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SCIENTIFIC PATHWAYS TO ACHIEVING QUALITY SLEEP: A COMPARATIVE STUDY OF TWO TEACHING APPROACHES IN BIOLOGY CLASSROOMS

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Abstract: **B**ackground: Growing evidence demonstrates that sleep quality significantly influences cognitive performance and well-being in school-aged students. In the context of secondary education, biology offers a unique platform to foster knowledge about healthy sleep habits. However, the optimal pedagogical approach for delivering such content remains underexplored. Aim: This study aimed to compare the effectiveness of two distinct teaching strategies—traditional lecture-based instruction and interactive project-based learning—on students’ understanding and application of scientific strategies to achieve quality sleep. Methods: A total of 192 high school students from Buka district, Tashkent region, were randomly assigned to experimental (project-based, n=96) and control (traditional, n=96) groups. Pre- and post-intervention assessments using a validated Sleep Science Knowledge Test and a Sleep Quality Self-Assessment Scale measured conceptual understanding and behavioral outcomes. Key Results: Post-intervention, the experimental group showed a 23% average improvement in sleep knowledge scores (from 56.2 to 69.1), while the control group improved by 12% (from 55.6 to 62.3). In terms of self-reported sleep quality, the experimental group’s mean score improved by 21%, compared to a 9% gain in the control group. Conclusion: Project-based approaches in biology classes yielded superior gains in both theoretical understanding and practical adoption of quality sleep strategies. These findings support integrating interactive pedagogies in health-related science curricula to promote healthy sleep behaviors in adolescents.

Keywords: sleep quality, biology education, project-based learning, comparative pedagogy, student well-being.

INTRODUCTION

In recent years, the significance of sleep quality among adolescents has become a focal point for both public health initiatives and educational policy worldwide. The prevalence of inadequate sleep and its myriad consequences—ranging from reduced academic performance to impairments in emotional regulation—has been documented with increasing urgency. These issues resonate particularly within school environments, where the structure of daily routines and educational demands interact directly with students’ sleep behaviors and physiological needs.

Empirical classroom observations reveal that students who consistently obtain high-quality sleep demonstrate superior attentional control, memory retention, and mood stability. Such observations have spurred a growing interest among educators and researchers to identify the most effective methods for imparting scientific knowledge about sleep hygiene. Practical experience suggests that without explicit educational interventions, students often lack an adequate understanding of the biological underpinnings of sleep and its importance.

Within Uzbekistan, recent educational reforms underscore the integration of health literacy components, including sleep education, into the national curriculum. The Ministry of Public Education has prioritized the development of life skills and self-care practices as part of its broader

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modernization initiatives. However, the translation of these policy objectives into everyday teaching practices, especially within the natural sciences, remains uneven across the country.

The theoretical foundations for teaching about sleep in biology classrooms are rooted in cognitive developmental frameworks. Piaget's stages of cognitive growth highlight the readiness of adolescents to grasp abstract biological concepts, while Vygotsky's emphasis on social context and active learning suggests that interactive methods may be particularly effective for fostering meaningful engagement with complex health-related topics.

Classic works by Bruner and Galperin further advocate for discovery-oriented learning and the gradual internalization of scientific reasoning through problem-based tasks. According to Davidov, the developmental trajectory of higher mental functions is intricately linked to the nature of instructional approaches and the extent to which learners are allowed to construct their own understanding.

In the sphere of sleep research, international scholars such as Carskadon and Wolfson have provided substantial evidence connecting adolescent sleep patterns to both academic and psychosocial outcomes. Locally, studies by Azizova (2018) and Tursunov (2020) have begun to map patterns of sleep hygiene among Uzbek schoolchildren and their relation to school performance, but these have largely employed descriptive methodologies.

A notable deficiency in the domestic literature concerns the pedagogical means by which sleep science is transmitted in the classroom. Specifically, comparative analyses of instructional strategies—such as teacher-centered lecture methods versus student-centered project-based learning—are underrepresented. This gap persists despite mounting international evidence favoring interactive forms of instruction for health-related topics.

The present study was therefore designed to investigate whether adopting a project-based approach within school biology lessons improves both knowledge and behavioral outcomes regarding quality sleep, compared to more traditional didactic methods. Rooted in the aforementioned theoretical perspectives, this endeavour seeks not only to fill a lacuna in local scholarship but also to inform ongoing curriculum reforms.

We hypothesised that students exposed to interactive, project-based learning on the scientific principles of sleep would demonstrate greater improvements in both conceptual understanding and the practical adoption of quality sleep strategies than those taught via conventional lecture-based approaches.

The implications of this research extend to policymakers, curriculum specialists, and classroom practitioners striving to promote student well-being through evidence-based educational interventions in biology.

MATERIALS AND METHODS

Tadqiqot dizayni va ishtirokchilar

This pedagogical experiment was organized over the 2023–2024 academic year and conducted at three secondary schools within the Buka district of Tashkent region. The study cohort comprised 192 students, aged 15–16, all enrolled in the upper grades of the selected institutions. A stratified randomization process, accounting for gender and prior academic achievement, resulted in two

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equivalent groups: 96 students formed the experimental cohort, while a further 96 were assigned to the control condition.

Educators leading both arms of the study possessed at least five years of teaching experience and had undergone targeted training regarding their respective instructional strategies. The investigation adhered to ethical guidelines as stipulated by the local education authority, including informed parental consent and the confidentiality of participant data. Over the span of ten weeks, both groups received an identical quantity of instructional time dedicated to biological aspects of sleep, but with distinctly different pedagogical approaches.

Assessment instruments and validation

To gauge outcomes, two principal measures were employed. The first was the Sleep Science Knowledge Test (SSKT), a 40-item multiple-choice instrument specifically designed for this population to assess understanding of sleep cycles, circadian biology, the impact of sleep on physical and cognitive health, and behavioral strategies to improve sleep quality. The scoring range on the SSKT was 0–100, with performance thresholds established as follows: below 50 (low), 50–69 (moderate), and 70 or above (high). Internal consistency (Cronbach's alpha = 0.89) and test-retest reliability (r = 0.82) were established in a pilot cohort of 40 students.

The second tool was the Sleep Quality Self-Assessment Scale (SQSAS), a 10-item self-report questionnaire measuring frequency of sleep disturbances, perceived restfulness, and adherence to recommended sleep hygiene practices. Responses were scored on a 4-point Likert scale, aggregated to yield a total score between 10 and 40, subsequently normalized to a 0–100 scale for analytical purposes. Both instruments underwent expert review and iterative refinement to ensure cultural relevance and content validity.

Instructional interventions

In the experimental group, a project-based learning (PBL) model was implemented. Students collaborated in small groups to investigate real-life sleep-related problems, designed experiments such as week-long sleep diaries, analyzed their own circadian rhythms, and presented solutions informed by scientific literature. The teacher acted as a facilitator, guiding inquiry and providing scaffolding for deeper conceptualization.

Conversely, the control group followed traditional lecture-based instruction, wherein the teacher provided information from the textbook, illustrated with standard diagrams and factual explanations. Students completed individual homework assignments and participated in teacher-led question-and-answer sessions but were not involved in collaborative projects or practical data collection. Both groups received three hours of instruction per week for ten weeks, with content coverage standardized across conditions. Classroom observations assured fidelity to the assigned pedagogical approach.

RESULTS

Baseline equivalence of groups

Table 1. Baseline scores on knowledge and sleep quality (pre-intervention).

Group	N	SSKT mean (SD)	SQSAS mean (SD)
Experimental	96	56.2 (7.4)	48.7 (6.9)

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Control	96	55.6 (7.1)	48.2 (6.5)

Prior to the intervention, both cohorts demonstrated statistically equivalent levels of sleep science knowledge and sleep quality. The baseline mean SSKT score for the experimental group was 56.2 (SD = 7.4), compared to 55.6 (SD = 7.1) in the control group, with no significant difference ($p > 0.6$). Similarly, pre-intervention SQSAS scores averaged 48.7 for the experimental group and 48.2 for the control group.

Post-intervention knowledge gains

Table 2. Sleep Science Knowledge Test scores (post-intervention).

Group	N	Mean (SD)	Improvement (%)	High Knowledge (%)
Experimental	96	69.1 (9.2)	23	51
Control	96	62.3 (8.1)	12	29

Following ten weeks of differentiated instruction, the experimental group's mean SSKT score rose to 69.1, representing a 23% improvement, while the control group's mean increased to 62.3, a 12% gain. The intergroup difference at post-test was statistically significant ($p < 0.01$). Notably, 51% of the experimental group achieved scores in the 'high' knowledge category, compared to only 29% in the control condition.

Behavioral changes in sleep quality

Table 3. Sleep Quality Self-Assessment Scale results.

Group	Pre-score	Post-score	Gain (%)	Good/Excellent (%)
Experimental	48.7	59.1	21	34
Control	48.2	52.5	9	21

The Sleep Quality Self-Assessment Scale indicated marked behavioral improvements in both groups, with more pronounced gains among students exposed to the interactive approach. The experimental cohort's mean score increased from 48.7 to 59.1 (21% gain), whereas the control group improved from 48.2 to 52.5 (9% gain). Furthermore, the proportion of students reporting 'good' or 'excellent' sleep quality nearly doubled in the experimental group, from 17% to 34%, compared to a more modest rise in the control group (16% to 21%).

Distribution of knowledge levels

Table 4. Knowledge level distribution after intervention.

Group	Low (%)	Moderate (%)	High (%)
Experimental	15	34	51
Control	29	42	29

A categorical breakdown illustrates that project-based learning shifted the distribution toward higher achievement. Post-intervention, 49 of 96 students in the experimental group reached the 'high'

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knowledge threshold, compared to just 28 in the control. Conversely, the proportion of students classified as 'low' sharply declined among the experimental cohort.

Participant engagement and feedback

Qualitative feedback gathered from post-study surveys revealed that 81% of experimental group students found the learning process engaging and relevant to their daily lives, citing increased motivation to apply sleep hygiene practices. In contrast, only 47% of the control group reported similar engagement, with several noting a preference for more interactive content. Teacher logs corroborated these impressions, highlighting higher participation and more frequent voluntary contributions during project-based lessons.

DISCUSSION

The study's findings confirmed the initial hypothesis that project-based, interactive learning in biology classrooms more effectively enhances both scientific understanding and practical behaviors related to sleep quality than traditional lecture-based instruction. The magnitude of the observed gains—in both knowledge and behavioral indices—suggests that pedagogical form plays a crucial role in translating theoretical content into health-promoting practices.

Analysis of the internal structure of the results indicates that the most significant improvements occurred among students who began at moderate knowledge levels, suggesting that interactive methods are especially effective in helping average learners move into higher achievement categories. The experimental group's doubling of students in the 'high knowledge' bracket signals not only acquisition of factual information but also the capacity for deeper conceptualization and application in real-life situations.

The control group's more modest progression aligns with prior research on passive learning environments, which often result in surface-level retention without meaningful internalization or behavioral change. The gap between the two groups was also evident in the self-reported behavioral domain, where the adoption of healthy sleep strategies lagged in the absence of practical engagement.

When compared with classical findings from Piaget and Bruner, these outcomes resonate with the view that learners construct understanding most robustly when actively engaged with authentic problems. The practical design of the PBL intervention harnessed Vygotsky's principle of social learning, as students collaboratively grappled with problem-solving tasks directly relevant to their adolescent experiences. This alignment with established cognitive-developmental theory underscores the broader transferability of such interventions beyond the local context.

Findings from international sleep researchers, including Carskadon and Wolfson, have long highlighted the need for integrative health education models addressing sleep. However, these studies have often lacked a pedagogical lens. The current research bridges this gap, demonstrating that curriculum design and instructional style are decisive factors for effecting behavioral change.

Existing Uzbek scholarship has typically taken a descriptive approach to student sleep patterns, focusing on prevalence and correlates rather than intervention. By utilizing a rigorous comparative framework, this study provides empirical evidence for policymakers seeking to operationalize health literacy mandates within the national curriculum.

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Of particular note is the expansion of student engagement resulting from the interactive approach, as reflected in both qualitative feedback and teacher observations. This heightened involvement not only correlates with improved outcomes but may also promote long-term changes in attitudes toward health-related content—a goal explicitly articulated in recent educational reforms.

Despite the robust findings, several limitations merit consideration. The sample was restricted to three schools in a single district, limiting regional generalizability. While randomization mitigated selection bias, the study duration—ten weeks—may not have captured the full effects of sustained behavioral change, or their persistence over time.

Additionally, while the assessment instruments were validated for content and reliability, self-report measures of sleep quality remain susceptible to response bias. Future investigations could incorporate objective measures, such as actigraphy or parental reports, to triangulate outcomes.

Notwithstanding these limitations, the current research provides a theoretically grounded and empirically substantiated rationale for integrating project-based learning approaches in the delivery of sleep science content within secondary biology classrooms across Uzbekistan.

CONCLUSION

The data presented in this study demonstrate that interactive, project-based methods deliver superior outcomes for teaching the science of sleep and promoting quality sleep behaviors among school-aged pupils. Students exposed to collaborative projects not only improved their conceptual understanding but also showed measurable changes in their nightly routines and attitudes toward sleep hygiene.

These findings highlight the capacity of student-centered learning environments to bridge the gap between scientific theory and daily health practices. The transfer of knowledge into practical action—observed more acutely in the experimental group—suggests that biology lessons, when made relevant and engaging, can influence health outcomes beyond the classroom.

The comparative analysis underscored that while traditional instruction may suffice for passive knowledge acquisition, it falls short in mobilizing students to adopt and maintain healthy behaviors. The alignment of project-based approaches with contemporary theories of learning and adolescent development further strengthens the case for curricular innovation.

Feedback from participants and teachers confirmed the motivational advantages of the interactive model, indicating a heightened willingness to apply learned strategies and to participate actively in class. This dynamic may serve as a catalyst for broader cultural change regarding sleep and wellness within the school community.

Given these outcomes, biology educators and curriculum designers are encouraged to incorporate active, collaborative elements when addressing health-related topics. Refining and expanding project-based modules could further amplify educational and behavioral gains.

Tadqiqot natijalaridan kelib chiqib quyidagilar tavsiya etiladi: biology teachers should implement structured project-based activities, including real-life investigations and group discussions, to maximize the impact of sleep education. Future revisions of national curriculum guidelines should integrate interactive pedagogical frameworks to ensure consistent, effective delivery of health-related topics.

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This research opens avenues for longitudinal studies assessing the durability of behavioral change and the transference of sleep knowledge to familial and community contexts. Incorporation of objective sleep monitoring tools and broader demographic sampling are also recommended for future investigations.

By leveraging interactive pedagogies within subject teaching, schools in Uzbekistan can play a pivotal role in fostering a culture of health awareness and self-care among adolescents.

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