

μ-Projects based on Hybrid CDIO-Scrum Methodology for STEM business

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Abstract

A μ-project methodology based on hybrid CDIO-Scrum framework is proposed for collaborative groupwork using currently available laboratory equipment, workshop training, simulators, emulators, online and virtual resources. These small yet intense projects enhance teambuilding capabilities, IT security and business innovation besides challenging the core learning objectives of science, technology, engineering, and mathematics (STEM). The proposed projects intend to level-6 and 7, due to needed knowledge, skills, and abilities (KSAs). Such collaborative coursework can support large size-cohorts and their randomised group selection promotes equality, diversity, and inclusion (EDI), and diminishes various academic misconducts (i.e., collusion, plagiarism, essay mill, etc).

Keywords: Sustainable Business, micro-projects, STEM, PDCA, CDIO, Scrum, Holacracy, Teamwork

Introduction

The education system is getting normalised after gradually exiting from the COVID-19 pandemic, which incited the online and cloud-based virtual learning management systems (LMS). It is not surprising that the leading E&T industry demands fresh graduates to have technical and business certifications in addition to their degree qualifications for greater sustainability and employability. To address this, the UH School of Physics, Engineering and Computer Science (SPECS) has recently introduced [CDIO-initiative](#) [1] and iHasco training for staff and students. The proposed μ-projects can benefit UH-SPECS in revising few E&T programme-specific coursework adding more professional practice and workshop training components. The revised virtual lab-based coursework can be designed as short (i.e., micro) but intense learning activities, involving project-based learning (PjBL)¹ group collaborated coursework to enhance the team building capabilities and IT business innovation.

The Proposed μ-Projects Framework for collaborative Groupwork

The μ-projects are implemented as teamwork for a large cohort-size (divided into small groups) based on the 'Plan, Do, Check, Act (PDCA)' methodology, which is a systematic approach to problem-solving and helps organisations identify opportunities for improvement, implement changes, and monitor their effectiveness. The PDCA's approach is employed in framework for engineering education the CDIO (Conceive, Design, Implement, Operate), which follows a systematic and linear progression. However, it involves a transitional upgrading from a PDCA to a CDIO framework to enhance the QoS for products and systems as demonstrated in Fig 1.

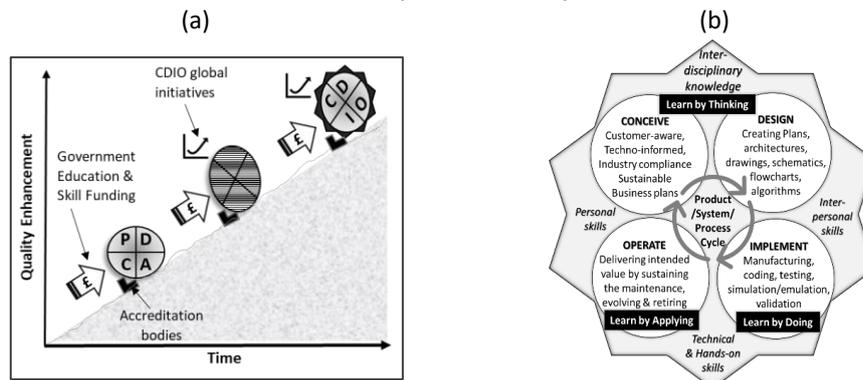


Fig 1. CDIO concept: (a) PDCA to CDIO transformation, (b) Pedagogic model of CDIO

The initial CRIO stages are mostly funded (i.e., by government, education, and skill funding agencies, etc) offering incentives to continue the policies, where the standards (e.g., accreditation bodies, etc) ensure the necessary accountability mechanism, holding institutions responsible for their actions, products, and services. The CDIO initiatives provide the thrust to continue enhancement while moving onto a steep developmental slope continuing the CDIO process cycle until the model successfully completes the implementation and enters Operational mode, e.g., delivery. The Fig. 1(b) demonstrates a pedagogic model describing the first two phases

¹ Project-based learning (PjBL) is a derivate of the problem-based learning (PBL) methodology.

(i.e., conceive and design) based on ‘learning by thinking’, whereas the remaining two phased (i.e., implement and operate) phases, by ‘doing’ and ‘applying’, strategies, respectively. Currently, ‘implement’ and ‘operate’ phases depend on human factors for observation and administration purposes to conduct fine-tuning, incremental and radical changes for performance optimisation, however, this will revive soon due to artificial intelligence AI-based and machine learning/deep learning models enhancing the quality of service (QoS). Scrum as a framework is used for managing and completing complex projects in technology (i.e., software development), but it can also be applied to various near- and far-STEM disciplines, however; the far-STEM must cover the prerequisites to comply with STEM learning objectives [2]. Like the CDIO, Scrum also uses the PDCA cycle as one of its core principles to continuously improve the product being developed and the process by which it is being developed. Additionally, Scrum involves business-centric principles (e.g., transparency, inspection, and adaptation), which altogether improve the team cohesion and marketing features of the products and services. Therefore, hybrid- CDIO-Scrum offers better QoS for business management, besides the regular features of a CDIO model. Fundamentally, the Scrum framework is based on an ‘Agile’ project management methodology involving a small team [3]. Fig. 2 presents a basic concept of project development and management methodologies for, Waterfall, Agile and Scrum techniques, respectively. Waterfall methodology is a linear, sequential approach and appears easy to understand but not flexible enough, and hence requires more expertise and professional managing skills to plan, review and deliver. However, Agile and Scrum are more flexible, iterative methods emphasising rapid development. The Scrum has additional component meeting daily goals.

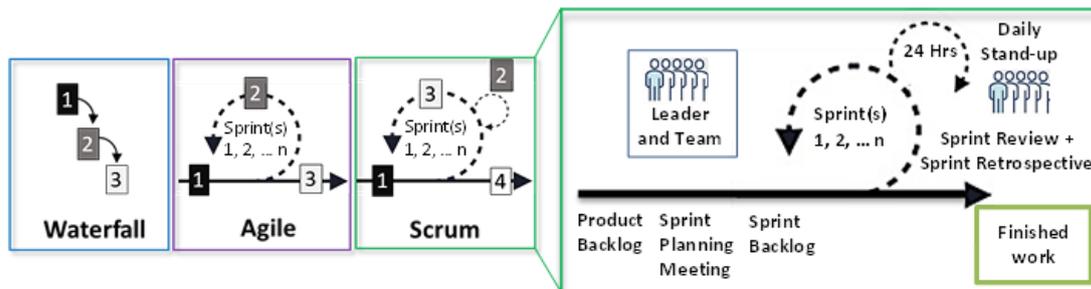


Fig 2. Simplified concept of different Methodologies, zooming out the Scrum operating process with multiple Sprints.

Fig. 2 demonstrate these as 1, 2, 3 and 4 stages on a time management plan, whilst describing the details of a Scrum scheme. In practice, there can be more iterative stages subject to the project type, requirements, and phases (i.e., plan, design, implement, test, analysis, review, marketing, deployment, maintenance, etc). The further operational and pedagogical details and their comparative studies can be found in the References [4,5].

Example of coursework based μ -Projects, and Implementation

The μ -project for each group can be organised with unique set of requirements, which can be randomly generated from the database comprising a few realistic parameters (i.e., sensors, communication channels, inputs, outputs, and operating voltages). Each project can be randomly generated by selecting a fixed set of components of the unique projects, based on combinations as given in Table 1. The tutors and moderator must carefully check the details of the randomly generated combinations (i.e., a few combinations may be more challenging or not viable products or services in the concurrent market but these could be innovated).

Table-1 List of parameters developing μ -Projects (i.e., group of 5 x 40 Projects = Total 200 students)

*The assessment landscape details, xlsx spread sheet, Rubric, Tutorial, and Lab support material, etc can be shared with interested staff.

Type of Sensors (Select any 3)	Communication channels (Select any 1)	Inputs (Select any 1)	Outputs (Select any 1)	Power Supply (Select any 1)
GPS, Accelerometer, Gyroscope, CO2, NO2, SO2, PM, Humidity, Pressure, Temperature, Range, Lux, Colour, Sound, Dissolved Oxygen, pH, Salinity, Wind Speed and Direction, Strain Gauge, Current, Magnetometer, LDR, Smoke, Force Sensitive Resistor, Flex Sensor, Strain Gauge (Load Cell), Voltage, Moisture, Motion, Thermocouple, Volatile Organic Compounds (VOCs), Gesture, Water Flow, Lightening Detector,	Bluetooth, Wi-Fi LoRaWAN(868MHz), 433/434MHz RF, 868MHz RF (Proprietary) LTE Cat-0, LTE Cat-M, LTE Cat-NB-IoT, Audible Speech, Infra-Red Receiver, NFC, Zigbee	Momentary push-button, Toggle switch, Magnetic switch, Photodiode, Phototransistor, Capacitive, Touch	OLED display, LED backlit LCD, TFT display, Alpha Numeric LED, e-ink(e-paper), LED Status, Audible beeps, Relay Contacts,	400 vac, 240 vac, 110 vac, 3 vdc, 5 vdc, 6 vdc, 9 vdc, 12 vdc, 24 vdc, 40 vdc, 400 vdc

This groupwork expects to challenge each group's ability to design the device schematic(s), and electronic circuit simulation, explore security resilience, develop a business plan, identify a market and sustainability strategy for the would-be product, and finally submit a collaborative PowerPoint presentation for the demonstrations with voice-over. Each group should analyse the constraints and determine the marketable use case for the product. The groupwork deals with multiple teams effectively communicating using a Google-App '[Clickup](#)', where each team should additionally carry out relevant strength, weakness, opportunities, and threats (SWOT) analysis to justify the market for the would-be product based on their knowledge, skills, and abilities. The group constitutes dynamic teams based on the Holacracy principle [6], where each member becomes a leader of a task delegated by the team (i.e., Scrum master). Intriguing feature of this collaborative work is the rotational leadership role within the team, which rotates within the group, and everyone gets fair chances to share their input on each task. Such learning activities were successfully implemented in UH-SPECS's Bachelor's modules at level 4 and 5 based on Mini-Projects framework encouraging students' teamwork building capabilities [7].

This hybrid CDIO-Scrum methodology engages learners with the identified roles, which helps in assessment process. For example, five tasks (i.e., five Scrum sprints) can be issued to the group of five members, then each member will lead (as Scrum Master) a team of 4 people for that specific task. It is important for the team meetings, that the 4 people should play the necessary roles effectively negotiating and discussing the 'out-source' stakeholders' part, e.g., customers, principal supplier, key partners, subcontractors, supply-chain/blockchain managers, and other relevant third parties to develop or provide products, services, and innovative solutions. For enhanced learning, the tutor can help learners by setting up tutorials using the Flipped Classroom approach. Each team leader should conclude the relevant Scrum sprint outcomes and keep the record of documents in the group coursework folder (e.g., project requirements, planning covering feasibility, desirability, and viability aspects, meetings agendas, logs etc). This collaborative work is peer-assessed with strict academic honesty. For consistency, an automated VBA-based Excel® spreadsheet can help identifying various components of groupwork and the number of submitted items by each individual, and their conclusive comments agreed by the respected team members.

Conclusions and Recommendations

A proposal to enhance group-coordination and collaboration whilst enhancing students' knowledge, skills and abilities (KSAs) has been proposed based on Hybrid CDIO-Scrum Methodology for STEM business. An example of one relevant coursework of μ -Projects based on this hybrid scheme was presented. The UH-SPECS academic staff liaising with learning technology professionals can develop more STEM business innovative μ -projects for group collaborative coursework making subjects interesting, eliminating plagiarism, collusion and enhancing the graduate's employability. The μ -projects are recommended for the level-6 and above due to the involvement of various core LOs, which a SPECS learner might have acquired during the past semesters in various modules, training and workshops or expected to learn during the completion of these short yet challenging projects.

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