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INTEGRATING STEAM EDUCATION IN EARLY CHILDHOOD AND PRIMARY CLASSROOMS: A COMPARATIVE ANALYSIS OF INTERNATIONAL PRACTICES

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Abstract

Science, Technology, Engineering, Arts, and Mathematics (STEAM) has become a key approach to developing 21st century skills, including problem-solving, collaboration, and critical thinking, in early childhood education. This study compares two types of educational systems, one advanced (South Korea and Singapore) and one developing (Uzbekistan, a post-Soviet country, undergoing systematic transition), as they are all dealing with their own STEAM frameworks, providing a comparative qualitative analysis of these frameworks in different educational contexts. The study draws on a range of curriculum structures, infrastructure preparedness and teacher professional development, providing a clear picture of the disparity between the most integrated, state-developed curriculum and local efforts that are hindered by resource differentials and the legacy of traditional pedagogies. The results indicate that a scalable low-cost STEAM solution, supported by structural adjustments in pedagogical training, can serve as an ideal pathway to closing these systemic gaps.

Keywords: STEAM education, early childhood education, primary school, comparative pedagogy, international practices, educational reform, low-cost STEAM.

Аннотация

Интеграция STEAM-образования (наука, технологии, инженерия, искусство и математика) в систему дошкольного и начального обучения становится ключевой стратегией формирования компетенций XXI века, таких как критическое мышление, коллаборация и навыки решения проблем. В данной статье проводится сравнительный качественный анализ структуры внедрения STEAM-подхода в различных образовательных системах: сопоставляются передовые мировые модели (Южная Корея и Сингапур) и развивающиеся образовательные системы постсоветского пространства, находящиеся в процессе системной трансформации (на примере Узбекистана). На основе анализа учебных планов, уровня материально-технической базы и профессиональной подготовки педагогов выявлены существенные различия между централизованно финансируемыми интегрированными моделями и локальными инициативами, ограниченными неравномерностью ресурсов и традиционным подходом к преподаванию. Результаты исследования показывают, что масштабирование доступных (бюджетных) STEAM-решений в сочетании со структурными изменениями в подготовке кадров является оптимальным путем для преодоления существующих системных разрывов.

Ключевые слова: STEAM-образование, дошкольное образование, начальная школа, сравнительная педагогика, международный опыт, реформа образования, бюджетный STEAM.

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Annotatsiya

Maktabgacha va boshlang‘ich ta’lim tizimiga STEAM (fan, texnologiya, muhandislik, san’at va matematika) yondashuvini integratsiya qilish XXI asr ko‘nikmalarini, xususan, tanqidiy fikrlash, jamoaviy ishlash va muammolarni hal qilish qobiliyatlarini shakllantirishning asosiy strategiyasiga aylanmoqda. Mazkur maqolada turli ta’lim tizimlarida STEAM yondashuvini joriy etish tuzilmasining qiyosiy-sifat tahlili olib borilgan: yetakchi jahon modellari (Janubiy Koreya va Singapur) hamda tizimli transformatsiya jarayonini boshdan kechirayotgan rivojlanayotgan postsovet ta’lim tizimlari (O‘zbekiston misolida) o‘zaro solishtirilgan. O‘quv rejalari, moddiy-texnik baza holati va pedagoglarning kasbiy tayyorgarlik darajasini tahlil qilish asosida davlat tomonidan markazlashgan holda moliyalashtiriladigan integratsiyalashgan modellar hamda resurslar yetishmovchiligi va an’anaviy o‘qitish usullari bilan cheklangan mahalliy tashabbuslar o‘rtasidagi jiddiy farqlar aniqlangan. Tadqiqot natijalari shuni ko‘rsatadiki, kadrlarni tayyorlashdagi tizimli o‘zgarishlar bilan bir qatorda, arzon (byudjetli) STEAM yechimlarini kengaytirish mavjud tizimli uzilishlarni bartaraf etishning eng maqbul yo‘lidir.

Kalit so‘zlar: STEAM ta’limi, maktabgacha ta’lim, boshlang‘ich maktab, qiyosiy pedagogika, xalqaro tajriba, ta’lim islohoti, kam xarajatli STEAM yechimlari .

Introduction

As the global economy becomes more complex, it is clear that the traditional, discipline-based educational models that are based on the education unit and teach subjects in blocks, are often unable to produce multidimensional skills such as critical thinking, digital literacy and creative expression. The STEAM approach is a response to these structural deficits, as it combines technical inquiry with artistic expression, and has become popular internationally. Research highlights the importance of introducing STEAM in the very early years (ages 3–7) when young children are naturally inquisitive and actively exploring their world, rather than cognitive misconceptions about the challenging work of exact sciences have set in. The educational benefits of early childhood STEAM has been widely recognised internationally, from improved sensorimotor development to project-based competency gained through collaborative learning and work, but its implementation is hugely different between countries. The goal of this research is to analyse cross-national approaches to integrating STEAM in the perspective of the innovative and established frameworks of East Asian countries in contrast to the emerging infrastructure of Uzbekistan. This analysis aims ultimately to bring together methodologies that can be implemented to assist in the transfer of elite global practices to local resource limitations for the transitional educational system.

Methodology

This paper adopts a qualitative comparative approach, relying on secondary text analysis, administrative policy reviews, and existing empirical research on international early childhood and primary education. The analysis focuses on three comparative criteria designed to evaluate systemic quality and operational sustainability:

1. Curriculum Design: The degree to which STEAM disciplines are genuinely synthesized as a cohesive, play-based approach versus treated as disparate subjects.
2. Infrastructure and Material Distribution: The availability of high-technology versus low-technology tools within educational settings.
3. Teacher Training and Professional Efficacy: The presence of structural development frameworks and the self-reported confidence of educators implementing STEAM.

Results

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1.1 Advanced Global Models: The Structural Integration of East Asia

In East Asia, STEAM has become a central aspect of national employment development and policy, most notably in South Korea and Singapore. In Korea, the Ministry of Education spearheaded the integration of sciences in a systematic way since 2011 with the creation of institutional STEAM plans and the development of STEAM teacher research communities that are continually developing cross-disciplinary toolkits. Likewise, Singapore has made STEAM central to the national curriculum guidelines, with a focus on play and inquiry-based learning and facilitating children's own experiences of learning. These areas are notable for an instance of very focused investment in dedicated makerspaces and special interactive technologies that are consistently provided for all classrooms to avoid inequity in classroom resources, for example: algorithmic toys (Bee-Bots), LEGO WeDo and introductory coding platforms (ScratchJr).

1.2 Transitional Educational Landscapes: The Case of Uzbekistan

Uzbekistan, in turn, had taken a more different route for STEAM and STEAM education spaces in schools and kindergartens are newer dimensions in fast-track national modernization reforms. In recent years, systematic steps have been taken to change the design of classrooms and to introduce interactive modeling into early childhood development in Uzbekistan, under the auspices of the Ministry of Preschool and school Education. Implementing them locally, however, is often challenging due to disparities in access to materials and continued use of teacher-led instruction. State standards encourage child-led inquiry, but few teachers are able to operate as a facilitator, and instead many teachers are instructional directors, with only a superficial integration of activities in the arts and crafts or in the prescribed math lessons.

1.3 Structural Synthesis of International Variations

Comparative Criteria	Advanced Global Models (South Korea / Singapore)	Transitional Educational Landscapes (Uzbekistan)
Curriculum Design & Layout	Highly integrated, inquiry-driven, and embedded organically across all daily play-based activities.	Frequently isolated, treated as distinct modules, or added onto traditional lessons.
Resource & Infrastructure Access	High-technology material access (Bee-Bots, LEGO WeDo, ScratchJr) backed by consistent public funding.	Reliance on manual tools, raw natural materials, and inconsistent physical equipment in public preschools.
Teacher Competency & Frameworks	Continuous peer evaluation, collective cross-disciplinary planning, and dedicated national training courses.	Visible gaps between modern classroom requirements and traditional training, leading to low teacher confidence.
Primary Role of the Educator	Active facilitator and supportive mentor who encourages student agency and trial-and-error.	Often functions as a rigid instructional director rather than a guide due to traditional mindsets.

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Discussion

The comparative data provides an example of how the STEAM initiative is successfully integrated, and how it is not simply a technical piece of kit. Instead, the main obstacle for the effective application of the model in the world as a whole is the lack of teacher confidence and content knowledge in integrated domains. To make meaningful impact, the traditional role of an educator needs to transform in a transitional system such as Uzbekistan from a rigid teacher to a teacher as facilitator that encourages students to take an active role, and allows for trial and error experimentation. Addressing the resource- and structure-related challenges, educational systems should be developed to focus on "Low-Cost STEAM". The classroom doesn't need any fancy robotics to teach the basic engineering or design thinking concepts; the basic items found around them can be used to illustrate scientific concepts like structural stability, gravity and cycles of the year, etc. using easily available materials such as recycled cardboard, weighing scales, water channels and leaves in the autumn season, etc.

Conclusion

This is supported by the international experiences that show how early childhood and primary STEAM education could be a strong basis for cognitive, logical and social-emotional development throughout life. To develop an effective and culturally responsive model, the following suggestions emerge from the East Asian models: Teacher training, use of creative, low-cost project materials, and more clearly defining the relationships between the levels in the educational process.

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