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DIGITAL ECOSYSTEMS IN K–5 CLASSROOMS AS A FOUNDATION FOR 21ST CENTURY SKILLS

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ABSTRACT

The research investigates how K–5 classrooms at One World International School (OWIS) Riyadh in Saudi Arabia develop 21st century competencies through a mixed-methods study that aligns with Vision 2030 national transformation goals. The educational concept of digital ecosystems describes how technology tools, teaching methods and student social interactions work together to develop inquiry-based learning communities that become digitally proficient. The research combines literature analysis with teacher interview data from six OWIS staff members to study what serves as a critical developmental period which helps students develop their curiosity, problem-solving abilities and collaboration competencies. Early digital learning environments are strategically created and executed through national policies and institutional practices. The research demonstrates that systematic technology implementation combined with ongoing teacher training leads to better student performance in creativity, collaboration, critical thinking, communication and digital citizenship skills which are widely considered as vital skills for the 21st century way of living. The competencies match the objectives of Vision 2030 to develop Saudi Arabian citizens who will drive the knowledge-based economy through their innovative and digital capabilities. The development of robust digital learning environments in K–5 education produces two essential advantages which enhance student readiness for school while supporting Saudi Arabia's educational progress toward modernization. On the other hand, future research should focus on studying how different educational institutions throughout Saudi Arabia maintain and evolve their digital learning systems.

Keywords: *Digital ecosystems, 21st-century skills, inquiry-based learning.*

INTRODUCTION

Globally, education systems face increasing demands to teach students digital competencies which move past basic technical skills and include creativity, collaboration, analytical thinking and communication abilities. Global research shows that students who start using digital learning tools early develop better adaptability, problem-solving skills and innovation abilities in modern technology-based societies (UNESCO, 2024; OECD, 2022). The educational environment has

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evolved into an active learning space through digital ecosystems which unite educational technology with teaching methods and human interaction (Luckin, 2021).

The K–5 developmental stage requires these educational ecosystems to be implemented specifically for this age group. Purposeful digital learning experiences in early education help children develop lifelong learning habits through the development of curiosity, persistence and teamwork abilities (Burnett & Merchant, 2023). Research conducted in multiple educational settings shows that students who participate in structured digital literacy training during their primary school years become better prepared to join knowledge economies and digital societies (Eickelmann & Gerick, 2022).

The Middle Eastern governments have fast-tracked educational reforms which make technology integration the main force behind innovation and social development. The United Arab Emirates together with Qatar and Bahrain have established national digital learning plans which implement inquiry-based teaching methods and competency-focused educational approaches (Al-Marri, 2023; World Bank, 2023). The programs follow international benchmarks while they implement digital citizenship principles that match the needs of their specific regions.

The Saudi Arabian Vision 2030 establishes digital transformation as an essential foundation for national development. The Human Capability Development Program and expanded EdTech infrastructure investments under the Ministry of Education show a dedicated effort to unite early education with digital transformation targets (MOE, 2023). The educational system now focuses on developing students' digital abilities and creative thinking and problem-solving skills because these competencies form the foundation for achieving a competitive knowledge-based economy.

The Global Schools Group (GSG) drives educational transformation by building technology-infused inquiry-based learning spaces across its worldwide campuses (GSG, 2024). The One World International School (OWIS) Riyadh serves as a member of this network by implementing a complete educational system which unites digital systems with creative learning and global-minded values. On the other hand, the Apple Distinguished School designation at OWIS Riyadh enables the school to use Apple learning technologies to develop innovative approaches within its inquiry-based teaching methods.

This research investigates how digital ecosystems at OWIS Riyadh K–5 classrooms develop 21st century competencies that fulfill both school targets and Saudi Vision 2030 targets. The research examines how early digital literacy education develops creativity, collaboration, communication, critical thinking and digital citizenship skills while determining effective methods to implement international best practices within Saudi educational frameworks.

LITERATURE REVIEW

This literature review synthesizes research, policy documents, and institutional sources related to digital ecosystems and 21st-century learning in primary education. The review draws from peer-reviewed academic studies, organizational reports such as those from UNESCO (2024) and the

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OECD (2022), and national education policies including *Saudi Vision 2030* and the *Human Capability Development Program* (Ministry of Education, 2022). It also examines institutional materials from *One World International School (OWIS) Riyadh* and *Global Schools Group (GSG)* to connect theoretical perspectives with school-level practices. The selected documents were analyzed thematically to identify recurring ideas about creativity, collaboration, critical thinking, communication, and digital citizenship as foundational 21st-century competencies in K–5 learning environments.

Digital literacy and 21st-century skills

Digital literacy has transformed from basic ICT skills into a complex set of abilities which combine creativity with critical thinking and collaborative work with ethical technology handling. The current educational framework demands students to demonstrate mastery of digital, social and cognitive abilities instead of focusing on individual technical skills (Burnett & Merchant, 2023; Eickelmann & Gerick, 2022). The Partnership for 21st Century Learning identifies communication and problem-solving as fundamental competencies for this educational approach.

The development of authentic inquiry-based digital activities serves as the foundation for K–5 students to learn these essential skills during their early education. Research findings show that children who learn digital storytelling, coding and multimedia collaboration develop better metacognitive abilities which helps them succeed in knowledge-based economic systems (UNESCO, 2024; OECD, 2022). Digital literacy education needs to become an integral part of regular classroom activities which enable students to use digital resources for meaningful exploration and questioning and creation.

K–5 digital ecosystems

The educational concept of digital ecosystems describes how learning tools, teaching methods and social interactions create flexible learning spaces that work together (Luckin, 2021). The digital ecosystems found in K–5 classrooms determine how young students experience their first encounters with inquiry-based learning and collaborative work and digital responsibility (Livingstone & Sefton-Green, 2022).

Digital learning activities in today's world combine free exploration with purposeful critical thinking activities (Marsh & Plowman, 2023). The combination of digital storytelling with AR/VR exploration and coding projects shows effectiveness in developing creative skills and communication abilities. In addition to that, in some places the implementation of digital learning faces ongoing obstacles due to students lacking equal access to devices, teachers needing better training and schools needing to find suitable content for young learners.

The success of digital ecosystems in Saudi studies depends on teacher preparedness and administrative backing which requires ongoing professional development to maintain early-years educational innovation (Alqahtani & Rajab, 2023).

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Guiding frameworks

The development of K–5 digital ecosystems receive guidance from multiple theoretical frameworks. The learning process according to Piaget and Vygotsky requires students to engage actively with peers, tools and real-world tasks. The frameworks of Siemens (2021) and Churchill et al. (2022) connect constructivist and socio-constructivist theories to connectivism which enables learners to build knowledge through networked information systems and technological tools.

Digital citizenship frameworks (Ribble, 2022) enhance constructivist learning by teaching students about ethical conduct, safety practices and responsibility in their early digital experiences. The developmentally suitable stage of privacy education, intellectual-property awareness and empathy training should be implemented through guided discussions for young students.

The inquiry-based learning frameworks used by international schools unite these principles through digital evidence collection, global teamwork and creative presentation of findings (Barron & Darling-Hammond, 2021). The successful development of K–5 digital ecosystems require a harmonious combination of cognitive development and ethical conduct and creative expression.

The theoretical frameworks support K–5 digital ecosystem development as they show how children learn essential competencies and values through genuine technology-based learning experiences. Students develop knowledge through active learning and peer collaboration when they work on digital storytelling projects and conduct projects based on assignments (Piaget, 1970; Vygotsky, 1978). Students develop digital skills through online platforms such as Apple native apps like Keynote, Safari, Pages and iMovie as they enable global information access, peer-to-peer learning and idea sharing (Siemens, 2021; Churchill et al., 2022). Teachers use Ribble's (2022) digital citizenship framework to teach students about online respect, privacy and attribution through age-specific lessons which help students develop ethical competencies in digital environments. The implementation of inquiry-based learning frameworks occurs when students explore real-world questions by using digital tools to collect evidence before presenting their findings through multimedia formats like presentation, videos and so much more (Barron & Darling-Hammond, 2021). The classroom examples demonstrate theoretical principles in action which supports the concept that digital ecosystems create an environment for cognitive development and ethical understanding and creative growth to occur simultaneously.

Global and regional practices

The OECD (2022) and UNESCO (2024) along with other organizations support primary digital literacy through the implementation of hybrid learning methods and project-based activities that use digital assessment tools. The educational systems of Finland, Singapore and Estonia teach coding, robotics and design thinking to their first-grade students through programs that follow teacher digital-competence standards.

The Middle Eastern region has adopted new educational approaches following the pandemic which follow a similar educational path. The Smart Learning Program of the UAE, the e-Education Strategy of Qatar and the Digital Schools Initiative of Bahrain received funding

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increases after 2020 to maintain learning continuity through cloud-based platforms and AI analytics systems (World Bank, 2023). The educational institutions of Oman and Kuwait have established digital citizenship programs and STEM maker spaces to develop innovative thinking (Al-Marri, 2023).

In addition to that the Saudi Arabian government established education as the core element of its national transformation plan under Vision 2030. The Ministry of Education (2022) reports that the Tatweer, Future Gate and Human Capability Development Program have brought modernization to infrastructure and educational content through AI and robotics integration in early learning programs.

Generally, the integration of AI and robotics into education faces ongoing obstacles because teachers need better preparation and schools need to improve their teaching methods (Al-Shehri & Cumming, 2023). The success of digital progress requires ongoing professional learning communities and national policy support for school-level innovation (Alqahtani & Alghamdi, 2024).

Institutional visions and research gaps

The Global Schools Group (GSG) operates under a core belief that supports both innovation and inquiry-based educational approaches (GSG, 2024). The Apple Distinguished School status of One World International School (OWIS) Riyadh demonstrates its commitment to uniting technological learning with complete values-based education. The educational programs at this school demonstrate international institutions on how to achieve Vision 2030 targets through AI-based creative learning, digital teamwork and global-minded education (Mwigani, 2024a; Mwigani, 2024b).

The field of research continues to expand yet research about how international schools adapt global digital-learning frameworks to Saudi cultural settings and policy requirements remains scarce. The current research has shortage of sufficient evidence about how K–5 digital ecosystems create twenty-first-century skills that fulfill both institutional and national educational targets. This research examines how One World International School Riyadh uses K–5 digital ecosystems to develop creativity, collaboration, critical thinking and communication (the 21st Century 4 C's) and digital citizenship skills which connect international standards to Saudi Vision 2030 educational targets.

METHODOLOGY

The research design used a mixed qualitative approach which combined a review of digital ecosystems and 21st-century learning literature with a reflective case study of One World International School (OWIS) Riyadh classroom practices. The research collected voluntary reflective data from six teachers about their experiences with digital tool integration in inquiry-based learning. The authentic teacher reflections about K–5 digital practices enhanced the study

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by providing additional evidence that supported information from institutional and national documents.

The research incorporated secondary data from policy documents, institutional reports and academic literature to understand how digital ecosystems in K–5 classrooms develop 21st-century competencies. Educational research benefits from conceptual papers as they combine existing knowledge while creating theoretical links and pointing out future research paths (Snyder, 2019).

The research took place at OWIS Riyadh which operates as a member of the Global Schools Group (GSG). The school supports Saudi Vision 2030 through its dedication to inquiry-based teaching methods, digital education and innovative approaches in primary school learning. The analysis examined GSG mission statements which link organizational targets to national educational transformation initiatives through their focus on innovation, digital competency and global citizenship.

The document analysis method as described by Bowen (2009) guided the data collection process. The research evaluated Saudi Vision 2030, Human Capability Development Program and Ministry of Education reports about digital transformation projects (Tatweer, Future Gate). The study incorporated OWIS curriculum documents such as the digital literacy continuum K-5, Apple iPad policy, technology policy together with institutional plans and academic research about digital literacy, 21st-century skills and ICT implementation in early childhood education together with previous case reflections and conceptual studies about OWIS Riyadh (Mwigani, 2024a; Mwigani, 2024b). Also, internal data from 'Apple distinguished school Journey' of 2024 case study are used in this study.

The researcher applied qualitative thematic synthesis (Thomas & Harden, 2008) to analyze the collected data. The researcher used inductive coding to find repeated concepts which linked digital ecosystems to 21st-century skills, institutional and national strategic priorities. The researcher transformed specific codes about access, pedagogy, citizenship and innovation into five broader themes which matched the 21st-century competency domains of creativity, collaboration, critical thinking, communication and digital citizenship. The thematic findings received assessment for their alignment with OWIS institutional targets and Saudi Vision 2030 strategic objectives to demonstrate educational reform connections at the local level.

The research used three different data sources which included policy documents, institutional records and academic literature to achieve triangulation. The research maintained an audit trail of coding choices to ensure dependability and included detailed information about Saudi Arabia and OWIS Riyadh to enhance transferability. The research obtained institutional permission from OWIS Riyadh while informing all six teachers about their reflections' contribution to Global Schools Group research activities. The study collected no information that could identify individuals or reveal their personal details rather than their first names and grade they are teaching.

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FINDINGS AND DISCUSSION

Creativity

The digital learning environment at OWIS Riyadh K–5 classrooms enable students to become content creators instead of passive content consumers through their use of iPads, for example creating informational presentations and videos using applications such as Keynote, Book Creator and Clips. Students in KG–G2 develop multimodal storytelling skills which enables them to create, tell and enhance their visual stories before moving to G4–G5 where they create documentaries, digital field guides and podcasts that need deliberate design choices and understanding of their audience and multiple editing cycles. The teacher at the lower primary level explained that students now use iPads to create their own stories instead of filling pre-made app spaces. The students achieve their highest level of creativity through designing, building and sharing their own stories using different apps including 'Our Story 2'. *'I would say, the students achieve their highest level of creativity at this stage'* (KG1 teacher). The examples show that technology boosts creativity when students generate authentic meaningful content instead of relying on pre-made materials (Fullan & Langworthy, 2014; Dede, 2016). The school practices follow OWIS's inquiry-based holistic learning approach while supporting Vision 2030's focus on knowledge economy innovation and creative thinking.

Collaboration

The digital environment at the school supports teamwork through its features which include document sharing, comment functions and organized group assignments. The production of media content by lower primary students happens in many ways of collaboration such as in pairs but upper primary students use Freeform to plan, assign roles and merge perspectives when working on collaborative projects. The teacher noticed students developed better understanding of their work while adding more substantial value to their assignments after they started using collaborative online platforms. *"Learners enjoy working together in Freeform, it's like they are sticking traditional stick notes on the board"* (Grade 3 teacher). The structured digital collaboration method helps students develop both peer learning abilities and responsibility toward their work. Research indicates that student learning success increases when they work together through systems which create interdependent relationships and shared accountability (Barron & Darling-Hammond, 2010; Eickelmann & Gerick, 2020). The collaborative learning approach at OWIS matches Vision 2030's objective to develop teamwork and communication abilities as vital elements of human capital.

Critical Thinking

Students who participate in inquiry-based projects need to develop their critical thinking abilities through questioning activities, evidence collection, proper source utilization and suitable presentation methods. Students in G2-G3 use credibility checklists to assess websites while G4-G5 students apply text annotation for evidence-based presentation support. The Grade 2 teacher at OWIS Riyadh told students that using search engines to find answers does not meet the

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requirements. Students need to check information reliability by asking themselves about available alternative sources that support their findings. *"As young researchers you need to find more than just one source, our world is full of information"* (Grade 2 teacher). The activities show how constructivist theories about active knowledge construction become practical through student reflection and digital inquiry (Piaget, 1973; Vygotsky, 1978; Luckin, 2017). The critical evaluation tasks at OWIS help students develop digital information literacy analysis and management skills which align with Vision 2030's digital transformation objectives through inquiry-based learning.

Communication

The digital ecosystem environment at OWIS enables students to develop multiliteracy skills through their ability to create content using text, audio, video and visual media. The younger students create short newsroom videos for oral communication practice, but the older students create infographics, podcasts and narrated presentations. Teachers teach students to be aware of their audience by showing them how to maintain proper tone and clear language while being respectful in their content sharing. According to a music teacher, students develop effective message delivery skills through understanding their target audience and the reasons behind their communication. The research supports digital literacy education as it enables students to create content for actual audiences (Burnett & Merchant, 2020). The communication methods at OWIS develop student language abilities and presentation skills while supporting the school's mission to develop global-minded students who possess essential IB learner profile characteristics for knowledge economy success.

Digital Citizenship

The school implements digital citizenship education through continuous classroom activities which teach students about privacy, protection, consent management, proper attribution practices and online conduct etiquette. A Grade 3 teacher at OWIS Riyadh taught students to think before posting comments by saying *"Never write online what you would avoid saying in person."* The school implements Ribble's (2022) framework through suitable activities which teach safety, empathy and ethical behavior while following UNESCO's (2022) guidelines for responsible online behavior. In addition to that the school celebrates Internet Safety Day, Digital citizenship week in style, with hands-on activities and student-led showcasing. The digital citizenship program at OWIS teaches students to be responsible and respectful while maintaining ethical conduct through its device policy which meets national and international digital responsibility standards.

Alignment Synthesis: OWIS Vision and Vision 2030

The research shows that OWIS Riyadh implements inquiry as its main organizing principle for its K–5 digital learning environment. The system teaches students to be creative and communicate effectively through real-world projects while teaching teamwork skills and evidence-based critical thinking. Digital citizenship through direct instruction about online behavior and responsible technology usage are also focused on K-5 practices in this school. The educational approach at

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OWIS follows its inquiry-based global learning model while Vision 2030 receives support through digital transformation efforts, knowledge-economy preparedness and human-capital development in early education (Ministry of Education, 2022). The research shows that primary students can achieve meaningful digital literacy through four critical elements which include platform coherence, task-based learning, ethical integration and teacher professional development programs (Fullan & Langworthy, 2014; OECD, 2021). The school demonstrates these principles through its direct connection between classroom learning spaces and national educational policy objectives.

The daily teaching methods of OWIS Riyadh show how these principles function in practice. The Islamic Studies teacher at OWIS Riyadh explained that "*Students who participate in daily activities of creation, questioning and collaboration will become the citizens of Vision 2030."* The research shows that K-5 digital learning spaces in classrooms establish settings which help students develop Vision 2030 skills for the twenty-first century. The combination of digital platforms with inquiry-based teaching methods and structured digital conduct guidelines at OWIS Riyadh enables students to build essential competencies which include creativity and collaboration and critical thinking and communication and digital citizenship.

CONCLUSION AND RECOMMENDATIONS

The K–5 years serve as a critical developmental period when students form essential learning attitudes and behaviors which determine their academic and social development in the future. The development of strong digital learning spaces during this period enables students to learn technology skills while building their analytical abilities and responsible communication skills and ethical digital engagement practices. The educational approach at OWIS Riyadh supports its inquiry-based holistic learning model while directly advancing the strategic goals of Vision 2030 regarding digital transformation through digital means, human capital development and knowledge-based economic growth.

Educational reform and national development priorities should focus on building complete digital learning systems throughout schools in the Kingdom of Saudi Arabia. Educational institutions should redirect their funding toward sustaining teacher development programs, digital citizenship education and real-world experiences for students to develop 21st century competencies. Research should follow students through time to study how these systems affect their development in international schools operating digital programs. Research on early digital literacy development will generate vital information to assess its effects on students' global competency development and Saudi Arabia's educational and economic targets.

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