the preclinical periodontology course are aimed at familiarizing them with the anatomy, histology, and physiology of the supporting tissues of the tooth, as well as the classification and epidemiology of periodontal diseases, the risk factors and determinants of these diseases, and their etiology. The competencies that students should acquire after completing the periodontology 1 course pertain to the occurrence of periodontal disease, the clinical signs and symptoms of these diseases, occlusal influences, and patient management in the field of periodontology. In the final semester, this area is further addressed in the periodontology 2 course, where students are trained in the treatment of periodontal diseases [6].

A significant portion of these courses consists of theory lectures, seminars, practical experiences, clinical simulations, and clinical courses [7]. Moreover, all dental students are obligated to complete a full year in an internship program, in which the graduating dentist will work in various dental specialties as a general practitioner.

Velayo et al [8] showed that the correlation between students' preclinical grades and clinical grades in operative dentistry and fixed prosthodontics was statistically significant (2010: $r^2=0.144$, $p<0.001$; 2011: $r^2=0.261$, $p<0.001$).

Following a review of the feedback, the educators acquire a more defined insight into the challenges, allowing them to train the students accordingly. This assists in minimizing adverse experiences and improving the quality of life for patients [9].

Based on the previously presented facts from modern scientific literature, the main aim of this study was set up- to investigate the correlations of final grades among dental students across three academic courses, examining both their preclinical and clinical performances, and to determine the relationships between their achievements in preclinical practical courses and clinical courses.

Material and method

Research data

For the purpose of evaluating the relationship between the performances from the preclinical course and two clinical courses, the following data were retrieved from the students' information system at the Goce Delcev University in Stip:

- First cycle of studies;
 - Generation of students enrolled in year 2017, listening the preclinical course Preclinical Periodontology in 8th semester, earliest in study year 2020/2021, and the clinical courses Periodontology 1 in 9th semester, as well as Periodontology 2 in 10th semester, giving total of 10 students, that is total of 30 passed courses;
 - Generation of students enrolled in year 2018, listening the preclinical course Preclinical Periodontology in 8th semester, earliest in study year 2021/2022, and the clinical

courses Periodontology 1 in 9th semester, as well as Periodontology 2 in 10th semester, giving total of 11 students, that is total of 33 passed courses, and

- Generation of students enrolled in year 2019, listening the preclinical course Preclinical Periodontology in 8th semester, earliest in study year 2022/2023, and the clinical courses Periodontology 1 in 9th semester, as well as Periodontology 2 in 10th semester, giving total of 13 students, that is total of 39 passed courses.

Given the nature of the clinical courses, for the purpose of this research they are grouped together in one grade, as average value per student. This resulted in having 34 pairs of values (one preclinical and one average clinical grade) for 34 students that were analyzed with both Pearson's and Spearman's method. Even though there is no absolute minimum for reliable results when applying Pearson's correlation, it is recommended that the minimum sample size that is commonly accepted is at least 30 pairs of data (based on Central Limit Theorem, saying that sampling distributions approach normality with bigger sample size).

Bear in mind that the analysis is conducted on sample of students that have passed all the three courses (one preclinical and two clinical) at the time when the research is done. Data such as how many times students has tried to pass the final exam and similar are not taken into consideration, since it is assumed that the performance shown at the preclinical course can indicate the performances related to the clinical courses in similar matter related to the final grade. It must be noted that all student participants in this research studied under the same accredited program, the same curriculum, and were assessed by the same professor.

Pearson's Correlation vs Spearman's Correlation in Statistical Analysis

Pearson's correlation coefficient (r) is commonly used statistical approach that enables quantification of the strength and direction of existing linear relationship between two continuous numbers (variables). It has been invented by Karl Pearson in the early 20th century. The coefficient is calculated using the following formula:

$$r = \frac{\sum(x_i - \bar{x})(y_i - \bar{y})}{\sum(x_i - \bar{x})^2 \sum(y_i - \bar{y})^2}$$

where x_i and y_i are individual values (observations) and $\bar{x}$ and $\bar{y}$ are means of the respective variables. The correlation analysis gave a result pointing the degree to which the results from the preclinical courses can predict the results from the clinical courses. The coefficient provides a standardized value in the range from -1 to +1. If the value is closer to +1, we have an indication for a strong positive correlation (meaning that two variables tend to move in the same direction). Otherwise, values that are closer to -1 are indicating (strong) negative correlation. Values close to 0 are suggesting that there is no linear relationship between the variables. Essentially, it measures how much the variables vary together, normalized by how much they vary separately from each other.

Spearman's correlation measures the strength and direction of a monotonic relationship. Unlike the Pearson's method that lies on linearity and at least approximate normally distributed data, Spearman's is more robust, meaning that it deals with relationships that can be non-linear, but are still consistently increasing or decreasing. Also, it is important to be noted that it is more robust to normality, meaning it works with no specific distribution assumptions (ordinal data) and it deals with data distributions that contain outliers. The correlation coefficient is calculated using the following formula:

$$\rho = 1 - \frac{6 \sum d_i^2}{n(n^2 - 1)}$$

where d_i is difference between the ranks of each pair, and n is the number of data points. The interpretation of the coefficient is the same, meaning values are between +1 (perfect increasing relationship), 0 (no correlation) and -1 (perfect decreasing relationship).

The following table shows the possible interpretations of the coefficient:

Table 1. Interpretation of correlation methods

<i>r value, ρ value</i>	Strength of linear association
0.90 to 1.00	Very strong
0.70 to 0.89	Strong
0.40 to 0.69	Moderate
0.10 to 0.39	Weak
0.00 to 0.09	None or negligible

Source: Based on reference [10]

In this research, both Pearson's and Spearman's correlation methods were applied to study the relationship between students' performances in one preclinical course which is Preclinical periodontology and the appropriate consecutive clinical courses, which are Periodontology 1 and Periodontology 2. Grades from all the courses (students) are treated as continuous variables on a comparable numerical scale. Linearity and normality were assessed through scatter plots and Shapiro-Wilk tests, as a must prior to application of Pearson's correlation. In such environment, correlation analysis was conducted for the sample of students (pair of grades) cumulatively, towards identification of patterns or differences between groups of students sharing same / opposite characteristics or experiences to the specific period of time or events – studying the preclinical and clinical courses and obtaining the final grade.

Results

The linearity of the data was analysed with scatter plot, where x axes represent the values of the grades from the preclinical course Preclinical Periodontology and y axes represents the averages from the values of the grades from Periodontology 1 and Periodontology 2.

Table 2. Statistical data

Courses (34 students)	Min	Max	Mean	SD
Preclinical Periodontology	6	9	6,56	0,82
Clinical (average from Periodontology 1 and Periodontology 2)	6	8,5	6,84	0,89

Source: Students' information system, Goce Delcev University in Stip

The scatter plot is shown on Figure 1. Each point represents a student. The red line shows a linear regression line (line of best fit). The data shows a moderate positive linear trend, suggesting that the rise of the preclinical grade would probably indicate tendency of increase of the clinical courses' grades.

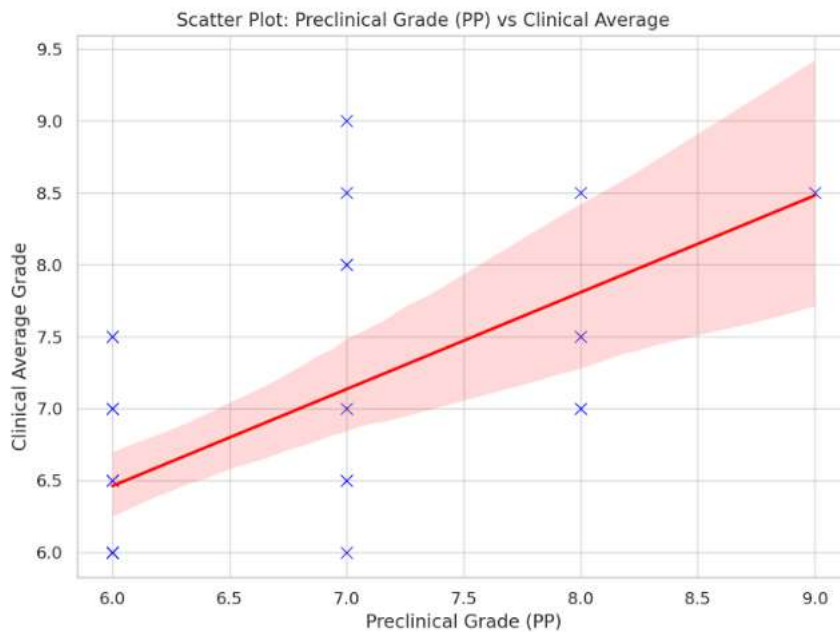


Fig. No. 1 Scatter plot of data showing linearity

Source: Students' information system, Goce Delcev University in Stip

The plot shows moderate positive linear tendency. It is not perfectly linear, but reasonably linear, meaning that Pearson's correlation is most likely appropriate. Related to the normality of the data, with application of Shapiro-Wilk test (table 3) it was shown that the p values for both preclinical and clinical grades data are far below 0.05 and that is an indication that the data in both preclinical and clinical grades are significantly deviating from a normal distribution.

Table 3. Normality test results

	Preclinical grade	Clinical average grades
W-statistic	0,705	0,847
p-value	0,00000582	0,00024

Source: Authors' calculation

Nevertheless, the sample size is reasonably large ($n > 30$) and we assume partial robustness of Pearson's method regarding the violations of normality and we do in along with Spearman's rank correlation. The results of both methods are shown in Table 4.

Table 4. Results from both Pearson's and Spearman's methods

Method	Correlation Coefficient	p-value	Interpretation
Pearson (r)	0.621	0.0000903	Moderate positive linear correlation
Spearman (ρ)	0.617	0.000101	Moderate positive monotonic correlation

Source: Authors' calculation

Both correlation coefficients indicate moderate, positive relation between the preclinical course Preclinical Periodontology and the average from the clinical courses Periodontology 1 and Periodontology 2 (their average, per student). The results are statistically significant (very

unlikely to have occurred by chance) at the $\alpha = 0.001$ level for both tests. It means that there are only 0.1% chance of wrongly concluding that a correlation exists when it actually doesn't (unlikely to be due to random variation). It is pretty strict limit – stricter than the commonly used $\alpha = 0.05$ (5%).

Discussion

Becoming a Doctor of Dental Medicine requires students to dedicate themselves to focus on practicing their skills. The significance of precision and details in dentistry is thoroughly emphasized in preclinical education. However, some students may need extra support and training to achieve proficiency. Each patient offers a distinct experience, allowing students to relate and apply their preclinical learning in practical situations.

Several studies have examined the difficulties students experience in transitioning from preclinical to clinical courses. From the published study of Mary et al [11], 3.3% of students faced difficulties in interpreting the subjective and objective symptoms of the patients, 7% of students faced difficulty in reading the radiographs, and 11.3% of students faced difficulty in chair positioning of the patient. But, according to Chichghare et al [9], 4.1% of students faced difficulties in interpreting the subjective and objective symptoms of the patients, 6.6% of students faced difficulty in reading the radiographs, and 4.5% faced difficulty in chair positioning of the patient.

According to Alraheem et al [12] there is statistically significant weak-to-moderate positive correlation found between each academic course and its preclinical or clinical counterparts and between preclinical and clinical courses in their study. A statistically significant positive moderate correlation ($p < .001$) was found between students' performance in fourth and fifth year restorative clinical courses.

Maybe the most important question is why is the correlation between courses grades essential? Primarily, for analyzing academic performance patterns. For example, when two courses (like preclinical and clinical course grades) show a positive correlation, it indicates: students who perform well and have greatest grades in one course are likely to perform well and have greatest grades in the other. Conversely, those who struggle in one course often face challenges in the other. Secondary, the correlation between courses grades has predictive relevance. A positive correlation (for instance, $r = 0.64$, $p = 0.62$) reflects a moderate to strong predictive relationship. Also, educators or academic advisors can estimate performance in one course based on a student's grades in another. As seen in our study, if a student performs well in preclinical course, they are likely to perform well in clinical courses. With this, educators can make early identification of students who may be at risk, and it can suggest remedial support before failure occurs. Tertiary, the correlation between courses' grades can influence on the curriculum structure and integration. Strong correlation may indicate that the courses: (1) share similar skill sets, cognitive demands, or areas of knowledge, (2) May be redundant or, alternatively, complementary. According to this it can guide curriculum reforms based on align teaching strategies, balance the workload across semesters, group assessments or design interdisciplinary modules.

The correlation between courses grades influences the validity and consistency of the assessment. The presence of strong positive correlation supports the reliability and fairness of assessment methods. If performance is systematically related across two courses, it might reflect stable academic abilities rather than randomness or bias in evaluation.

The key reason reported by students for their struggle with adaptation was the contrast between the workstations utilized in preclinical and clinical training. This is because the laboratory workstation is confined to a dental stool, lighting, and a fixed bench, while the clinic is equipped with a dental chair, dental stool, lighting, a dental unit, an auxiliary table, and other necessary

items. Furthermore, another aspect that added to this adaptation challenge was the students' apprehension about the procedures they were conducting in the mouths of patients.

According to the results from our study Pearson's correlation ($r = 0.640$, $p < 0.001$) and Spearman's correlation ($\rho = 0.617$, $p < 0.001$) indicate: (1) a positive relationship, suggesting that performance trends are aligned and (2) statistical significance, implying that this observed pattern is unlikely to occur by chance. In other words, this indicates that there is reliable and significant connection between students' performance in preclinical and clinical course grades, as evidenced by both raw scores (Pearson) and rank order (Spearman).

The statistically significant positive correlations identified between the preclinical and clinical course grades (Pearson's $r = 0.640$; Spearman's $\rho = 0.617$; $p < 0.001$) imply that student performance is consistently correlated across both disciplines. This relationship may indicate shared cognitive demands or skill sets, providing predictive insights for academic advising. Furthermore, the results underscore the potential for curriculum integration, early detection of at-risk students, and the maintenance of assessment consistency throughout the program.

The limitation of this study is associated with the non-probabilistic sampling design, which exclusively involved students from the faculty of medical sciences, Goce Delcev University. It is likely that individuals from schools with differing philosophies may experience alternative challenges in applying ergonomic posture requirements. However, in light of the limited literature on this topic, this study represents a valuable contribution to the discipline.

The results derived from this research empower educators from diverse institutions to formulate strategies, overcoming the challenges identified during the transition from preclinical to clinical phases. Consequently, we believe that this could be more firmly established in the routines of dental students, enabling them to commence their professional journeys.

This result suggests there might be a beneficial association between the preclinical and clinical outcomes of these students; however, the individual factors that play a role in this relationship were not analyzed in this research and require further exploration.

Conclusion

This research show a statistically significant, moderate positive correlation between the performances shown in Preclinical Periodontology as a predecessor and Periodontology 1 and Periodontology 2 as successors, confirmed by both Pearson's and Spearman's methods. These findings support the conclusion that increases the preclinical course performance are generally associated with increases in clinical courses performances, under both linear and rank-based assumptions.

References

- [1] Kovacevska, Ivona, et al. "Self assessment of dental students as learning modality in preclinical dental education." *Quality of Assessment, Qualification and Evaluation in higher education*, 2015, pp. 55-63.
- [2] Schmidt, Henk G./ Geoffrey R. Norman/ Henny P. Boshuizen. "A cognitive perspective on medical expertise: theory and implication [published erratum appears in Acad Med 1992 Apr; 67 (4): 287]." *Academic medicine*, 65.10, 1990, pp. 611-21.
- [3] de Souza Ferreira, Franciele, et al. "Stress amongst dental students in the transition from preclinical training to clinical training: a qualitative study." *European Journal of Dental Education*, 27.3, 2023, pp.568-574.
- [4] Maragha, Tala, et al. "The six-domain well-being framework in oral health sciences: A pathway from theory to practice." *Journal of Dental Education* 88.2, 2024, pp. 157-168.
- [5] Radcliffe, Christina / Helen Lester. "Perceived stress during undergraduate medical training: a qualitative study." *Medical education* 37.1, 2003, pp. 32-38.
- [6] Petrovski, Mihajlo, and Riste Timovski. "The impact of online teaching on the dental students' exam success." *Conference Proceedings Second International Conference ETIMA 2023*.

- [7] Aldowsari, Mannaa K., et al. "Comparisons between preclinical and clinical dental students' perceptions of the educational climate at the college of dentistry, Jazan University." *Advances in Medical Education and Practice*, 2021, pp. 11-28.
- [8] Velayo, Bianca C., et al. "Using dental students' preclinical performance as an indicator of clinical success." *Journal of dental education* 78.6, 2014, pp. 823-828.
- [9] Chichghare, Rohini Pramod/ Anita Kahar / Jayashree Joshi. "Evaluation of experiences and challenges faced by dental students during their transition from preclinical to clinical year of study." *Journal of Advances in Dental Practice and Research* 2.1, 2023, pp. 2-6.
- [10] Schober, Patrick, Christa Boer, and Lothar A. Schwarte. "Correlation coefficients: appropriate use and interpretation." *Anesthesia & analgesia* 126.5, 2018, pp. 1763-1768.
- [11] Mary, A. Vinita, et al. "Transition from preclinicals to clinicals: Difficulties faced by students." *Int J Appl Dent Sci* 5, 2019, pp. 222-4.
- [12] Abd Alraheam, Islam, et al. "Predictability of dental students' performance in clinical courses based on their performance in pre-clinical and academic courses." *European Journal of Dental Education* 26.4, 2022, pp. 781-786.