



2nd Asia Pacific Conference on Industrial Engineering and Operations Management

-Indonesia

organizer

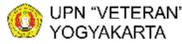


Host University



September 13-16, 2021

Sponsors and Partners



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IEOM Society

"Achieving and Sustaining Operational Excellence"

www.ieomsociety.org

Industrial Engineering and Operations Management Society International

IEOM Society International, 21415 Civic Center Dr., Suite 217, Southfield, Michigan 48076, USA

Phone: 1-248-450-5660, Email: info@ieomsociety.org



Welcoming Message by Host, Universitas Sebelas Maret (UNS)

Prof. Dr. Kuncoro Diharjo, S.T., M.T.

The Vice-Rector for Research and Innovation Affairs

Universitas Sebelas Maret (UNS), Surakarta, Indonesia

Honorary Chair of the 2nd Asia Pacific Conference on IEOM

Assalamu 'alaykum wa rahmatullahi wa barakatuh

Ladies and Gentlement,

It is a great pleasure and an honor for me to deliver this welcome remark at the Opening Ceremony of the 2nd Asia Pacific Conference on Industrial Engineering and Operations Management (2nd APIEOM), September 13-16, 2021, organized by IEOM Society International and Hosted by Universitas Sebelas Maret. Distinguished guests, 15 outstanding keynote speakers, 30 invited speakers, and 7 presenters technical session from 35 countries in this conference. Welcome to Universitas Sebelas Maret in virtual mode due to the current COVID-19 global pandemic. Welcome to Solo, a city of culture. Solo is the one place where you can feel the Spirit of Java.

Many thanks to the university partners that get involved in this event. They are Diponegoro University; Universitas Islam Negeri (UIN) Sunan Kalijaga Yogyakarta, UPN Veteran Yogyakarta, Telkom University, Tarumanagara University; and *the Indonesian industrial engineering higher education institution cooperation agency* or (BKSTI). This event is a part of the long collaboration with IEOM Society International that was initiated by the academic staffs of the Industrial Engineering Department, Faculty of Engineering, Universitas Sebelas Maret in 2018. I appreciate the support from the Faculty of Engineering and especially Industrial Engineering Department to join with international collaboration organizations, such as The IEOM Society International, and to conduct and actively participate in international events, such as 2nd APIEOM.

Ladies and Gentlem

These efforts support The Universitas Sebelas Maret's Vision: "*Becoming the excellent center of development of science, technology, and art at international level based on the noble values of the national culture*". Moreover, 2nd APIEOM 2021 will support the line synergy towards UNS as a World Class University, as well as building stronger relationships between universities and industries, globally. Furthermore, we hope this event strengthens the cooperation between Universitas Sebelas Maret and other local and international partner universities. This collaboration should also involve more students in various countries in the world because they will be the successors of us to make a better world.

On behalf of Universitas Sebelas Maret and the Organizing Committee, I officially open **the 2nd Asia Pacific Conference on Industrial Engineering and Operations Management**. "*Success is a part of progress, as a reward from moving forward. It is time for Indonesia to go global and be global*".

Thank you very much. *Terima kasih. Matur nuwun*

Wassalamu 'alaykum wa rahmatullahi wa barakatuh

Have a good time to join the conferen



Welcome to the 2nd Asia Pacific Conference on Industrial Engineering and Operations Management Surakarta, Indonesia, September 13-16, 2021

Prof. Dr. Ir. Wahyudi Sutopo, ST., M.Si
Conference Chair & President IEOM Indonesia Chapter
 Department of Industrial Engineering, Faculty of Engineering
 University of Sebelas Maret (UNS), Surakarta, Indonesia

Greetings Conference Attendees:

On behalf of the IEOM Society International, we would like to welcome you to Surakarta, Indonesia and the Second Asia Pacific Conference on Industrial Engineering and Operations Management, September 13-16, 2021. This event host is University of Sebelas Maret (UNS). This prestigious event provides a forum for academics, researchers, and practitioners from many industries to exchange ideas, knowledge and experiences on issues related to changing and dynamic trend in Industrial Engineering and Operations Management. Held annually by IEOM International, this diverse international event provides an opportunity to collaborate and advance the theory and practice, as well as, an healthy competition atmosphere among fellow researchers and students.

Our keynote speakers will address some current issues in Industrial Engineering and Operations Management:



Dr. Jessika E. Trancik
 Massachusetts Institute of Technology, USA



Dr. Jay Lee
 Foxconn Technology Group



Prof. George Q. Huang
 The University of Hong Kong, Hong Kong



Dr. Robert de Souza
 National University of Singapore, Singapore



Harry Kasuma Aliwarga
 UMG Myanmar, Jakarta, Indonesia



Dr. Ahad Ali
 Lawrence Tech, Michigan, USA
 Executive Director of IEOM



Prof. Dr. Eng. Koichi Murata
 Nihon University, Japan



Dr. Rajesh Piplani
 Nanyang Technological University, Singapore



Bertha Maya Sopha, PhD
 Gadjah Mada University; Chair of BKSTI, Indonesia



Prof. Anicia Peters
 University of Namibia, Windhoek Khomas, Namibia



Tom Gaasenbeek
 Nexas Networks Inc., Ontario, Canada



Adil Daial
 Operations Enviromedica, Texas, USA



Dr. John Blakemore
 University of Newcastle, Australia



Dr. Basuki Rahmad
 PT Transforma Engineering & Solutions, Indonesia



Dr. Zain Tahboub
 MENA College of Management (MCM) Dubai, UAE

Held concurrently, the 25th IEOM Global Engineering Education or Indonesian Engineering Education Conference (IEEC) session will feature distinguished speakers who will discuss workforce readiness and engineering education challenges and opportunities. The 24th IEOM Industry Solutions and Industry 4.0 will showcase industry best practices and intelligent integration. IEOM Global Supply Chain and Logistics will address the global logistics challenges due to the worldwide pandemic situation. In addition, several outstanding panel sessions will explore current worldwide issues, such as Halal Supply Chain, Women in Industry and Academia (WIIA), Renewable Energy, Diversity and Inclusion, and Technopreneurship.

The IEOM Society expresses our deep appreciation to the conference organizing committee, international and local organization partners, 15 distinguished keynote speakers, 30 outstanding invited speakers, and 700 paper authors from 35 countries who create a wonderful collaboration in making an overwhelmingly successful event.

Success is a part of progress, as a reward from moving forward. It is time for Indonesia to go global and be global.
 Enjoy the conference!

On behalf of the organizing committee,



Professor Don Reimer
Director of Membership & Chapter of IEOM Society
 Lawrence Technological University, USA



Dr. Muh. Hisjam
Program Chair
 University of Sebelas Maret, Surakarta, Indonesia



Dwi Agustina Kurniawati, PhD
Program Chair
 State Islamic University Sunan Kalijaga, Yogyakarta, Indonesia



Dr. Manik Mahachandra
Program Chair
 Diponegoro University, Semarang, Indonesia

We also thank to the host and local partners:



Conference Program

Day 1 – September 13 (Monday)

08:00 – 9:45 am Technical Presentations – Zoom Meeting Rooms 1-6
 10:00 – 11:45 am Technical Presentations – Zoom Meeting Rooms 1-6
 12:00 – 1:45 pm Technical Presentations – Zoom Meeting Rooms 1-6
 02:00 – 3:45 pm Technical Presentations – Zoom Meeting Rooms 1-6
 04:00 – 5:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

Day 2 – September 14 (Tuesday)

8:00 am – Officially Opening the Conference from UNS Vice Rector – Zoom Meeting Room 1
 8:20 am – Keynote Speaker I: **Dr. Jessika E. Trancik**, Associate Professor, Institute for Data, Systems and Society (IDSS), Massachusetts Institute of Technology (Opening Keynote) – Zoom Meeting Room 1
 9:00 am – Keynote Speaker II: **Dr. Jay Lee**, Vice Chairman and Board Member of Foxconn Technology Group, Member of World Economic Forum Global Future Council on Advanced Manufacturing and Production – Zoom Room 1
 9:40 am – Keynote Speaker III: **Prof. George G. Q. Huang**, Chair Professor and Head, Department of Industrial and Manufacturing, Systems Engineering, The University of Hong Kong – Zoom Meeting Room 1
 10:20 am Break
 10:40 am – Keynote Speaker IV: **Dr. Robert de Souza**, The Executive Director of the The Logistics Institute – Asia Pacific (TLI – Asia Pacific), National University of Singapore, Singapore City, Singapore – Zoom Meeting Room 1
 11:20 am Keynote Speaker V: **Harry Kasuma (Kiwi) Aliwarga**, CEO and Co-Owner, UMG Myanmar – Zoom Meeting Room 1

12:00 pm – LUNCH BREAK

1:00 pm – 2:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6
 2:45 pm – Break
 3:00 pm – 4:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6
 4:45 pm – Break
 5:00 pm – 6:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

Day 3 – September 15 (Wednesday)

8:00 am – Conference Co-Chair Remarks – Zoom Meeting Rooms 1
 8:20 am – Keynote Speaker VI: **Dr. Ahad Ali**, Associate Professor and Director of Industrial Engineering, Lawrence Technological University, Michigan, USA – Zoom Meeting Room 1
 9:00 am – Keynote Speaker VII: **Prof. Dr. Eng. Koichi Murata**, College of Industrial Technology, Nihon University, Japan – Zoom Room 1
 9:40 am – Keynote Speaker VIII: **Dr. Rajesh Piplani**, Associate Professor, The school of Mechanical and Aerospace Engineering, Systems and Engineering Management division, Nanyang Technological University, Singapore – Zoom Meeting Room 1
 10:20 am Break
 10:40 am – Keynote Speaker IX: **Dr. Ir. Bertha Maya Sopha**, Past Director of Industrial Engineering Undergraduate Program, Faculty of Engineering, Universitas Gadjah Mada (UGM), Yogyakarta, Indonesia and President – Indonesian Association of Industrial Engineering Higher Education Institution (BKSTI) – Zoom Meeting Room 1
 11:20 am Keynote Speaker X: **Prof. Anicia Peters**, Pro-Vice Chancellor: Research, Innovation & Development, University of Namibia

12:00 pm – LUNCH BREAK

1:00 pm – 2:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6
 2:45 pm – Break
 3:00 pm – 4:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6
 4:45 pm – Break
 5:00 pm – 6:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

Day 4 – September 16 (Thursday)

8:00 am – Conference Co-Chair Remarks – Zoom Meeting Rooms 1
 8:20 am – Keynote Speaker XI: **Tom Gaasenbeek**, Founder and CEO, Nexas Networks Inc., Hamilton, Ontario, Canada – Zoom Meeting Room 1
 9:00 am – Keynote Speaker XII: **Adil Dalal**, Vice President of Operations, Enviromedica, Austin, Texas, USA – Zoom Meeting Rooms 1
 9:40 am – Keynote Speaker XIII: **Dr. John Blakemore**, Adjunct Professor at University of Newcastle, Blakemore Consulting International, Sydney, Australia – Zoom Meeting Room 1
 10:20 am Break
 10:40 am – Keynote Speaker XIV: **Dr. Basuki Rahmad**, ST, MT, CEO, PT. Transforma Engineering & Solutions, Bandung, Java, Indonesia
 11:20 am Keynote Speaker XV: **Dr. Zain Tahboub**, President, MENA College of Management (MCM), Dubai, UAE – Zoom Meeting Room 1

12:00 pm – LUNCH BREAK

1:00 pm – 2:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6
 2:45 pm – Break
 3:00 pm – 4:45 pm – Technical Presentations – Zoom Meeting Rooms 1-6
 4:45 pm – Break
 5:00 pm – 6:45 pm Technical Presentations – Zoom Meeting Rooms 1-6

8:00 – 10:00 pm, September 16: Conference Awards Ceremony and Announcing Competition Winners

ID 703 The Influence Of Good Corporate Governance, Audit Quality, Profitability, And Leverage On Financial Statement Integrity (Empire Study On Basic Industry & Chemicals Manufacturing Companies In Bei):

Saiful Anam, Nurrohman Hari Mulyono, Inuk Wahyuni Istiqomah, Ade Setia Pratama, Ahmad Iuthfi, Putri Ambarwati, Accounting Study Program, Faculty Economy, STIE Al Anwar Mojokerto, Indonesia

Rony Wardhana, Faculty Economy and Business, Universitas Narotama Surabaya, Indonesia, Student of Doctoral Accounting, Universitas Airlangga Surabaya, Indonesia

Abdul Talib Bin Bon, Fakulti Pengurusan Teknologi dan Perniagaan, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia

ID 704 Effect of Good Corporate Governance, Profitability, Firm Size, and Intellectual Capital on Company Value (Empirical Study of NON-Financial Companies LQ45 Index Listed on Indonesia Stock Exchange)

Nurrohman Hari Mulyono, Saiful Anam, Inuk Wahyuni Istiqomah, Ade Setia Pratama, Rizki Arvita, Risa Mayasari, Munzidahtul Aidha, Accounting Study Program, Faculty Economy, STIE Al Anwar Mojokerto, Indonesia

Rony Wardhana, Faculty Economy and Business, Universitas Narotama Surabaya, Indonesia, Student of Doctoral Accounting, Universitas Airlangga Surabaya, Indonesia

Abdul Talib Bin Bon, Fakulti Pengurusan Teknologi dan Perniagaan, Universiti Tun Hussein Onn Malaysia (UTHM), Johor, Malaysia

ID 708 The Effect Of Strategic Flexibility, Strategic Innovation, Job Satisfaction And Employee Performance In The Covid-19 Pandemic: Study On Small And Medium Clothing Industry In East Java Province

Mirhamida Rahmah, Noermijati Noermijati, Achmad Sudiro, Mintarti Rahayu, Doctorate Program Management Department, Faculty of Economics and Business, University Brawijaya, Malang, Indonesia

5:00 – 6:30 pm, THURSDAY**Machine Learning****Room 4**

Session Chair: Akmal Khansa Hafsa, Universitas Gadjah Mada, Yogyakarta, Indonesia

ID 079 A Proposed of Lean Six Sigma Framework for Higher Education Institution (LSSF - for HEdu) To Improve Effectiveness and Efficiency of Higher Education in Indonesiaveness and Efficiency of Higher Education in Indonesia

Ig. Jaka Mulyana 1,2, Moses Laksono Singgih 1 and Sri Gunani Partiw 1

1 Department of Industrial and Systems Engineering, Institut Teknologi Sepuluh Nopember, Surabaya Indonesia

2 Department Industrial Engineering, Widya Mandala Surabaya Catholic University, Surabaya Indonesia

ID 174 Developing e-logistics system for Plastic Recycle in order to Enhance the Role of Community-Based Waste Bank

R.B. Seno Wulung, Midarto Dwi Wibowo, Yuli Suwarno, Rofiatun Nafiah, Politeknik ATK Yogyakarta, Jl.Ateka, Bangunharjo, Sewon, Bantul, D.I.Yogyakarta

ID 179 Brand Communication and Service Quality Contribution in Building Brand Loyalty through Brand Trust in Indonesia's Garuda Airways

Evanny Andoko and John Tampil Purba, Department of Management Faculty of Economics and Business, Universitas Pelita Harapan, Tangerang-15811, Indonesia

Sidik Budiono, Department of Management Faculty of Economics and Business, Universitas Pelita Harapan, Tangerang-15811, Indonesia

Gidion P. Adirineko, Department of Management Faculty Economics and Business, Universitas Kristen Krida Wacana, Jakarta, 11470 Indonesia

ID 150 Development of Automatic Tomato Plant Diseases Detection System based on Convolutional Neural Network

Raditya Rifqi Rayhan, Winda Astuti, Muhammad Nurul Puji, Automotive and Robotics Program, Computer Engineering Department, BINUS ASO School of Engineering, Bina Nusantara University, Jakarta, Indonesia 11480

ID 429 Sustainable Marketing Strategy: The Psychological Factors of Consumer

Doni Purnama Alamsyah, Chyntia Ika Ratnapury, Indriana, Bina Nusantara University, Indonesia

ID 477 Household Behavior on Plastic Waste Separation in Indonesia

Akmal Khansa Hafsa and Anna Maria Sri Asih, Departemen Teknik Mesin dan Industri, Universitas Gadjah Mada, Yogyakarta, Indonesia

5:00 – 6:30 pm, THURSDAY**Technoprenurship Panel****Room 5****Technoprenurship Panel****Panel Chairs**

Dr. Ir. Wahyudi Sutopo, ST., M.Si, IPM

Professor, Department of Industrial Engineering

Vice Dean for General and Financial Affairs, Faculty of Engineering, 2019-2023

Past Head of Department of Industrial Engineering

Coordinator of Industrial Engineering and Techno-Economy (RITE) Research Group Universitas Sebelas Maret (UNS), Surakarta, Indonesia

Dwi Agustina Kurniawati, M.Eng., Ph.D.

Associate Professor

Industrial Engineering Department

Former Head of Industrial Engineering Department

Head of Faculty Quality System Controller

Faculty of Science and Technology

UIN Sunan Kalijaga, Indonesia

Panelists:



IEOM Society International

The Second Asia Pacific Conference on
Industrial Engineering and Operations Management
Surakarta, Indonesia, September 13-16, 2021, Host: Universitas Sebelas Maret (UNS)

Certificate of Presentation

This is to certify that

Ig. Jaka Mulyana

Institut Teknologi Sepuluh Nopember and

Widya Mandala Surabaya Catholic University, Surabaya Indonesia

Co-authors: **Moses Laksono Singih and Sri Gunani Partiw**

Delivered an Oral Presentation entitled "A Proposed of Lean Six Sigma Framework for Higher Education Institution (LSSF - for HEdu) To Improve Effectiveness and Efficiency of Higher Education in Indonesiaveness and Efficiency of Higher Education in Indonesia" at the Second Asia Pacific Industrial Engineering and Operations Management Conference Virtually via Zoom.

Dr. Ir. Wahyudi Sutopo, ST., M.Si, IPM
Conference Chair

Professor, Department of Industrial Engineering
Vice Dean for Human Resources, Finance, and
Logistics, Faculty of Engineering
Universitas Sebelas Maret (UNS), Indonesia
President, IEOM Indonesia Chapter

Professor Donald M. Reimer
Conference Co-Chair

Director of Membership and Chapters,
IEOM Society and President, The Small
Business Strategy Group, Michigan
Adjunct Professor at Lawrence Tech
Southfield, Michigan, USA

Dr. Ahad Ali

Associate Professor
Director of Industrial Engineering Program
Lawrence Technological University
Southfield, Michigan, USA
Executive Director, IEOM Society

Sponsors and Partners



A Proposed of Lean Six Sigma Framework for Higher Education Institution (LSSF - for HEdu) To Improve Effectiveness and Efficiency of Higher Education in Indonesia

Ig. Jaka Mulyana^{1,2}, Moses Laksono Singgih¹ and Sri Gunani Partiw¹

¹Department of Industrial and Systems Engineering
Institut Teknologi Sepuluh Nopember, Surabaya Indonesia

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Abstract

Improvement of the effectiveness and efficiency of Higher education institutions (HEI) are required to alter the teaching and learning process, research, and community service. HEI are also improve student abilities and focus on customers requirement. HEI must redesign business processes to reduce the administrative overhead and improve the services delivered to students, industry partners, faculty, and researchers. As a result, HEI should increase all its resources by using various quality improvement methods. Currently, universities in America, Europe, and Australia adopted several frameworks. Universities can carry out accreditation using these frameworks. Accreditation is comparing specific criteria with established standards. For this reason, HEI must have a framework for improving its quality. Lean Six Sigma (LSS) approach is one of the frameworks for improvements.

LSS is a business strategy and methodology that increases process improvement, resulting in enhanced customer satisfaction and improved processes. Lean Manufacturing (LM) is a manufacturing concept to produce products efficiently by reducing waste. The Six Sigma methodology is a disciplined and structured approach to improving process performance and achieving high levels of quality. Many service industries, including at HEI, implemented Lean Six Sigma (LSS), i.e., the integration of Lean Manufacturing and Six Sigma. So far, the adaptation of LSS has been only partial and has focused on reducing waste rather than a holistic approach. There are not many studies that discuss LSS comprehensively, develop models and carry out cost evaluations. This paper proposes the Lean Six Sigma Framework for Higher Education (LSSF - for HEdu) comprehensively. The framework hopefully can increase the effectiveness and efficiency of the HEI so that it can satisfy all customers and reduce costs

Keywords:

Lean Six Sigma, LSSF - for HEdu, effectiveness, efficiency, HEI.

1. Introduction

Higher Education Institution (HEI) was greatly influenced by the Industrial Revolution 4.0. Digitalization affects all aspects of teaching, research, knowledge transfer, and administrative activities (Dräger et al., 2017). HEI must improve and develop teaching and learning strategies, improve student competency and focus on customers, and increase all resource utilization (Davidson et al., 2020; Svensson et al., 2015; Wawan et al., 2018). Currently, universities in America, Europe, and Australia adopt several frameworks. Universities can carry out accreditation using these frameworks. Accreditation is comparing specific criteria with established standards. Accreditation systems widely used include the Accreditation Board for Engineering and Technology (ABET), Association to Advance Collegiate Schools of Business (AACSB), European Quality Improvement System (EQUIS), ASEAN University Network-Quality Assurance (AUN-QA), and Japan Accreditation Board for Engineering Education (JABEE). The framework has no specific methodology for continuous improvement (Davidson et al., 2020). HEI must improve its business processes systematically. Lean Six Sigma is a methodology for improving business processes systematically (Svensson et al., 2015). The American Society for Quality (ASQ) stated many advantages of implementing LSS at HEI, i.e., meeting accreditation requirements, making improvements, encouraging collaboration between organizations, knowing customer desires, identifying, and reducing costs (Simons, 2013).

The concept of quality continues to evolve and results in several methodologies. Total Quality Management (TQM) is a quality management system that improves companies such as Texas Instruments, Xerox, IBM, and Motorola. Furthermore, there are several quality development models, i.e., Malcolm Baldrige Award, European Foundation for Quality Management, the Deming Prize Criteria, and Kaizen quality development models (Sunder M & Antony, 2018). Kaizen is a gradual and continuous improvement. Lean is a quality improvement philosophy that fosters a CI culture in an organization. The Lean concept developed in Japan after World War II. Japanese manufacturers realized that they could not make the significant investments required to rebuild the destroyed facilities (Bhamu & Sangwan, 2014). Lean Manufacturing (LM) is a well-known and widely used approach in companies because of its ability to increase process efficiency and productivity (Bittencourt et al., 2019).

LM implementation began in the automotive industry, followed by other industries, including textiles, construction, food, medical, electricity and electronics, ceramic industry, plywood, furniture, slippers, shell, and the service industry (Alifiya & Singgih, 2019; Bakkali et al., 2017; Bhamu & Sangwan, 2014; Hardiningtyas et al., 2011; Mulyana & Angka, 2014). LM has also been implemented well in HEI (A. C. Alves et al., 2016; Balzer, 2010). Lean Manufacturing in HEI is an adaptation of Lean Thinking to HEI, both in administrative and academic activities (Vukadinovic et al., 2017). The Technical School in Morocco improves quality, reduces waste and costs, and shortens time through the implementation of LM (Bakkali et al., 2017). Other several other studies have shown the contribution of LM implementation in universities. Some benefits of LM implementation are accelerating the administration process, increase student satisfaction, and design curricula (Bârsan & Codrea, 2019; Emiliani, 2004; Koromyslova et al., 2019; Kumar et al., 2016; Sremcevic et al., 2018).

Six Sigma methodology is a disciplined and structured approach to improve process performance and achieve high-quality levels. Lean Manufacturing and Six Sigma, referred to as the Lean Six Sigma (LSS), are complementary methods that have been widely used in companies. Lean Six Sigma (LSS) is a methodology that focuses on eliminating waste and defects by using Six Sigma to achieve customer satisfaction related to quality, delivery speed, and cost and generating financial benefits (Salah et al., 2010). Opportunities for improvement in HEI using LSS can be carried out in several activities, especially teaching, service administration, new student registration processes, marketing, and research (Hess & Benjamin, 2015). There have been several implementation LSS in HEI. Vats & Sujata (2015) reported that the implementation of LSS reduces waste in the teaching and learning process. Svensson et al. (2015) stated that LSS increases efficiency at King Abdullah University of Science and Technology.

Meanwhile, Allameh Tabatabai University in Tehran, Iran, increase student satisfaction levels, reducing the waiting time for consultations by 15 percent and increasing the number of applicants by 5 percent (Haerizadeh & Sunder M, 2019). Another benefit of implementing LSS in HEI is being an enabler to meet accreditation requirements (Sunder M & Mahalingam, 2018). The LSS approach in HEI can be applied to improve teaching methods, administrative processes, improve the quality of HEI and add value that can continuously increase customer/student satisfaction (Cudney et al., 2018). However, much of the research focused on implementing LSS to reduce waste rather than a holistic approach (Hines & Lethbridge, 2008). HEI requires an integrated method to increase business process efficiency and effectiveness. This paper proposes a conceptual framework of Lean Six Sigma for HEI. The framework will be developed in a comprehensive way to manage teaching process, research, and community services.

2. Literature Review

2.1 Lean Manufacturing

The basic principle of Lean Manufacturing (LM) is Lean Thinking. Lean Thinking consists of 5 principles: specify the value, identify value streams, create flow, pull system, and pursue perfection (James P Womack & Jones, 2003). LM implementation benefits include reducing lead time, improving productivity, and reducing WIP (Patel & Patange, 2017). Waste in manufacture consist of (J P Womack & Jones, 1997):

- a. Transportation. Unnecessary transport of parts under production.
- b. Inventory. Stacks of parts waiting to be completed or finished products waiting to be shipped.
- c. Motion. Unnecessary movement of people working on products.
- d. Waiting. Unnecessary waiting by people to begin the next step
- e. Over-Processing the product with extra steps.
- f. Over-Production of products not needed.
- g. Defects in the product.

2.2 Lean Six Sigma (LSS) in HEI

Lean and Six Sigma have a complementary relationship that is widely accepted today, and more companies are establishing Lean Six Sigma (LSS) programs (Salah & Rahim, 2019). The term LSS was introduced around 2000. LSS is widely used in the industry (Antony et al., 2017). Snee (2010) defined LSS as a business strategy and

methodology that increased process performance resulting in enhanced customer satisfaction and improved bottom-line results by improving quality, speed and cost. The LSS methodology helps to improve capabilities within the organization, reduce production costs and improve quality. LSS has become a widely used strategy for continuous improvement in the manufacturing industry (automotive, heavy equipment, small industry, construction, textiles), process industry (paper, sugar, food industry), and service industries (health, finance, education, military, insurance, retail) (Shokri, 2017; M. Singh & Rathi, 2019). Although initially, LM came from the manufacturing industry, it has been implemented successfully in various industries, including HEI (Balzer, 2010). For more than 15 years, LSS has demonstrated its potential for realizing improvements in the delivery of higher education and its supporting services. Examples of improvement noted in the literature include (Balzer et al., 2016):

- reducing student waiting time at counseling centers from an average of 21 days to 0 days without adding staff
- reduce the response time of prospective students from 3 weeks to 1 hour.
- reduced the time to repair campus facilities from an average of 24 working days to an average of less than three working days, where 80 percent of repairs were completed on the same day as requested.
- half the administrative process for recruiting new staff, reducing hiring time from 22 to 8 weeks.
- more than \$ 27.2 B in financial savings at US public universities over four years.

The role of LSS in HEI includes several aspects, both operational and managerial aspects. The number of articles related to the implementation, concept, and study of literature at HEI (Figure 1). Figure 1 shows LSS research in PT has been started in 2006 and continues to increase in number until now. This shows that LSS is needed in PT and needs to be continuously developed.

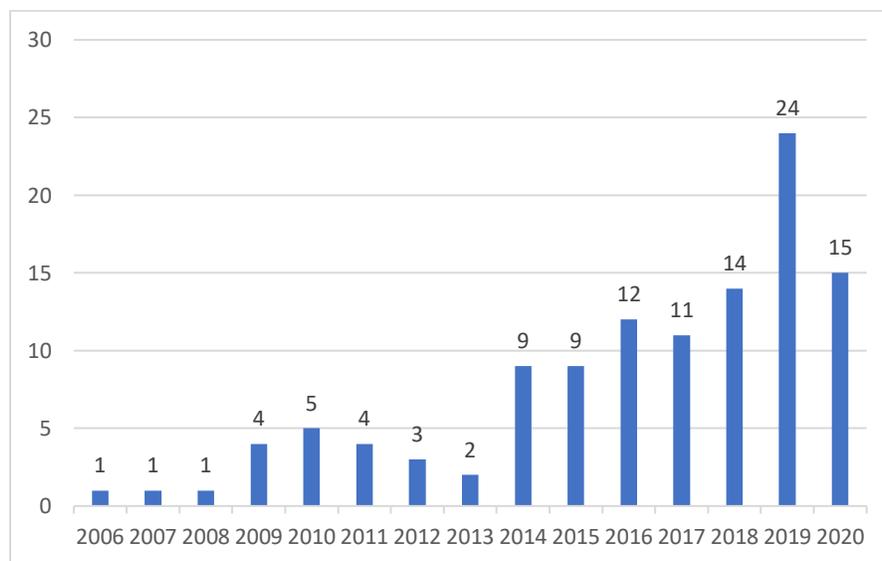


Figure 1. Number of LSS article in HEI
(Source: Scopus Database, retrieved 30-12-2020)

3. Proposed Framework

This article discusses the Lean Six Sigma Framework for Higher Education Institution (LSSF - For HEdu) to improve the effectiveness and efficiency. The framework consists of 4 stages, namely:

- a. Identification and Prioritize of Waste.
- b. Identification of Critical Success Factors (CSF) and Analysis of its Relationship.
- c. Identification Voice of HEI stakeholders.
- d. Development of improvement project selection.

Figure 2 shows the proposed framework.

3.1. Identification and Prioritize of Waste Framework

Kang & Manyonge (2014) identified the types of waste and classified them into three perspectives: students, research, and employees. Meanwhile, according to Sunder (2016), some examples of waste are as follows:

- a. Uncoordinated teaching so that students do not pass the test.
- b. Graduates who cannot get a job and cannot learn for life.
- c. Class schedules that make it difficult for students to graduate.
- d. Course does not contribute to customer value.
- e. Miss planning in teaching schedule that causes students/lecturers to change rooms or locations.
- f. Poor planning of materials and facilities required does not match both cost and quality.
- g. Lecturers and students wait because of activities that are not on time.
- h. Curricula design and supporting activities that are not under the needs of students and industry.

To develop LSS in HEI, it is necessary to identify the type of waste. Hussain & Malik (2016) argued that to develop LM successfully, waste must be identified and prioritized to eliminate. Waste in each HEI should be different both in type and impact on performance so that continuous efforts are needed to find and reduce waste. Unlike in manufacturing, waste in HEI is not clearly defined, and there is still no agreement (Kazancoglu & Ozkan-Ozen, 2019). Hartanti et al. (2020), in their study, classified waste in HEI in to nine types, i.e., overproduction, over-processing, waiting, motion, transportation, inventory, defect, people, and information. Douglas et al. (2015) and Kazancoglu & Ozkan-Ozen (2019) used semi-structured interviews and brainstorming with academic staff to identify waste. Due to a lack of definition, it is necessary to involve HEI leaders, faculty members and staff, and LSS experts in identifying waste.

The process for identifying waste is not accessible due to overlapping processes and interrelatedness between waste. Rawabdeh (2005) proposed assessing seven types of waste in the manufacturing industry using the Waste Relationship Matrix (WRM). WRM was used to determine the relationship between 7 wastes and determine their ranking. Another researcher, El-namrouty & Abushaaban (2013), also used WRM to assess waste. Pessôa et al., (2009) identified ten types of waste in a product development system and ranked the waste using the Waste Net. The other methods were used to prioritize waste in manufacture are *Quality Function Deployment* (QFD) (Rawabdeh, 2011), *Weighted Average* (Arunagiri & Gnanavelbabu, 2014), *Failure Mode Effect Analysis* (FMEA)(Souza & Carpinetti, 2014), *Fuzzy Analytical Hierarchy Process* (AHP) (Arunagiri & Gnanavelbabu, 2016), questionnaire (Aka et al., 2019), *Decision Making Trial and Evaluation Laboratory* (DEMATEL) (Gupta et al., 2019) dan *Modified Failure Mode Effect Analysis* (FMEA) (Sutrisno et al., 2020). Hussain et al. (2016) and Hussain & Malik (2016) used AHP, and Bharsakade et al. (2021) used AHP in the healthcare industry. Regarding HEI, the rating of waste by using Fuzzy DEMATEL (Kazancoglu & Ozkan-Ozen, 2019) and AHP (Klein et al., 2021).

3.2. Identification of Critical Success Factors (CSF) and Readiness of Lean Six Sigma (LSS) Framework.

Laureani & Antony (2012) surveyed to determine the critical success factors for LSS in various industries. The survey results show that 19 factors determine the success of LSS, namely management commitment, organizational culture, the relationship between LSS and business strategy, leadership, communication, the relationship between LSS and customers, concern, selection of LSS staff, database approach, selection of improvement projects, review of LSS projects, LSS staff resources, training, technical LSS, project management skills, finance, organizational infrastructure, expansion of the LSS to the supply chain, and linkage of the LSS to the reward system. Antony (2014) identified the readiness factors of 7 universities in the United Kingdom consisting of leadership and vision, management commitment and resources, linking LSS to the university's strategy, customer focus, and selecting the right people. By knowing the level of readiness to develop LSS (Lean Six Sigma Readiness/LESIRE), organizations can identify obstacles in developing LSS. Bayou & de Korvin (2008) measured the leanness of two automotive industries using fuzzy logic. Meanwhile, Vinodh & Chintha (2011) dan Vinodh & Vimal (2012) measured the leanness index and score. Wong et al. (2014) conducted an integrated leanness level (index) measurement, which includes three aspects (quality, cost, and on-time delivery). In addition to identifying CSFs, determining relationships between factors is also essential (Swarnakar et al., 2019, 2020; Yadav & Desai, 2017). The relationship between factors in a system is very complex, and it is difficult to determine the influence between factors (Swarnakar et al., 2020). Some researchers investigated the relation and interaction of CSF in the manufacturing industry. The method that is widely used to analyze the relationship between factors and categorize factors is the integration between Interpretive Structural Modeling (ISM) and Fuzzy Matrices 'Impacts Croise's Multiplication Applique'ea'un Classement (Fuzzy MICMAC) (Ben Ruben et al., 2018; Cherrafi et al., 2017; Malek & Desai, 2019; Raval et al., 2018; Swarnakar et al., 2019; Yadav & Desai, 2017). However, the limitations of ISM are (i) only describes the variables that are directly related (ii) does not explain the reasons for the relationship between variables. Total Interpretive Structural Modeling (TISM) can overcome these limitations by identifying and interpreting direct and indirect relationships between variables. By interpreting the relationship, directly and indirectly, TISM can be more easily applied in real life (Sushil,

2012). According to Sushil (2012), TISM only considers the interactions between existing variables. To consider the possibility of other interactions, TISM can be developed into Fuzzy TISM.

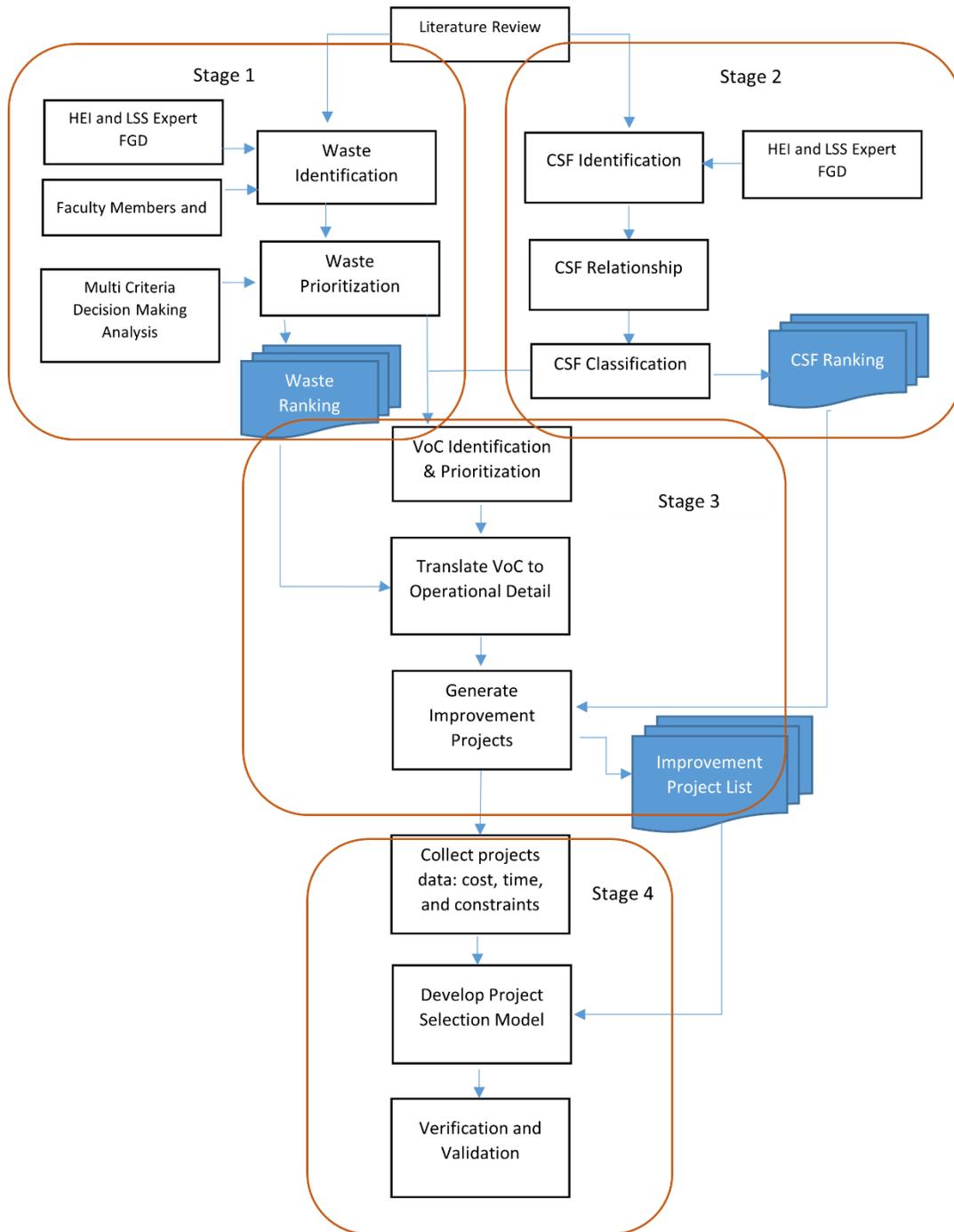


Figure 2. Proposed Framework of LSS in HEI

3.3. Voices of Customer in HEI.

In the competition era, an organization, including HEI, must improve quality. In facing competition, HEI ought to adopt a customer-oriented approach (Wulandari & Jager, 2018). HEI that adopt customer-oriented will understand and assess stakeholders' perceptions about education to find out their needs. The question that often arises in education, especially HEI, is who the stakeholders are? (Pereira & Silva, 2003). Reavill (1998) identified twelve stakeholders

HEI, namely owners, student families, university leaders and employees, suppliers, high schools, other universities, industry, state, government, taxpayers, and professional organizations. Based on a study conducted by Pereira & Silva (2003), HEI customers consist of students, owners, lecturers, family, community/government, and employees. Of course, every stakeholder has their own desires that may be the same or different. HEI that can fulfill the desires of stakeholders can be said to have good quality. Like an industry, HEI must also focus on the desires of its stakeholders. The question now is not how important quality is but how to organize a qualified HEI. Most of the articles indicated that students as customers of HEI (H. Alves & Raposo, 2007; Brkanlić et al., 2020; Campos et al., 2018; Cavallone et al., 2020; Clemes et al., 2007; Elliott & Healy, 2001; Hwang & Teo, 2001; Koris & Nokelainen, 2015; Mark, 2013; Santini et al., 2017; Skea, 2017, 2019; Wiers-Jenssen et al., 2002; Wulandari & Jager, 2018; Zineldin et al., 2011). Some other articles did not merely consider students as the customer. Chen et al. (2006) developed a satisfaction measurement model of faculty members. Gonzalez et al. (2011) used employees as customers in designing curriculum. Sandmaung & Khang (2013) determined quality indicators from students, faculty members, university leaders, and staff perspectives.

To find out the Voice of Customer (VoC) and determine the priority of VoC, the KANO method can be used. KANO model was able to identify product attributes that meet customer desires (Sharif Ullah & Tamaki, 2011; Suef et al., 2014, 2017). Several articles show the effectiveness of KANO in identifying VoC HEI. Sahney (2011) uses the KANO method to determine priorities for improving HEI services in India. Mcdowall (2016) conducted research to determine quality attributes and measure student satisfaction using the KANO method. Hamzah et al. (2018) used the KANO method to classify the quality attributes of HI in Indonesia. In its use, KANO also integrated with other methods such as Quality Function Deployment (Hamzah et al., 2018; Sahney, 2011) and Importance Performance Analysis (Ku & Shang, 2020).

3.4. LSS Project Selection Model in HEI.

One of the critical factors for the success or failure of LSS development is determining improvement projects (Albliwi et al., 2014; Laureani & Antony, 2012; Sreedharan V et al., 2019). The improvement project is a process improvement project. A process improvement project is defined as a systematic approach to improving organizational performance, which consists of activities, tools, techniques, and technology, as well as implementing a series of improvement projects. In determining project selection, there are several criteria: the customer perspective, financial perspective, conformity with business strategy objectives, employee perspective, availability of resources, time, and risk. The model for determining the LSS project is grouped into 3, namely the unstructured peer review/ scoring/ranking model, Multiple Criteria Decision Making (MCDM) model, and mathematical programming (Padhy, 2017).

Researchers most widely use the Multiple Criteria Decision Making (MCDM) model to select improvement projects. One of the methods used is the Analytical Network Process (ANP). Some researchers use ANP or combine it with other methods, for example, Meade & Presley (2002) combining it with AHP, Büyüközkan & Öztürkcan (2010) integrating with Decision-Making Trial and Evaluation Laboratory (DEMATEL) and Vinodh & Swarnakar (2015) using an approach based on Fuzzy DEMATEL, ANP, and TOPSIS. Meanwhile, Abdel-Basset et al. (2019) integrated the Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) with DEMATEL to determine project priorities.

4. Conclusion

In this article, we have proposed an integrated LSS framework in HEI. The proposed framework is integrated, starting from identifying waste to determining the improvement project. Lean Six Sigma is a fundamental concept in the development of this framework. This framework helps HEI management to increase the efficiency and effectiveness of HEIs. This framework is unique in that HEI customers are different from other manufacturing or service industries. HEI customers consist of students, lecturers, staff, government, industry. In this framework, the Voice of the customer considered are lecturers, students, administrative staff, and industry. The method of developing LSS in HEI uses some MCDM methods. Some examples of MCDM methods are AHP, ANP, TOPSIS, DEMATEL, MICMAC.

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