Bulletin
of the Jusup Balasagyn
Kyrgyz National University

Vol. 17 | №4 | 2025

Journal homepage:
https://balasagynbulletin.com/en

UDC 37.026:573/577(510)
DOI: 10.58649/1694-8033-2025-4(124)-65-73

Received: 09.06.2025
Revised: 07.11.2025
Accepted: 15.12.2025

Teaching biology in China: Between Confucian heritage and STEM modernisation

Asel Shaiyldaeva*

PhD in Sociological Sciences, Associate Professor
Jusup Balasagyn Kyrgyz National University
720033, 547 Frunze Str., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0003-6412-829X

Awuti Nuermaimaitti

Master's Student
Kyrgyz State University named after I. Arabaev
720026, 51-A I. Razzakov Str., Bishkek, Kyrgyz Republic
https://orcid.org/0009-0001-7024-3169

Abstract. The relevance of this study is determined by the fact that biology has become one of the key subjects of STEM modernisation in China, as the country's strategic priorities – biotechnology, medicine, genetics, food security, and ecology – are concentrated within this field. These national goals require a new model of biology education that is shifting from an exam-oriented system toward a research-based, interdisciplinary, and technologically enhanced learning environment. The purpose of the study was to analyse how the integration of STEM approaches, digitalisation, and Confucian cultural traditions jointly influence the teaching of biology in China and shape a unique hybrid educational model. The methodology was based on a qualitative comparative analysis of policy documents, curriculum standards, and scholarly publications by Chinese and international researchers, as well as a content analysis of reforms related to STEM integration, digital tools, and the transformation of pedagogical practices. The findings showed that biology has become central to STEM education not by accident but because it provides interdisciplinary links with medicine, chemistry, mathematics, engineering, and environmental science. It was established that Chinese schools and universities are increasingly adopting project-based learning, digital simulations, virtual laboratories, and the integration of biology with big-data analysis and engineering tasks. At the same time, Confucian values – discipline, respect for teachers, and moral norms – continue to shape interaction styles and student motivation, creating a balance between innovation and tradition. Additional systemic challenges were identified, including reduced laboratory practice, a shortage of teachers with research competencies, and digital inequality across regions. The practical significance of the study lies in its potential application in curriculum development, the modernisation of biology teaching, and the adaptation of STEM approaches in countries seeking to harmonise cultural traditions with innovative educational practices

Keywords: biology education; educational reforms; digital technologies; cultural context

INTRODUCTION

Modern educational systems are increasingly required to prepare learners for emerging technological, biomedical, and environmental challenges, which enhances the importance of science education. Recent academic literature emphasises that the integration of STEM (Science, Technology, Engineering, Mathematics) approaches has become one of the key directions of educational modernisation in many countries, including China (Golegou & Peppas, 2025). STEM is viewed not only as a teaching method but as a comprehensive educational framework aimed at fostering critical thinking, research skills, digital literacy, and the ability to work in interdisciplinary environments. Studies published

Suggested Citation:

Shaiyldaeva, A., & Nuermaimaitti, A. (2025). Teaching biology in China: Between Confucian heritage and STEM modernisation. *Bulletin of the Jusup Balasagyn Kyrgyz National University*, 17(4), 65-73. doi: 10.58649/1694-8033-2025-4(124)-65-73.

*Corresponding author

over the past few years, like the one by V. Županec *et al.* (2022), indicate that the effectiveness of STEM education largely depends on its implementation within specific subject areas, particularly biology. Biology is considered a strategically important discipline, as it underpins China's priority development areas such as biotechnology, genetic engineering, medicine, pharmacology, food security, and environmental protection. Research also demonstrates that biology has a high potential for integrating engineering tasks, mathematical modelling, digital technologies, and big data, making it one of the most suitable subjects for the implementation of STEM approaches (Avci *et al.*, 2025).

Digitalisation plays a significant role in transforming education and has become a major direction of Chinese educational reforms. The Education Informatisation 2.0 Action Plan (Ministry of Education, 2018) highlighted the need to develop digital competencies and implement online platforms, virtual laboratories, and intelligent learning systems. C. Papaneophytou & S. Nicolaou (2025) confirmed that digital technologies greatly facilitate the study of biology by enabling the modelling of complex biological processes, the use of interactive simulations, and improved access to laboratory tools. This is particularly important for regions with limited resources, where virtual laboratories compensate for the lack of physical equipment (Sipii *et al.*, 2024). The integration of STEM into biology education in China is also directly linked to national educational reforms. Among the key policy documents are China's Education Modernisation 2035 Plan (2019), the updated Biology Curriculum Standards for High Schools (Yu *et al.*, 2022), and the Digital Education Strategic Action Plan (Ministry of Education, 2025). These documents outline a strategic shift toward developing research competencies, scientific literacy, and modernising the content of biology education. Recent studies show that these reforms aim to move away from exam-centred learning toward practice-oriented, project-based, and interdisciplinary instructional models.

However, contemporary academic literature also highlights several barriers to the development of STEM-oriented biology education. According to K. Tzafilkou *et al.* (2022), key challenges include a shortage of teachers with competencies in digital and engineering technologies, a lack of practice-oriented learning resources, and substantial digital inequality between urban and rural schools. Additionally, researchers emphasise the influence of cultural factors – primarily Confucian pedagogical traditions, which maintain an emphasis on discipline, respect for teachers, and high academic achievement (Marinette & Hui, 2021). These values shape the characteristics of the Chinese educational environment and influence the pace and nature of innovation.

Analysis of recent studies shows that biology education in China is shaped by three major groups of factors: (1) governmental reforms and regulatory documents, (2) digital technologies that transform approaches to practical learning, and (3) cultural traditions that define teacher–student interaction. This combination creates a unique educational model in which innovation is integrated with long-standing cultural norms. The purpose of this study was to analyse contemporary trends in biology teaching in China, including the integration of STEM approaches, the impact of digitalisation, and the role of cultural factors in shaping the modern educational model.

MATERIALS AND METHODS

This study is theoretical and analytical in nature and was conducted between January and May 2025. The methodological framework was based on qualitative content analysis, comparative analytical methods, and consensus-based thematic grouping. To identify and select relevant sources, the following academic databases were consulted: Scopus, Web of Science, ScienceDirect, and CNKI, supplemented by open-access repositories such as ResearchGate and official platforms of the Ministry of Education of the People's Republic of China. The search was conducted using the following keywords: "STEM education", "biology teaching China", "Confucian heritage education", "digital biology education", and "biology curriculum reform China". The publication period was limited to 2018-2025 to ensure the inclusion of the most recent studies reflecting current trends in biology education. Inclusion criteria: thematic relevance (STEM, biology education, digitalisation, educational policy); presence of empirical findings or a clearly articulated theoretical framework; publication in a peer-reviewed academic journal; availability of full text. Exclusion criteria: duplicate materials; studies not related to biology or digital education; publications lacking identifiable authorship or complete bibliographic information.

Qualitative content analysis was employed to identify major directions in the development of biology education in China. The analysis focused on conceptual approaches, pedagogical models, curricular elements, and research findings presented in the selected publications. This method made it possible to reveal recurring thematic structures across works by different scholars. To enhance the reliability of analytical conclusions, a consensus-based thematic grouping approach was applied. This method involved comparing the findings of multiple studies and identifying thematic categories consistently confirmed across the majority of included sources. The use of thematic consensus helped to minimise subjective interpretation and ensured coherence in the classification of the data. Application of the consensus approach made it possible to confirm four key thematic domains: the influence of Confucian educational traditions; the integration of STEM into biology teaching; methodological transformations in school and university curricula; the role of digital technologies and virtual laboratories in the modernisation of biology education.

The comparative analytical method was applied to contrast different approaches found in the literature, identify shared tendencies, and reveal distinctions across educational levels and regions in China. Based on the synthesis of content analysis results and consensus-derived thematic categories, the table was developed, which summarises the key characteristics of the contemporary model

of biology teaching in China and represents the combined outcome of content analysis, thematic consensus, and comparative assessment of the sources. In conclusion, the methodology employed in this study was grounded in a systematic and reproducible research design, integrating qualitative content analysis, consensus-based thematic grouping, and comparative analytical procedures. This combination ensures the objectivity and credibility of the obtained results and provides a solid foundation for interpreting the current state and development trends of biology education in China.

RESULTS AND DISCUSSION

Structural shifts in biology education: Curriculum reform, STEM integration, and digital transformation

The analysis of the literature demonstrates that the transformation of biology education in China is driven by a combination of nationwide curriculum reforms, the strategic incorporation of STEM-based pedagogies, and the rapid expansion of digital learning tools. Through qualitative content analysis and consensus-based thematic grouping, several recurring structural trends were identified across policy documents, empirical research, and case studies. According to X. Lin *et al.* (2023), X. Wei *et al.* (2024), these trends reflect the overall direction of China's educational modernisation and form the foundation of the systemic shift from exam-oriented knowledge reproduction toward inquiry-driven and competency-based learning. A central finding concerns the revision of national biology curriculum standards and the increased emphasis on scientific literacy, higher-order thinking, and interdisciplinary competencies. The Biology Curriculum Standards for High Schools situate biology as a key discipline for national scientific and technological development, highlighting its connection to biotechnology, genetics, environmental sustainability, and health (Yu *et al.*, 2022). Research conducted by S. Lin *et al.* (2023) confirms that the updated curriculum encourages students to engage in hypothesis formulation, experimentation, and interpretation of scientific evidence rather than memorising factual content.

Digital transformation reinforces this shift. Several studies note that virtual laboratories, digital microscopes, online simulations, and AI (artificial intelligence) supported learning platforms now play an essential role in biology education (Ma *et al.*, 2025; Thanh *et al.*, 2025). These tools expand access to experimental work – particularly in rural or underfunded regions – and facilitate the visualisation of complex biological processes such as genetic mutations, ecological interactions, and cellular dynamics. The prominence of digital learning aligns with the goals outlined in Education Informatisation 2.0 (Ministry of Education, 2018), which emphasised the construction of "intelligent learning environments" across the country. Recent scholarship further underscores that effective large-scale implementation of digital tools in higher and secondary education demands systematic, multi-stage planning rather than ad-hoc adoption. M. Vaintraub *et al.* (2025) propose a comprehensive framework comprising needs analysis, teacher digital upskilling, curriculum modernisation, creation of dedicated electronic resources, and continuous evaluation and optimisation. Their model exhibits strong parallels with China's ongoing efforts to build sustainable digital biology education ecosystems, particularly in addressing teacher training deficits and regional digital inequality highlighted in the present study. The synthesis of these studies reveals that the transformation of biology education in China follows several recurring structural patterns. These patterns were refined using a consensus-based thematic grouping approach, allowing the identification of trends validated by multiple independent sources. The consolidated thematic categories are presented in Table 1.

Table 1. *Key features and emerging trends in biology education in China*

Feature/Trend	Description
Curriculum reform and competency orientation	National reforms emphasise inquiry, scientific literacy, and core competencies over rote memorisation.
Integration of STEM and interdisciplinary approaches	Biology teaching incorporates STEM concepts and links biology with mathematics, engineering, and environmental science.
Digital learning technologies and virtual laboratories	Simulations, massive open online courses (MOOCs), and virtual labs expand access to experimentation and enhance inquiry-based learning.
Transition from teacher-centred to student-centred instruction	Confucian respect for teachers persists, but project-based learning and collaborative methods are increasingly adopted.
Cultural context and examination pressure	Exam orientation creates tension with STEM practices; Confucian values influence student motivation and discipline.

Source: *compiled by the authors based on consensus thematic analysis*

In summary, the contemporary model of biology education in China is characterised by a clear shift towards competency-based, inquiry-driven and interdisciplinary learning, underpinned by systematic curriculum reform, deep integration of STEM elements, widespread adoption of virtual laboratories and digital tools, and a gradual transition to more student-centred practices. Although Confucian-inspired discipline and examination pressures remain influential, they increasingly coexist with innovative pedagogies, producing a distinctive hybrid framework that balances global modernisation trends with deeply rooted cultural norms.

Confucian heritage, examination culture, and STEM pedagogies: Interaction, tension, and hybridisation

Beyond structural reforms, several deeper cultural and pedagogical tensions shape the adoption of STEM pedagogies in China. As shown by Y. Liang & K. Matthews (2022), Confucian values – discipline, respect for authority, and moral development – continue to influence classroom interactions and define expectations for both teachers and students. At the same time, research indicates that these values may support STEM implementation by fostering persistence, responsibility, and strong work ethics during scientific inquiry (Davis *et al.*, 2020; Nguyen *et al.*, 2025). However, despite this potential alignment, significant contradictions remain. Studies by C. Tan (2019) have shown that the exam-oriented culture, deeply rooted in Confucian educational traditions, poses one of the most serious challenges, as high-stakes standardised testing encourages memorisation rather than creative inquiry. This tension is further reflected in findings suggesting that teachers often struggle to balance exam preparation with the need to adopt open-ended, project-based methods encouraged by STEM reforms (Wang, 2022).

Chinese schools navigate these tensions by adopting hybrid instructional models. STEM elements – such as project-based modules, interdisciplinary research tasks, and digital experiments – are frequently introduced through elective courses and extracurricular science clubs, while core curriculum hours remain aligned with examination standards. This gradual integration reflects what H. Ma *et al.* (2025) describe as the transformation of STEM education in China into a form of "praxis" shaped by sociocultural conditions rather than merely technical reform. The role of teachers is also undergoing transformation: recent studies highlight that effective educators combine Confucian authority with modern facilitation techniques, creating a hybrid teaching style that preserves structure while promoting collaboration, experimentation, and student agency (Tan, 2019; Wang, 2022). This hybrid approach distinguishes Chinese classrooms from Western constructivist models and from the highly exam-driven systems of Japan, South Korea, and Singapore.

A comparative analysis helps illuminate the uniqueness of China's hybrid educational model. As J. Xiao & J. Zhang (2022) note, China's approach to STEM modernisation differs from Western models by attempting to integrate high academic performance expectations with rapid digital transformation, interdisciplinary learning, and research-oriented instruction. Unlike Japan and South Korea, where strict examination systems often limit exploratory learning, China seeks to blend exam preparedness with innovative pedagogical practices, especially through digital platforms and large-scale technological modernisation. A similar pattern of culturally sensitive adaptation of foreign educational models can be observed in other national contexts undergoing rapid modernisation. For instance, Yu. Lukashevych & I. Popozohlo (2024) demonstrate that successful transfer of European vocational education practices is only feasible when cultural, economic and institutional differences are explicitly taken into account and hybrid solutions are designed. This finding reinforces the broader observation that global STEM-oriented reforms rarely succeed through direct transplantation; instead, they require deliberate hybridisation with local pedagogical traditions and systemic constraints – a process clearly evident in China's integration of STEM methodologies with Confucian educational heritage. This combination produces a distinctive model in which traditional cultural norms coexist with emerging digital pedagogies. The contradictions identified through consensus-based thematic grouping – such as the tension between examination pressure and inquiry-based learning, or between traditional teacher authority and student autonomy – are synthesised in Table 2.

Table 2. *Key contradictions in biology education reform in China and strategies for resolution*

Critical challenge/ contradiction	Traditional model (Confucian values/exam system)	STEM modernisation requirements	Synthesis/resolution in China
Examination pressure vs. inquiry-based learning	Emphasis on memorisation and standardised testing	Need for experimentation, creativity, open-ended tasks	Hybrid curricula combining exam prep with STEM electives and research modules
Teacher authority vs. learner autonomy	Teacher as moral authority and central figure	Teachers as facilitators, mentors, collaborators	Dual-role pedagogy balancing authority with student-centred research
Limited laboratory access vs. need for practical inquiry	Resource limitations, especially in rural regions	Hands-on experiments, data analysis, complex modelling	Digital labs, simulations, mobile science units, national investments in infrastructure
Cultural continuity vs. innovation	Preservation of stable moral norms and discipline	Integration of AI, digital tools, interdisciplinary thinking	Cultural adaptation of STEM – innovation introduced without discarding tradition

Source: *authors' analytical synthesis based on consensus analysis of contemporary STEM-biological education literature*

The combined results indicate that the modernisation of biology education in China constitutes not simply a pedagogical reform but a systemic reorientation of the entire educational framework. The integration of STEM, digital tools, and interdisciplinary connections positions biology as a strategically important discipline for technological and scientific development. These findings hold several implications. First, Chinese reforms show that educational modernisation does not require abandoning cultural traditions. As X. Li & F. Wei (2023) argue, Confucian values can

coexist with STEM methodologies, providing stability and ethical grounding for scientific inquiry. Second, the hybrid resolution of the exam – STEM contradiction offers a model applicable to countries facing similar structural tensions. As demonstrated by national policy frameworks such as China's Education Modernisation 2035 Plan (2019) and the Digital Education Strategic Action Plan (Ministry of Education, 2025), gradual integration allows innovation to be adopted without destabilising existing systems. Third, China's experience highlights the necessity of aligning curriculum, teacher development, and digital infrastructure under a coherent national strategy. The combination of curriculum reform, technological investment, and cultural adaptation results in a distinctive, sustainable, and scalable model of biology education. Fourth, digital laboratories and shared online resources help address regional inequalities, illustrating a pathway that may be particularly relevant for developing countries (Wei *et al.*, 2024; Peng *et al.*, 2025). Finally, this study contributes to international discussions on how cultural frameworks mediate the implementation of STEM. China's case suggests that innovation rooted in cultural continuity can produce a resilient and balanced educational model.

Policy- and practice-oriented recommendations based on analytical findings

The analytical synthesis of structural reforms, cultural dynamics, and pedagogical transformations reveals several actionable directions for strengthening the development of biology education in China. These recommendations follow directly from the identified contradictions – particularly the tension between examination culture and inquiry-based learning, the uneven integration of digital technologies, and the changing role of teachers. The proposed measures emphasise system-level coherence and long-term sustainability, ensuring that educational modernisation benefits all learner groups. One of the pressing needs highlighted by the findings is the restoration and expansion of practical laboratory training. Although digital laboratories and simulations significantly improve access to experimental work, particularly in rural regions, they cannot fully replace hands-on biological investigation. Strengthening practical training requires coordinated investments: upgrading laboratory infrastructure, increasing funding for consumable biological materials, and encouraging schools to establish partnerships with local research institutes. Such measures would address the current imbalance between digital and physical experimentation and ensure deeper scientific literacy. This recommendation is grounded in the literature showing that hybrid experimentation – virtual plus physical – produces the strongest learning outcomes by combining conceptual clarity with procedural competence.

Equally important is the professional development of teachers, who serve as the mediating link between Confucian educational norms and modern STEM pedagogy. The analysis indicates that teachers capable of combining disciplinary authority with facilitation skills are the most effective in implementing inquiry-based instruction. Consequently, national and regional educational authorities should expand long-term training programs focusing on digital literacy, interdisciplinary teaching strategies, and project supervision. These programs should go beyond technical upskilling and incorporate reflective practice, peer learning networks, and mentoring systems. Such teacher development initiatives will help bridge the gap between traditional instructional models and innovative pedagogical requirements. The third priority concerns the reform of evaluation and assessment systems. The current reliance on high-stakes standardised examinations creates a structural contradiction with the aims of STEM-oriented biology education. A more holistic assessment framework is needed – one that values creativity, collaboration, ethical reasoning, and research skills. Incorporating formative assessments, scientific portfolios, inquiry reports, and project-based evaluation would align testing practices with the competencies emphasised in national reforms. Such an approach would help resolve the conflict between examination pressure and authentic scientific learning, offering students a more balanced and motivating educational environment. Addressing digital inequality is another crucial recommendation derived from the findings. While large urban schools benefit from advanced educational technologies, many rural institutions struggle with unstable internet access or outdated equipment. Targeted policy interventions – mobile science units, subsidised devices, cloud-based laboratory simulations, and centrally maintained digital resource platforms – can help reduce these disparities. Ensuring equitable access to digital tools is essential for maintaining national cohesion in STEM modernisation and preventing long-term regional divides in scientific education. Finally, the analysis underscores the need for stronger coordination between policy documents, curriculum reforms, and school-level implementation. Although national strategies such as China's Education Modernisation 2035 Plan (2019) and the Digital Education Strategic Action Plan (Ministry of Education, 2025) provide a clear vision, their application at the institutional level remains uneven. Establishing monitoring frameworks, offering implementation guidelines, and supporting data-driven decision-making will help schools interpret policy directives consistently and adapt them to local conditions. Enhanced coordination will also enable the systematic sharing of best practices, further strengthening the hybrid educational model that blends Confucian cultural continuity with global scientific innovation.

CONCLUSIONS

The findings of this study demonstrate that the modernisation of biology education in China is shaped by the interaction of three core forces: nationwide policy reforms, rapid digital transformation, and the enduring influence of Confucian educational values. The analysis confirms that biology has become a central discipline within China's STEM agenda, enabling the integration of biotechnology,

ecological literacy, data analysis, and interdisciplinary problem-solving into school and university curricula. A key scientific result of this study is the identification of a hybrid pedagogical model in which inquiry-based, technologically enhanced instruction coexists with culturally rooted norms of discipline, respect, and academic rigor. The study also reveals several structural contradictions that continue to shape the evolution of biology education. The most prominent tensions include the persistence of exam-oriented assessment, uneven access to laboratory resources, and the shortage of educators trained in both digital technologies and research-oriented pedagogies. These challenges explain why many institutions adopt hybrid strategies – combining exam preparation with STEM electives, virtual laboratories, and project-based learning modules. Such approaches illustrate China's capacity to adapt innovations without disrupting cultural continuity. The significance of these results lies in showing that educational modernisation in China is not merely technological; it reflects a deeper systemic shift toward competency-based learning aligned with national scientific priorities. The findings offer practical implications for policy design, suggesting that sustainable reform requires synchronised development of curriculum standards, assessment models, and teacher training. Future research should further examine the long-term effectiveness of hybrid STEM-Confucian models, investigate regional inequalities in resource access, and evaluate how digital laboratories can complement hands-on experimentation. Comparative studies across Asian and Western contexts would also help clarify the global applicability of China's emerging educational framework.

ACKNOWLEDGEMENTS

The authors confirm that the article was prepared independently and that no external assistance or consultancy was involved in the development of this research.

FUNDING

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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Кытайда биологияны окутуу: Конфуцийдин мурасы менен STEM-модернизациянын ортосунда

Асель Шайылдаева

Социология илимдеринин кандидаты, доцент
Ж. Баласагын атындагы Кыргыз улуттук университети
720033, Фрунзе көч., 547, Бишкек ш., Кыргыз Республикасы
https://orcid.org/0009-0003-6412-829X

Авути Нуэрмаймаитти

Магистрант
И. Арабаев атындагы Кыргыз мамлекеттик университети
720026, И. Раззаков көч., 51-А, Бишкек ш., Кыргыз Республикасы
https://orcid.org/0009-0001-7024-3169

Аннотация. Бул изилдөөнүн актуалдуулугу Кытайда биология сабагы STEM-модернизациясынын негизги багыттарынын бирине айлангандыгы менен түшүндүрүлөт. Анткени өлкөнүн стратегиялык артыкчылык берген тармактары – биотехнология, медицина, генетика, азык-түлүк коопсуздугу жана экология – түздөн-түз биологиялык билимге таянат. Улуттук өнүгүү максаттары биологияны окутуунун жаңы моделин талап кылууда, ал экзаменоцентризмден изилдөөгө багытталган, междисциплинардык жана санариптик технологиялар менен камсыздалган билим берүү чөйрөсүнө өтүүнү шарттайт. Изилдөөнүн максаты – STEM ыкмасынын интеграциясы, санариптештирүү жана конфуцийчилик билим берүү салты Кытайда биология сабагын окутууга кандай таасир этерин жана алар биргелешип кандайча уникалдуу гибриддүү билим берүү моделин түзөрүн талдоо. Методологиясы нормативдик документтерге, окуу программаларына, кытай жана эл аралык изилдөөлөргө жасалган сапаттык салыштырма анализге, ошондой эле STEMдин киргизилиши, санариптик куралдар жана педагогикалык тажрыйбанын өзгөрүшү боюнча контент-анализнге негизделген. Изилдөөнүн негизги жыйынтыктары биологиянын STEM тармагында борбордук орунду ээлеши кокустук эмес экенин көрсөтөт: ал медицина, химия, математика, инженерия жана экология менен тыгыз связдарын камсыз кылат. Кытай мектептери жана университеттери долбоордук окууга, санариптик симуляцияларга, виртуалдык лабораторияларга жана биологияны чоң маалыматтар жана инженердик тапшырмалар менен интеграциялоого барган сайын көбүрөөк көңүл буруп жатканы аныкталды. Ошол эле учурда конфуцийчилик баалуулуктар – тартип, мугалимге болгон урмат, адеп-ахлактык эрежелер – окуучулардын жүрүм-турумуна жана мотивациясына таасир этүүнү улантууда, натыйжада инновация менен салттуулуктун ортосунда тең салмак түзүлүүдө. Кошумча түрдө системалык көйгөйлөр да аныкталды: лабораториялык практиканын кыскарышы, изилдөө жүргүзө алган педагогдордун жетишсиздиги жана региондор ортосундагы санариптик теңсиздик. Изилдөөнүн практикалык мааниси – анын жыйынтыктарын окуу пландарын иштеп чыгууда, биологияны окутууну модернизациялоодо жана STEM ыкмасын маданий өзгөчөлүктөрдү сактоо менен айкалыштырган өлкөлөрдө колдонууга мүмкүнчүлүк түзөт

Негизги сөздөр: биологиялык билим берүү; билим берүү реформалары; санариптик технологиялар; маданий чөйрө

Преподавание биологии в Китае: между конфуцианским наследием и STEM-модернизацией

Асель Шайылдаева

Кандидат социологических наук, доцент
Кыргызский национальный университет имени Ж. Баласагына
720033, ул. Фрунзе, 547, г. Бишкек, Кыргызская Республика
https://orcid.org/0009-0003-6412-829X

Авути Нуэрмаймаитти

Магистрант
Кыргызский государственный университет имени И. Арабаева
720026, ул. И. Раззакова, 51-А, г. Бишкек, Кыргызская Республика
https://orcid.org/0009-0001-7024-3169

Аннотация. Актуальность исследования определяется тем, что биология в Китае превратилась в один из ключевых предметов STEM-модернизации, поскольку именно в этой области сосредоточены стратегические приоритеты страны – биотехнологии, медицина, генетика, продовольственная безопасность и экология. Эти национальные задачи требуют новой модели обучения биологии, которая переходит от экзаменоцентрической системы к исследовательской, междисциплинарной и технологически оснащенной образовательной среде. Цель работы заключалась в том, чтобы проанализировать, каким образом интеграция STEM-подхода, цифровизация и конфуцианская культурная традиция совместно влияют на преподавание биологии в Китае и формируют уникальную гибридную модель образования. Методология исследования основана на качественном сравнительном анализе нормативных документов, учебных программ, научных публикаций китайских и международных исследователей, а также на контент-анализе реформ, связанных с внедрением STEM, цифровых инструментов и трансформацией педагогических практик. Основные результаты показали, что биология стала центральным предметом STEM не случайно: именно она обеспечивает междисциплинарные связи между медициной, химией, математикой, инженерией и экологией. Установлено, что в китайских школах и университетах усиливается ориентация на проектное обучение, цифровые симуляции, виртуальные лаборатории и интеграцию биологии с данными больших данных и инженерными задачами. При этом конфуцианские ценности – дисциплина, уважение к учителю, морально-нравственные нормы – продолжают формировать стиль взаимодействия и мотивацию учащихся, создавая баланс между инновациями и традицией. Дополнительно выявлены системные трудности: сокращение лабораторной практики, дефицит педагогов с исследовательскими компетенциями и цифровое неравенство между регионами. Практическая значимость исследования заключается в возможности использовать его результаты при разработке учебных программ, модернизации биологического образования и адаптации STEM-подходов в странах, стремящихся совместить культурные традиции с инновационными формами обучения

Ключевые слова: биологическое образование; образовательные реформы; цифровые технологии; культурный контекст