i-SPiKE 2023

INTERNATIONAL EXHIBITION & SYMPOSIUM ON PRODUCTIVITY, INNOVATION, KNOWLEDGE & EDUCATION

"Optimizing Innovation in Knowledge, Education and Design"

EXTENDED ABSTRACT

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CATEGORY: BSC YOUNG INVENTOR

Assalamualaikum warahmatullahi wabarakatuh,

First and foremost, I would like to express my gratitude to the organizing committee of i-Spike 2023 for their tremendous efforts in bringing this online competition a reality . I must extend my congratulations to the committee for successfully delivering on their promise to make i-Spike 2023 a meaningful event for academics worldwide.

The theme for this event, 'Optimizing Innovation in Knowledge, Education, and Design,' is both timely and highly relevant in today's world, especially at the tertiary level. Innovation plays a central role in our daily lives, offering new solutions for products, processes, and services By adopting a strategic approach to 'Optimizing Innovation in Knowledge, Education, and Design,' we have the potential to enhance support for learners and educators, while also expanding opportunities for learner engagement, interactivity, and access to education.

I am awed by the magnitude and multitude of participants in this competition. I am also confident that all the innovations presented have provided valuable insights into the significance of innovative and advanced teaching materials in promoting sustainable development for the betterment of teaching and learning. Hopefully, this will mark the beginning of a long series of i-Spike events in the future.

It is also my hope that you find i-Spike 2023 to be an excellent platform for learning, sharing, and collaboration. Once again, I want to thank all the committee members of i-Spike 2023 for their hard work in making this event a reality I would also like to extend my congratulations to all the winners, and I hope that each of you will successfully achieve your intended goals through your participation in this competition.

Professor Dr. Roshima Haji Said
RECTOR
UiTM KEDAH BRANCH

WELCOME MESSAGE (i-SPiKE 2023 CHAIR)

We are looking forward to welcoming you to the 3rd International Exhibition & Symposium on Productivity, Innovation, Knowledge, and Education 2023 (i-SPiKE 2023). Your presence here is a clear, crystal-clear testimony to the importance you place on the research and innovation arena. The theme of this year's Innovation is "*Optimizing Innovation in Knowledge, Education, & Design*". We believe that the presentations by the distinguished innovators will contribute immensely to a deeper understanding of the current issues in relation to the theme.

i-SPiKE 2023 offers a platform for nurturing the next generation of innovators and fostering cutting-edge innovations at the crossroads of collaboration, creativity, and enthusiasm. We enthusiastically welcome junior and young inventors from schools and universities, as well as local and foreign academicians and industry professionals, to showcase their innovative products and engage in knowledge sharing. All submissions have been rigorously evaluated by expert juries comprising professionals from both industry and academia.

On behalf of the conference organisers, I would like to extend our sincere thanks for your participation, and we hope you enjoy the event. A special note of appreciation goes out to all the committee members of i-SPiKE 2023; your dedication and hard work are greatly appreciated.

Dr. Junaida Ismail
Chair
3rdInternational Exhibition & Symposium Productivity, Innovation, Knowledge, and Education 2023 (i-SPiKE 2023)

COUPLING OF COMPUTATION SIMULATION AND HANDS-ON EXPERIENCE IN PROCESS CONTROL LABORATORY INLINE WITH IR 4.0 ORIENTED EDUCATION

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ABSTRACT
Integrating principles of Industry 4.0 into hands-on laboratory programs is crucial for mastering process control. However, many laboratories curriculum mainly rely on direct instrument use. This does not adequately train students for the demands of Industry 4.0. In response, Universiti Teknologi PETRONAS introduces an updated curriculum, transitioning to simulation-driven laboratories. The transition is especially valuable in CEB3032 Chemical Engineering Laboratory III for Jan and May 2021 cohort that involves 207 and 162 students to address the challenges in developing genuine psychomotor abilities by simply viewing video recordings since they are not interacting with the actual devices during the COVID-19 pandemic. Before rolling it out, the university meticulously chooses experiment suitable for process simulation. These are then modeled using a dynamic simulation tool applying ordinary differential numerical techniques, e.g., Euler's, Runge Kutta and Gear, for lumped parameter systems and partial differential methodologies, such as finite difference, for distributed parameter systems, respectively. As part of this curriculum, students create simulations, perform experiments, document results, and juxtapose their findings with traditional laboratories presented to them. The application of advanced Bloom's Taxonomy and the Five Es Inquiry-Based Learning is evident, as students actively engage in establishing and designing their own laboratories, starting with the foundational control systems. Feedback and student performance metrics serve as indicators of this approach's success. After adopting the IR 4.0-focused curriculum, there is a noticeable enhancement in students' results, evidenced by an increase in top grades such as A's and a higher median score. The learning outcomes have also seen a boost, with roughly 30% more students achieving grades ranging from B to A. Majority of the students find that integrating process simulation into CEB3032 has aided in applying their knowledge in the process control laboratories too. The success underscores this methodology’s viability for broader academic adoption.

Keywords: Computation simulation, Hands-on experience, Process control laboratory, IR 4.0 education

INTRODUCTION

Malaysia's higher education system has emphasized the importance of the Industrial Revolution (IR) 4.0, ensuring that upcoming professionals are adept in new-age technologies. This emphasis is particularly vital for courses in process control, given the intricate involvement of automation and computational tech. Literature reviews reveal that while there is a shift towards computer-assisted laboratories for enriched student experiences, many of Malaysia's tertiary institutions primarily employ hands-on practical tasks augmented by digital controls (Saniuk, Caganova, & Saniuk, 2021). Notably, the use of process simulation software in laboratory modules remains sparse. Many implementations are restricted to computer simulations focusing on single process units, which doesn't mirror the intricate industry setups composed of multiple linked process units for a singular control goal. The digital aspect in most laboratories often only highlights the shifts in input variables related to control objectives.It misses out on demonstrating the complex interplay between process variables crucial for design and control, which demands advanced cognitive skills. Furthermore, the curriculum either emphasizes wholly hands-on tasks or entirely virtual simulations, sidelining the importance of blending both to truly resonate with IR 4.0 education (Gamage et al., 2020).

FEATURES AND NOVELTY OF INNOVATION

The creation introduces a fresh approach to IR 4.0-based design in standard laboratory courses by uniquely merging computational simulation with hands-on activities, depicted in Figure 1.

Figure 1. Innovative design of traditional laboratory courses with integration of Industry 4.0

The introduced innovation is special, merging computational simulation with tangible hands-on training for the process control laboratories. Traditionally design-focused Aspen Tech simulation software have been integrated into the process control curriculum. Techniques including Euler's, Runge Kutta, and Gear are utilized to model behaviors for lumped parameter systems like heaters, coolers, and continuous reactors. For distributed parameter systems, such as heat exchangers and plug flow reactors, the finite difference method is employed.

The process simulation tool provides more than just visualization and examination of process data like pressure, velocity, and temperature. It clarifies the relationship between process variables to realize specific control objectives. The tool elevates students' ability to apply previously learned knowledge, facilitating a deeper understanding of theoretical connections when setting up simulations. Moreover, this innovation encourages advanced learning as students assess the scope of their knowledge against real-world challenges by contrasting experimental and simulation results. Crucially, it aligns with Malaysia's Higher Education goals, preparing students for a future shaped by IR 4.0, digitalization, and simulation. This

methodology holds promise for adoption across higher educational institutions, fostering an IR 4.0-centric lab learning environment. It resonates with the evolving education landscape, emphasizing digital solutions, especially during the COVID-19 pandemic, which mandates limited physical interactions. Infusing process simulation into the curriculum paves the way for online lab sessions as viable replacements for in-person ones.

Many process control laboratories in Malaysia's higher education institutions emphasize hands-

on practical work augmented by digital and computerized means for control and automation. Yet, the integration of process simulation software into laboratory modules is not widespread. As far as we're aware, this pioneering approach is the first in Malaysia's higher education sceneto merge computational simulation with traditional hands-on laboratory setups using equipment and digital instruments, framing it within an IR 4.0 context. Enhancements from this innovation relative to past methodologies are depicted in Figure 2, using a level control experiment for illustration. Figure 2(a) presents the conventional laboratory setup where students engage with sensors and devices to manage fluid levels in equipment. In contrast, Figure 2(b) showcases the advanced setup introduced by our innovation, adding a simulation aspect for a more comprehensive grasp on the process for students.

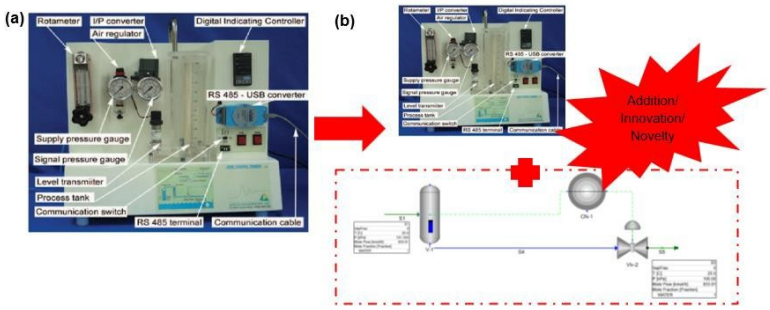

Figure 2. Enhancements in innovation when contrasted with earlier versions include (a) traditional level control tests and (b) process simulation combined with video documentation

METHODOLOGY

A cutting-edge interactive computational simulation laboratory has been introduced as an alternative to traditional process control experiments. Several educational philosophies underpin this innovation's framework. The Education 4.0 framework has been employed, reflecting Malaysia's emphasis on preparing students for the demands of the digitally-driven workforce. The "Five Es Inquiry-Based Learning" strategy has been integrated, particularly emphasizing exploration as students engage in hands-on tasks virtually. Additionally, the simulation integrates advanced levels of Bloom's Taxonomy, embracing the "creation" aspect. Herein, students can assemble laboratory setups in a simulated environment, a flexibility often limited in traditional implementations where equipment setups are fixed. This pedagogical innovation has been adopted in the CEB3032 course for the January and May 2021 batches, involving 207 and 162 students, respectively. Aspen HYSYS, a standard engineering software, is utilized for computational simulations. Of the seven labs, three has been transitioned to a simulation-based format, covering heat exchangers and temperature & cascade controls. The implementation process is segmented into pre, during, and post-stages, detailed in Figure 3.

A cutting-edge interactive computational simulation laboratory has been introduced as an alternative to traditional implementations. Before rolling out, all manuals are scrutinized to identify experiments aligning with process simulation curriculum objectives. The capabilities of various process simulators are evaluated. A literature review helped highlight related research and challenges linked to implementing IR 4.0-focused practical laboratories. Students are introduced to the new approach through preparatory videos showcasing the significance of simulation tools in process control, coupled with practical examples. During the active implementation, students accessed the simulation laboratories where they recreated unit operations found in the simulator. Emphasizing higher Bloom's Taxonomy and Five Es Inquiry-Based Learning approach, students were encouraged to innovate, building their control systems from ground up.

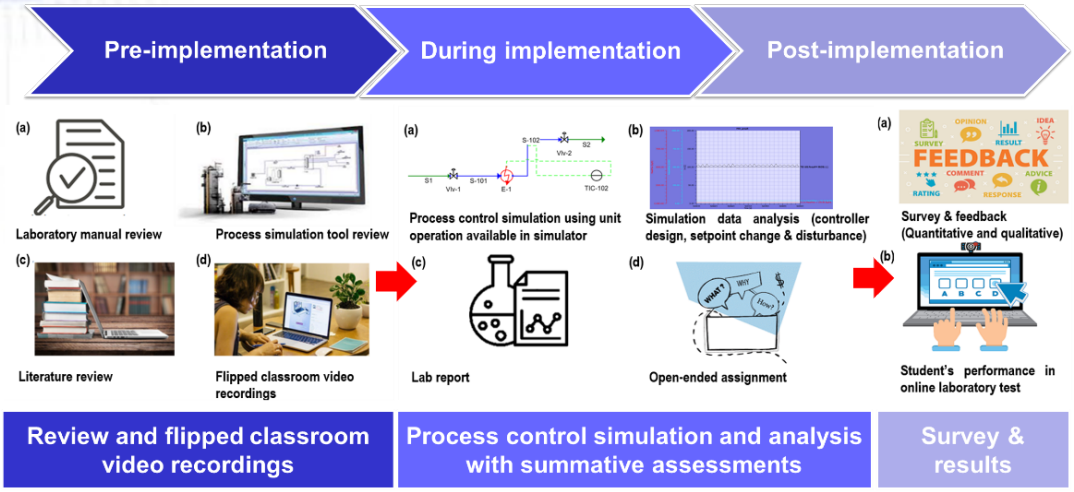

Figure 3: Approach and activities before, during, and after the setup of a simulation-centric laboratory curriculum for CEB3032

This initiative aims to enhance their critical thinking skills, enabling them to analyze, evaluate, and discuss data derived from their simulations. Additionally, students tackle an open-ended project based on frequently encountered control systems, fostering an appreciation for their significance, reliability, and the engaging nature of simulations. In the post-implementation phase, the innovation's success is assessed through surveys, feedback, and analyzing student outcomes from assessments. Lab tests also incorporated questions about process control simulation to measure the new approach's efficacy. Furthermore, the course learning outcome (CLO) and program outcome (PO) for CEB3062 Chemical Engineering Lab III have undergone an evaluation to ensure alignment with the new methodology, as illustrated in Figure 4. This evaluation helps ascertain student learning achievement based on the innovation. Notably, the novel method aligns with CLO1 of the course, emphasizing the use of relevant sensors, instruments, and computing tools to gauge process variable physical properties.

Course Learning Outcome		Programe Outcomes (POs)		
		PO4	PO5	PO9
CLO1	Apply appropriate sensors, instrumentation and/or computing tools to measure physical quantities.		x	
CLO2	Device suitable procedures and implement them in order to characterize dynamic and control systems.	x		
CLO3	Analyze and interpret experimental data for writing and presenting technical reports.			x

PO4	Investigate complex chemical engineering problems using research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions
PO5	Select and apply modern engineering and IT tools to evaluate complex chemical engineering activities
PO9	Communicate clearly on complex chemical engineering activities with the engineering community and society

Figure 4. Mapping of Course Learning Outcome (CLO) and Program Outcome (PO) to ensure innovation is consistent with the course objectives

RESULTS

The overall performance of the students in laboratory test has been improved via implementation of the IR 4.0 oriented laboratory design as shown in Figure 5. When assessing student performance against data from 2016 in Figure 5(a), a noticeable improvement was observed in the January and May 2021 semesters. This enhancement has been achieved after introducing an IR 4.0-focused curriculum that blends simulation with hands-on experience.

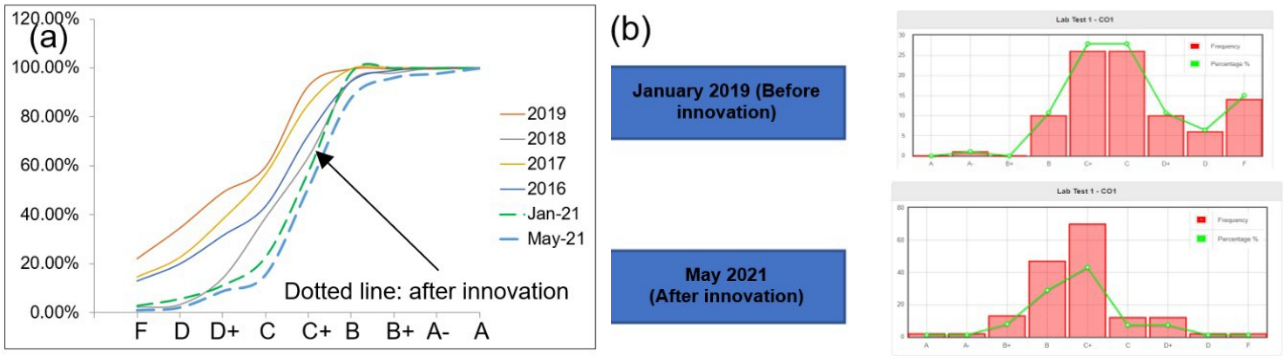

Figure 5. Analysis of (a) aggregate frequency distribution and (b) student achievement in course learning outcomes as assessed through outcome-based education (OBE) in a lab test of similar difficulty and question variation.

Results show not only an uptick in top grades like A's but also a reduction in failures. Moreover, there is an approximate 30% rise in students securing grades in the B to A range, as illustrated in Figure 5(b). This underscores the value of integrating process simulation components closely tie to hands-on laboratories to enrich the student learning experience. Engaging in both simulation and practical activities empowers students to grasp the nuances of process control theory, especially considering the advanced cognitive skills for simulation setup. Student opinions were gathered through surveys and feedback using the Student Self Reflection Tools Survey (SSRT), in which 70% indicated that integrating process simulation into CEB3032 has effectively helped them to apply their understanding in the process control laboratories.

COMMERCIALIZATION OR TRANSFERABLE POTENTIAL

The innovation doesn't necessitate extra resources, as it combines existing learning tools to forge a novel IR 4.0 educational experience. Given its cost-effectiveness and the myriad benefits from the project results, it's advisable for all higher educational institutions in Malaysia to adopt this approach in alignment with IR 4.0 education standards.

CONCLUSION

Universiti Teknologi PETRONAS has introduced a pioneering curriculum focused on process simulation for process control laboratories. This approach facilitates interactive online learning, especially during the COVID-19 pandemic, enhances students' comprehension, and prepares them for the demands of the IR 4.0 landscape. It's encouraging for other higher education institutions in Malaysia to consider adopting this innovative approach.

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