Assessing the Effectiveness of UMP STEM Cube as a Tool for Developing Digital Making Skill Sets

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Abstract*—*Contribution: **This study presents an innovative experiential learning model utilizing an educational pico satellite kit as a tool for cultivating digital making skills. The distinct approach showcases a positive impact on students' learning experiences and serves as a motivating force, offering valuable implications for engineering and technical education.**

Background: **In response to the dynamic technological landscape and escalating demand for digital making skills, this research addresses the need for cutting-edge educational tools. The UMP STEM Cube, strategically designed to elevate hands-on learning in digital making, emerges as a promising applicable solution across diverse educational programs.**

Intended Outcomes: **An experiential learning module that elevates digital making skills in engineering education, specifically focusing on programming competencies and proficiency in physical computing. This study conducts an evaluation of the UMP STEM Cube's influence on experiential learning and skill development.**

Application Design: **The instructional approach of employing the UMP STEM Cube aligns with Kolb's Experiential Learning Theory. The modular design of the UMP STEM Cube bridges the theoretical–practical gap in digital making education, fostering a holistic and impactful learning experience.**

Findings: **This study establishes a correlation between hands-on engagement with the UMP STEM Cube and a significant learning gain in programming competencies and physical computing skills among students. Participants' positive perceptions, better competency in programming, and increased interest in digital making activities further emphasizes the efficacy of the UMP STEM Cube in fostering digital making skill sets.**

***Index Terms*—Educational pico satellite, educational technology, electronics engineering education, engineering education, physical computing, programming competencies, STEM.**

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This work involved human subjects or animals in its research. Approval of all ethical and experimental procedures and protocols was granted by the Ethical Review Boards under Application No. IREC 2023-173.

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I. Introduction

DIGITAL making skills have evolved into a critical component in the swiftly changing technological landscape. These skills, including programming, physical computing, 3-D design, and digital fabrication, play an important role in empowering individuals to innovate and create, fostering advancements across diverse sectors. The increasing demand for digital making skills, particularly in the design, construction, and maintenance of digital products and systems, highlights their significance.

In the context of engineering education, digital making skills offer a hands-on approach to problem solving, allowing students to translate theoretical concepts into real-world scenarios [1], [2], [3], [4], [5]. This practical experience not only deepens students' understanding of engineering principles but also enables them to navigate the potentials and limitations of digital technologies while fostering innovative solutions.

In physical computing learning activities, students delve into the exploration of electronic components and gain hands-on experience in programming microcontroller-based systems, such as Arduino and Raspberry Pi. This exploration involves essential topics, such as circuit design, digital logic, and microcontroller programming [6]. The emphasis on physical computing aligns with the broader theme of algorithmic thinking development [7]. In the context of physical computing with microcontrollers such as Arduino, students engage in activities that involve implementing algorithms for programming the microcontroller. This encourages algorithmic thinking, which refers to the ability to conceptualize and design step-by-step procedures or algorithms to solve problems. It is typically included in learning activities related to kinematics (movement algorithms for robotics), control systems (algorithms for regulating and controlling devices), and computer vision (algorithms for processing visual data).

A. Learning Kits for Digital Making

Throughout the years, a variety of learning kits have been developed to stimulate digital making learning among students [8], [9], [10], [11], [12], [13], [14], [15], [16], [17], [18], [19], [20], [21], [22], [23], [24]. The UNC++Duino kit is an example an open-source learning kit that provides a well-organized setting for acquiring proficiency in Python and C++ programming specifically designed for robotic applications [9]. In a similar work, Robotic Decathlon project prioritizes project-based learning labs and thoughtfully