OPERATIONALIZING CDIO ENGINEERING LEARNING WORKSPACES IN EAST KAZAKHSTAN TECHNICAL UNIVERSITY

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ABSTRACT

This paper discusses the effort by East Kazakhstan Technical University (EKTU) in collaboration with Singapore Polytechnic (SP), in using the CDIO Standard 6 Engineering Learning Workspaces to align EKTU's Luban Workshop (EKTU and China's Tianjin Vocational Institute collaborative project). EKTU had earlier adopted the Chinese teaching model Engineering Practice Innovation Project (EPIP) for its Luban Workshop. The paper shares a brief literature review on CDIO workspaces, SP experience in CDIO Standard 6 implementation, combined use of the CDIO and EPIP in engineering education. This paper concludes with ideas for moving, including the design thinking integration and students survey learning experience.

KEYWORDS

Learning workspace, Luban Workshop, CDIO Standard 6.

INTRODUCTION AND SCOPE OF THIS PAPER

East Kazakhstan Technical University (EKTU) joined the CDIO initiative in 2023. Currently the institution is the only university implementing the concept of engineering education based on international standards and the CDIO initiative in Central Asia and Kazakhstan. This is in line with the university's effort towards reinventing its approach to conducting engineering education based on practice-oriented models of engineers' preparation aligned to international standards. This started in 2023, under a scientific project funded and guided by the Ministry of Education and Science of Kazakhstan, East Kazakhstan Technical University developed the National Model of Engineering Education for Kazakhstan practices. The Worldwide CDIO initiative and Chinese teaching model Engineering Practice Innovation Project (EPIP) were chosen as the foundation of the Kazakhstan model. The main elements of EPIP comprise 4 elements which are "Engineering", "Practice", "Innovation", and "Project". "Engineering" of EPIP means real life-oriented, industrialized, realistic, socialized projects. "Practice" reflects simultaneous study of theory and practice. "Innovation" means trying new things, using new concepts, development of original solutions. "Project" of EPIP characterizes development of cognitive competence, independent thinking, logical reasoning, expression ability, information processing, word application, ability of cooperation, self-control, team-working, innovative thinking via project-based learning (Lyu, 2022). As a result of this project, East Kazakhstan Technical University aims to share own experience of implementing these standards with all technical universities in Kazakhstan by 2025.

One of the key focus areas is to align the various engineering learning workspaces within the East Kazakhstan Technical University campus in Oskemen. A notable feature of the workspaces in this university is a recently introduced Luban Workshop, set up with the assistance from the Tianjin Vocational Institute from China (Lyu, 2022). The workshop, opened in December 2023, is named after Luban, who was a Chinese architect or master carpenter, structural engineer, and inventor, during the Zhou Dynasty; and revered as the Chinese Deity (Patron) of builders and contractors. Using the teaching model of EPIP, students in the Luban Workshop will be trained in transportation equipment and technology, with four practical training areas: fuel vehicle maintenance, fuel vehicle systems, new energy vehicles and intelligent connected vehicles.

Being a new member of CDIO, East Kazakhstan Technical University actively engaged in learning about best practices from other CDIO collaborators. One area is to harmonize the teaching and learning approaches in their engineering programs with their engineering learning workspaces, especially with a view to supporting the EPIP. To this end, selected university faculty embarked on a learning journey to Singapore Polytechnic in March 12-15, 2024; with the aims of learning about using CDIO for curricular continual improvement and accreditation; with special focus on how workspaces are used in the School of Mechanical & Aeronautical Engineering, to support student projects and collaboration with industry partners.

This paper shares the outcomes of the initial working partnership between East Kazakhstan Technical University and Singapore Polytechnic. It first presented relevant information of learning workspaces framed within the CDIO perspectives. It then provides a use case of how Singapore Polytechnic enhanced its CDIO adoption with design thinking framework to drive innovation from student projects and share the example of the Singapore Polytechnic Aero Hub as a specific example of how learning workspaces is used to engage students in learning. The paper then moves on to explain work done in East Kazakhstan Technical University with respective to the development of the Luban Workshop.

LITERATURE REVIEW

The "learning by doing" approach has been widely recognized as an effective method in engineering education due to its active learning principles. This method emphasizes hands-on experiences, problem-solving, and real-life simulations, which are crucial for developing both technical and soft skills among engineering students. This hands-on approach helps improve retention and mastery of subjects, making students more confident in applying what they have learned to real-world problems (Bot et al., 2005). An industry-based learning space affords authentic learning for a particular industry sector. Gibson et al (2009) highlighted that a "work-based learning gives students the opportunity to develop both general and field-specific skills, such as personal, communication, teamwork and research skills, experience in project design and management, professional work experience and the opportunity to secure on going employment".

CDIO Standard 6 Engineering Learning Workspaces

Core Standard 6 of CDIO explains engineering learning workspaces as "*A physical learning environment that includes engineering workspaces and laboratories that support and encourage hands-on learning of product, process, system, and service building, disciplinary knowledge, and social learning, combined with a digital learning environment that includes on-line tools and spaces that support and enhance the quality of teaching and student learning*".

Crawley et al (2007, pp.119) provide the essential and desirable attributes of CDIO workspaces as shown in Table 1 and various utilization modes as shown in Figure 1.

Table 1. Essential and Desirable Attributes of CDIO Workspaces

Essential Attributes	• Encourage hands-on learning of product, process, and system design and implementation, while at the same time supporting disciplinary and interdisciplinary knowledge
	• Facilitate student learning of personal and interpersonal skills
	• Facilitate group activities, social interaction, and communication leading to social learning
	• Comply with local health and safety regulations
	• Provide sustainable resources
Desirable Attributes	• Be organized and managed by students
	• Provide flexible equipment, furniture and facilities
	• Facilitate access by students beyond normal class hours
	• Provide access to modern tools, equipment and software

Within the CDIO literature, Cunningham et al (2009) discussed the use of requirement specifications for renovation of existing workspaces or building new workspaces by mapping different types of workspaces (studio room, laboratory, workshop, etc) to the various learning modes of Figure 1. Various institutions had adapted the standard for their own educational needs (e.g. González et al, 2013; Petrova et al 2021). Innovative use had also been reported, for example Clausen & Binder (2017) shared an interesting approach on using the standard for mining engineering. The study concludes that students' learning success is related to the integration of authentic and innovative learning spaces. Gerlein et al (2018) described how community building among students is achieved by making the Electronics Lab from Pontificia Universidad Javeriana available 24/7. Sluijs et al (2019) described the setting up of a living lab for co-creation at the Hague University of Applied Sciences, that is accessible for all faculties and research programs.
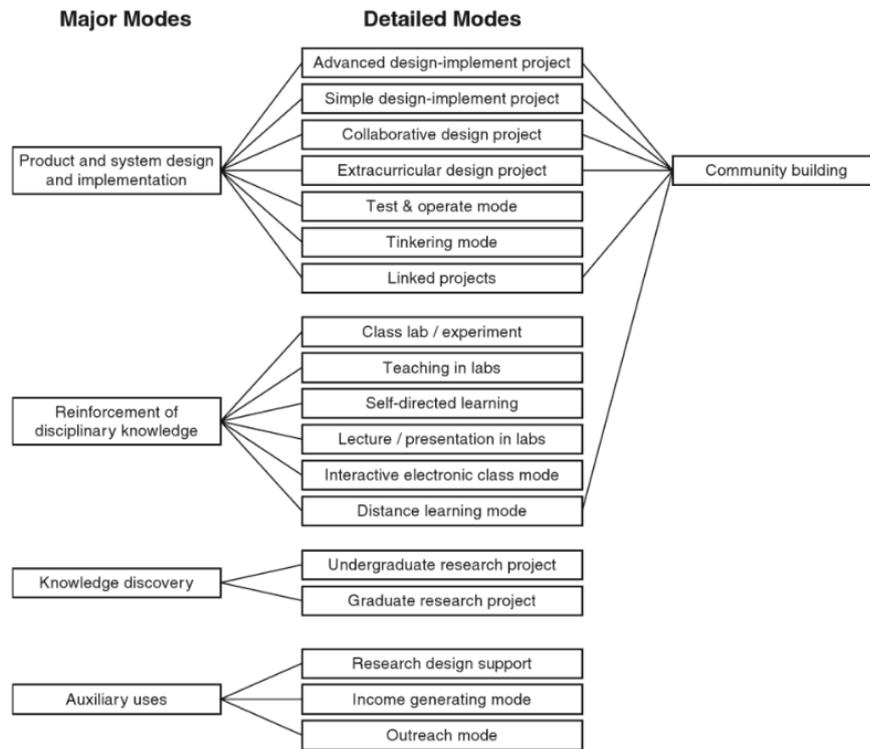
Figure 1. Teaching and Learning Modes in CDIO Workspaces

Key Takeaways from Learning Journey to Singapore Polytechnic

Use of engineering learning workspaces in Singapore Polytechnic is largely organized along this line: Each school retained the laboratories and workshops that supported learning along disciplinary lines, whereby one can easily infer from a facility's name the type of activities contained therein, e.g. Mechanics Lab, Analytical Chemistry Lab, etc. These facilities are dominantly used to instill foundational skills and attitudes (e.g. teamwork and collaboration, communication, critical and creative thinking) within the disciplinary context. There are also specialized labs supporting project works where students worked on their capstone projects, i.e. CDIO design-implement experiences; some of which are in collaboration with industry partners. The project labs supported key project management competencies as shown in Table 2 below.

Table 2. Competencies to be developed from CDIO Design-Implement Experiences

Conceive	Design	Implement	Operate
Define Issues, Analyze Problems	Project Management (Planning, Scheduling, Monitoring, Budgeting etc.)		
Empathy: Identify Needs, Target User	Propose (simulate) Possible Solutions	Build Prototype	Operate Prototype, Prepare Deployment
Background Research	Identify Constraints (incl. Assumptions)	Test, Troubleshoot, Verify	Collect Data, Analysis and Communicate Results
Specify User Requirements and Product Functions	Develop Criteria, Evaluate Alternative Solutions, Select Design, Details and Drafting	Prepare Standard Operating Procedures	Modify or Redesign, Optimise and/or Improve
Prepare Initial Product Concept, Plan	Analyse Impact on Engineering on Society and Environment	Prepare Maintenance Procedure	Consider Disposal Options

To better support the conceiving capacity of its students, Singapore Polytechnic also introduced design thinking into all its curriculum, i.e. it is made mandatory for all students. The Design Thinking Framework when used in conjunction with CDIO, is shown in Figure 2. The detailed information has been presented in Chong et al (2011), Soh (2011), Ng & Cheah (2012).
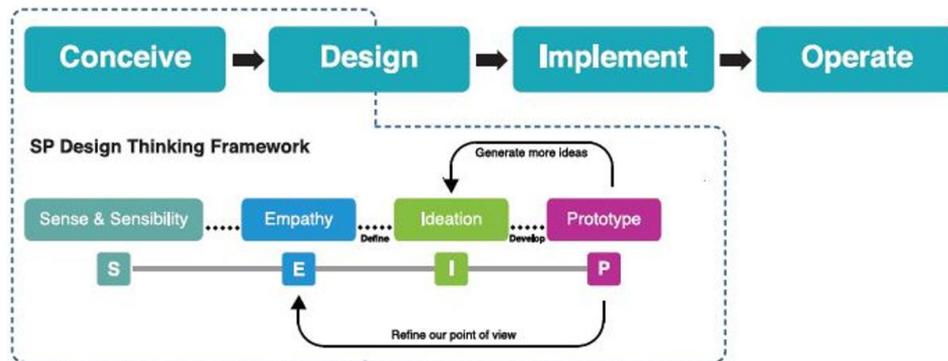

Figure 2. SP Approach to Integrated Design Thinking into CDIO Framework

Of interest for this paper, is the Aero Hub from School of Mechanical & Aeronautical Engineering. The Aero Hub is a four-storey building that provides training facilities to students from the Aeronautical Engineering and Aerospace Electronics programs with authentic training environment. It houses a hangar with several live-size aircrafts and a helicopter, laboratories and Research & Development center that supports the development of full-motion flight simulators, hybrid rocket propulsion systems and vertical take-off and landing vehicle, and Unmanned Aerial Vehicle. The Aero Hub satisfies much of the requirements of CDIO workspaces of Figure 1, namely product and system design and implementation (e.g. design-implement projects), reinforcement of disciplinary knowledge (e.g. class or laboratory experiment), knowledge discovery (e.g. applied research projects, innovative student capstone projects) and auxiliary uses (e.g. outreach and income generating). A full summary of Aero Hub facilitating various courses and their coverage of CDIO syllabus is shown in Appendix 1.

The integration of design thinking into the CDIO Framework and the example of the Aero Hub serve as a good example for East Kazakhstan Technical University to integrate its Luban Workshop into its engineering program which is made up the rest of the discussion for this paper.

EAST KAZAKHSTAN TECHNICAL UNIVERSITY'S ADOPTION OF CDIO TO-DATE

Adoption of CDIO initiative in East Kazakhstan Technical University is conducted by the following educational directions which are mechanical engineering, automotive engineering, energy, construction, water engineering, mining, etc. Workplaces for the implementation of project-based learning process are presented by 12 Competence Centers, 53 training laboratories, 2 workshops equipped by essential training equipment. Among the existing types of workspaces, the most interesting one is Luban Workshop oriented to the preparation of engineers in the field of automotive engineering.

Based on CDIO Standards, a practice-oriented model of engineering education (Figure 3) has been developed which comprises 5 consecutive educational levels. These are: "PU" (pre-university), "c-d" (basic engineering competence), "C-D" (Conceive-Design), "I-O" (Implement-Operate), and "PE" (Postgraduate Education).

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"PU" level is pre-university preparation through the work of "engineering classes" in comprehensive schools. Under the pre-university stage the study of advanced physics, mathematics, and IT is conducted using gamification.

"c-d" level is formation of basic engineering qualifications in 1st-2nd year undergraduate students. At this level, students work on a small (simple) project, the purpose of which is to acquire skills in applying the knowledge of natural sciences acquired at school within the framework of the discipline "Introduction to Engineering Education".

This project is carried out in a special Fab Lab workshop based on the CDIO syllabus and the EPIP model. Fab Lab is a workshop for the creation of creative projects implemented within the framework of the discipline "Introduction to Engineering Education" at the Conceive (C) and Design (D) stages of the World CDIO Initiative. The main objectives are developing basic engineering skills, creating conditions for developing innovative products, a platform for communication between representatives of different Schools and areas of East Kazakhstan Technical University, providing students with access to modern tools and equipment, promoting the development of student startups, and implementing initiatives aimed at solving social problems.

"C-D" level is the formation of deep practical knowledge of the technical foundations of the profession in 3rd-4th year bachelor's students. This level includes the implementation of a more complex project in the specialty based on the professional knowledge acquired at the university. The result of the stage is the definition of the problem and the creation of an engineering model for solving this problem. At the same time, within the framework of this stage, an interdisciplinary approach is possible in accordance with the principle of the EPIP model.

"I-O" level is development of research competencies in 3rd-4th year undergraduate students. At this stage, work is carried out to implement the ideas formed at the previous level. Regarding the educational programs of "Automotive engineering", the implementation of this stage is carried out using the equipment of the Luban Workshop.

"PE" level is training of master's and PhD students on examples of solving production and experimental design problems of specific enterprises and the needs of the regional economy. These are complex interdisciplinary tasks that require the combined efforts of several competence centers, various groups of researchers, which make it possible to implement various technologies which are practical engineering, team educational technologies, project management, start-up, etc.

Aligning the Luban Workshop to CDIO Standard 6

The core of Luban Workshop is the teaching model of EPIP which is the educational strategy directed to the development of practical engineering skills, critical thinking, collaboration, communication, creativity, innovation, cross-disciplinary learning (Getachew, 2023; Ying, 2019). The goal of the Luban Workshop is to create a unique educational and methodological base in Kazakhstan in the field of advanced technologies in road transport. The expected result is a new model of professional and engineering education according to world standards, the translation of advanced technologies, and development of engineering practice taking into account the needs and characteristics of the national economy.

"5 main elements" of the creation of the Luban Workshop:

- Construction of a site with educational demonstration and educational laboratory equipment.
- Educational and methodical equipment and advanced technologies in teaching.
- Directions and specialties for training personnel for local socio-economic development.
- Teacher training with adaptation to local economic and social development.
- Educational resources developed within the framework of cooperation between partner universities and enterprises (Lyu, 2024).

According to EPIP teaching model the desired learning outcomes are the following ones:

- acquiring the real-world engineering experience;
- development of critical thinking and problem solving skills;
- development creativity and innovation;
- development communication and collaboration skills;
- development of skills to use cross-disciplinary approach for problems solving.

The Luban Workshop consists of two sections which are Section of Technologies for Servicing Fuel, Hybrid and Electric Vehicles and Section of SMART-technologies of Vehicles. It should be noticed that all the equipment in Luban Workshop includes innovative Chinese technologies in the field of automotive engineering. The section of technologies for servicing fuel, hybrid and electric vehicles is equipped with contemporary 3 training cars which are Haval H6 (fuel vehicle), BYD (electric vehicle), Haval M6 (hybrid vehicle). In addition, the Section is equipped with modernized training stands for practical study of engine design, engine diagnosis, electrical system, transmission, chassis, battery and electric motor of an electric vehicle, charging station.

The section of SMART-technologies of vehicles includes the sand table for study miniaturized SMART cars, advanced driver assistance systems, and autonomous robotic platform. Using the sand table, students conduct projects related to V2X technologies. Advanced driver assistance systems stand allow realizing the projects connected with providing safety systems while driving a car. Applying the autonomous robotic platform, students implement the project on developing unmanned transport systems.

Aligning the Luban Workshop to CDIO Syllabus

The interesting fact is that Luban Workshop is not only a learning laboratory for students training according to EPIP principles but also a workspace for implementation CDIO standards. Based on CDIO Syllabus 3.0 let us describe the mechanisms for achieving the CDIO learning outcomes using Luban Workshop.

For example, the learning outcomes related to advanced engineering fundamental knowledge, methods and tools according to CDIO Syllabus is achieved by acquiring the skills of work with training equipment on engine assembly and disassembly, engine diagnosing, transmission assembly and disassembly, wheel balancing, tire fitting, lighting system maintenance, battery and traction motor of an electric vehicle maintenance, autonomous system, advanced driver assistance systems by students. The learning outcomes connected with analytical reasoning and problem solving are achieved by solving the problems related to the improvement of parts of fuel, electric and hybrid cars. Experimentation, investigation and knowledge discovery learning results are reached by conducting student research related to, for example, investigation of frost resistance of electric car batteries, parameters of traction battery of electric car, characteristics of engine, etc. System thinking is achieved by taking into account all the factors affecting the effectiveness of electric cars which are ecological problems, energy

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efficiency, charging system infrastructure, aerodynamics, etc. Attitudes, thought and learning are achieved by creative and critical thinking used for implementation projects related to maintenance and operation of the automobiles systems. Teamwork and collaboration are reached by organization of the educational process by dividing students into groups. It should be noticed that all the equipment in Luban Workshop is arranged in pairs (Figure 3).

This equipment organization gives the opportunity to realize learning processes based on the development of cooperation, teamwork, and competition. Communications are realized by conducting discussions on the results of projects.

As a result of joint use of CDIO and EPIP, a new format of student engagement is possible for East Kazakhstan Technical University using Luban Workshop. At the point of this writing a course of "Diagnosing of the Automobile Systems" with 15 weeks of contact time can be realized as the competition of 2 student team groups. The teachers create a malfunction in a certain system of the car in advance which leads to its inoperability. The students are offered to tackle this problem. Each project task is the level of the competition and is assessed by scores. The team that completes the task in the least amount of time wins.

Figure 3. Training Equipment Layout in Luban Workshop

Thus, combined use of CDIO principles and Luban Workshop equipment allows us to utilize a new approach for the learning process.

MOVING FORWARD

One area in the CDIO-EPIP Framework that can be enhanced in accordance with Figure 1, is to systematically introduce design thinking into various engineering programs. Referring to the presented teaching and learning modes in CDIO Workspaces (Figure 1), it should be noted that the modes of "Product and system design and implementation" and "Reinforcement of disciplinary knowledge" are covered in Luban Workshop.

For example, under the courses of "Theory of mechanisms, principles of design and machine parts" and "The structure of an electric vehicle and a hybrid vehicle" (Year 2) students realize

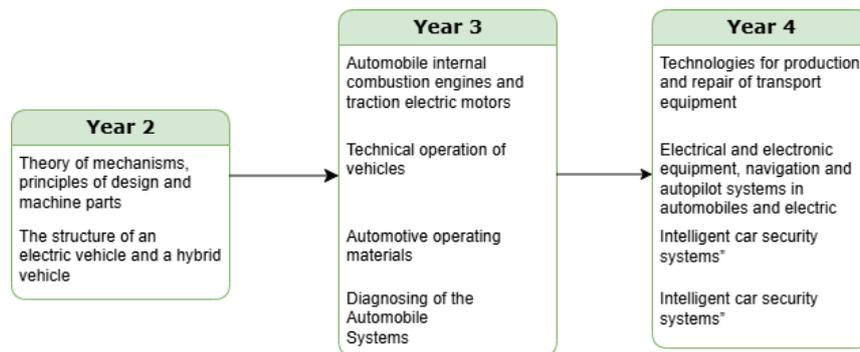projects related to creation of the improved interaction system between automobile elements (Figure 4).

Figure 4. The courses studied in Luban Workshop

To do this, the methods of "Class lab / experiment", "Teaching in labs", and "Lecture – presentation in labs" are used. Under the course of "Automobile internal combustion engines and traction electric motors" (Year 3) students implement projects related to the development of the new technical solution on automobile energy source system. Taking the course of "Technical operation of vehicles" (Year 3), students realize the projects connected with new methods of diagnosing of the technical condition of automobiles. Under the course of "Automotive operating materials" (Year 3) students develop projects aimed at improving batteries and charging systems for electric vehicles, creating more energy-efficient batteries, and improving battery life. Based on the modes presented in Figure 3, "Advanced design-implement project" and "Collaborative design project" modes are used for the Year 3 teaching and learning process. Under the course of "Technologies for production and repair of transport equipment" (Year 4) students develop the projects on the creation of the automobile models. Taking the course of "Electrical and electronic equipment, navigation and autopilot systems in automobiles and electric vehicles" (Year 4), students implement the projects related to development of the simple autonomous systems. Under the course of "Intelligent car security systems" (Year 4) students develop projects connected with advanced driver assistance system (ADAS). It should be noticed that in Luban Workshop, the development of students' research competencies is achieved through project-based work using real equipment and technologies in close collaboration with industrial enterprises (Allur, Astana Motors, QazTechna) and interaction with Chinese research centers and universities. This provides opportunities for international knowledge exchange and the publication of research findings in scientific journals. Overall, the LuBan Workshop contributes to the formation of research skills by combining practical training, technological innovation, and international cooperation.

The further intensions are to provide mode of "Knowledge discovery" (conducting of undergraduate and graduate research projects) related to conducting the scientific investigations directed to the improvement of artificial intelligence in the automobiles. To do this, East Kazakhstan Technical University works on the development of the Luban Workshop workspace by building of Section of Smart Driving Technology including the latest technological equipment and electric vehicles implementing "The Internet of Vehicles" SMART-technologies and intelligent driving safety systems, satellite navigation and third-level autopilot. In July 2024, the university teaching staff completed an internship in Tianjin Vocational Institute (China) on the studying contemporary intellectual automobile systems. The undergraduate and graduate research projects will be conducted under new engineering program of "Smart technologies and artificial intelligence in transport engineering".

CONCLUSIONS

This paper shared how East Kazakhstan Technical University, as a new member of the CDIO community, worked with Singapore Polytechnic, a more-experienced CDIO member, to merge CDIO Framework (notably Standard 6 Engineering Learning Workspaces) into its Luban Workshop which was setup by implementation of CDIO initiative in educational process, coupled with experiences from a learning journey to a more-experienced CDIO member. The Luban Workshop in East Kazakhstan Technical University has been presented, for which the university had merged the CDIO Framework with the EPIP Educational Model. The integration of CDIO and EPIP has led to a transformation of the roles of students and teachers. For students, it impacted them by increasing motivation and engagement, developing professional skills, and fostering innovative thinking. For teachers, it influenced them by changing teaching approaches, enhancing professional competence, and stimulating research activity. Thus, this integration has cultivated a more dynamic, student-centered learning environment where collaboration, creativity, and practical application of knowledge are prioritized.

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BIOGRAPHICAL INFORMATION

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Sin-Moh Cheah is the Centre Director of the SP-CDIO Centre for Innovative Teaching and Learning; under the Department of Educational Development, Singapore Polytechnic. He has more than 17 years of experience implementing CDIO in the Diploma in Chemical Engineering curriculum and had conducted various CDIO workshops for universities in Asia for various disciplinary programs, including non-engineering ones.

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APPENDIX 1. Summary of Zoning of SP Aero Hub for Facilitating Aeronautical Training

Zones	Purpose of training facilities	Domain courses involved	CDIO syllabus covered
Central	• General maintenance of aircraft • Artefacts for case studies * Industry partners: 1. ST Engine-Aero 2. SIAEC 3. SASEL 4. RSAF 5. SUSS	• Aircraft Maintenance Practice/ Gas turbine engine operation/ Aircraft ground handling/ Operational Environmental Training • Computer Aided DesignwithCATIA/ Aircraft structure/ Fundamental of Flight/ AMP • Short courses * *Year 2 & 3*	2.1.1 / 2.2.3/ 2.3.1/2.3.2/ 2.4.1/ 3.2.1/ 3.2.2/4.2.5/ 4.4.1/ 4.5.2/ 4.5.5/ 4.6.1/ 4.6.6/
Ground floor: workshops /Propulsion Test Lab	• Repair aircraft sheet metal &fasteners of aircraft components • Operate and study propulsion systems * Industry partners: 1. ST Engine-Aero 2. ZEN	• AMP • Aircraft powerplant/ Introduction to Space Technology/Final Year Projects * *Year 2 & 3*	2.1.1 / 2.2.3/ 2.3.1/ 2.3.2/ 2.4.1/2.4.4/3.1.2/ 3.2.2/ 3.2.3/ 4.1.1/ 4.2.2/ 4.2.5/ 4.3.1/4.3.2/ 4.3.3/ 4.3.4/ 4.4.1/ 4.4.2/ 4.4.3/4.4.4/4.4.6/ 4.5.2/ 4.5.5/ 4.6.1/4.6.2/4.6.6/
2nd floor Labs	• Aircraft System and Aerodynamics • NDT • Flammability test * Industry partners: 1. JADE	• Aircraft system/ Fundamental of Flight • Short course * *Year 2 & 3*	2.1.1 / 2.2.3/ 3.1.2/ 3.2.2/ 3.2.3/ 4.2.5/ 4.5.5/ 4.6.1/
3rd Floor Labs	• Structural testing lab • Composite repair workshop • VR Learning Space * Industry partners: 1. ACRATS 2. TUM	• Aircraft Structure • Fundamentals of Composite repair • Short course * *Year 2 & 3*	2.1.1/ 2.1.2/ 2.2.3/ 2.2.4/3.2.2/ 3.2.3/ 4.5.2/ 4.5.5/ 4.6.1/ 4.6.5
Simulator Room	• Pilot flight experience * Industrial partners: 1. Primus	• Short course (Private Pilot License Ground Theory (Primus) • Short course (Experiential Pilot Program)	4.5.5/ 4.6.1/ 4.6.2/
Project Centre	• UAV development • General projects	• Final year project • Short course * *Year 2 & 3*	2.1.1/2.1.2/ 2.1.3/ 2.1.4/2.2.2/ 2.2.3/ 2.2.4/ 2.3.1/ 2.3.2/ 2.3.4/ 2.4.1/ 2.4.2/ 2.4.3/ 2.4.4/ 2.4.7/ 3.1.1/ 3.1.2/ 3.1.3/ 3.2.2/3.2.6/ 3.2.7/ 4.1.1/ 4.2.2/ 4.2.5/ 4.3.1/4.3.2/ 4.3.3/ 4.3.4/ 4.4.1/ 4.4.2/ 4.4.3/ 4.4.4/ 4.4.6/ 4.5.2/ 4.5.4/ 4.5.5/ 4.6.1/4.6.2/ 4.6.6/

APPENDIX 2. Summary of Zoning of EKTU Luban Workshop

Zones	Purpose of training facilities	Domain courses involved	CDIO syllabus covered
Section of Technologies for Servicing Fuel, Hybrid and Electric Vehicles	• General maintenance of fuel cars • General maintenance of hybrid and electric cars Industry partners: 1. Astana Motors 2. Allur 3. QazTechna	• Theory of mechanisms, principles of design and machine parts • The structure of an electric vehicle and a hybrid vehicle • Automobile internal combustion engines and traction electric motors • Technical operation of vehicles • Automotive operating materials • Technologies for production and repair of transport equipment	2.1.1 / 2.1.4 / 2.1.5 / 2.2.2 / 2.2.3 / 2.3.1 / 2.4.4 / 2.4.5 / 2.4.6 / 2.4.7 / 3.1.1 / 3.1.3 / 3.2.1 / 3.2.2 / 3.2.6 / 3.3.1 / 4.1.2 / 4.4.1 / 4.5.1
Section of SMART-technologies of Vehicles	• V2X technology training • Training in autonomous vehicle systems Industry partners: 1. Astana Motors 2. Allur 3. QazTechna	• Electrical and electronic equipment, navigation and autopilot systems in automobiles and electric vehicles • Intelligent car security systems	2.1.1 / 2.1.4 / 2.1.5 / 2.2.2 / 2.2.3 / 2.3.1 / 2.4.4 / 2.4.5 / 2.4.6 / 2.4.7 / 3.1.1 / 3.1.2 / 3.1.3 / 3.2.1 / 3.2.2 / 3.2.6 / 3.3.1 / 4.1.2 / 4.4.1 / 4.4.5 / 4.5.1

Technology Acceptance Questionnaire

Questions were contextualised to reflect the use of chatbots for professional development.

Perceived Usefulness (PU) of Chatbots for Professional Development

1. Using the chatbot would improve my performance in doing my job	1 – Strongly Disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly Agree
2. Using the chatbot at work would improve my productivity	1 – Strongly Disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly Agree
3. Using the chatbot would enhance my effectiveness in my job	1 – Strongly Disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly Agree
4. I would find the chatbot useful in my job	1 – Strongly Disagree 2 – Disagree 3 – Neutral 4 – Agree 5 – Strongly Agree

Perceived Ease of Use Questions (PEU) of Chatbots for Professional Development

1. Learning to operate the chatbot would be easy for me	1 – Strongly Disagree 2 – Disagree

	3 – Neutral
	4 – Agree
	5 – Strongly Agree
2. I would find it easy to get the chatbot to what I want it to do	1 – Strongly Disagree
	2 – Disagree
	3 – Neutral
	4 – Agree
	5 – Strongly Agree
3. It would be easy for me to become skilful in the use of the chatbot	1 – Strongly Disagree
	2 – Disagree
	3 – Neutral
	4 – Agree
	5 – Strongly Agree
4. I would find the technology easy to use	1 – Strongly Disagree
	2 – Disagree
	3 – Neutral
	4 – Agree
	5 – Strongly Agree

Behavioural Intention (BI) to use

1. I presently intend to use the chatbot regularly at work	1 – Strongly Disagree
	2 – Disagree
	3 – Neutral
	4 – Agree
	5 – Strongly Agree

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