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Designing a Digital Twin Framework for General Foundation Program Students to Enhance Skill Development and Support National Competitiveness

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Abstract

The General Foundation Program (GFP) serves as the primary gateway for Omani students entering higher education, focusing on the development of academic and soft skills essential for national development. However, traditional assessment methods, primarily static grades, fail to capture the complexity of a student's journey or their readiness for the Fourth Industrial Revolution (4IR). This research proposes a Student Digital Twin (SDT) framework—a dynamic, data-driven virtual profile that mirrors a student's academic performance, learning behavior, and digital skill acquisition in real-time. By utilizing a qualitative conceptual synthesis, this paper outlines a four-layer architecture designed to provide personalized pedagogical support. The model explicitly aligns GFP learning outcomes with the strategic goals of Oman Vision 2040, transforming the foundation year into a predictive, high-tech engine for national competitiveness.

Keywords:- Digital Twin, Oman Vision 2040, Learning Analytics, Educational Technology, Skill Development, General Foundation Program (GFP).

I. INTRODUCTION

The General Foundation Program (GFP) is the bedrock of Omani higher education. It is strategically designed to ensure that students possess the English proficiency, mathematical logic, and digital literacy required for specialized undergraduate studies. However, as the global economy transitions toward the Fourth Industrial Revolution (4IR), the definition of "student success" is undergoing a radical transformation. In 2026, it is no longer sufficient to merely "pass" an exam; students must demonstrate adaptability, critical thinking, and a mastery of digital tools to support national priorities.

A significant pedagogical challenge currently exists: the "*Data Silo*" problem. Academic performance is often measured in isolation, with little connection between a student's behavior in an IT lab and their performance in an English seminar. This fragmentation prevents educators from seeing the "whole student." This paper addresses this gap by introducing the *Student Digital Twin (SDT)*. The SDT is an evolving virtual profile that mirrors the student's journey. By integrating diverse data points into a unified framework, Omani Higher Education Institutions (HEIs) can provide predictive support and align student outcomes directly with the national priorities of Oman Vision 2040.

II. LITERATURE REVIEW: THE CONVERGENCE OF AI AND PEDAGOGY

2.1. The Digital Twin Concept and Human-Centric Evolution

The Digital Twin (DT) concept was originally conceptualized by NASA and the manufacturing industry to monitor physical assets through virtual replicas. However, recent academic shifts have moved toward the "*Human-Centric Digital Twin*". In an educational context, a DT is not a 3D avatar but a semantic data model. It utilizes "Shadowing" technology—where every digital footprint (e.g., logging into Moodle, submitting a quiz, or participating in a peer-review forum) updates the virtual model in real-time. This allows for a "living" representation of student capability that transcends the limitations of periodic testing.

2.2. Theoretical Framework: Connectivism

The proposed framework is theoretically rooted in *Connectivism*. Connectivism posits that learning is the process of connecting specialized nodes of information. In the traditional GFP context, these nodes—English, Math, and IT—are often disconnected. The SDT serves as the "Hub" that connects these nodes, providing a holistic view of "readiness" that a traditional GPA cannot capture. This aligns with global trends in *Learning Analytics (LA)*, where data is used not just to record the past, but to predict and improve future learning outcomes.

2.3. Oman Vision 2040 and the Skill Gap

Oman Vision 2040 emphasizes a "Knowledge-Based Society" and the development of "Competitive National Talents". Recent research suggests that while Omani students are technically proficient, a "Skill Gap" exists regarding self-directed learning and complex problem-solving. Traditional grades do not determine a student's development or capability to face these specific challenges. The SDT framework is specifically designed to measure these "Soft Skills" by analyzing behavioral patterns, such as a student's ability to navigate digital challenges without instructor intervention.

III. METHODOLOGY: SYSTEMATIC CONCEPTUAL DESIGN

This research utilizes a *Qualitative Conceptual Synthesis*. Unlike empirical studies that rely solely on subjective surveys, this methodology focuses on *Theory Building* to create a robust technological framework. To ensure reproducibility and clarity, the design process followed three distinct stages:

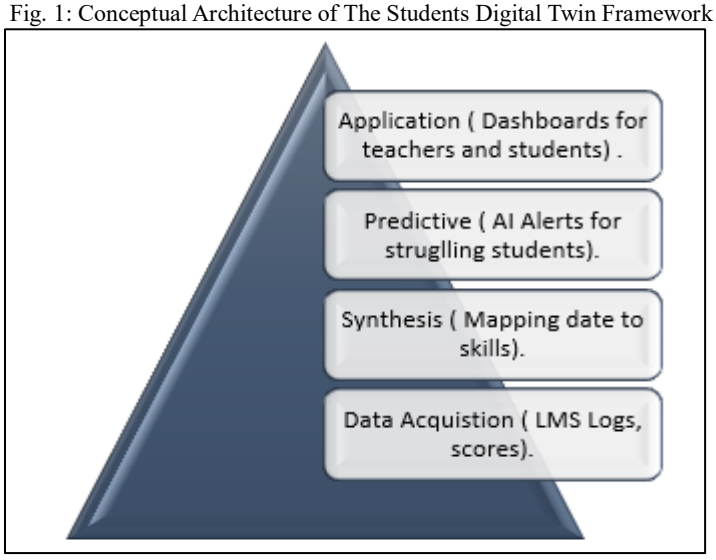
- Requirement Mapping: Analyzing the Oman Authority for Academic Accreditation and Quality Assurance of Education (OAAAQA) standards for the GFP to identify key "Data Entry Points" (e.g., VLE logs, attendance, and formative scores).
- Strategic Alignment: Mapping 4IR competencies (e.g., digital literacy, critical thinking) to the Oman National Framework for Future Skills.
- Architectural Modelling: Designing a four-layer data flow that ensures data privacy while maximizing pedagogical insight. This systematic approach addresses previous concerns regarding methodological depth.

IV. THE PROPOSED STUDENT DIGITAL TWIN ARCHITECTURE

The architecture of the SDT is designed to be integrated into existing university infrastructure (e.g., Moodle or Blackboard). It operates through four distinct layers:

- Layer 1: The Data Acquisition Layer- This is the "Sensory" part of the twin. It captures objective data: time spent on reading materials, frequency of forum posts, and performance in formative quizzes. It moves beyond "what" the student learned to "how" they are learning.
- Layer 2: The Synthesis Layer- This layer uses Skill Mapping to translate logs into competencies. For example, if a student consistently revises their work after receiving feedback, the Twin flags a high score in "Resilience" and "Feedback Receptivity."
- Layer 3: The Predictive Layer- Using AI algorithms, the Twin simulates the student's future performance. It can alert a tutor if a student's "English Vocabulary Growth" slows down, allowing for a personalized intervention weeks before the final exam.
- Layer 4: The Application Layer- The user interface provides a Spider Map visualization for the student. This transparency allows students to see exactly where they stand in relation to the skills needed for their future career, fostering self-directed learning.

Fig. 1: Conceptual Architecture of The Students Digital Twin Framework



V. RESULTS AND STRATEGIC ALIGNMENT

The primary result of this study is the *Competency-Vision Matrix*. This matrix proves that the Digital Twin is not just a technical tool, but a strategic asset for national development.

Table 1. Alignment of GFP Digital Twin to Oman Vision 2040

GFP Module	Digital Twin Metric	National Strategic Target (Vision 2040)
English	Vocabulary diversity & peer-interaction logs	Global Communication & Cultural Exchange
Math	Algorithmic logic & error-correction speed	Analytical Thinking & Innovation
IT Skills	Tool mastery & digital troubleshooting	4IR Readiness & Digital Economy
General Skills	Collaborative project logs & self-study time	Leadership & Lifelong Learning

VI. DISCUSSION: IMPLEMENTATION AND ETHICAL CONSIDERATIONS

6.1. Data Privacy and Omani Ethics

In an Omani academic environment, data privacy is paramount. The implementation of an SDT must follow strict Omani Data Protection Laws. The framework must ensure that students are the "owners" of their data and that the Twin is used as a supportive mentor rather than a tool for surveillance. *Informed Consent* must be integrated into the registration process of the GFP, ensuring students understand how their digital footprints are being used to support their growth.

6.2. The Shift from Teacher to Mentor

The SDT changes the role of the GFP instructor. Instead of spending hours manually identifying who is struggling, the teacher receives an automated "Early Warning Report." This allows the teacher to spend more time on high-value activities like one-on-one mentoring and emotional support, which are essential for student retention in the foundation year.

6.3. Limitations and Future Research

While the proposed framework is theoretically sound, it faces limitations. Current HEI infrastructure may lack the *Data Interoperability* required for different departments to share data on a single platform. Furthermore, as a conceptual study, empirical validation is required. Future research should focus on a *pilot study* within a single Omani university to test the predictive accuracy of the AI algorithms and student receptivity to "Shadowing" technology.

VII. CONCLUSION

The *Student Digital Twin* represents a paradigm shift for the General Foundation Program in Oman. By moving away from static, fragmented assessments and toward a dynamic, holistic virtual model, HEIs can ensure that every graduate is a competitive asset for the nation. This framework provides the "missing link" between the classroom and the goals of *Oman Vision 2040*, transforming the GFP into a world-class engine for talent development and national readiness.

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