Journal of Basic and Applied Pharmacology
Vol. 4 No. 1 January - June 2024

Page: [O12-24]

Original research article

Reforming clinical pharmacokinetics education: a study on the implementation of the SPOC blended learning model

Jingyi Lu[1,3], Yanping Chen[1,3], Mengyu Li[1,3], Xiaofang Zhang[1,3], Ji Li[1,3], Jian Yang[1,2,3*]

[1]School of Pharmaceutical Sciences & Yunnan Provincial Key Laboratory of Pharmacology for Natural Products, Kunming Medical University; Kunming, Yunnan 650500, P.R. China.
[2]Yunnan Provincial Center for Drug Policy Research; Kunming, Yunnan 650500, P.R. China.
[3]College of Modern biomedical industry; Kunming Medical University; Kunming, Yunnan 650500, P.R. China.

Received 24 August 2023; Received in revised form 25 December 2023
Accepted 14 February 2024; Available online 15 February 2024

ABSTRACT

Objective: This study investigates the effectiveness of the Small Private Online Course (SPOC) blended learning model in teaching clinical pharmacokinetics, focusing on its impact on students' academic performance, engagement, and satisfaction compared to traditional classroom teaching methods.

Methods: The study involved 311 third-year undergraduate clinical pharmacy students at a designated academic center, randomly assigned to either the experimental group (SPOC blended learning) or the control group (traditional teaching). The data collection encompassed final exam scores, regular assessment results, and satisfaction questionnaire responses. Statistical analysis was conducted using SPSS, including t-tests, correlation, regression, and factor analyses.

Results: The experimental group displayed a higher average final exam score (79.86 *vs.* 78.08) and a lower standard deviation, indicating more consistent performance compared to the control group. Engagement, as measured by regular assessment scores, was significantly higher in the experimental group (average score of 75.61 *vs.* 68.95). Satisfaction levels were also notably superior in the SPOC group (significant *t*-value of -6.210, $p<0.001$). Correlation and regression analyses provided additional insights into the relationships between teaching methods, student engagement, satisfaction, and academic performance.

Conclusion: The SPOC blended learning model demonstrates a positive influence on students' academic performance, engagement, and satisfaction in the context of clinical pharmacokinetics. These findings suggest the model's potential as an effective alternative to traditional teaching methods in complex, interdisciplinary academic subjects.

Keywords: SPOC (small private online course), blended learning, clinical pharmacokinetics, teaching reform, academic performance

*Corresponding author: hamars@126.com
https://li01.tci-thaijo.org/index.php/JBAP

1. Introduction

"Clinical Pharmacokinetics," as a newly established core course in clinical pharmacy by the National Pharmacy Teaching Steering Committee, represents a significant advancement in the curriculum for third- year undergraduate students majoring in clinical pharmacy. This course plays a pivotal role in medical- related majors, delving into the intricacies of drug absorption, distribution, metabolism, and excretion (ADME) processes within the human body and their clinical applications in the rational use of medications. Given its complexity and interdisciplinary nature, "Clinical Pharmacokinetics" encompasses a broad range of knowledge, integrating abstract and challenging formulas, and complex content that requires a deep understanding of mathematical analysis methods to address the dynamic processes of drugs in the body. This complexity often leads to difficulties in student comprehension, with a tendency towards superficial understanding of principles and formulas, resulting in a disconnect from practical applications.[1,2]

Traditional classroom teaching methods, while tried and tested, exhibit limitations in engaging students effectively in such complex subjects. These methods often emphasize principles and concepts at the expense of practical application, leading to teaching approaches that are perceived as dull, boring, and unidirectional. This approach can result in passive learning, stifling creativity, yielding suboptimal learning outcomes, and lacking in providing individualized learning support.[3] The challenge lies in transforming the teaching of "Clinical Pharmacokinetics" from a purely theoretical exercise into an interactive, practical learning experience that resonates with students and enhances their understanding and application skills.

In recent years, the advent of the Small Private Online Course (SPOC) blended learning model has offered a promising alternative to conventional teaching methods. This model effectively combines the advantages of online and offline learning, circumventing the high investment costs and low completion rates commonly associated with Massive Open Online Courses (MOOCs). The SPOC model is characterized by its sharing, openness, targeting, and flexibility features, making it especially suitable for in- school students with similar professional backgrounds and clear learning objectives. Through the SPOC model, personalized teaching activities can be effectively implemented, catering to the diverse learning needs of students.[4]

This study aims to evaluate the effectiveness of the SPOC blended learning model in the context of teaching "Clinical Pharmacokinetics." The research compares the academic performance, student engagement, and satisfaction levels of students in an experimental group (engaging in SPOC blended learning) with those in a control group (undergoing traditional teaching methods). The findings are expected to provide empirical evidence on the potential benefits of the SPOC model in enhancing student learning, examination preparedness, and overall performance and competency in this challenging and critical field. This study's outcomes could significantly contribute to the evolving landscape of clinical pharmacy education, offering insights into more effective and engaging teaching methodologies.

2. Materials and Methods

2. 1 Randomization method and sample size

The study was conducted in a medical university (at a designated academic center) in Yunnan province China, with participants being undergraduate students majoring in clinical pharmacy. In this study, a simple random assignment was utilized to allocate 311 undergraduate students majoring in clinical pharmacy with the third academic year into experimental and control groups, with 176 and 135 students, respectively. This approach minimized selection bias, ensuring equal chances of assignment and creating

comparable groups. The sample size was determined based on the enrollment numbers in the clinical pharmacokinetics course for the semester, thereby maximizing the external validity of the findings by including the entire cohort. A post-hoc power analysis, assuming a medium effect size of 0.5, a significance level of 0.05, and a desired power of 0.8, indicated that a minimum of 64 students per group was required to achieve sufficient power. With both groups exceeding this threshold, the study was confirmed to have adequate power for effectively testing the research hypothesis and detecting significant differences in teaching outcomes between the SPOC blended learning and traditional classroom methods. This random assignment was instrumental in maintaining a uniform educational background among all participants. Ethical considerations were paramount throughout the research process. The study was conducted in strict adherence to ethical standards, having received the requisite approval from the Institutional Review Board of Kunming Medical University (Protocol Number: 202300157). Prior to the study's initiation, informed consent being obtained from all participants to ensure their full understanding of the study's objectives and their rights. This ethical adherence was pivotal in maintaining the research's integrity and fostering an environment of trust and respect.

2.2 Comparison of SPOC blended learning model and traditional teaching methods

In this study, the experimental group was exposed to the Small Private Online Course (SPOC) blended learning model, which integrated online and traditional face-to-face classroom teaching. The online component of this model included video lectures, quizzes, interactive discussions, and additional learning resources. The offline aspect involved direct classroom teaching, where instructors provided individualized guidance, facilitated group discussions, and conducted problem-solving activities. In contrast, the control group engaged in conventional classroom teaching methods, characterized by standard lectures, textbook-based learning, and teacher-led discussions. Despite the differences in instructional approaches, both groups received identical course content over the duration of one semester, ensuring a controlled comparison of the two teaching methodologies.

2.3 Data collection and outcome measures

Data were collected through three main outcomes:

1) Academic performance: Students' academic performance was evaluated by the final exam scores and the number of correct answers in quizzes throughout the semester.

2) Student engagement: The level of student engagement was assessed using an online Micro teaching assistant intelligent teaching platform, which measured students' active participation, learning motivation, and interaction with peers and teachers.

3) Satisfaction: Students' satisfaction with the teaching method was evaluated using a satisfaction questionnaire, which included items related to course content, teaching methods, and learning environment.

Data were collected at the end of the semester, and the comparison was made between the experimental and control groups. The data were analyzed using descriptive statistics and t-test.

2.4 Inclusion and exclusion criteria:

Inclusion criteria:

1) Participants were required to be undergraduate students enrolled in a clinical pharmacy program at the time of the study.

2) Students eligible for the study needed to be registered for the clinical pharmacokinetics course offered during the semester in question.

3) Participants had to be willing to be randomly assigned to either the experimental group receiving the SPOC blended learning model or the control group experiencing traditional classroom teaching.

4) Students who agreed to participate had to consent to the collection of data regarding their academic performance, engagement, and satisfaction levels for the duration of the semester.

Exclusion criteria:

1) Students not majoring in clinical pharmacy were excluded from the study to maintain a homogeneous participant background relevant to the educational content.

2) Those who were not taking the clinical pharmacokinetics course during the specified semester were not included in the study.

3) Students who did not consent to random assignment or data collection on academic performance, engagement, and satisfaction were excluded.

4) Participants who were unable or unwilling to complete the entire semester of the course were also excluded to ensure that outcome measures reflected the full intervention period.

2.5 Integrated statistical analysis

A comprehensive statistical analysis was performed using SPSS version 17 to evaluate the outcomes of the experimental and control groups in this study. The analysis commenced with descriptive statistics to summarize basic data trends. This was followed by a 'Comparative Correlation Analysis between Control and Experimental Groups,' aimed at elucidating the relationships between various variables. Subsequently, a 'Regression Analysis for Control and Experimental Groups' was conducted to investigate predictive relationships. In addition, 'Factor and Cluster Analysis of Student Data' was carried out to identify underlying factors and cluster groupings within the dataset. Furthermore, a 'Performance Comparison of Regression Models' was undertaken to assess the efficacy of different predictive models. All analyses adhered to an alpha level of 0.05 for determining statistical significance, ensuring the robustness and reliability of the findings. This multifaceted analytical approach provided a comprehensive understanding of the data, facilitating a thorough examination of the research hypotheses.

3. Results

3.1 Academic performance—comparison of final exam scores

In this study, the final assessment results of the clinical pharmacokinetics course for the experimental and control groups were analyzed using SPSS software to further evaluate the effectiveness of the teaching reform. The control group had an average final exam score of 78.08 (on a 100-point scale), a median score of 79.00, a mode of 73.00, and a standard deviation of 13.065. The experimental group had an average final exam score of 79. 86, a median score of 82. 00, a mode of 79. 00, and a standard deviation of 8.693, as shown in Table 1-2, and Figure 1-2. The experimental group's average score was slightly higher than that of the control group, with a lower standard deviation, indicating that the experimental group's overall performance was slightly better and more stable than that of the control group ($p< 0.001$). Moreover, the analysis of the distribution of students' scores showed that the experimental group had more students with higher scores than the control group. This result suggests that the SPOC blended learning mode may have improved students' learning outcomes by providing more personalized and interactive learning experiences.

3.2 Student engagement—comparison of students' regular assessment results

In the course of clinical pharmacokinetics, regular assessment results, as a part of the final grade, often reflect students' participation in the course. The average score of the control group, which used traditional teaching methods, was 68.95, while the experimental group, which used SPOC blended learning mode, had an average score of 75.61, the regular assessment results showed a significant improvement ($t=-6.353$, $p <0.001$) as shown in Table 1-2, and Figure 1-2, reflecting that

the SPOC blended learning mode has greatly increased students' participation and improved their interaction and discussion in the classroom after the teaching reform in clinical pharmacokinetics ($p < 0.001$). Furthermore, the SPOC blended learning mode provides students with more flexible learning opportunities, allowing them to access the course content anytime and anywhere, which can encourage self- directed learning and improve their learning efficiency. In addition, the personalized feedback and guidance provided by the SPOC platform can help students identify their strengths and weaknesses, which can further promote their learning outcomes.

3.3 Student satisfaction

To explore the application of the SPOC blended learning mode in the teaching reform of the clinical pharmacokinetics course, the teaching evaluation feedback was obtained from the control group (using traditional teaching methods) and the experimental group (using SPOC blended learning mode). The students actively participated in the evaluation, providing multi- dimensional ratings for both theoretical and experimental courses.

The results showed that the experimental group had significantly higher satisfaction levels with the SPOC blended learning mode than the control group had with traditional teaching methods ($t=-6.210$, $p <0.001$), as shown in Table 2 and Figure 3. Many students gave high praise for the SPOC teaching in this course, stating that the teacher was well- prepared, proficient in the content, and that the teaching materials, lesson plans, and courseware were complete and the teaching design was optimized. The teacher effectively used multimedia, visual aids, blackboard writing, and other teaching tools to explain the concepts and principles clearly, accurately grasped the key and difficult points, and presented the content in a clear and organized manner, with abundant learning resources.

3.4 Correlation analysis of academic performance and satisfaction

The correlation analysis between student performance and satisfaction within the control and experimental groups offers compelling insights, as delineated in our results and further illustrated in Figure 4. Within the control group, a minimal correlation ($r = 0.065$) between regular assessment grades and final exam scores was observed, suggesting an insubstantial link between ongoing assessments and ultimate academic outcomes. Intriguingly, there exists a slight positive correlation ($r = 0.26$) between student satisfaction and regular grades, whereas a negligible and slightly negative correlation ($r = -0.15$) with final exam scores was noted. Conversely, the experimental group exhibited a moderate positive correlation ($r = 0.53$) between regular assessment grades and final exam scores, signifying a consistent relationship between students' performance throughout the course and their final evaluations. Nevertheless, this group also showed a moderate negative correlation with regular grades ($r = -0.35$) and a slight negative correlation with final exam scores ($r = -0.14$) in terms of satisfaction, indicating that higher satisfaction levels do not necessarily correlate with higher academic achievements. These contrasting patterns elucidate the nuanced dynamics between academic achievements and student satisfaction, highlighting the impact of diverse teaching methodologies on student outcomes. The findings suggest that while the SPOC blended learning approach may bolster engagement and consistency in performance, it does not invariably lead to enhanced satisfaction or superior exam scores, thus challenging the prevailing belief that student satisfaction is directly proportional to academic success.

3.5 Exploring predictive relationships in academic performance

The regression analysis for both control and experimental groups, depicted in Figure 5, elucidates the predictive relationships among regular assessment grades, satisfaction

scores, and final exam grades, offering a nuanced understanding of their interplay. In the control group, the regression line reveals an ability to predict final exam grades based on regular assessments and satisfaction scores, albeit with considerable scatter indicating variability and hinting at the potential for enhancing the model's predictive accuracy. In stark contrast, the regression analysis for the experimental group demonstrates a tighter correlation, with a strong predictive relationship ($r = 0.53$) evident between regular assessments, satisfaction scores, and final exam grades. This indicates that within the experimental cohort, regular assessments and satisfaction scores serve as more reliable predictors of final outcomes.

The distinct predictive dynamics observed between the groups highlight the significance of regular assessments and satisfaction in forecasting final exam performance. Notably, the experimental group's clear alignment suggests the efficacy of the SPOC model, characterized by its comprehensive assessments and feedback mechanisms, in accurately signaling academic success. This alignment offers valuable insights for educational strategy and the development of personalized learning approaches, emphasizing the SPOC model's potential in enhancing the predictability of academic outcomes.

3. 6 Unveiling student performance and satisfaction dimensions through factor and cluster analysis

The factor and cluster analysis, as visualized in Figure 6, has succinctly distilled student data into two principal factors, likely indicative of the key dimensions of academic performance and overall satisfaction. This analytical approach has identified three distinct clusters of student groups, graphically represented by red 'x', teal 'x', and yellow 'x' marks, each marking the centroid of their respective clusters. Cluster 0 (red 'x') seems to embody students exhibiting high levels of satisfaction alongside variable academic performance, underscoring a scenario where contentment with the learning experience does not uniformly equate to high grades. Cluster 1 (teal 'x'), in contrast, encapsulates students demonstrating moderate satisfaction and performance levels, reflecting a balanced, albeit less intense, response to both their academic achievements and learning experiences. Meanwhile, Cluster 2 (yellow 'x'), the smallest of the groups, likely represents students with lower satisfaction levels, which do not consistently align with their academic performance, suggesting the influence of extrinsic factors on their course contentment. This detailed segmentation facilitates a more nuanced approach to educational interventions, acknowledging the heterogeneity of student experiences and emphasizing the necessity for differentiated support mechanisms to enhance individual learning trajectories.

3.7 Instructor insights on SPOC implementation and key success factors

Instructor feedback, collected through semi-structured interviews, offers insightful perspectives on the efficacy and critical success factors of the SPOC blended learning model, as further detailed in Figure 7. Instructors unanimously highlighted an enhanced educational experience, crediting the SPOC model for enabling more individualized attention and support during face-to-face sessions. This advantage is derived from the students' initial engagement with content through online modules, effectively laying the groundwork of foundational knowledge. The learning management system also received commendation for its role in monitoring student progress and participation, thus equipping instructors with essential data for timely and customized interventions. Moreover, discussions underscored not merely the value of video content but significantly, the bespoke feedback facilitated via the SPOC platform. Such personalized interactions are deemed crucial

to the model's success, in conjunction with structured online activities that cultivate a rich, interactive learning environment. Together, these components—online resources, active learning engagements, and individual feedback—are considered fundamental to the course's effectiveness, contributing to a dynamic and adaptive educational experience.

4. Discussion

4.1 Enhancing learning outcomes through blended learning

The study's findings suggest that the SPOC blended learning model significantly enhances learning outcomes in Clinical Pharmacokinetics. The experimental group demonstrated better academic performance compared to the control group, as evidenced by their higher average scores and more stable performance in the final exams. This improvement can be attributed to the blended model's ability to provide personalized and interactive learning experiences. The model facilitates deeper understanding and retention of complex concepts, which are fundamental in clinical pharmacokinetics. The integration of online resources and face- to- face interactions creates a more engaging and effective learning environment, enabling students to grasp abstract formulas and apply theoretical knowledge practically. This blend of traditional and modern teaching methods addresses the challenges of teaching complex subjects like pharmacokinetics, which require both conceptual understanding and practical application.[5]

4.2 Impact of SPOC on student engagement

The SPOC blended learning model significantly increases student engagement, as reflected in the higher regular assessment scores of the experimental group. This model fosters an interactive and dynamic learning environment where students are more actively involved in the learning process. The availability of online resources allows for flexible learning, enabling students to access course material at their convenience. This flexibility encourages self- directed learning, which is crucial for deep understanding in subjects like pharmacokinetics.[6] Moreover, the personalized feedback and interactive features of the SPOC platform cater to individual learning needs, promoting a more inclusive and effective learning experience. This approach is particularly beneficial in complex subjects, where students often require additional support to understand and apply challenging concepts.[7]

4.3 Student satisfaction with the blended learning approach

The significantly higher satisfaction levels in the experimental group underline the effectiveness of the SPOC blended learning model in enhancing the educational experience. This increased satisfaction is likely due to the diverse and interactive nature of the blended learning environment, which contrasts with the more passive nature of traditional teaching methods. The use of multimedia, visual aids, and other innovative teaching tools in the SPOC model makes learning more engaging and enjoyable.[8] Furthermore, the clear and organized presentation of content, coupled with the ability to access learning materials flexibly, caters to different learning styles and preferences. This adaptability is essential in a subject like clinical pharmacokinetics, where students may struggle with the abstract nature of the content.[9]

4.4 Correlation analysis: academic performance *vs.* student satisfaction

The correlation analysis presents intriguing insights into the relationship between academic performance and student satisfaction. In the control group, the minimal correlation between regular assessment grades and final exam grades suggests a disjointed learning experience. However, in the experimental group, the moderate positive correlation indicates a more consistent and integrated learning journey. Interestingly, the negative correlation between satisfaction and academic performance in the experimental group may suggest that while students appreciate the teaching method, this does not necessarily translate into higher grades. This

finding highlights the complexity of academic achievement and underscores the importance of aligning teaching methods with learning outcomes, especially in a challenging subject like clinical pharmacokinetics.[10]

4.5 Predictive relationships and educational strategies

The regression analysis underscores the potential of regular assessments and satisfaction metrics as predictors of final exam performance, especially in the experimental group. This finding is particularly relevant for the continuous improvement of teaching strategies in clinical pharmacokinetics. By understanding these predictive relationships, educators can tailor their teaching methods to better support student learning and performance. For instance, regular assessments can be used to identify areas where students struggle, allowing for timely interventions. Similarly, satisfaction metrics can provide feedback on the effectiveness of teaching methods, guiding educators in refining their approaches. This data-driven strategy is crucial for subjects like pharmacokinetics, where the depth and complexity of content require a nuanced approach to teaching and learning.[11]

4.6 Future research directions and instructor perspectives

The positive outcomes of the SPOC model in teaching clinical pharmacokinetics, as reported by both instructors and students, open avenues for further research. Future studies could explore the long-term impacts of this model on students' practical skills and their ability to apply theoretical knowledge in clinical settings. Additionally, investigating the application of the SPOC model in other complex, theory-intensive subjects could provide valuable insights into its broader efficacy in educational settings. Instructor feedback emphasizes the importance of individual feedback and personalized interaction in the SPOC model, suggesting areas for further enhancement. This feedback aligns with the need for ongoing development and refinement of blended learning models to meet the evolving demands of higher education, particularly in specialized fields such as clinical pharmacy.

Table 1. Distribution of final exam and regular assessment scores.

Scores Fractional interval	Final exam scores of control group	Final exam scores of experimental group	Regular assessment scores of control group	Regular assessment scores of experimental group
[0,50]	5（3.70%）	4（2.27%）	1（0.74%）	6（3.41%）
[50,60]	0（0.00%）	5（2.84%）	18（13.33%）	7（3.98%）
[60,70]	3（2.22%）	5（2.84%）	48（35.56%）	17（9.66%）
[70,80]	70（51.85%）	57（32.39%）	59（43.70%）	87（49.43%）
[80,90]	49（36.30%）	97（55.11%）	9（6.67%）	55（31.25%）
[90,100]	8（5.93%）	8（4.55%）	0（0.00%）	4（2.27%）

Table 2. Independent sample t-test results for scores (M±SD).

Group	Final exam scores	Regular Assessment Scores	Satisfaction Scores
The control group	78.08±13.065	68.95±8.36	4.9017±0.02417
The experimental group	79.86±8.693	75.61±9.72	4.9530±0.00986
t	-4.015	-6.353	-6.210
P	0.001	0.001	0.001

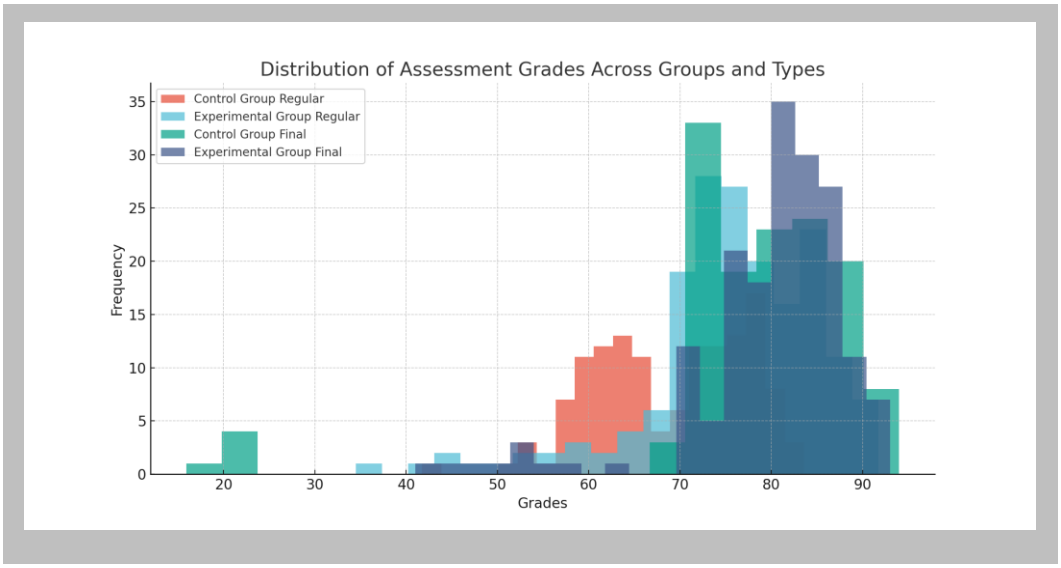

Fig. 1. Distribution of assessment grades across groups and types.

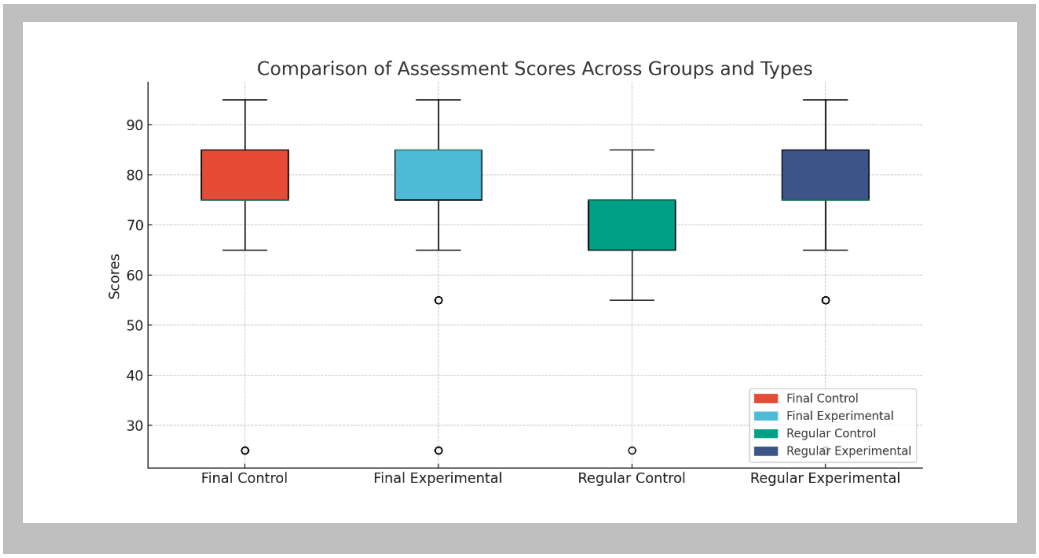

Fig. 2. Comparison of assessment scores across groups and types.

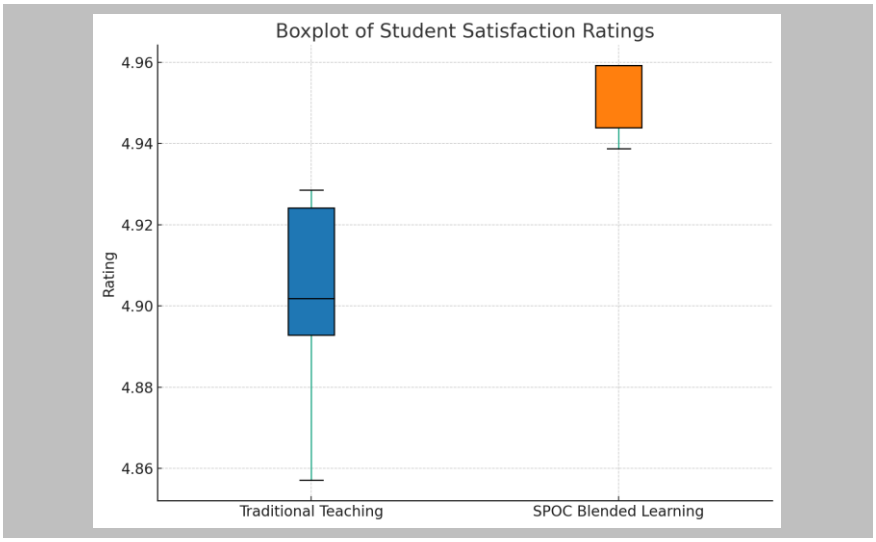

Fig. 3. Student satisfaction ratings for the SPOC blended learning approach and traditional teaching method.

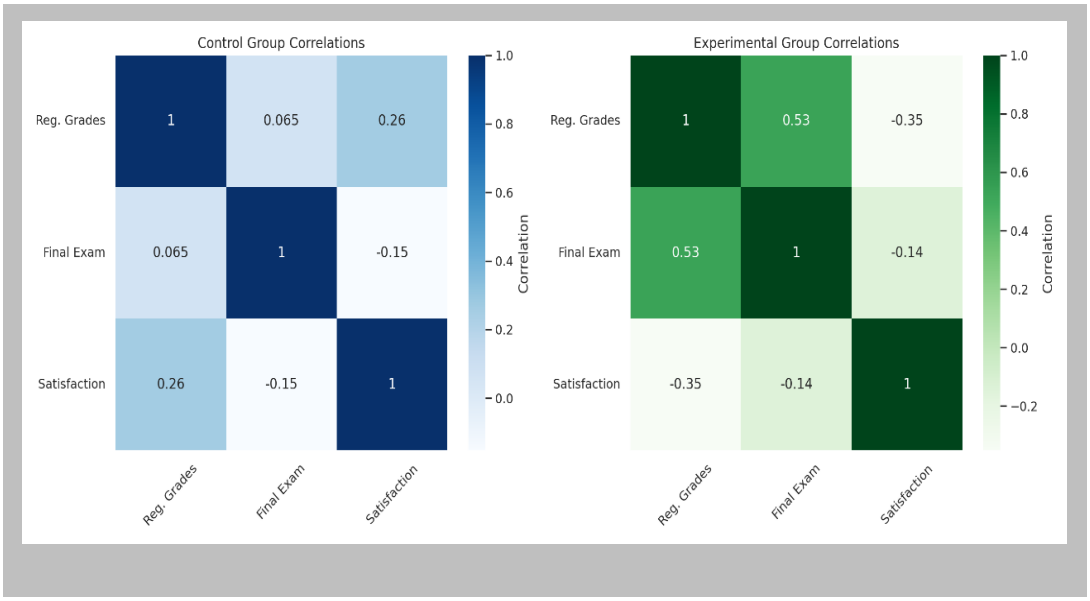

Fig. 4. Comparative correlation analysis between control and experimental groups.

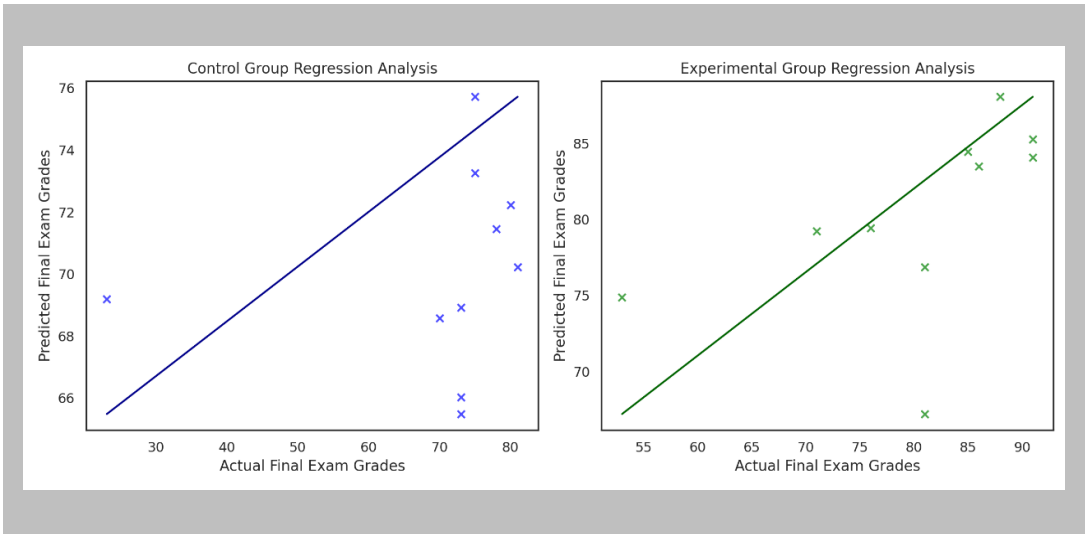

Fig. 5. Regression analysis for control and experimental groups.

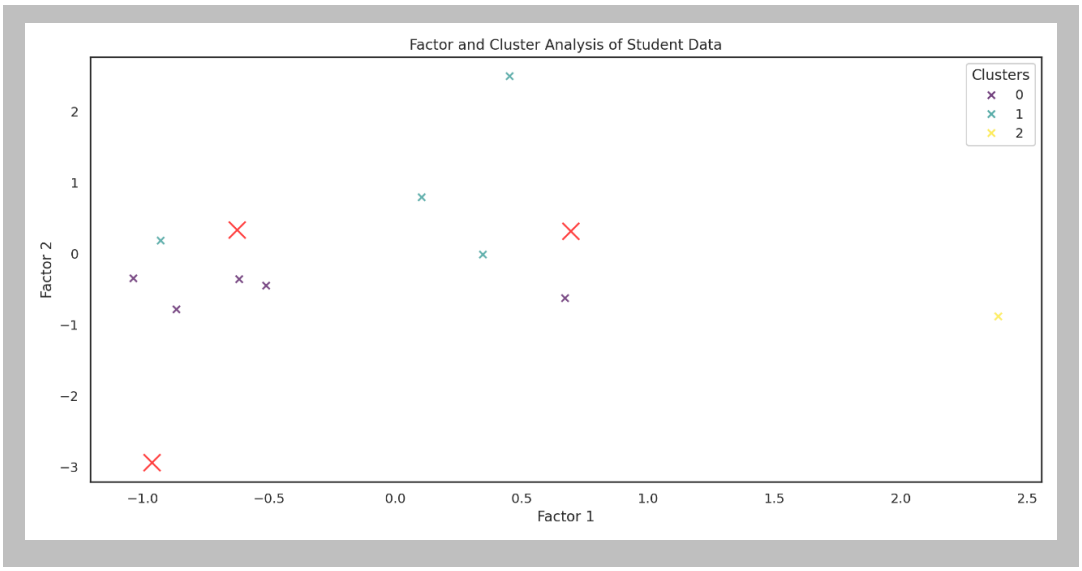

Fig. 6. Factor and cluster analysis of student data.

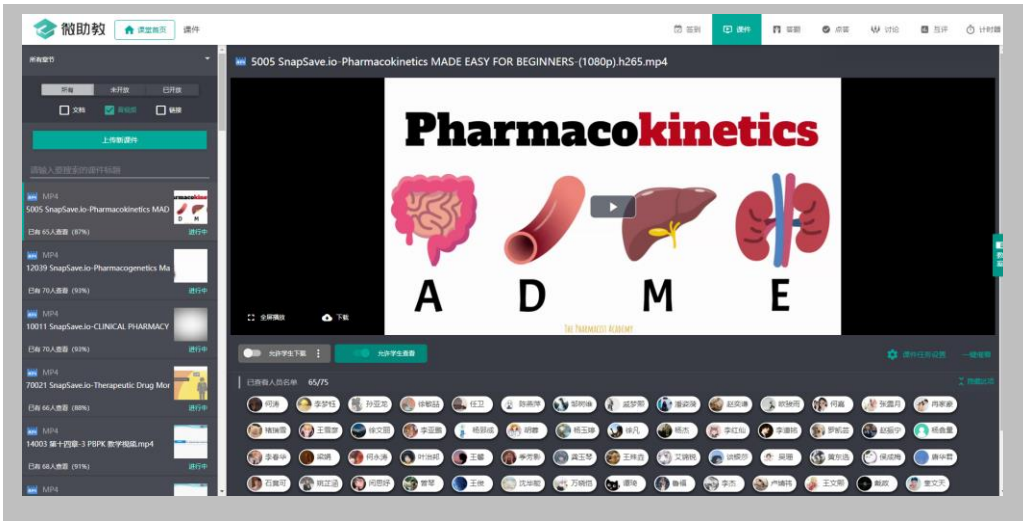

Fig. 7. Implementation of SPOC teaching on the micro-assistant intelligent teaching platform.

5. Conclusion

The implementation of the Small Private Online Course (SPOC) blended learning model in the Clinical Pharmacokinetics curriculum has demonstrated substantial benefits in enhancing student learning outcomes. This study confirms that the SPOC model, integrating online modules with traditional face- to- face teaching, significantly improves student engagement, understanding, and academic performance. Key to this success is the model's ability to frontload foundational knowledge through online resources, facilitating deeper in- class discussions and comprehension. Continuous assessment, a hallmark of the SPOC approach, emerged as an effective tool in predicting and improving student performance, underscoring its value in academic settings. Moreover, the study highlights the importance of accommodating diverse learning needs, as reflected in the varied student experiences and performances. The positive reception from both instructors and students suggests that the SPOC model not only enriches the learning experience but also fosters a more dynamic educational environment, proving its potential as a transformative tool in complex, theory- intensive subjects. These findings advocate for the broader adoption and ongoing refinement of blended learning models, particularly in specialized fields of study, aligning with the evolving needs of higher education.

Acknowledgements

The authors express heartfelt thanks to Kunming Medical University and the School of Pharmaceutical Sciences for their invaluable support and resources, crucial for this study on enhancing clinical pharmacokinetics teaching with the SPOC model. This collaboration has significantly contributed to the research's success, providing a rich academic foundation and essential logistical backing. Special appreciation goes to the faculty, staff, and students for their engagement and feedback, enriching this educational reform endeavor.

Conflicts of Interest

The authors declare that they have no competing interests.

Author contribution

All authors conceived and designed the study. Jingyi Lu and Xiaofang Zhang and Ji Li collected and analyzed the data.

Yanping Chen and Mengyu Li and Jian Yang drafted the manuscript. All authors critically reviewed and approved the final manuscript, figures and tables.

Funding

This study received financial support from several prestigious sources: (1) the Research Project on Education and Teaching at Kunming Medical University (Project Number: 2023-JY-Y-090), aimed at advancing educational methodologies; (2) the project "Exploring the Establishment of a Model Modern Biomedical Industry College: A Study on Undergraduate Educational Reform in Yunnan Province" (Project Number: JG2023001), focusing on innovative reforms in undergraduate education; and (3) the Kunming Medical University's project on developing online and offline mixed first-class courses (Project Number: 2021JXZ022), highlighting the commitment to excellence in educational delivery.

Click or tap here to enter text.

References

[1] Bonk CJ, Graham CR. (Eds.) . The handbook of blended learning: global perspectives, local designs. San Francisco, CA: Pfeiffer Publishing; 2006.

[2] Li RJ, Lv XJ, Liu J, LI H, Sai N, Gu Yl. Classroom teaching reform of pharmacokinetics of biological drugs based on SPOC hybrid teaching mode. Chin J Mod Dist Educ Tradit Chin Med. 2022;20(01):187-188.

[3] Shi FG. Application of PBL teaching method in pharmacokinetics teaching. Guangdong Chem Ind. 2022;49(14):201-202.

[4] Guo L, Han J, Lv DM. Teaching experience of clinical pharmacokinetics. Basic Med Educ. 2020;22(07):477-479.

[5] Hu W, Zheng X, He H, Liu H, Liu L, Ha H. Application of JoVE science education video database in teaching reform of pharmacokinetics experiments. Pharm Educ. 2022;38(05):77-83.

[6] Zhou XY, Lu Q, Wang JY, Yin XX. Reflections and suggestions on clinical pharmacokinetics practical teaching. Basic Med Educ. 2020;22(07):483-486.

[7] Yu YL. Teaching reform and reflection on pharmacokinetics under the new medical reform. Shandong Chem Ind. 2019;48(18): 220-221.

[8] Lin CH, Wu WH, Lin S, Lin RF, Wu ZH, Zhou J, et al. Investigation on the popularization status of precision pharmaceutical services for undergraduate clinical pharmacy majors. China Pharm. 2022;31(22):19-24.

[9] Smith A, Johnson B, Anderson C, et al. Blended learning in clinical education: a systematic review and meta-analysis. Med Educ. 2018;52(7):769-778.

[10] Chen L, Wang Y, Chen Y. A systematic review of blended learning interventions in health professions education. Med Educ Online. 2020;25(1):762665.

[11] Zolfaghari M, Mehrdad N, Parsa Yekta Z, et al. Challenges in blended learning implementation in medical education: a qualitative study. J Adv Med Educ Prof. 2014;2(2):43-50.