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INTEGRATING METACOGNITIVE PROBLEM-BASED MODULES OF HYBRID LEARNING TO ADVANCE PREVENTIVE MEDICINE EDUCATION

INTEGRISANJE METAKOGNITIVNIH-PROBLEM BAZIRANIH MODULA HIBRIDNOG UČENJA I UNAPREĐENJE EDUKACIJE IZ OBLASTI PREVENTIVNE MEDICINE

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SAŽETAK

Uvod: Metodologija učenja u medicinskoj nauci se brzo razvija, sa naglaskom na aktivno učešće studenata, korišćenjem inovativnih alata, kao što su Metakognitivni Problem-Bazirani (MCPB) moduli.
Cilj: studije bio je procjena stavova i iskustava studenata prema hibridnom modelu nastave i procjena njihove metakognitivne svjesnosti.
Metod: Studija je sprovedena na Katedri za higijenu Medicinskog fakulteta Univerziteta u Banjoj Luci, tokom nastave iz predmeta higijena u akademskoj 2024/25. godini. Studenti šeste godine medicine, učestvovali su u hibridnom modelu nastave (online predavanja, tradicionalna predavanja i MCPB moduli). Nakon završetka nastave, studenti su popunili upitnik koji je obuhvatao socio-demografske podatke i evaluaciju kursa i upitnik za procjenu metakognitivne svjesnosti (MAI). Na pitanja za evaluaciju i MAI odgovaralo se pomoću petostepene Likertove skale (1 = malo, 5 = odlično). Rezultati: Ukupno 43 studenta je pratilo predmet higijena, od kojih je 93,02% pratilo hibridni model učenja. Nakon završetka kursa, 55% studenata koji su pratili hibridni model su popunili upitnike. Većina studenata ocijenila je hibridni model nastave kao visoko zadovoljavajući (prosječna ocjena 4,05), dok su MCPB moduli ocijenjeni kao zadovoljavajući (prosječna ocjena 3,95). Analiza MAI pokazala je izraženo proceduralno (4,14), uslovno (3,90) i deklarativno (3,84) znanje o kogniciji. U oblasti regulacije kognicije, najviša ocjena zabilježena je za ispravljanje grešaka (4,13), a najniža za evaluaciju (3,73).
Zaključak: Rezultati su pokazali su pozitivan stav studenata prema primjeni hibridnog modela nastave. Studenti su pokazali visok nivo metakognitivne svjesnosti, posebno u proceduralnom znanju i regulaciji kognicije. Istraživanje ukazuje na potencijal hibridnog učenja za unaprjeđenje nastave iz oblasti preventivne medicine.
Ključne riječi: Hibridno učenje, MCPB moduli, MAI, Medicinsko obrazovanje, Evaluacija.

ABSTRACT

Introduction: Learning methodology in medical science is rapidly evolving, with an emphasis on active student participation, using innovative tools such as Metacognitive Problem-Based (MCPB) modules.
The study aimed to assess students' attitudes and experiences towards the hybrid teaching model and to assess their metacognitive awareness.
Method: The study was conducted at the Department of Hygiene, Faculty of Medicine, University of Banja Luka, in the academic year 2024/25. Sixth-year students participated in the hybrid teaching model (online lectures, traditional lectures, and MCPB modules). Upon course completion, students completed a questionnaire covering demographic data, course evaluation, and metacognitive awareness using the Metacognitive Awareness Inventory (MAI). All responses were recorded on a five-point Likert scale (1 = low, 5 = excellent). Results: A total of 43 students attended the hygiene course, with 93.02% participating in the hybrid learning model. Post-course, 55% of these students completed the questionnaire. Most students rated the hybrid teaching model as highly satisfactory (mean score 4.05), while MCPB modules were rated as satisfactory (mean score 3.95). MAI analysis revealed pronounced procedural (4.14), conditional (3.90), and declarative (3.84) knowledge of cognition. In the domain of cognitive regulation, the highest scores were observed for error correction (4.13), while the lowest were for evaluation (3.73).
Conclusion: The results showed students' positive attitude towards applying the hybrid teaching model. Students showed a high level of metacognitive awareness, especially in procedural knowledge and cognitive regulation. The results indicate the potential of hybrid learning for improving teaching in the field of preventive medicine.
Keywords: Hybrid learning, MCPB modules, Metacognitive Awareness Inventory, Medical education, Evaluation.

UVOD

Metacognitive problem-based modules of hybrid learning combine principles of metacognition with problem-based learning in a learning environment that integrates various teaching modalities such as face-to-face and online interactions [1]. The integration of metacognitive problem-based learning (MCPB) modules within hybrid learning environments is increasingly important for improving educational practices. According to some authors [2-4] the application of metacognitive frameworks can empower medical students to introspectively manage their learning processes, leading to improved problem-solving skills and improved academic achievement.

Today, metacognition usually defined as thinking about thinking or cognition about cognition. involves awareness and regulation of one's cognitive processes [5]. In medical education, the cultivation of metacognitive skills is crucial, as these abilities not only contribute to individual learning effectiveness but also prepare students for the complexities inherent inpatient care and medical decision-making. Studies indicate that students who develop metacognitive skills show improved independent learning, including deeper theoretical understanding and more effective practical application of knowledge [6-8]. These benefits extend to clinical practice, where metacognition is linked to better patient care [9], stronger clinical judgment [10,11], and more informed decision-making [4,12]. Furthermore, metacognitive training fosters lifelong learning, an essential competency for healthcare professionals [13–16].

As contemporary educational methods increasingly move toward hybrid models, there is a unique opportunity to enhance metacognitive skills through digital platforms. This integration can provide personalized learning experiences tailored to students' individual needs [17-19]. Consequently, using instructional strategies that explicitly teach metacognitive skills within these hybrid frameworks can improve student engagement and promote deeper understanding of the material [4,20].

Metacognitive training, along with initiatives that encourage reflective practice, helps students to critically evaluate their learning strategies and adapt their approaches. This is particularly valuable in preventive medicine, where adaptability and critical thinking are essential [4,8,21].

This study aims to assess sixth-year medical students' attitudes and experiences towards a hybrid learning model, as well as to assess their metacognitive awareness.

METHOD

Study Design

The pilot study was performed at the Department of Hygiene, Faculty of Medicine, University of Banja Luka, during the obligatory hygiene course in the 2024-25 academic year. Sixth-year undergraduate medical students were invited to participate in a blended learning format, combining online MCPB (Metacognitive Problem-Based) learning with traditional face-to-face lectures.
The hybrid learning model combines traditional, on-site learning and the e-learning model, including various forms of content (lessons, quizzes, and MCPB modules). The students take two midterm exams, each worth 10 points, which are incorporated in overall academic performance (Grade Point Average; GPA). Students' GPA and earned points on midterm exams were compared with the performance of students from the previous academic year, during which the course was delivered through a traditional on-site teaching model.
After completing the hygiene course and passing the final exam upon first attempt at the earliest available date, students were asked to complete two questionnaires covering demographics, course evaluation, and metacognitive awareness, assessed by the Metacognitive Awareness Inventory (MAI) [22].
The study was approved by the Ethics Committee for Research in Humans and Biological Materials at the Faculty of Medicine, University of Banja Luka (No. 18/4.174-/24). Participation in this study was voluntary, and Informed consent was obtained from all participants.

Data collection

The students' feedback on hybrid learning was collected using a questionnaire, which consists of a total of 20 items, with ten five-point Likert scale questions. Mean scores of 3.0–3.5 were considered low satisfactory, 3.6–3.9 satisfactory, and 4.0 or above highly satisfactory. Data for the 2023/24 academic year were obtained from official student records.
The MAI was translated, adapted, and validated in Serbian language [23]. The evaluation questions and all the items in MAI were rated on a five-point Likert scale ranging from 1 (always false) to 5 (always true). The MAI is a self-report tool, consisting of 52 items, divided into two main categories: "Knowledge of Cognition" (17 items) and "Regulation of Cognition" (35 items). The "Knowledge of Cognition" category includes three subcategories: declarative, procedural and conditional knowledge. The "Regulation of Cognition" category includes following subcategories: planning, information management strategies, comprehension monitoring, debugging strategies and evaluation. Higher scores indicate greater awareness of cognition and its regulation.

Data analysis

Data were analyzed using IBM SPSS 20 (Chicago, IL, USA). Normality of variables' distribution was assessed by Shapiro-Wilk's test. Descriptive statistics were calculated for the baseline student characteristics and outcome measures, knowledge test, and final scores. Baseline differences between groups were analyzed using Students t-test for continuous variables, and the Pearson chi-squared test for categorical variables.

RESULTS

A total of 43 students attended the obligatory hygiene course in the 2024-25 academic year, and 40 of them were enrolled in the hybrid format. The response rate was 93.02%. During the course, students completed lectures, accompanying MCPB materials, and took two midterm tests. Following course completion and passing the final exam, 55% of students completed the evaluation questionnaire (n = 22; 12 females, and 10 male students). The average age of participants was 25.70 ± 2.00 years (male students: 26.13 ± 2.42; female students: 25.42 ± 1.73). No statistically significant differences were observed between the 2024/25 and 2023/24 academic year cohorts in terms of age, gender distribution, GPA, or midterm test scores (Table 1).

Variable	2024/25 AY	2023/24 AY	p value
Age of students; mean ± SD	25.70 ± 2.00	26.23 ± 2.08	.350
Female	25.42 ± 1.73	26.41 ± 1.73	.263
Male	26.13 ± 2.42	25.89 ± 2.71	.869
Gender; n (%)	22 (100)	26 (100)	.824
Female	12 (54.55)	17 (65.38)	.444
Male	10 (45.45)	9 (34.62)	
GPA total; mean ±SD	9.05 ± 1.05	8.88 ± 1.01	.618
Female	9.08 ± 0.99	8.76 ± 1.03	.414
Male	9.00 ± 1.15	9.11 ± 1.54	.860
Midterm scores; mean ± SD	17.92 ± 1.48	17.94 ± 0.99	.962
Female	17.63 ± 1.69	17.85 ± 0.75	.625
Male	18.28 ± 1.16	18.11 ± 1.39	.770

AY= academic year; p-values calculated using independent samples t-test for continuous variables and Chi-square test for categorical variables.

Table 1. Comparison of demographic and academic characteristics between student cohorts in the 2024/25 and 2023/24 academic years.

The following section presents the results in terms of students' feedback on the hybrid learning model. A total of 86.36% (n=19) of the surveyed students found the e-lectures helpful in mastering the course content, while 77.27% (n=17) considered the MCPB modules useful for understanding the subject matter. Table 2 summarizes students' perceptions of the hybrid learning experience, regarding the usefulness and quality of the e-lectures and MCPB modules implemented in the online hygiene course.

Questions	Mean ± SD	95% CI
Did the e-lectures help you in mastering the course content?	3.73 ± 1.07	3.25 - 4.20
Did the MCPB modules help you in mastering the course content?	3.73 ± 1.07	3.25 - 4.20
Was the content of the MCPB modules appropriate for the course?	4.05 ± 0.95	3.62 - 4.47
Did you find the MCPB modules interesting?	3.95 ± 1.13	3.45 - 4.46
Did the MCPB modules help you learn how to solve problems?	4.00 ± 1.19	3.47 - 4.53
Did the MCPB modules help you understand the course material?	4.09 ± 1.23	3.55 - 4.64
How satisfied are you with the implementation of the MCPB modules in the course?	4.09 ± 1.19	3.56 - 4.62
Overall satisfaction with the course e-learning format.	4.09 ± 1.19	3.56 - 4.62

Responses were rated on a 5-point Likert scale (3.00-3.59 = low satisfactory; 3.6-3.99= satisfactory; 4.00 or above = highly satisfactory). MCPB = Metacognitive problem-based modules; CI= Confidence interval.

Table 2. Students' feedback on e-lectures and MCPB modules in the online hygiene course

Most of the students rated the overall satisfaction with hybrid learning model and the MCPB modules as highly satisfactory (4.09 ± 1.19). Students rated the appropriateness of the MCPB content highly satisfactory (4.05 ± 0.95), suggesting that the material was well-aligned with course objectives. The MCPB modules were also perceived as interesting (3.95 ± 1.13), and students felt they contributed to their problem-solving abilities (4.00 ± 1.19) and understanding of the course content (4.09 ± 1.23).
The average scores in all subcategories of metacognitive awareness among medical students are presented in Table 3. The mean score on the scale was 202.93.

Variable		Mean ± SD
Categories		
	Knowledge of cognition	66.89 ± 6.61
	Regulation of cognition	136.04 ± 5.93
Subcategories of knowledge		
	Declarative knowledge	31.34 ± 8.01
	Procedural knowledge	16.06 ± 8.27
	Conditional knowledge	19.49 ± 8.54
Subcategories of regulation		
	Planning	26.79 ± 7.53
	Comprehension monitoring	27.11 ± 4.46
	Information management strategies	39.03 ± 7.41
	Debugging strategies	20.67 ± 2.64
	Evaluation	22.44 ± 4.55
Total score		**202.93** ± 6.48

Data are expressed as Mean ± SD; n=22.

Table 3. The average scores of metacognitive awareness among medical students.

The sixth-year undergraduate medical students are fully aware of their metacognition (3.98 ± 0.73). In terms of categories, knowledge of cognition and regulation of cognition are at high level: Knowledge of cognition (3.93 ± 1.06) and Regulation of cognition (3. 87± 1.07), Figure 1.

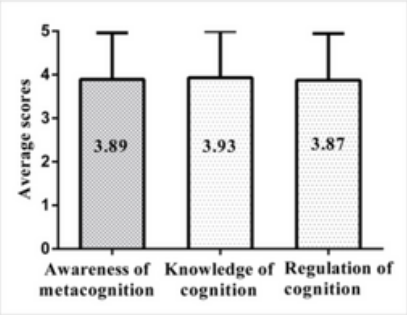

Figure 1. The average scores for awareness, knowledge and regulation of cognition in medical students using MAI Data are expressed as Mean ± SD

Furthermore, analysis of the MAI subcategories showed that students demonstrated strong procedural (mean score 4.01 ± 1.11), declarative (3.92 ± 1.01), and conditional (3.90 ± 1.12) knowledge of cognition Figure 2. And in the domain of cognition regulation, the highest score was in debugging of strategies (mean score 4.13 ± 0.15), while the lowest score was in evaluation (mean score 3.74 ± 0.25), Figure 3.

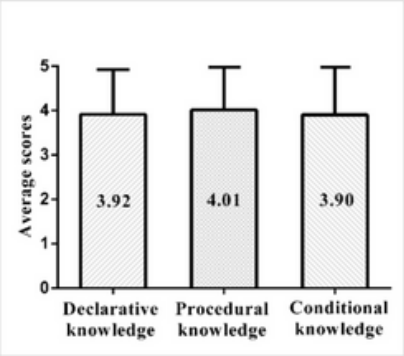

Figure 2. The average scores for subcomponents of knowledge of cognition in medical students using MAI Data are expressed as Mean ± SD

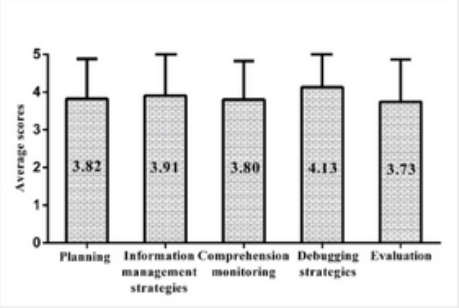

Figure 3. The average scores for subcomponents of regulation of cognition in medical students using MAI Data are expressed as Mean ± SD

DISCUSSION

The implementation of hybrid learning and MCPB modules in the curriculum for final-year medical students aims to modernize educational content and enhance the overall quality of education. Student satisfaction represents a key indicator of quality in higher education [24]. Feedback on satisfaction with this teaching approach can significantly contribute to its enhancement and the introduction of innovations in teaching methods. By promoting an engaging learning environment, we can encourage active student participation, ultimately leading to improved academic outcomes and greater professional capability.

The overall student performance was higher in the academic year 2024/25 with the implementation of the hybrid learning model compared to traditional on-site learning (9.05 ± 1.05 vs. 8.88 ± 1.01). Female students achieved higher overall GPAs, whereas male students performed better on the midterm exams (18.28 ± 1.16 vs. 18.11 ± 1.39). The previous studies have report similar results [25-28]. However, our findings are not in line with a study during COVID-19 pandemic, which reported lower GPAs among students in the hybrid teaching group [29]. In contrast, a meta-analysis by Valée et al., which included 56 studies, found that blended learning was more effective than classical on-site learning in health education [30].

This study provides additional evidence supporting the effectiveness of the hybrid learning model in medical education. Students expressed positive attitudes toward various components of the e-course, particularly emphasizing the usefulness of the MCPB modules in understanding hygiene-related content. These findings are consistent with previous studies [31,32].

However, a previous study indicated that, from an academic perspective, students may exhibit lower motivation and engagement, and interaction in hybrid courses [33]. These results contrast with those of a prospective study conducted among medical students over three academic years, involving more than 7,000 participants. That study observed that students were actively engaged in both face-to-face and online activities. Furthermore, blended learning approaches were more helpful than both only traditional face-to-face learning and e-learning only approaches, and allows students better communication with teachers [34]. This is further supported by the results of a recently published randomized study, which showed high levels of student satisfaction with electronic content, and found that students in the blended learning model reported greater overall engagement compared to those in traditional learning environments [35].

Assessing metacognitive awareness becomes an essential factor within educational environment, plays a central role in students' ability to enhanced their academic performance and accomplishment [36]. The implementation of active learning strategies, like problem-based model, among nursing students has contributed to the enhancement of generic capabilities and higher level in knowledge and regulation of cognition [37]. Furthermore, older students tend to demonstrate a higher level of knowledge related to cognitive processes [38]. Additional aim of this study was assessment of metacognitive awareness among medical students. The average score on the scale for the overall measurement of metacognitive awareness among medical students, was 202.93 (max=260), which is comparable to the score reported by Bukumirić [23]. The sixth-year undergraduate medical students demonstrated higher score in the Knowledge of cognition category, indicating an advanced ability to understand learning processes and strategies.

The previous results are not consisted. While the current findings are in line with prior research [38], they contrast with the other studies by [39-41], which report variability in metacognitive knowledge and regulation across student populations. This inconsistency underscores the need for further cross-disciplinary and longitudinal research to clarify the contextual factors influencing the development of metacognitive awareness.

Although there is no meta-analysis that directly compares categories and subcategories of metacognitive awareness among students from different academic disciplines, available studies provide valuable insight into the development of metacognitive skills within specific fields.

Conclusion

The results of this pilot study showed a positive attitude of students towards the implementation of a hybrid learning model. In summary, the integration of MCPB modules into hybrid learning systems can significantly enhance preventive medicine education. By focusing on metacognitive skills, self-regulated learning, and academic motivation, medical education can better prepare students to navigate complex modern healthcare systems, ensuring that they are prepared for both current demands and future advances in the field. This approach also facilitates inclusion in the modern concept of lifelong learning.

Study Limitations

This study has limitations that should be considered, namely the relatively small sample size and the fact that the study was conducted among sixth-year medical students enrolled in a one course (hygiene) at a single institution.

Further research involving a larger, more diverse and representative sample is needed to confirm these findings. Despite the limitations, the results offer valuable preliminary insights into the potential benefits of hybrid learning and problem-based metacognitive modules in medical education.

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