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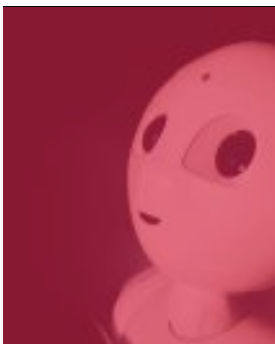
Higher Education 4.0
and the Readiness of Indonesia's Future Workforce

Center for Digital Society
Universitas Gadjah Mada





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1. INTRODUCTION

This research is one of the earliest and most comprehensive efforts to understand the level of digital competencies and soft skills of higher education students across Indonesia, as well as the readiness of higher education institutions therein to prepare themselves and their students for the new digital era. It does so through a survey of 1,162 university students from across the country, as well as interviews with formal representatives of 19 higher education institutions.

This report presents the findings of said research, as well as the background, theoretical underpinnings, and methodology that make up the foundation of the research.


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1.1. BACKGROUND

The automation of work occurring across the globe will undoubtedly bring exceptional changes to the future of the job market. The rapid advancement of both digital and internet technologies, also known as the fourth industrial revolution or Industrial Revolution 4.0 presents a new direction in the development of industries. Historically, technological advances have led to the disruption of the job market, at least in the short term. Recent technological advancements in the field of artificial intelligence, the Internet of Things, and 3D printing have a significant impact on the production and consumption of goods and services.

The integration of technology leads to unprecedented transformation in how work is planned, organized, and managed. Automation has increased efficiency by replacing costly human labor with machines and computers, which are increasingly becoming cheaper. This phenomenon has triggered debates about the future of the job market. A study compiled by the McKinsey Global Institute in 2017 suggests the increasing use of automation may cause displacement of up to one-third of jobs by 2030.[1] The resulting rise in unemployment might lead to a chronic economic crisis if not managed appropriately and immediately.

As in many countries, the debate on the impact of technology on employment is gaining more attention in Indonesia. Over the last two decades, the country has experienced rapid advancements in technology and has seen some disruptions in the labor market. Anticipating the future, the Indonesian government, as demonstrated by the Ministry of Industry, has launched an initiative called "Making Indonesia 4.0".[2] This is a roadmap that aims to prepare and create a technology-literate workforce as a response to the demands of future industries.

The budget for research and development budget in Indonesia made up a meager 0.3 percent of the country's gross domestic product (GDP) in 2018, and over 80 percent of that budget came from the central government.[3] The budget is managed under the provision of the Ministry of Research, Technology, and Higher Education or Kemenristekdikti. This policy puts higher education in a strategic position as more

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[1] McKinsey & Company. (2017). Job Lost, Job Gained: workforce Transitions in A Time of Automation. San Fransisco: McKinsey.

[2] The Ministry of Industry of Indonesia (Kemenperin). (2017). Making Indonesia 4.0. [online] Available at https://www.kemenperin.go.id/download/18384. [Accessed 25 Sep. 2019].

[3] Katadata.co.id. (2019). Anggaran Minim, Pengelolaan Dana Riset Belum Maksimal. [online] Katadata Available at: https://katadata.co.id/infografik/2019/04/15/anggaran-minim-pengelolaan-dana-riset-belum-maksimal. [Accessed 25 Sep. 2019].

budget will be allocated to improve the education system. This policy will also complement the government's existing investment in vocational schools that aims to produce skilled technical workers. Additionally, it also aims to complement the program to build digital literacy skills in elementary schools, junior high schools, and senior high schools.

Investment in the future workforce is dependent on the development of ICT and the presence of a technology-literate generation. According to World Economic Forum research in 2016, the ideal workforce in the future would have skills that entail complex problem-solving, critical thinking, creativity, people management, and teamwork.[4] In other words, aside from technical skills, the future workforce also needs to be provided with strong analytical and leadership skills. Higher education institutions play an essential role in shaping these qualities.[5]

Very few attempts to understand Indonesia's readiness to engage with the digital economy has been made. One of such rare efforts is a survey of 323 businesses, as reflected in the Indonesia Industry 4.0 Readiness Index, prepared by the Ministry of Industry.[6] Despite a growing acknowledgment of the issues, Indonesia does not yet have a solid understanding of the capacity and skills of the future workforce in the form of existing university students. Neither is there a good grasp on the readiness of higher education institutions, such as universities, institutes, and polytechnics in preparing for a future-ready workforce.

1.2. **OBJECTIVES**

This research intends to fill the gap in the existing literature on the readiness of Indonesia's university students and higher educational institutions in preparing their students to enter the increasingly technology-based job market.

4. World Economic Forum (WEF). (2016). The Future of Jobs Employments, Skills, and Workforce Strategy for the Fourth Industrial Revolution. Global Challenges Insight Report, p.20.

5. Capgemini. (2017). The Digital Talent Gap, Are Companies Doing Enough?, [online] Available at: https://www.capgemini.com/wp-content/uploads/2017/10/report_the-digital-talent-gap_final.pdf. [Accessed 25 Aug. 2019]

6. Bisnis.com. (2019). Kemenperin Luncurkan Indonesia Industry 4.0 Readiness Index. [online] Available at https://ekonomi.bisnis.com/read/20190415/9/912016/kemenperin-luncurkan-indonesia-industry-4.0-readiness-index. [Accessed 25 Aug. 2019].


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The research proposes two main questions:

(1) How ready are students of Indonesia's higher education institutions (i.e., university students) for Industrial Revolution 4.0 (IR 4.0)? To what extent have they acquired the digital competencies and soft skills needed to excel in the IR 4.0 era? How do they perceive their own readiness?

(2) How ready are Indonesia's higher education institutions in adapting to the changing educational requirements of IR 4.0? To what extent are their infrastructure, lecturers, and curriculum prepared for the future demands?

To answer these questions, we conducted an extensive survey of 1,162 students and conducted in-depth interviews with representatives of 19 higher education institutions across Indonesia. A complete explanation of the research methodology is described in Chapter 3.

1.3. **FINDINGS**

1.3.1 Readiness of Students

From the student surveys we find that, first, Indonesia's higher education students are not doing very well in terms of digital competencies, having obtained an aggregate score of 57.92 out of 100. The students obtained a rather good score of 73 out of 100 for basic digital competencies but were still struggling beyond basic requirements, where they scored 56 out of 100 for intermediate competencies, and 45 out of 100 for advanced competencies.

Second, for soft skills related to IR 4.0, Indonesian higher education students obtained a slightly better aggregate score of 63.33 out of 100. Out of the 10 soft skills measured, coordination scored the highest (67.78 out of 100) and negotiation scored the lowest (61.29 out of 100). These scores imply that university students in Indonesia, on average, admitted having acquired more than half of the needed soft skills.

Third, however, when asked to evaluate their own digital competencies and soft skills, the students gave themselves an aggregate score of 72.84 out of 100, or higher than their actual scores of 57.92 for digital competencies, and 63.33 for soft skills. This implies that there is an over-estimation or over-confidence on the parts of the students in their readiness for IR 4.0.

1.3.1. Readiness of Higher Education Institutions

From interviews with officials representing 19 universities, we find that, first, all 19 institutions have acquired a basic level of infrastructure, namely having Wi-Fi/internet connection, laboratory, and online library. However, only four institutions can be classified as acquiring a more advanced level of infrastructure by the availability of an online education platform. Some have developed their own online education platforms, while others utilized commercial education platforms. One of them has established cooperation with private platform providers, to build a custom platform. Second, all 19 institutions admitted that most of their lecturers are not yet ready and that certain lecturers have shown a lack of willingness and capability to learn unfamiliar topics and faced more challenges in applying the curriculum and teaching methods in line with the needs in IR 4.0.

Third, the ideal curriculum as perceived by the higher education institutions should cover four major aspects: (1) availability of e-Learning platform, (2) courses and training on digital entrepreneurship, (3) technical courses that introduce the core technologies of IR 4.0, and (4) English language course. The technological courses related to the IR 4.0 technology, however, as an aspect more closely linked to the IR 4.0, have only been applied by one HEI under a course called Digital Transformation course.

Fourth, the establishment of this ideal curriculum has faced several challenges, including by a traditional market-driven agenda for private education institutions to increase the number of student enrollments, as well as the institutions' compliance to higher-level authorities' interest to maintain a certain focus or "identity" on a curriculum that is not related to technology.

1.4. **STRUCTURE OF THE REPORT**

The report is structured into six chapters. **Chapter 1** has provided a starting point by presenting the background, objectives, and the questions that it aims to answer.

Chapter 2 presents a literature review that explores the state of knowledge on IR 4.0, the essential human resource (skills) that are needed to excel in IR 4.0, and the required educational infrastructure, teaching capabilities and curriculum that higher education institutions should have in order to adequately prepare their students for IR 4.0.

Chapter 3 presents the methodology used in this research, namely the surveys to university students and interviews with university officials. It also presents the sampling techniques and a profile of the survey respondents, as well as the interview questions posed to the university officials.

Chapter 4 presents findings on students' level of digital competencies and soft skills, based on quantitative survey results. The digital competencies are divided into basic, intermediate, and advanced skills. This chapter also reports the students' ownership of ICT tools or "gadgets", and their self-assessed readiness to excel in IR 4.0.

Chapter 5 presents findings on Indonesia's higher education institutions' readiness to prepare students for the digital era. These are reported based on qualitative analysis of interview responses. The responses range from the readiness in terms of infrastructure, teaching staff capability, curriculum, and the challenges that they faced.

Chapter 6 concludes the report through a summary and highlights of the research findings, discussing the limitations of the current research, as well as recommendations and opportunities for future research.


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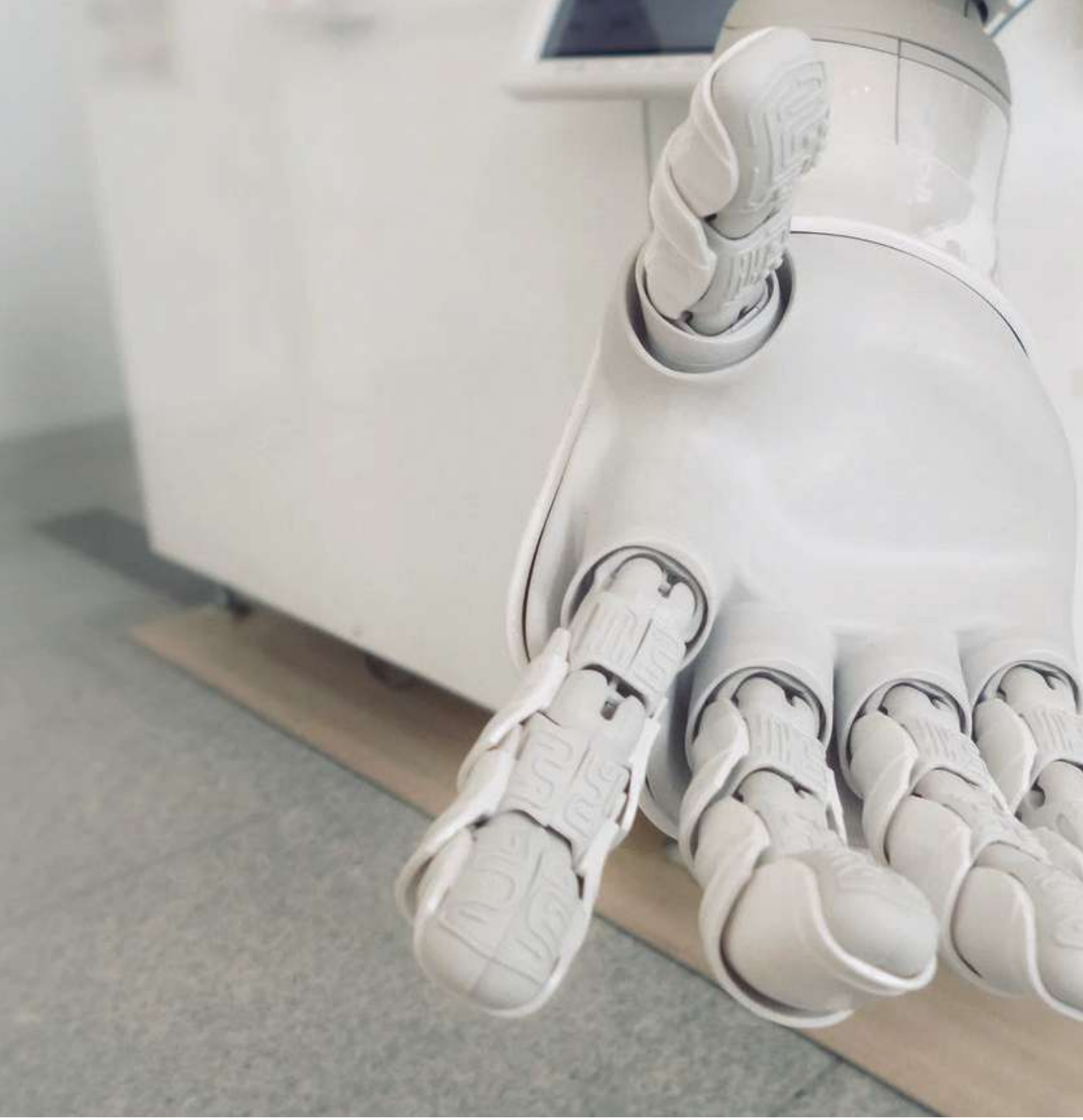

2. LITERATURE REVIEW

The literature review is conducted to develop a framework to answer the central questions in this research. It is composed of four parts: (1) a general review of Industry 4.0, (2) the skills or human resources needed in IR 4.0, (3) access to ICT, and (4) the required higher education curriculum to respond to the era of IR 4.0. Findings from the literature review are then further developed into survey and interview questions, explained in the following chapter on Methodology.


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2.1. THE FOURTH INDUSTRIAL REVOLUTION (IR 4.0)

The speed of technological advancement cannot be understated. In the last two centuries alone, the main modes of industrial production have changed a few times, from what is known as Industry 1.0 to Industry 4.0. While Industry 1.0 was primarily about the mechanization of production based on steam power, Industry 2.0 concentrated in mass production through the moving assembly line powered by electrical energy. The next phase was Industry 3.0, where automation, computers, and electronics played dominant roles. More recently, with the advancement of the internet and computing power, we have reached a stage known as Industry 4.0. According to Schwab (2017), advancement is characterized by a range of new technologies that are fusing the physical, digital and biological worlds, impacting all disciplines, economies, and industries.[7] Industry 4.0, enabled by digitization, would be the industrial foundation of the modern economic society. According to Pozdnyakova et al. (2018), the concept includes the development of clever service, clever data, cloud technologies, digital networks, digital science, digital education, and digital environment for living.[8]

Some scholars have argued that the transition to Industry 4.0 is equivalent to an industrial revolution (i.e. the fourth industrial revolution or IR 4.0) since the changes in technological mode encapsulate industrial innovations and systemic transformations in the industry (Popkova et al. 2018). According to research by McKinsey in 2017, automation technologies, including artificial intelligence and robotics, will augment productivity and economic growth. At the same time, IR 4.0 is unprecedented and entails a whole range of peculiarities compared to the previous industrial revolutions.[9]

IR 4.0 has become a prominent topic in many countries. Even some of the least-developed countries are impacted by IR 4.0 as the world is increasingly connected through political and economic means. Indonesia, one of the countries with the highest ICT penetration,[10] is also struggling with the question. McKinsey

7. Schwab, K.. (2016). The Fourth Industrial Revolution. Switzerland: World Economic Forum.

8. Pozdnyakova, U., Golikov, V., Peters, I., and Morozova, I. (2019). Genesis of the Revolutionary Transition to Industry 4.0 in the 21st Century and Overview of Previous Industrial Revolutions. In: Popkova, E., Ragulina, Y., and Bogoviz, A., ed., Industry 4.0: Industrial Revolution of the 21st Century. Poland: Springer.

9. Popkova, E., Ragulina, Y., Bogoviz, A. (2019). Fundamental Differences of Transition to Industry 4.0 from Previous Industrial Revolutions in the 21st Century and Overview of Previous Industrial Revolutions. In: Popkova, E., Ragulina, Y., Bogoviz, A., ed., Industry 4.0: Industrial Revolution of the 21st Century. Poland. Springer.

10. WeAreSocial and Hootsuit. (2019). Global Digital Report 2019. [online] Available at: https://wearesocial.com/blog/2019/01/digital-2019-global-internet-use-accelerates. [Accessed 25 Aug. 2019].

predicts that Indonesia will benefit by as much as US$ 150 billion from its digital economy in 2025.[11] The expectation is realistic enough, with almost 86% of internet users in Indonesia enjoying the ease of online shopping. Above all, digital start-up companies in Indonesia are attracting many young people. However, the country is also suffering from a lack of human resources with adequate skills for the Industry 4.0 era.[12] Therefore, educational institutions can be a significant base to increase the number of people who are ready for this revolution.[13]

2.2. HUMAN RESOURCES IN IR 4.0

Higher education institutions hold a crucial role in building the skills needed to excel in Industry 4.0. Research by Capgemini finds that there is an existing gap between supply and demand in the digital competencies. The gap means that the demand from industry is higher than the supply of proficient skills.[14]

The impact of technological development on employment and society has been a topic of debate for a long time. In 1933, John Maynard Keynes argued that the development of industrial technology is so fast that it will eventually substitute the workforce – thus, Keynes introduced the terminology of "technological unemployment.[15] This argument is often cited by scholars working on unemployment and technology – which means, the use of sophisticated technology creates a higher rate of unemployment. For example, Brynjolfson & McAfee (2011) argued that the use of ICT is one of the reasons for the increased rate of unemployment.[16] Furthermore, some scholars argued that jobs with a high level of repetition are easily replaced by a smart algorithm (Charles et al., 2013).[17]

However, other scholars also believed jobs that demand flexibility and a degree of cognitive skills are not likely to be computerized, at least in the near future. (Autor, et al., 2003; Goos & Manning, 2007; Autor & Dorm, 2013). To be precise, computers

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[11] McKinsey & Company. (2017). Unlocking Indonesia's Digital Opportunity. [online] McKinsey. Available at: https://www.mckinsey.com/~/media/McKinsey/Locations/Asia/Indonesia/Our%20Insights/Unlocking%20Indonesias%20digital%20opportunity/Unlocking_Indonesias_digital_opportunity.ashx. [Accessed 25 Aug. 2019].

[12] Puspita, R. (2019). Indonesia Diproyeksi Kekurangan SDM Digital 600 Ribu. [online] Republika. Available at: https://www.republika.co.id/berita/trendtek/internet/19/01/20/plm7xi428-indonesia-diproyeksi-kekurangan-sdm-digital-600-ribu. [Accessed 25 Aug. 2019]

[13] Pozdnyakova et al. (2019)

[14] Capgemini, 2017, p. 8-9.

[15] Keyness, J., 1933. Essays in persuasion. In: Economic possibilities for our grandchildren. s.l.:s.n., pp. 358-373.

[16] Brynjolfson, E. and McAfee, A. (2011). Race Against the Machine. Lexington: Digital Frontier Press.

[17] Charles, K. K., Hurst, E. & Notowidigdo, M. J., (2013). Manufacturing decline, housing booms, and non-employment. NBER Working Paper Series.

and digital technology need humans to operate them. Therefore, individuals with significant cognitive skills have a comparative advantage (Katz & Murphy, 1992; Acemoglu, 2002; Autor & Dorn, 2013). A different argument, however, is proposed by Frey and Osborne (2015), who found that while computers and automation have been disrupting repetitive jobs, big data and algorithms have intruded non-repetitive jobs, implying that cognitive skills may be replaced by artificial intelligence after all.

The complex development of ICT is now disrupting the industrial world. Popkova et al. (2018) argued that IR 4.0 encompasses broad aspects. These include the formation of fully automated production, elimination of humans from the production process, revolutionary changes in all business processes of industrial production, changes in the nature of industrial patents, and changes in the specializations required in industrial production.[18] These changes undoubtedly trigger more questions about the most demanded skills in the era of Industry 4.0, as the changes are broader and more profound compared to the previous revolutions. Some of the skills required to manage the advancement and to adapt to the new industry are cognitive capabilities, natural language processing, social and emotional capabilities, and physical capabilities, according to McKinsey (2017).[19]

Another report published by UNESCO (2018) found that in the era of Industry 4.0, people must have some degree of digital literacy due to the digitization of all aspects of life.[20] The five core skill sets in using ICT, which are: information and data literacy, communication and collaboration, digital content creation, safety, as well as problem-solving.[21] Table 1 describes those five skill sets in more detail. In higher education, these competencies are essential and can be measured to evaluate students' use of ICT and what they could produce with their ICT skills.

[18] Ibid.

[19] McKinsey & Company (2017). Job Lost, Job Gained: workforce Transitions in A Time of Automation.

[20] UNESCO, and UNESCO Institute for Statistics. (2018). A Global Framework of Reference on Digital Literacy Skills for Indicator 4.4.2. Canada: UNSECO. p.7

[21] McKinsey & Company. (2017)

Table 1. ICT Skill Sets

No	Skill Sets	Skills
1	**Information and Data Literacy**	• Browsing, searching and filtering data, information and digital content • Evaluating data, information and digital content • Managing data, information and digital content
2	**Communication and Collaboration**	• Interacting through digital technologies • Sharing through digital technologies • Engaging in citizenship through digital technologies • Collaborating through digital technologies • Netiquette • Managing digital identity
3	**Digital Content Creation**	• Developing digital content • Integrating and re-elaborating digital content • Copyright and licenses • Programming
4	**Safety**	• Protecting devices • Protecting personal data and privacy Protecting health and well-being Protecting the environment
5	**Problem Solving**	• Solving technical problems Identifying needs and technological responses • Creatively using digital technologies • Identifying digital competences gaps

The European Commission's Science and Knowledge Department has published the Digital Competence framework[22] which analyzes three levels of personal competences: basic, intermediate, and advanced, based on the competencies presented in Table 1. These three levels are based on the extent to which the students can apply the competencies. The classification falls under three categories, which are basic user, independent user (intermediate), and proficient user (advanced).

Other skills that are required in the era of IR 4.0 are soft skills or cross-functional skills. The World Economic Forum, in their report titled "The Future of Jobs Employment, Skills and Workforce Strategy for the Fourth Industrial Revolution," elaborated these cross-functional skills,[23] which are summarized in Table 2.

Table 2. Five important cross-functional skill sets for Industry 4.0

No	Skill Sets	Skills
1	**Social Skills**	• Coordinating with Others • Emotional Intelligence • Negotiation • Service Orientation
2	**System Skills**	• Judgement and Decision making
3	**Process Skills**	• Critical Thinking
4	**Complex Problem Solving Skills**	• Problem Solving
5	**Cognitive Abilities**	• Cognitive Flexibility • Creativity

[22] European Union. (2016). The European Digital Competence Framework for Citizens. Luxembourg: Publications Office of the European Union

[23] World Economic Forum (WEF), 2016, p.20.

2.3. ACCESS TO ICT IN HIGHER EDUCATIONAL INSTITUTION

Technology is the core of Industry 4.0. Thus, the integration of technology in teaching and learning infrastructure is essential. The newer kinds of software and technologies need to be introduced earlier. Industries now demand that graduating students must be able to understand, use, and manage the latest technology. Therefore, the use of technology in higher education institutions is also believed as a way to cultivate innovative talent. These talents are expected to be trained in an interdisciplinary environment where technologists should understand humanities and social sciences, and social scientists should understand technology.[24]

Anwar & Mathew (2014) defines the use of ICT in HEI into three categories. First, ICT as a tool to support traditional teaching subjects, which means the instructors use ICT to deliver their class through high-end multimedia presentations, web-based activities, virtual labs, and sophisticated software. Second, ICT as a tool for collaborative learning that supports the spread of education through e-learning. This requires cyberinfrastructure, virtual portfolios, and online education. Third, ICT as an administrative tool, which means ICT helps campus management in a way that gives students and instructors new tools to manage their teaching and learning activity effectively. This can take the form of a platform where students and instructors easily find information using e-media.[25] Meanwhile, Bo Xing and Marwala (2018) argue that the teaching in the IR 4.0 must cover wearables-assisted teaching, learning, and training; embrace massive open online courses (MOOCs); cultivate innovative talent, and generalize blended learning.[26]

Since the three visible trends in the era of Industry 4.0 are cyber-physical systems, the internet of things, and networks, access to ICT becomes an essential factor. Based on the annual report published by ITU, access to ICT can be defined by two factors: ICT possession and broadband coverage. The two factors are essential to boost the economic activities in the era of IR 4.0, which is based on IoT and integrated production systems.[27]

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[24] Xing, B., and Marwala, T. (2017). Implications of the fourth industrial age for higher education.

[25] Anwar, S., and Mathew, S. K. (2014). The Contribution of ICT in Higher Education: a multifaceted approach. IOSR Journal of Electronics and Communication Engineering, Vol. 9 (1), pp. 60-63.

[26] Xing, B., and Marwala, T. (2017). Implications of the fourth industrial age for higher education.

[27] Thoben, K. D., Wiesner, S., and Wuest, T. (2017). "Industrie 4.0" and smart manufacturing-a review of research issues and application examples. International Journal of Automation Technology, 11(1), 4-16.

According to the literature above, variables that pertain to ICT access at HEI are: first, an online library where students can access materials and online education platform. Second, MOOC is expected to overcome or eliminate shortcomings of the conventional classroom, namely the costs of physical proximity and limits to productivity. The first obstacle refers to the cost of having more students because it means the university must expand buildings and instructors. Meanwhile limits to productivity simply mean that the maximum number of students who can sign up to take a course is limited. Therefore, MOOC provides a different method of teaching-learning activities by implementing online model, and extra students become an advantage.[28] The last is about the use of technology to improve university service. This may include admission inquiry by students applying for admissions through electronic media, registration/enrolment using computers, course allotment, and availability of information like timetable or class schedule in electronic form.[29]

Infrastructure plays a significant role in supporting innovation. The study asked the extent to which WiFI, as well as internet broadband, were provided on the campus. This becomes critical because innovations such as online courses and online libraries depend on the presence of broadband internet. The research also explored students' possession of digital devices (laptop, smartphone, or tablet) and how much money they spend to buy internet data from telecom providers.[30]

2.4. HIGHER EDUCATION CURRICULUM

According to Gleason (2017), HEI has a crucial role in shaping societal transitions necessary to adjust to IR 4.0. The most prominent fact is that almost everyone will work with artificial intelligence in various aspects, in demographics, global health, economic, nuclear proliferation, climate change, etc.[31] It has been mentioned that there is a gap between supply and demand of skilled human resources in the job market. Higher education becomes a fundamental base to introduce students to IR 4.0 and further, train them with the skills needed in the job market. Education should be given in a form of combination of liberal arts education and upskilling depending on where the students are in their educational journey. The questions are: what are

[28] Coetzee, M. (2019). Thriving in Digital Workspaces: An Introductory Chapter. In Thriving in Digital Workspaces (pp. 1-11). Springer, Cham.

[29] Anwar, S., and Mathew, S. K. (2014). The Contribution of ICT in Higher Education: a multifaceted approach. IOSR Journal of Electronics and Communication Engineering, 9 (1), p. 60-63.

[30] ITU. (2014). Manual for Measuring ICT Access and Use by Households and Individuals. International Telecommunication Union, [online] pdf. Available at: https://www.itu.int/dms_pub/itu-d/opb/ind/D-IND-ITCMEAS-2014-PDF-E.pdf [Accessed 21 Mar. 2019]

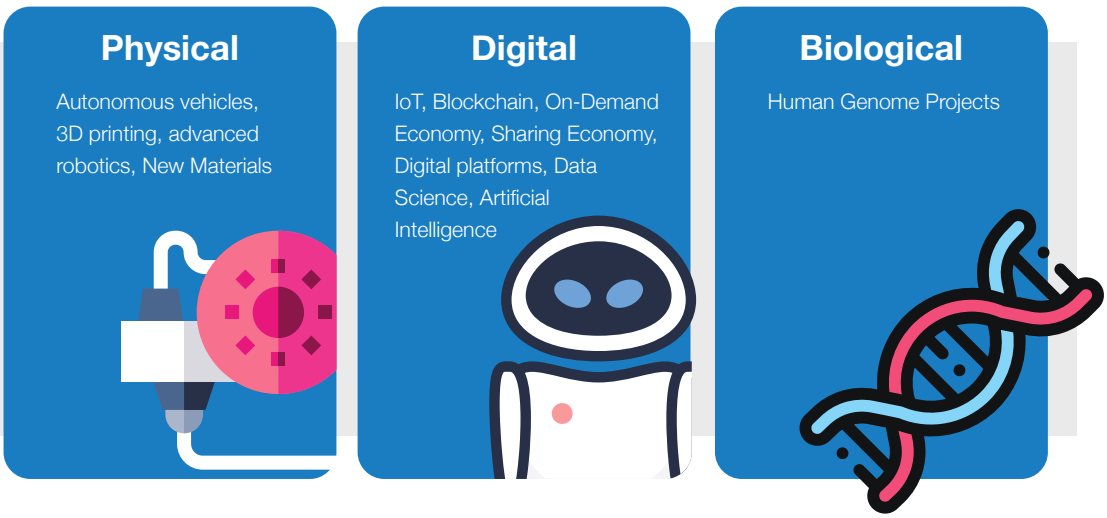
[31] Gleason, N. W. (Ed.). (2018). Higher education in the era of the fourth industrial revolution. Palgrave Macmillan.

the new essential subjects (knowledge and skills) that need to be taught at universities? What types of infrastructure must be provided by the university and how must the instructors employ them in the teaching-learning process? What kind of competencies must be obtained by the instructors so they can share adequate knowledge of IR 4.0 to students?

Penrase (2018) emphasized the urgency of substantial changes to the science and technology curriculum. Furthermore, some ethical understanding of the human condition and how new technologies are impacting people of all socioeconomic levels are also necessary.[32] These approaches maximize the development of intercultural and interpersonal skills, which will be a hallmark of the future workplace.[33] Necessary preparations must be taken before the employee enters the industry.[34] Research conducted by Baygin et al. (2017) shows that an education curriculum that takes into account the principles of Industry 4.0 is necessary.[35]

The existing literature argues that some subjects must be taught in class due to the changing knowledge and demands in IR 4.0. Some literature has pointed out that innovations must be prepared and learned. Schwab (2016) mentions it as Mega Trends of IR 4.0. These include three aspects: physical, digital, and biological.[36]

Table 3. Three aspects of Mega Trends in Industry 4.0



Source: Schwab (2016)

[32] Penprase, B. E. (2018). The fourth industrial revolution and higher education. In Higher education in the era of the fourth industrial revolution (pp. 207-229). Palgrave Macmillan, Singapore.

[33] Ibid.

[34] Baygin, M., Yetis, H., Karakose, M., and Akin, E. (2016, September). An effect analysis of industry 4.0 to higher education. In 2016 15th international conference on information technology based higher education and training (ITHET) (pp. 1-4). IEEE.

[35] Ibid., p.5.

[36] Schwab, K. (2017). The fourth industrial revolution. Currency.

In a more localized context, Robandi, Kurniati and Sari (2018) argued that higher education curriculum in the IR 4.0 era should aim to elevate technological literacy, develop the students' character, behavior, attitude, and personality, namely having a hardworking ethics, and encourage students to contribute to the society and local communities.[37] The curriculum envisaged by Robandi, Kurniati, and Sari (2018) emphasized the formation of students' behavior and attitude towards technology and social context. This is deemed important due to the current minor portion allocated to character building in the current technology-focused teaching.[38]

With regards to the relevant curriculum in the era of IR 4.0, Ellahi et al. (2019) proposed a matrix consisting of five major topics: big data, internet of things, cloud computing, artificial intelligence and augmented reality.[39] These five major topics are concluded after conducting content analysis research on over 72 selected publications. Ellahi et al. (2019) also stated that in order to augment communication and digitization, universities must enhance students' skills to the capture, analysis, and communication of data towards the available infrastructures.[40]

3. METHODOLOGY

This research utilizes a mixed methodology to explore the two major topics: the readiness of university students, and the role of universities (higher education institutions) to prepare their systems and their students for IR 4.0. Students' readiness towards IR 4.0 is measured through a survey of university students throughout Indonesia. Meanwhile, the readiness of higher education institutions is measured through interviews with high-level university officials. The chapter presents a more detailed explanation of the methodology. Findings from the surveys are presented in Chapter 4, while those from the interviews are presented in Chapter 5.

3.1. SURVEY

This research uses a survey to collect quantitative data of university students' characteristics and perceptions of their readiness in facing IR 4.0. The samples are chosen based on a stratified random sampling technique (using the RAND function on Microsoft Excel), where classifications of the target sample are specified.

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[37] Robandi, B., Kurniati, E., and Sari, R. P. (2019, April). Pedagogy In The Era Of Industrial Revolution 4.0. In 8th UPI-UPSI International Conference 2018 (UPI-UPSI 2018). Atlantis Press.

[38] Ibid., p. 43.

[39] Ellahi, R. M., Khan, M. U. A., and Shah, A. (2019). Redesigning Curriculum in line with Industry 4.0. Procedia Computer Science, p. 707.

[40] Ibid., p. 708.

3.1.1 Survey respondents

Two classifications were used to ensure a better representation of university students throughout Indonesia. The first classification is based on university rank or tier. We classified Indonesia's top-100 universities in 2019 (according to by Webometrics[41]) into three tiers according to university performance: first-tier, second-tier, and third-tier. From these 100 universities, we focused on 20 universities to conduct student surveys. To ensure a balanced distribution of the universities, we randomly picked seven first-tier universities, six second-tier universities, and seven third-tier universities (20 universities in total).

The second classification is based on the type of faculty or school. For this, we classified faculties within the 20 universities into those that correspond to science, technology, engineering, and mathematics (STEM) and those that don't (i.e., non-STEM type faculties). To ensure a representative sample of students based on their faculty type, we randomly picked faculties within the university according to the actual ratio of STEM and Non-STEM faculties that exist in each university.

After determining the target universities and faculty types, we aimed to collect a sample of 1,200 student respondents from a reported total of 6,924,511 Indonesian university students in 2017, according to the Ministry of Education.[42] After data is collected, there were 1,162 valid survey responses that could be processed. This translates to a 2.875% margin of error, with a 95% confidence interval. The distribution of respondents by university tier and faculty type is shown in Table 3.1.

Table 3.1. Distribution of survey respondents by university name, university tier and faculty type

	No	University Name	STEM	Non STEM	Total
first-tier	1	Universitas Gadjah Mada (Sleman, Yogyakarta)	46	24	70
	2	Universitas Indonesia (Depok, West Java)	31	6	37
	3	Universitas Sebelas Maret (Solo, Central Java)	47	29	76
	4	Universitas Pendidikan Indonesia (Bandung, West Java)	20	38	58
	5	Universitas Jenderal Sudirman (Purwokerto, Central Java)	36	20	56
	6	Universitas Dian Nuswantoro (Semarang, Central Java)	37	19	56
	7	Universitas Udayana (Badung, Bali)	33	26	59
		Sub-total for first-tier universities	**250**	**162**	**412**

[41] Webometrics. (2019). Ranking Web Of Unversities: Indonesia. Webometrics [online]. Available at: https://www.webometrics.info/en/Asia/Indonesia%20 [Accessed 14 Mar. 2019]

[42] Kementerian Riset, Teknologi, dan Pendidikan Tinggi Republik Indonesia. (2017). Statistik Pendidikan Tinggi. Kemenristekdikti, [online] pdf. Available at: http://kopertis3.or.id/v5/wp-content/uploads/Buku-Statistik-Pendidikan-Tinggi-2017.pdf [Accessed 18 Mar. 2019]

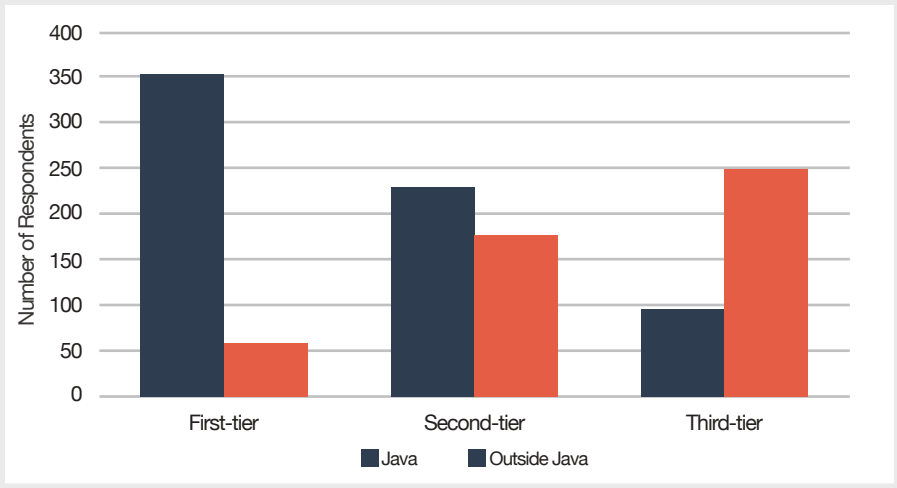
Photo by sol on Unsplash

	No	University Name	STEM	Non STEM	Total
second-tier	1	Universitas Sanata Dharma (Sleman, Yogyakarta)	59	25	84
	2	Universitas Islam Indonesia (Sleman, Yogyakarta)	37	44	81
	3	Universitas Islam Negeri Sultan Syarif Kasim Riau (Kampar, Riau)	8	20	28
	4	Universitas Negeri Semarang (Semarang, Central Java)	26	40	66
	5	Universitas Pendidikan Ganesha (Denpasar, Bali)	35	31	66
	6	Universitas Negeri Padang (Padang, West Sumatera)	33	46	79
		Sub-total for second-tier universities	**198**	**206**	**404**

	No	University Name	STEM	Non STEM	Total
third-tier	1	UIN Alauddin Makasar (Makasar, South Sulawesi)	22	40	62
	2	Politeknik Negeri Pontianak (Pontianak, West Kalimantan)	41	24	65
	3	Universitas Medan Area (Medan, North Sumatera)	20	35	55
	4	Universitas Muhammadiyah Semarang (Semarang, Central Java)	22	3	25
	5	Institut Informatika dan Bisnis Darmajaya (Lampung)	31	31	62
	6	Universitas 17 Agustus 1945 (Surabaya, East Java)	17	54	71
	7	Universitas Muhammadiyah Metro (Lampung)	0	6	6
		Sub-total for third-tier universities	**153**	**193**	**346**
		Grand Total	601	561	1162

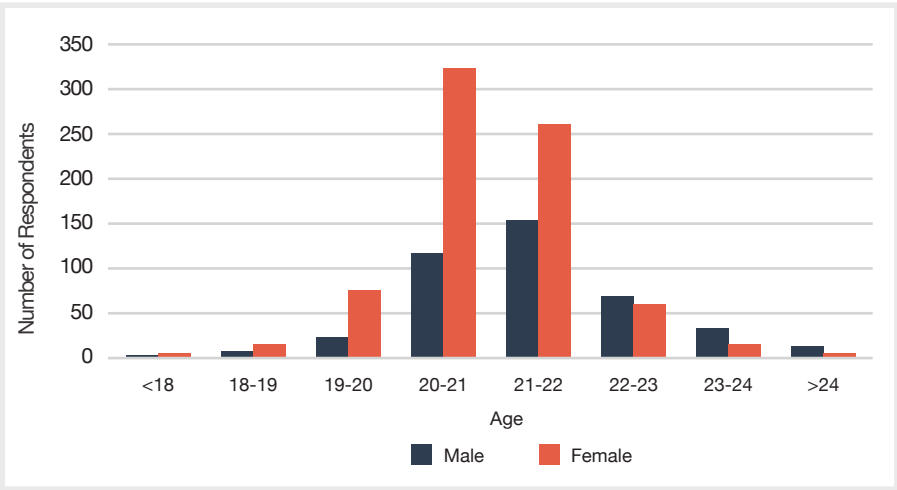
We did not specify distributional requirements based on the location of universities. Conventional wisdom states that there are substantial development differences between Java and other parts of Indonesia, and therefore the expectation is that university ranking would also differ between the two locations. Using Excel's randomize function to select universities, we ended up with a rather balanced distribution between first-tier, second-tier, and third-tier universities (35%, 35%, and 30%, respectively), and a rather but not extremely unbalanced distribution between Java and outside Java locations (58% and 42%, respectively). However, when looking at where the different tiers of universities are located, we find that most first-tier university respondents are located in Java (85%), a substantial portion of second-tier university respondents are in Java (57%), and most of the third-tier university respondents are outside of Java (72%). See Figure 3.1 for more details.

Figure 3.1 Distribution of survey respondents by university tier and location



We also did not specify a requirement for the distribution of survey respondents by gender and age. As seen in Figure 3.1, the distribution of respondents is unbalanced by gender (64.5% female and 35.5% male). The age of respondents, however, is not a considerable demographic variable to consider in this research because the distribution is rather normal, with an average age of 20-21 years old. This means that most of the survey respondents are third-year and fourth-year students. The youngest respondent is 17 and the oldest is 30 years old. See Figure 3.2 for more details.

Figure 3.2 Distribution of survey respondents by gender and age



Survey data collection was conducted by enumerators in each university, coordinated by a person in charge. Enumerators identified eligible respondents in STEM and non-STEM faculties within their respective universities and asked the respondents to fill the online survey. Some also collected respondents in classrooms.

3.1.2 Survey questions and resulting scores

The survey questionnaire was developed based on the literature review presented in Chapter 2, especially on the human resources required to excel in IR 4.0. Questions were developed to explore the students' ICT skill sets or "digital competencies", as well as their cross-functional skill sets, or "soft skills."

To understand the students' level of digital competencies (or "ICT skills"), a total of 67 questions were asked based on the EU's Digital Competencies self-assessment grid.[43] These questions are distributed according to five different types of digital competencies (information processing, communications, content creation, safety, and technical problem solving) and three proficiency levels (basic, intermediate, and advanced). In the survey questionnaire, we asked students to confirm if they have each of the 67 specific skills. The distribution of said skills are laid out in Table 3.2, and a detailed list of those specific skills can be reviewed in the survey questionnaire, presented in **Appendix 1.**

Table 3.2. Number of questions on digital competencies by proficiency level

Types of digital competency	Number of questions based on proficiency level			Total
	Basic	Intermediate	Advanced	
Information processing	3	3	6	12
Communications	5	5	4	14
Information processing	4	5	6	15
Safety	3	5	5	13
Technical problem solving	-	6	7	13
Total	**15**	**24**	**28**	**67**

Based on the proportion of "yes" answers to each question, we created aggregate scores for each of the three digital competency levels: *basic* (proportion of "yes" over 15 basic skill questions), *intermediate* (proportion of "yes" over 24 intermediate skill questions), and *advanced* (proportion of "yes" over 28 advanced skill questions). To create an overall digital competency score, we then aggregated the scores of the three levels by way of simple averaging. The following describes the calculation for the digital competency scores.

[43] European Union. (2016). Digital competences – Self-Assessment grid. Europass, [online]. Available at: https://europass.cedefop.europa.eu/sites/default/files/dc-en.pdf [Accessed 15 Mar. 2019].

- Basic digital competency score$_i$ = ((∑ "Yes" on basic digital skills) / 15) x 100
- Intermedia digital competency score$_i$ = ((∑ "Yes" on intermediate digital skills) / 24) x 100
- Advanced digital competency score$_i$ = ((∑ "Yes" on advanced digital skills) / 28) x 100
- Digital competency score$_i$ = (∑ basic, intermediate, advanced scores) / 3)

To understand the students' cross-functional competencies (or "soft skills"), we asked them to rate their level on the nine types of skills according to the WEF's "Future of Jobs" report.[44] These include coordinating with others, emotional intelligence, negotiation, service orientation, judgment and decision making, critical thinking, problem-solving, cognitive flexibility, and creativity. For each soft skill, the students were asked to rate themselves on a Likert Scale of 1 to 5, with 1 being "bad," 2 "not good," 3 "good," 4 "very good," and 5 "excellent." The overall cross-functional competency score is created by taking the average score out of nine types of cross-functional competencies.

- Cross-functional competency score$_i$ = (((∑ Likert scores on soft skills) / 9) /5) x 100

Ultimately, the digital competency and cross-functional competency scores are further aggregated through simple averaging to form the "IR 4.0 readiness score" based on the students' reported competencies.

- IR 4.0 Readiness Score$_i$ = (∑ Digital competency score$_i$, Cross-functional competency score$_i$) / 2

Towards the end of the survey, we asked the students to report their self-perceived readiness for IR 4.0, through a rating on a scale of 0-100. This self-reported perception of IR 4.0 readiness later will be compared to the readiness score described above, which is obtained by answering questions on specific digital and cross-functional skills.

Aside from asking questions related to digital and cross-functional competencies, we also asked questions on basic demography (gender, age) and access to ICT (number of digital devices owned, type of network most often accessed, monthly spending for internet connectivity). Responses to questions on ICT access will help to provide an overview of the intensity and ways in which students access the internet.

[44] World Economic Forum. (2016). The Future of Jobs Employments, Skills and Workforce Strategy for the Fourth Industrial Revolution. Global Challenges Insight Report, Geneva.

3.2. **INTERVIEWS**

This research uses a survey to collect quantitative data of university students' characteristics and perceptions of their readiness in facing IR 4.0. The samples are chosen based on a stratified random sampling technique (using the RAND function on Microsoft Excel), where classifications of the target sample are specified.

3.2.1 Interviewees

The targeted interview respondents are the top-level decision-makers in each university, namely the rector or director. The decision to interview rectors is made under the consideration that the rector holds a significant role in the university's policymaking process. It is important to know the rectors' perception of IR 4.0 and its impact on higher education, or vice versa. Rectors hold the highest-level organizational post in higher education institutions, thus, they have a markedly important influence in determining the vision, missions, and strategies adopted by the institution. Undoubtedly, rectors have a comprehensive understanding of the readiness of university which implies its vision, human resources, infrastructure, as well as curriculum.

We started the interviews by contacting the rectors via formal email and letter. The letters were then replied and followed-up by sending an introduction to the research. In the beginning, we expected to interview 20 rectors. The methodology used to determine the selected universities to interview is similar to that utilized in identifying universities for the survey respondents, which is based on Webo's World University Ranks. However, one potential interviewee canceled the appointment due to scheduling changes. As a result, this interview could not take place and only 19 university officials were interviewed.

The interviews with rectors mainly took place face-to-face. However, seven of the rectors preferred to be interviewed by phone. These respondents were interviewed in approximately one-hour duration. The interviews were conducted in a semi-structured manner, which contains the components of both structured and unstructured interviews. We prepared a consistent set of questions to be answered by the rectors. However, during the interview itself, it is still possible to have additional questions. The semi-structured format was chosen to accommodate the fact that each university may have its own policy and strategy in facing the impacts of IR 4.0.

However, there was a problem related to incomplete interviews. One of the shortest interviews lasted only for around 17 minutes and two other short ones lasted around 30 minutes. When this happened, the interviewer prioritized asking the rectors'

perception of IR 4.0 and some policies undertaken by the university to prepare their students. A few respondents were also not clear enough in answering the question, explicitly saying that they do not have an adequate understanding of a particular issue (i.e., how the curriculum was formulated).

3.2.2 Interview questions

The structure of the interview follows and expands on those presented in the literature review (Chapter 2) as important aspects to consider in IR 4.0. They are grouped into five topics: human resources, infrastructure, curriculum, government initiatives, and decision-making process. Each topic is queried through several questions, as presented in Table 3.3 below.

Table 3.3. List of Interview Questions

No	Topic	Questions
1	**Human resources**	• What is the first thing that comes to your mind when you hear the phrase "industrial revolution 4.0"? • How do your lecturers adapt to IR 4.0 and what is your university's strategy to improve their adaptability? • How confident are you on the level of your students' readiness towards industry 4.0?
2	**Infrastructure**	• What infrastructure does your university have to support teaching and learning processes in IR 4.0?
3	**Curriculum**	• What is the ideal curriculum to prepare students for IR 4.0? • What are the challenges in formulating and implementing the curriculum?
4	**Government initiatives**	• What is your opinion on the government's initiatives to prepare for the demanded skills in IR 4.0? • How does Indonesia's current higher education system address the changing skills of workforces in IR 4.0?
5	**Decision-making processes**	• How does IR 4.0 impact decision-making processes in your university?

In this research, qualitative content analysis is applied to the text of answers to the questionnaire in interviews with the respondent. Initially, some transcripts are carefully read several times to extract a preliminary coding frame in which sub-categories and categories are clearly defined.

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4. THE READINESS OF STUDENTS

This section reports the readiness of Indonesia's higher education students in facing the challenges of IR 4.0. The quantitative findings presented in this section is based on a survey of 1,162 students throughout the country, using the methodology presented in Chapter 3. In this chapter, the survey findings are presented in the following sequence: (1) access to ICT, (2) digital competencies or "ICT skills", which consist of basic, intermediate, and advanced level of digital competencies, (3) cross-functional competencies or "soft skills", and (4) overall IR 4.0 readiness score and self-perceived readiness.

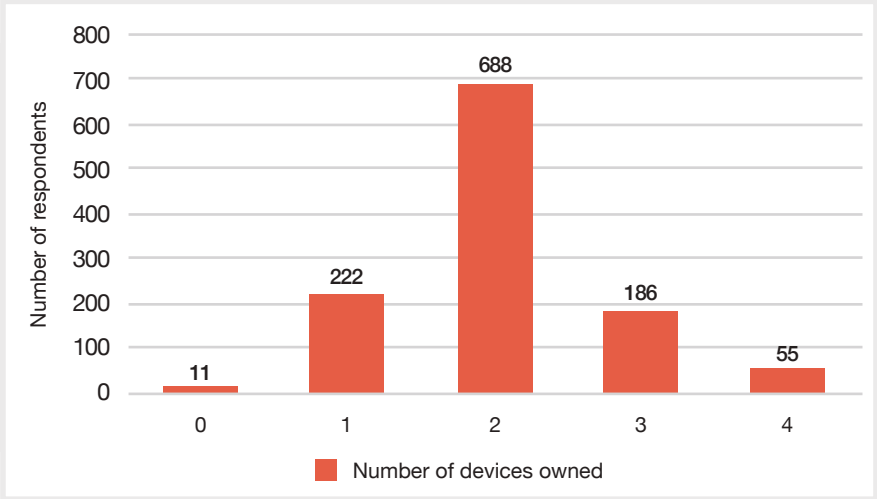
4.1. **ACCESS TO ICT**

In this research, access to ICT covers ownership and types of digital devices that students owned, type of network connectivity that they access, and the amount of spending on internet connectivity. This section aims to build a basic understanding of the extent and ways in which university students are accessing ICT in various universities and faculties across Indonesia.

4.1.1. Ownership of digital devices

For internet accessibility, the students rely on ownership. Most (80%) of the students surveyed admitted to owning multiple digital devices or "gadgets. These can in the form of smartphones, tablets, laptop computers, desktop computers, or others such as Playstation or Xbox. As seen in Figure 4.1., close to 60% of students owned two devices, while those who owned three and four devices were 16% and 4.7%, respectively. Only 11 respondents did not own any digital devices at all, making up 0.9% of the respondents. Out of these, 63.6% were based outside of Java.

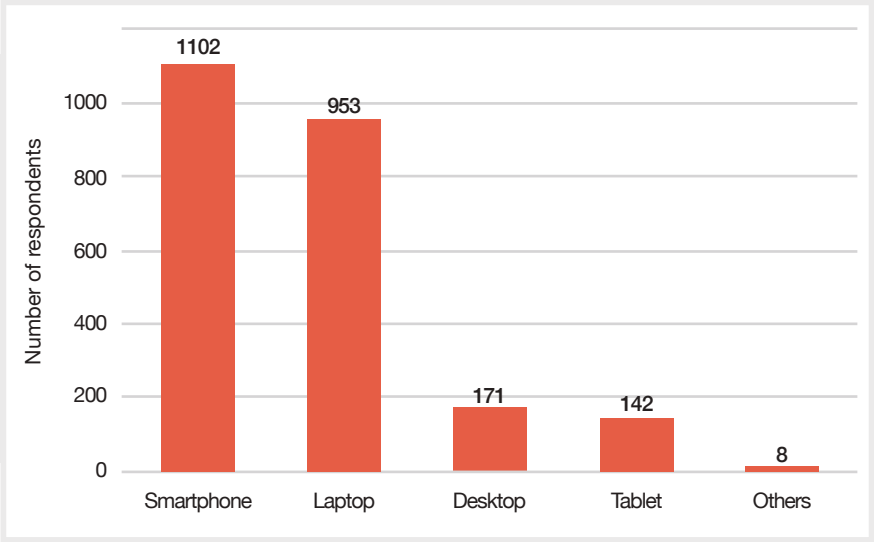
Figure 4.1 Survey respondents by number of digital devices owned



Source: Authors

Since digital devices are an important way of accessing the Internet, specifying the type of devices used could further the analysis. As seen in Figure 4.2, most of the digital devices owned by students are smartphones and laptop computers. Close of 95% of students owned smartphones. This shows that most students were accessing the Internet by their fingertips. Meanwhile, 82% of students owned laptop computers, most likely to conduct schoolwork. Only 14.7% owned desktop computers, and 12.2% owned tablets.

Figure 4.2 Types of digital devices by number of students who own them

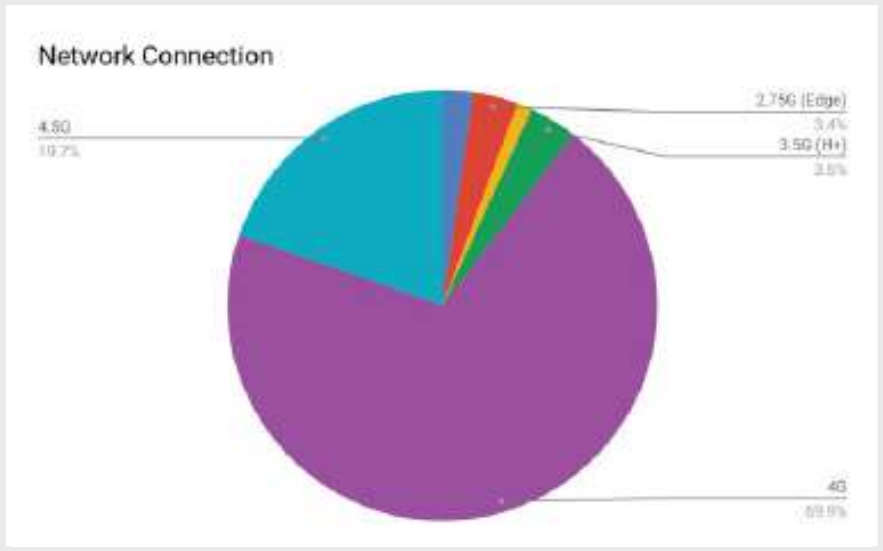


Source: Authors

4.1.2. Network connectivity

In terms of network connectivity, most (close to 70%) of students said that the network most often accessible to them were 4G, and close to 20% accessed 4.5G or LTE connectivity. Only about 10% of the students had 3.5G connectivity or slower. This shows that most students had pretty good access to the Internet, regardless of location or university tier.

Figure 4.3 Types of network connectivity most often accessed

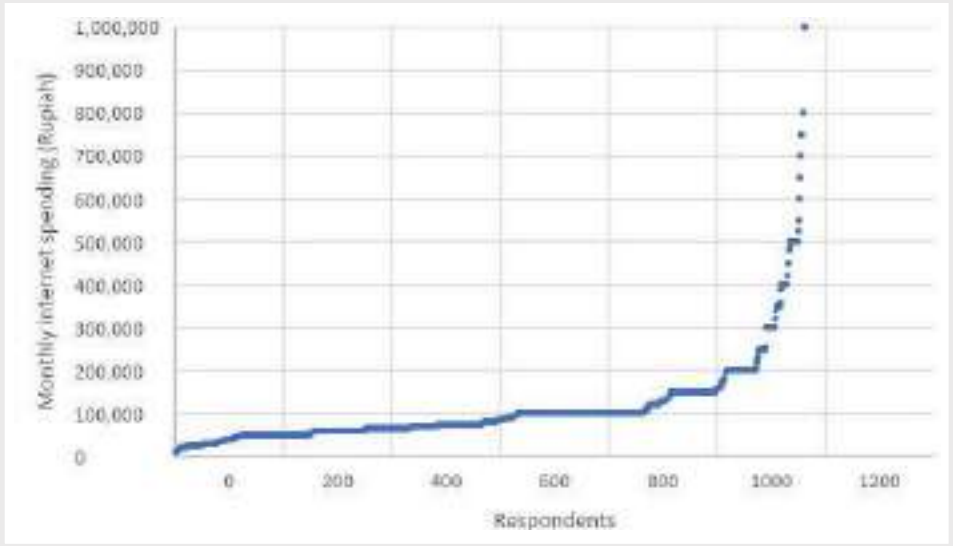


Source: Authors

4.1.3. Spending on connectivity

Besides understanding what type of connectivity is most accessible to students, figuring how much they spend on Internet connectivity is also asked in this research. The survey finds that students' average monthly spending for connectivity was Rp 112,515, with a minimum of Rp 10,000, a maximum of 1,000,000, a median of Rp 80,000, and a mode of Rp 100,000 (230 people, or about 20% answered that they spend Rp 100,000 per month). Only 91 people, or equivalent to about 7.8% of respondents, answered that they spent more than Rp 200,000 a month. The Lorenz Curve in Figure 4.3 shows the unequal distribution of internet spending.

Figure 4.4 Distribution of monthly internet spending across respondents



Source: Authors

4.2. DIGITAL COMPETENCY

The digital competency of Indonesia's university students is measured based on the EU's Digital Competencies self-assessment grid, explained earlier in Chapter 3 (Methodology). These "hard" ICT skills are categorized into five types of skill sets: 1.) Information Processing, 2.) Communication, 3.) Content Creation, 4.) Safety, and 5.) Problem Solving. They are also divided into three levels of proficiency: 1.) Basic, 2.) Intermediate, and 3.) Advanced. Ideally, each student should have all of the skills in the self-assessment grid.

The aggregate score for digital competencies was **57.92 out of 100**. This means that just slightly more than half (or less than 60%) of the respondents have acquired all the basic, intermediate, and advanced ICT skills required for IR 4.0. This aggregate score was derived by taking the simple average of the three scores for basic, intermediate, and advanced digital competencies (respectively: 72.89, 56.35,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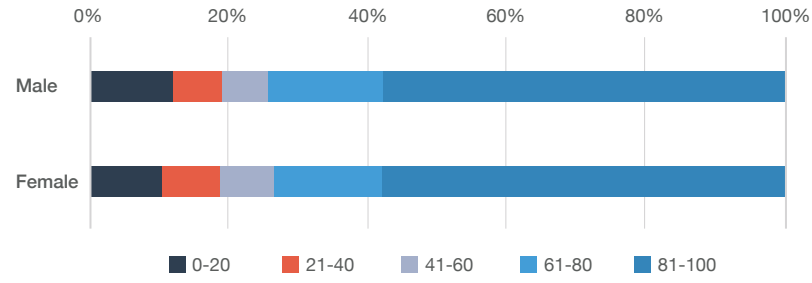
and 44.53). The following sub-sections explain how Indonesia's university students fared in each of the basic, intermediate, and advanced digital competencies.

4.2.1. Basic digital competency

Over the last decade, digital competencies have become some of the most important functional competencies. Basic digital competencies, in particular, are becoming more important as the utilization of digital technology has become a significant part of daily life. These competencies encompass a set of rudimentary skills on the utilization of digital technology. They can be considered as a prerequisite to participating in IR 4.0.

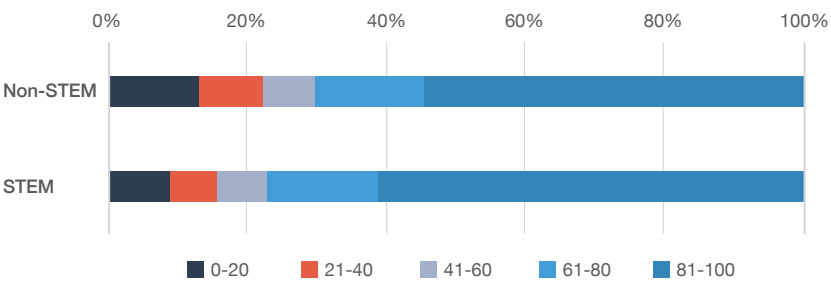
First, we explore how the students fared on the 15 skills that correspond to a basic level of digital competency (see Table 4.1). The average score among all respondents for basic digital competency was 72.89 out of 100. The distribution of the scores is shown in Figures 4.4, 4.5, and 4.6 for gender, faculty type, and university tier, respectively.

Figure 4.4 Distribution of basic digital competency scores by gender



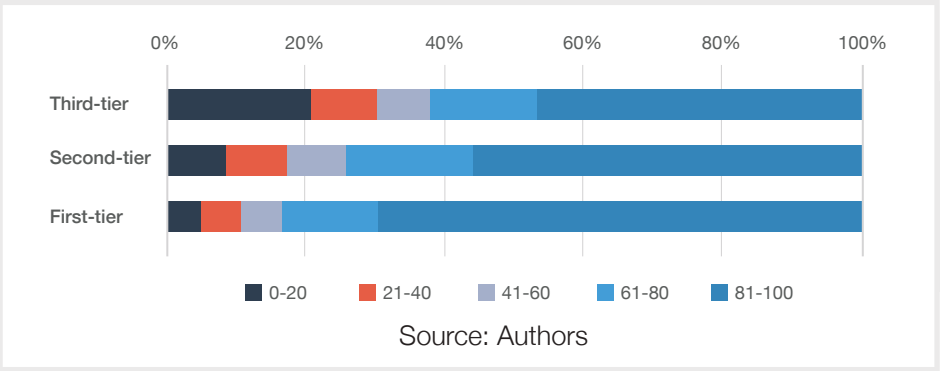
Source: Authors

Figure 4.5 Distribution of basic digital competency scores by faculty type



Source: Authors

Figure 4.6 Distribution of basic digital competency scores by university tier



Source: Authors

In Figure 4.4, we see that the distribution of scores for basic digital competency does not vary much by gender. In Figure 4.5, we see that STEM faculties tend to have a higher proportion of students who received a high score of 81-100, and fewer students who received a low score of 0-20, compared to non-STEM students. In Figure 4.6, we find that first-tier universities tend to have more students who received a high score of 81-100, and fewer students who received a low score of 0-20, compared to second-tier and third-tier universities.

In more detail, the scores range from a high percentage of students who "can communicate through handphone, email, and other means" (88.64%) to a relatively low percentage who "can save power when using an electronic device" (68.67%). These scores indicate that most students have already acquired a set of basic digital skills.

Table 4.1 Average scores for basic digital skills

No	Basic digital skill	Avg. Score	Type of skill
1	Can communicate through handphone, email, and other means	88.64	COM
2	Can seek information online using a search engine	86.83	IP
3	Understands that not all online information can be trusted	84.77	IP
4	Can save and reopen a document	82.36	IP
5	Can use the internet to access public services	81.58	COM
6	Understands the presence of social media and online	80.81	COM
7	Can produce content using a digital tool (i.e. taking a photo)	80.38	CC
8	Can share a document	79.86	COM
9	Applies safety standards on a digital tool (i.e. passwords, anti-virus)	76.85	SAF
10	Understands that content is protected by copyright	75.04	CC

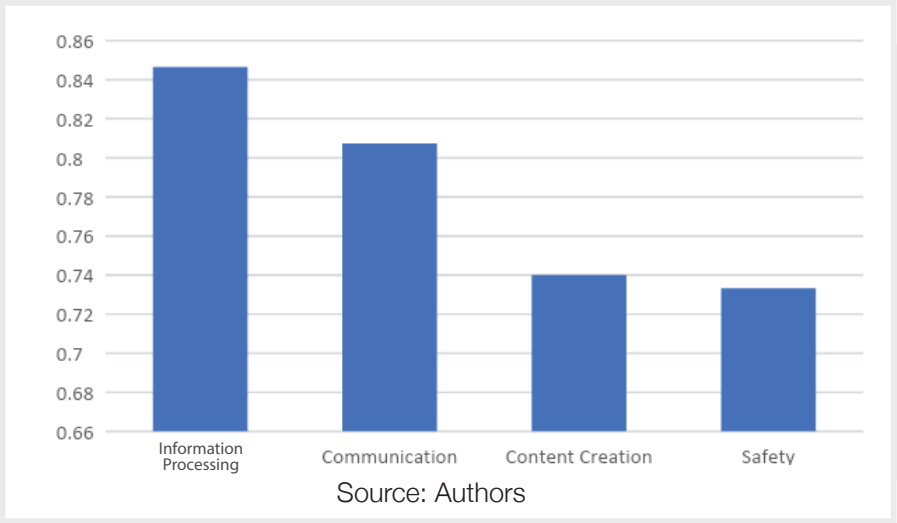
No	Basic digital skill	Avg. Score	Type of skill
11	Understands that private data should not be stolen or published online	74.27	SAF
12	Understands the presence of netiquette	72.81	COM
13	Can modify settings in a software/app (i.e. change default language)	71.94	CC
14	Can edit content (photo, document) produced by other people	68.67	CC
15	Can save power when using an electronic device	68.67	SAF
	Aggregate basic digital competency	*72.89*	

Note: **IP** = Information processing; **COM** = Communications skills; **CC** = Content creation; **SAF** = Safety

Source: Authors

Table 4.1 above identifies the type of skill on the right-most column.[45] When we aggregated the basic skills by type (see Figure 4.7 below), it becomes clear that skills that correspond to the "Information Processing" type scored the highest. High ownership of mobile phones and access to information perhaps contribute to the ability to process such information. However, skills that correspond to the "Safety" and "Content Creation" types are the lowest skillsets understood by students. Basic safety skills encompass how users ensure their accounts will not be hacked; yet most students still do not understand the basics of being safe on the Internet, despite their high level of communications.

Figure 4.7 Average scores for basic digital skill types



Source: Authors

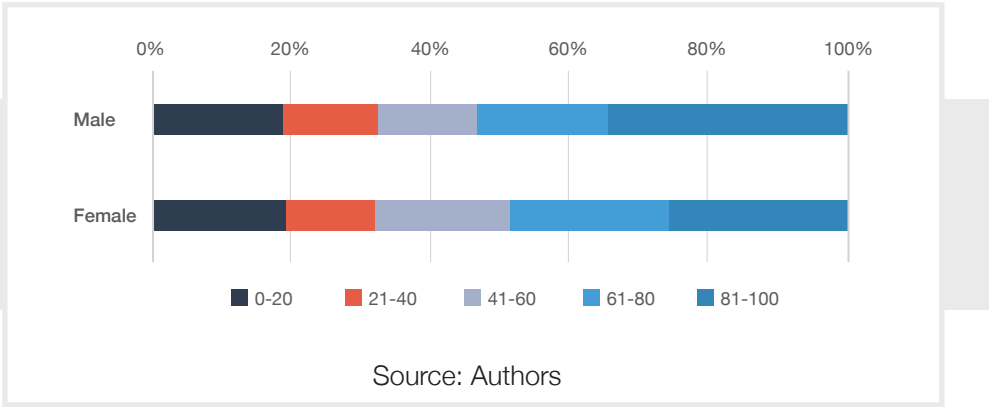
[45] It is worth noting that for basic competencies, skills from the "Problem Solving" typology are not included.

4.2.2. Intermediate digital competency

Individuals with intermediate digital competencies already have the ability to utilize digital technology independently. The difference between intermediate competency and basic competency is the problem-solving ability (EC DigComp, 2015). While individuals with basic digital skills may not know where to seek help and solve some routine problems, those with intermediate skills are able to solve most of the routine problems themselves. Individuals with basic digital competency may know when an issue or problem occurs, but they lack the ability to solve it independently.

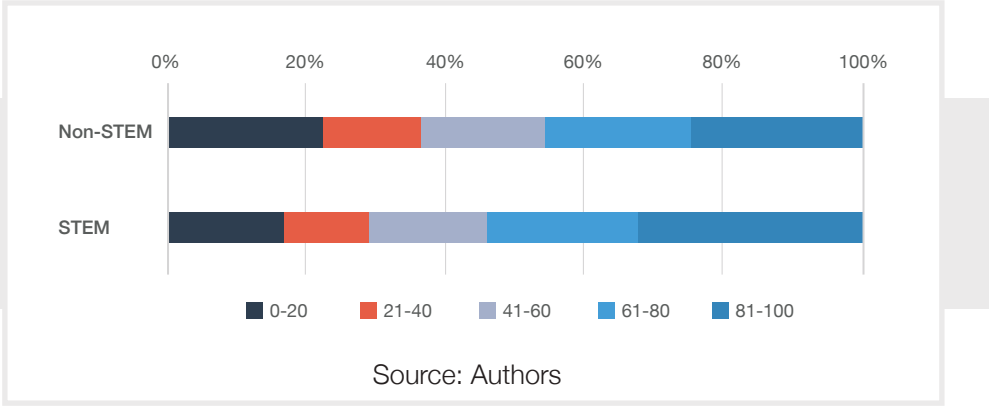
Next, we explore how the students fared on the 24 skills that correspond to an intermediate level of digital competency (see Table 4.2). The average score among all respondents for intermediate digital competencies is 56.35 out of 100. This is substantially lower than the average score of 72.89 that they obtained for basic digital competency. The distribution of the scores is shown in Figures 4.8, 4.9, and 4.10 for gender, faculty type, and university tier, respectively.

Figure 4.8 Distribution of intermediate digital competency scores by gender



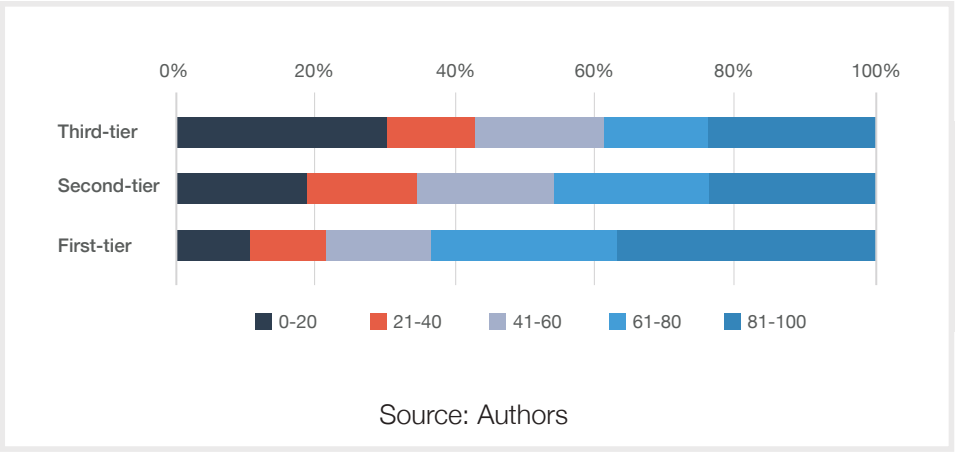
Source: Authors

Figure 4.9 Distribution of intermediate digital competency scores by faculty type



Source: Authors

Figure 4.10 Distribution of intermediate digital competency scores by university tier



Source: Authors

In Figure 4.8, we see that there is a higher proportion of male students who received a high score of 81-100 than the proportion of female students. Meanwhile, the proportion of students who received a score of 0-40 was relatively equal between men and women. In Figure 4.9, we see that STEM faculties tend to have a higher proportion of students who received a high score of 81-100, and fewer students who received a low score of 0-20, compared to non-STEM students. In Figure 4.10, we find that first-tier universities tend to have higher proportion students who received a high score of 81-100, and fewer students who received a low score of 0-20, compared to second-tier and third-tier universities.

In more detail, the percentage of students who had intermediate digital skills range from a high of 78.31% for “uses multiple online services” to a low of 34.08% for “understands digital identity and can trace one's own digital footprint.” These scores indicate that just slightly more than half of students have acquired the set of intermediate digital skills.

Table 4.2 Average scores for intermediate digital skills

No	Basic digital skill	Avg. Score	Type of skill
1	Uses multiple online services (i.e. public services, e-banking, E-commerce)	78.31	COM
2	Can use more than one search engine	77.62	IP
3	Shares knowledge with others online (i.e. through social	74.18	COM
4	Understands credibility and compares information from multiple	73.49	IP
5	Understands the effects of technology on the environment	71.34	PS
6	Understands and applies netiquette	68.85	COM
7	Understands the health risks of using digital technology	67.21	PS
8	Classifies information using files and folders	65.83	IP
9	Produces digital content in various format (i.e. text, tables, images)	64.37	CC
10	Contributes in using collaborative tools (i.e. sharing a document)	59.38	COM

No	Basic digital skill	Avg. Score	Type of skill
11	Installs safety features in tools used to access the internet	58.18	SAF
12	Understands personal limitations and upgrades digital skills.	54.91	PS
13	Can troubleshoot various problems when using digital technology	54.39	PS
14	Uses digital technology to solve non-technical problems	51.38	PS
15	Uses and updates safety features in software regularly	50.09	SAF
16	Uses multiple passwords to access digital services	49.91	SAF
17	Can apply basic formatting in content produced by others	47.42	CC
18	Uses tools, features, and templates to create a website	46.73	CC
19	Solves problems by exploring settings and options in a digital tool	46.21	PS
20	Knows how to reference and reuse content protected by copyright	43.98	CC
21	Uses advanced communication features (i.e. VoIP, file sharing)	41.57	COM
22	Can identify potential threats in a website or email	38.98	SAF
23	Understands basic programming language	34.08	CC
24	Understands digital identity and can trace one's own digital footprint	34.08	SAF
	Aggregate basic digital competency	***56.35***	

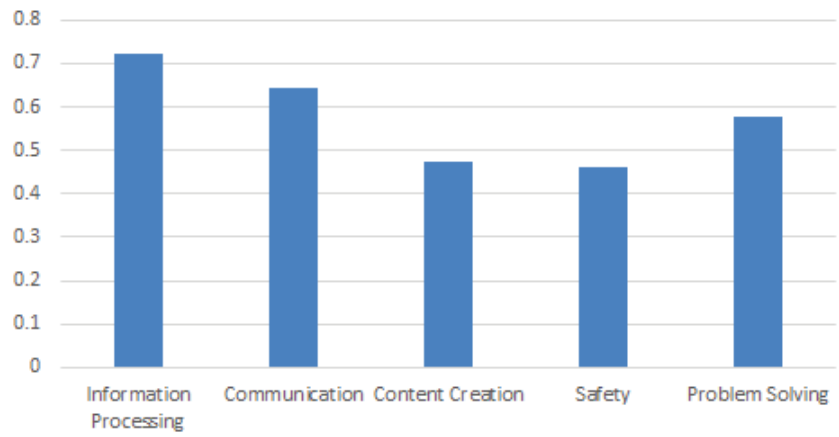
Note: **IP** = Information processing; **COM** = Communications skills;
CC = Content creation; **SAF** = Safety; **PS** = Problem solving

Source: Authors

When we aggregated the scores of intermediate skills by type (see Figure 4.11 below), we see that skills that correspond to "Information Processing" and "Communications" types, again, scored the highest. And consistent with the basic competency scores, again we find that skills that correspond to the "Safety" and "Content Creation" types are skills with the lowest scores. However, at the intermediate level, scores for these skill types are even lower than at the basic level. The students are also still lacking in other more technical skills. For example, only 34% of students stated that they know the basics of programming. The same relatively low percentage of students have the ability to shape their digital identity and track their own digital footprints.

In the intermediate level competencies, we started to introduce "Problem Solving" type skills. The average scores for these types of skills were, interestingly, higher than those for "Content Creation" and "Safety". The message seems to be consistent: content creation and safety are the types of skills that university students had the least understanding of.

Figure 4.11 Average scores for intermediate digital skill types



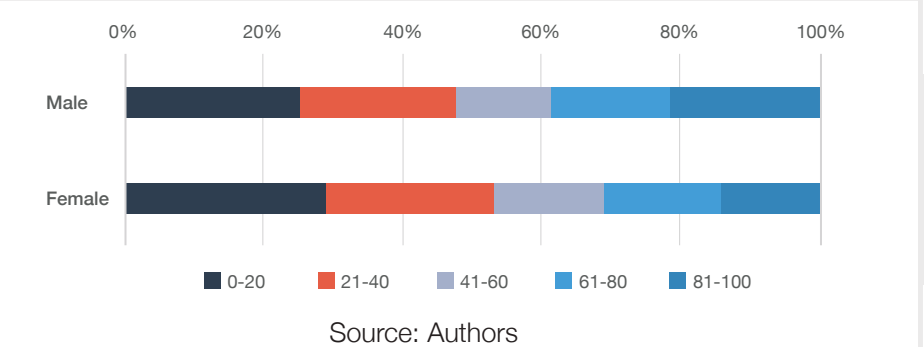
Source: Authors

4.2.3. Advanced digital competency

Having an advanced digital competency is perceived as the most favored skill in the future labor market. It is also likely to pave a pathway for individuals to hold middle to high skill jobs, which will also offer more salaries and benefits (Burning Glass, 2017). While basic ICT skills have become the minimum entry point for middle-skill jobs, those who possessed advanced digital technology skills will have a wider array of options and offers.

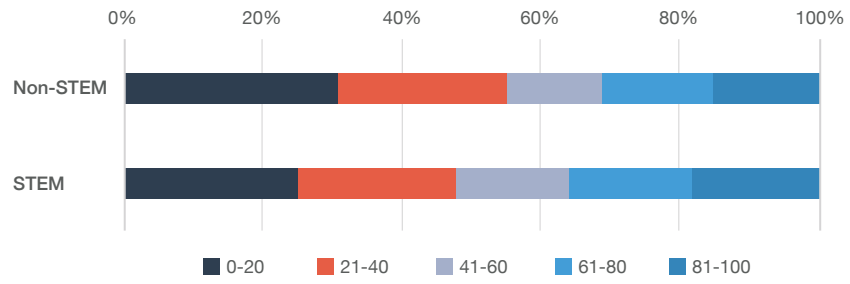
Third, we explore respondents' scores on 28 skills that make up the advanced level of digital competency (see Table 4.3). The average score among students who for advanced digital competency is 44.53 out of 100. This was lower than the average for intermediate level competency (56.35) and for basic level competency (72.89). This also shows that the higher the digital competency, scores tend to be lower. The distribution of the scores is shown in Figures 4.12, 4.13, and 4.14 for gender, faculty type, and university tier, respectively.

Figure 4.12 Distribution of advanced digital competency scores by gender



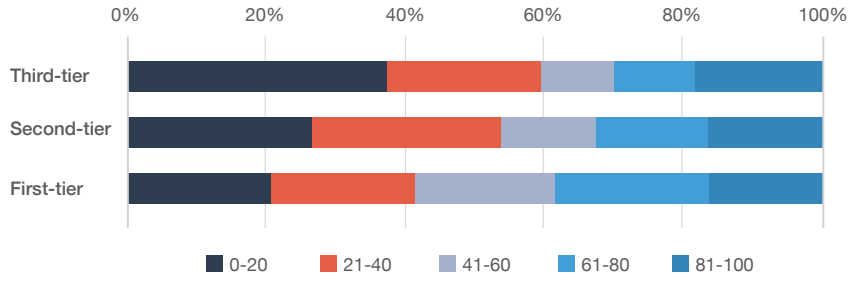
Source: Authors

Figure 4.13 Distribution of advanced digital competency scores by faculty type



Source: Authors

Figure 4.14 Distribution of advanced digital competency scores by university tier



Source: Authors

In Figure 4.12, we see that there is a higher proportion of male students who received a high score of 81-100, and a lower proportion who received a low score of 0-20, than the proportion of female students. In Figure 4.13, we see that STEM faculties tend to have a higher proportion of students who received a high score of 81-100, and fewer students who received a low score of 0-40, compared to non-STEM students. In Figure 4.14, we find that first-tier universities tend to have a lower proportion of students who received a low score of 0-40 compared to second-tier and third-tier universities.

In more detail, the percentage of students who have advanced digital skills range from a high of 79.43% for “uses multiple communications tools” to a low of 21.51% for “can create a website using programming language.” These scores indicate that less than half of students have acquired a set of advanced digital skills.

Table 4.3 Average scores for advanced digital skills

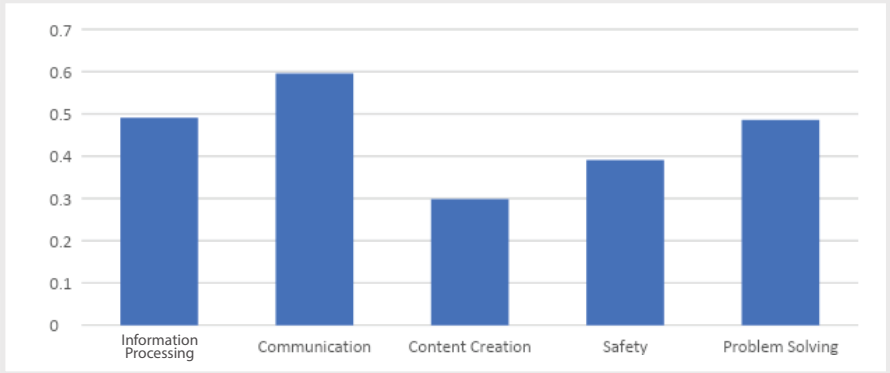
No	Basic digital skill	Avg. Score	Type of skill
1	Uses multiple communication tools (i.e. email, chat, SMS, blog, social media)	79.43	COM
2	Saves information from the internet in various formats	72.46	IP
3	Participates in the virtual world using multiple online services (i.e. e-banking, e-commerce)	66.44	COM
4	Knows the latest development of technology	59.81	PS
5	Understands the impacts of digital technology on everyday life, consumption	58.78	PS
6	Understands the latest technology for searching, storing, and retrieving information	58.61	IP
7	Uses advanced strategy to find credible information	50.26	IP
8	Uses advanced features in communication tools (i.e. video conference, data sharing)	49.48	COM
9	Knows how the latest technology works	49.31	PS
10	Uses ICT to keep healthy (physically and psychologically)	48.71	PS
11	Understands what to do when a computer is attacked by a virus	47.85	SAF
12	Upgrades digital competencies regularly	45.87	PS
13	Uses cloud services to store information	44.23	IP
14	Chooses the appropriate tools, software, and services to troubleshoot issues	43.89	PS
15	Creates and organizes content through collaborative tools (i.e. e-calendar)	43.03	COM
16	Understands the validity and credibility of information using certain criteria	42.17	IP
17	Knows how to apply for copyrights	42.17	CC
18	Knows how to encrypt emails and documents	41.05	SAF
19	Applies email spam filter	39.67	SAF
20	Sets and modifies safety features of digital devices	35.28	SAF
21	Creates and modifies multimedia content in various formats and platforms	33.82	CC
22	Solves almost all issues derived from using digital	33.48	PS
23	Checks safety features and configurations of software used regularly	31.58	SAF
24	Uses advanced formatting functions in various software	30.98	CC
25	Uses web feeds (i.e. RSS) to keep up with the latest information	26.59	IP
26	Knows how to design, create and modify a database	26.59	CC
27	Uses multiple programming languages	23.84	CC
28	Can create a website using programming language	21.51	CC
	Aggregate basic digital competency	***44.53***	

Note: **IP** = Information processing; **COM** = Communications skills; **CC** = Content creation; **SAF** = Safety; **PS** = Problem solving

Source: Authors

When we aggregated the advanced skills by type (see Figure 4.15 below), we now see that skills corresponding to the "Communications" skill types scored the highest, and those corresponding to the "Content Creation" skill types were the least-adopted. We also see that scores for skill types in the advanced digital competency were even lower than those in the intermediate level. From the section on intermediate competency above, we find that only a small portion (34.08%) of students knew the basics of programming. Looking at specific advanced skills, the three skills with the lowest scores were those related to content creation, namely: (1) creating a website using a programming language, (2) using multiple programming languages, and (3) designing, creating, and modifying a database.

Figure 4.15 Average scores for advanced digital skill types



Source: Authors

4.3. CROSS-FUNCTIONAL COMPETENCY

It has been widely predicted that IR 4.0 will bring transformation to the workplace and change the way we work. One of the ultimate transformations is a merged environment where humans will be working together with robots. Along with the development of artificial intelligence, there is an increasing possibility where repetitive and monotonous jobs will be replaced by machines. However, some also argued that jobs that require high cognitive skills are less prone to automation. To classify the required cognitive skills, The World Economic Forum (WEF) released a report in 2016 mentioning the top-nine skills which will be highly valued in 2020.

These nine skills were used to measure the extent to which Indonesian university students have reportedly acquired "soft skills" or cross-functional competencies. Our survey found, based on an aggregate of these nine skills, the overall cross-functional competency score for Indonesian students was **63.33 out of 100** (see Table 4.4). Of the nine specific skills measured, "coordinating with others" scored the highest (67.78 out of 100) and "negotiation" scored the lowest (61.29 out of 100). These numbers reflect a rather positive snapshot in which students are quite confident of their soft skills.


Photo by Jessica Da Rosa on Unsplash

Table 4.4 Average scores for cross-functional skills

No	Cross-functional skill	Avg. Score
1	Coordinating with Others	78.31
2	Cognitive flexibility	77.62
3	Judgement and Decision-Making	74.18
4	Creativity	73.49
5	Emotional intelligence	71.34
6	Problem-solving	68.85
7	Critical thinking	67.21
8	Service-orientation	65.83
9	Negotiation	64.37
	Aggregate cross-functional skill	*63.33*

Source: Authors

The following presents further descriptions of the cross-functional competency skills, starting from the skill that obtained the highest score.

Coordinating with Others: This is explained as the ability of an individual to adjust his or her actions based on others'. Working in the future does not only require digital and technical competencies but also working with multi-disciplinary teams and doing cross-functional work. Therefore, having the ability to synchronize work with others to achieve common goals is becoming more critical. The survey indicates that students are most confident with this skill as the overall score is the highest among other skills, at 67.78 out of 100.

Cognitive Flexibility: The majority of jobs in IR 4.0 will be those that offer a solution for problems in society. Therefore, a capacity to shift the thinking process, from one concept to another, is important. Furthermore, the speed in which an individual can shift their cognition varies, and it is defined as the degree of cognitive flexibility. An individual with higher cognitive flexibility is able to adapt to new concepts or environments at a faster pace. According to the survey, the students score 64.65 /100 for this skill.

Judgment and Decision Making: This skill measures the capacity of individuals to make effective decisions. In doing so, an individual must have a clear judgment and understands the situation. It also involves cognitive processes that lead an individual to take an objective and reasonable decision. Individuals who demonstrate an ability to identify all options and compare them to choose the best options are surely more attractive than those who do not. Based on the survey, the score for judgment and decision making is tiered as the third-highest (63.96/100).

Creativity: In general, this is the ability to express breakthrough ideas about a given topic or situation, or develop unusual ways to solve a problem. WEF classifies creativity as one of the cognitive abilities in the landscape of core-work related skills. Creativity is a valuable skill for students to compete with machines. In the work environment where machines are capable of doing patterned jobs, creativity from individuals is required to innovate. Based on the survey, the overall score for creativity is 63.17 out of 100.

Emotional Intelligence: This implies how a person can manage self-awareness, self-management, social awareness, and relationships (see Goleman, 1998).[46] In the context of the working environment, the level of one's emotional intelligence determines how he/she communicates with other professionals and partners. Individuals who excel in emotional intelligence will arguably be able to maintain a good relationship with others. From the survey results, the level of emotional intelligence of respondents was rated 62.48 out of 100.

Problem-solving: This measures the ability of the higher education students to solve problems that they face. Wang and Chiew (2010), argued that there are several approaches to problem-solving: direct facts, heuristic, analogy, hill climbing, algorithmic deduction, exhaustive search, divide-and-conquer, and analysis and synthesis.[47] Problem-solving, in any form of approach, is imperative for the performance of students in the future. Based on the survey results, the problem-solving skills of respondents can be rated as 62.36 out of 100.

Critical Thinking: This is defined as the use of logic and reasoning to identify the strengths and weaknesses of alternative solutions, conclusions, or approaches to problems. Critical thinking involves analytical, communication, creativity, open-minded, and problem-solving skills. WEF examines critical thinking as one of the basic skills in core-work related skills. The survey shows that the average score for critical thinking is 62.31/100.

Service Orientation: This implies the ability to display a positive attitude in providing service. This skill is imperative to maintain satisfactory relations with clients. Moreover, to have a service-oriented person also means that employees are obliged to provide the best solutions for their clients' demands. WEF identifies service

[46] Goleman, D. (1998). What Makes a Leader?. Harvard Business Review [online] Best of HBR 1998. Available at http://jbedwardsandassociates.com/wp-content/uploads/2015/12/HBR-What-makes-a-great-leader-D.-Goleman.pdf [Accessed 17 Mar. 2019].

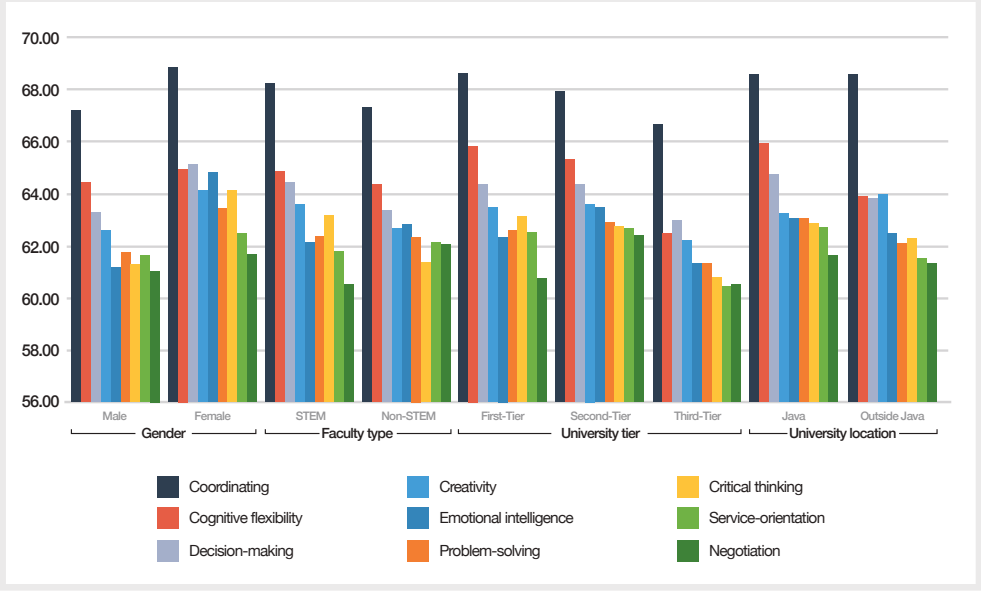
[47] Wang, Y., and Chiew, V. (2010). On the cognitive process of human problem solving. Cognitive System Research [online] Vol. 11(2010), pp. 81-92. Available at https://www.researchgate.net/publication/222705878_On_the_cognitive_process_of_human_problem_solving [Accessed 15 Mar. 2019].

orientation as a skill that falls under the scope of social skills as it requires the capability to communicate and interact with other individuals. The survey finds that students marked themselves at 61.96/100 for this.

Negotiation: This implies the discussion of two or more actors to produce an advantageous outcome of an issue. There are two types of negotiations: (1) distributive negotiation and (2) integrative negotiation. The former assumes that the negotiation would produce a zero-sum outcome, and the latter assumes that the negotiation would produce a positive-sum outcome. Both types of negotiations arguably exist and are paramount skills. Based on the survey results, respondents' negotiation skills are rated 61.29 out of 100.

The distribution of scores for the cross-functional skills varies according to the respondents' basic characteristics, as shown in Figure 4.16. It is interesting to note that across all nine types of skills, men scored higher than women, and those who studied in Java scored higher than their counterparts outside of Java. With a few exceptions, those who studied in STEM faculties and in first-tier universities tended to obtain higher scores than their counterparts. The exception was that non-STEM students actually scored higher than STEM students for Negotiation, Service Orientation, and Emotional Intelligence. Also, students from second-tier universities scored higher than those from first-tier universities for Negotiation, Service Orientation, and Emotional Intelligence.

Figure 4.16 Distribution of cross-functional competency scores by gender, faculty type, university tier, and university location

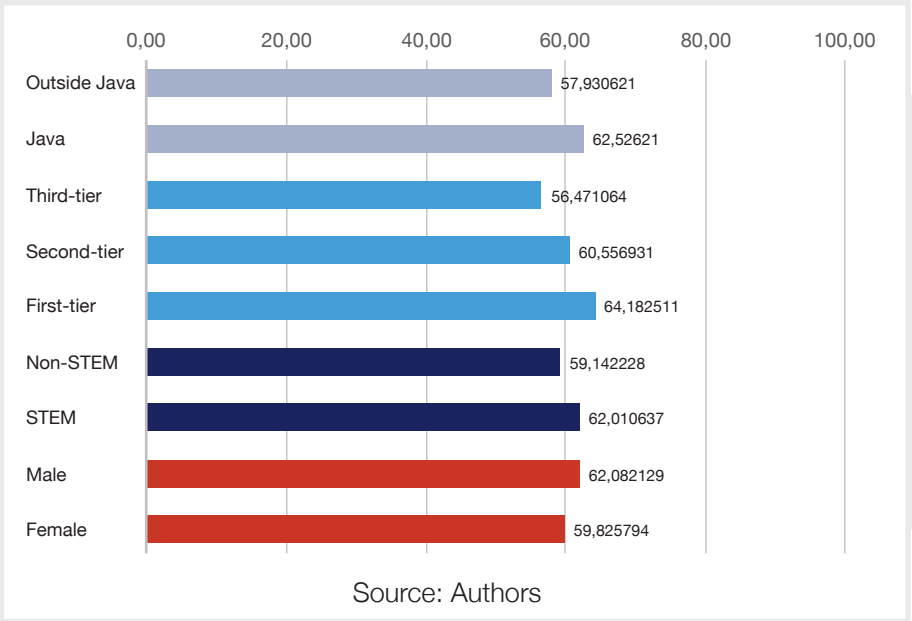


Source: Authors

4.4. OVERALL IR 4.0 READINESS

The level of readiness shows an individual's likelihood of thriving in a working environment in IR 4.0. In this study, we measure students' readiness towards IR 4.0 by taking the average of a respondent's digital competency score and cross-functional competency score. Based on that formula, on aggregate, Indonesia's overall IR 4.0 readiness score is (57.92 + 63.33) / 2, which is 60.62 out of 100. The distribution of this aggregate score, however, varies according to the respondents' basic characteristics, as shown in Figure 4.17.

Figure 4.17 IR 4.0 readiness score by gender, faculty type, university tier, and university location



Source: Authors

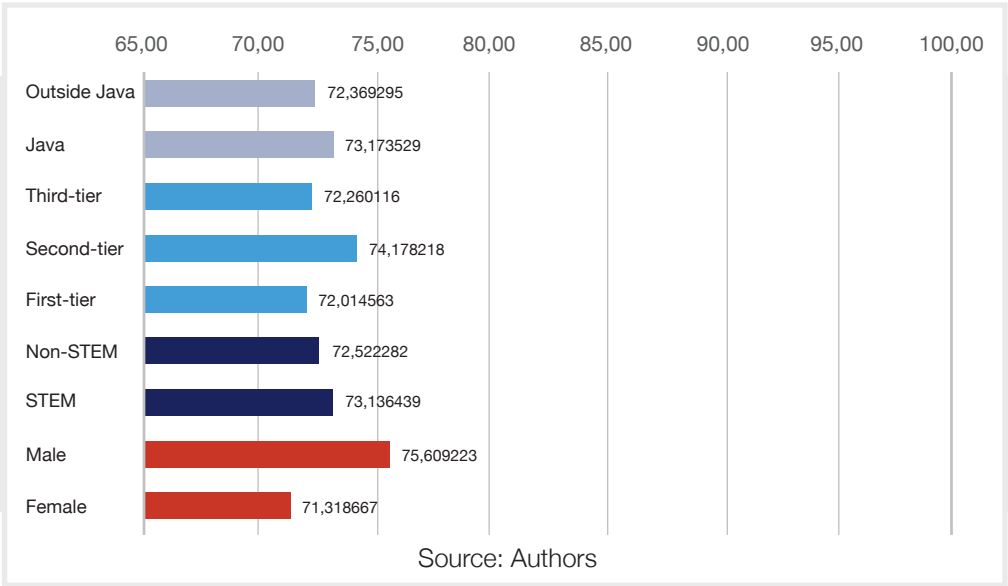
After calculating both digital competencies and cross-functional competencies into an aggregate score on measuring the higher education students' readiness, Figure 4.17 shows that those who are more ready for IR 4.0 are: (1) male students over female students, (2) students from STEM faculties over those from non-STEM ones, (3) students from first-tier universities over those from second-tier and third-tier universities, and (4) students studying in Java over those studying outside Java.

Aside from calculating an IR 4.0 readiness score, we also asked the students for a self-assessment, in which they were asked about their confidence in entering the job market, using a scale of 0-100. Self-readiness refers to the level of confidence of an individual regarding their current or future performance in the IR 4.0 era. In the survey sheet, self-readiness is represented by the question of "In the scale of 0-100, how ready are you in entering the IR 4.0 era?". Questioning the self-readiness of the higher education students is important to understand the confidence level of the students regarding their participation in the IR 4.0 era.

The aggregated readiness score based on self-assessment or perception was 72.84 out of 100. This is substantially higher than the readiness score based on digital and cross-functional competency scores, which was 60.62 of 100. Compared to the two numbers above, we find that the level of objective readiness of university students is lower than their self-perceived readiness. This seems to indicate that the students tend to possess a rather overconfident perception of their readiness for the IR 4.0 era.

The distribution of this aggregate perception also differs according to the respondents' basic characteristics, as shown in Figure 4.18. Aside from the higher scores, results in Figure 4.18 are almost similar to those in Figure 4.17, i.e. STEM students have higher confidence in facing IR 4.0, and so do male students and those studying in Java. The difference lies in university tiers, where it is interesting to note that first-tier institutions were not as optimistic as the second- and third-tier institutions. Students studying in second-tiered institutions were the most confident in their readiness for IR 4.0.

Figure 4.18 Self-perceived IR 4.0 readiness by gender, faculty type, university tier, and university location



Source: Authors

To present a more complete picture of the student's readiness, this study also includes the perspective of higher education decision-makers on their students' readiness level. This is based on interviews with 19 university officials and presented in the following chapter.

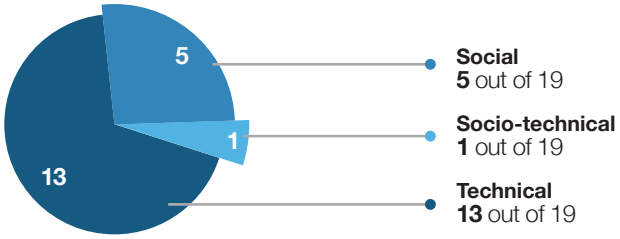
5. THE READINESS OF HIGHER-EDUCATION INSTITUTIONS

This section reports the varied perceptions of readiness of Indonesia's higher education institutions in facing the challenges of IR 4.0. The qualitative statements presented in this section is based on interviews conducted with representatives of 19 private and public higher education institutions in Indonesia, ranging from the first-tier, second-tier, and third-tier universities. All respondents are high-level officials in their respective institutions, in charge of operating the academic service and formulating the curriculum. Details on the questions and the respondent selection process are described in Chapter 3 on Methodology.

Ten questions were asked to the respondents, ranging from their general perspective on IR 4.0, the readiness of their ICT infrastructure and teaching staff, the required curriculum to answer the challenges of the IR 4.0 era, and policies that should be taken by the government to strengthen the higher education institution's capacity towards IR 4.0.


Photo by Nathan Dumlao on Unsplash

5.1. PERSPECTIVES TOWARDS IR 4.0



First, we report the officials' general perspective on IR 4.0 to understand what comes to their find when the subject is raised. Based on the interviews, we found that the officials' general perspective towards IR 4.0 can be classified into three categories: *technical*, *social*, and *socio-technical*. The technical perspective is the most adopted perspective, while the more complete or hybrid socio-technical perspective is only adopted by one institution official.

5.1.1. Technical

Most (13 out of 19) of the higher education institution officials interviewed tend to see IR 4.0 from a largely technical perspective, as a change in the industry caused current technological advancements. This is supported by the frequent mention of words and phrases related to technology, such as big data, cloud computing, artificial intelligence (AI), internet of things (IoT), algorithm, etc.

The following quotes reflect some of the technical perspectives given by the respondents:

> *"At least there are four (subject areas) that must be mastered, namely big data, IoT, AI and (computing) sensors. If I'm not mistaken this 4.0 era is about controlling, automation."*
>
> **- A representative of a Third-Tier, Private Higher Education Institution**

> *"Industrial revolution 4.0 is marked by increasing connectivity. Information is interwoven with various services that we now know as the Internet of Things. Then, with this connectivity, various data (will produce) information that we call Big Data. On one side, this becomes the means and potential for development (and) knowledge, but it requires better infrastructure so that the connectivity is beneficial for users too. On the other side, because a variety of information is also available and can be applied to the development of computers and algorithms, routine work can be done by a smart system based on robotics."*
>
> **A representative of a Second-Tier, Private Higher Education Institution**

5.1.2. Social

A smaller proportion (5 out of 19) of higher education institution officials tend to view IR 4.0 from a more *social* perspective, where soft-skills and social changes are being coined in the conversation as imperative aspects to master in the IR 4.0 era. The social perspective on IR 4.0 is supported by frequently mentioned phrases associated with social capabilities, such as social order, social behavior, creativity, change of job competencies, etc.

> *"It is a necessity that no one can escape. Industry 4.0 (is a) phenomenon where the rapid advancement of information and communication technology has resulted in new (social) behaviors, new social order, and then new career opportunities that had never been imagined before."*
>
> **A representative of a First-Tier, Private Higher Education Institution**

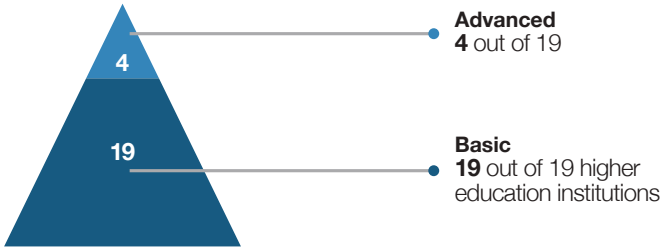
> *"It's simple but that actually (important) to our students. We must deliver (and) explain to them that as the fourth industrial revolution progresses, the types of jobs that have existed so far will change and (new ones will) come, right? Thus, the competencies they possess must also adjust to that, of course."*
>
> **A representative of a Second-Tier, Public Higher Education Institution**

5.1.3. Socio-technical

The hybrid, *socio-technical* perspective tends to see IR 4.0 more broadly, as a phenomenon where a technology-driven change in the industry results in the change of the workforce as well as the social order. This is a less-popular perspective currently, as there is only one (out of 19) university officials who mentioned the importance of both aspects, where technical and humanist phrases are mentioned in the conversation.

> *"Industry 4.0 means that we are faced with an era of highly advanced information technology, especially big data. Maybe with the advancement of big data, statistical theory will also change. If in the past (we) only (view) the data of a population through census or sampling, now everything has been tabbed by a system. Yes, through the Google Maps system we are self-reporting. I'm here, too. With my GPS, I've found out where I am and contributed to the big data information system. Also, with the internet of things, everything is all interconnected, shopping, business, are all online."*
>
> **A representative of a Second-Tier, Public Higher Education Institution**

5.2. INFRASTRUCTURE AND EDUCATION FACILITIES



Second, we report the officials' perspectives on the extent to which necessary infrastructure and education facilities have been provided to prepare students for IR 4.0. Based on the interviews, we found that the level of an institution's infrastructure and education facilities can be broken down into two categories: *basic* and *advanced*. All 19 universities interviewed reported that they have at least a basic level of infrastructure, while 4 out of 19 reportedly have a more advanced level of infrastructure.

5.2.1. Basic

We define basic infrastructure and education facilities as having a WiFi connection, laboratory, online library, and online information system. According to the interviews, basic infrastructure and education facilities have been provided in all 19 higher education institutions. However, the quality of these infrastructures and facilities vary in each institution, sometimes greatly. For instance, in some higher education institutions, Wi-Fi connection is well-maintained and periodically updated with greater bandwidth. However, in other institutions, the quality of the Wi-Fi connection is poor due to the unstable electricity in the area.

The following quotes illustrate how basic infrastructure and facilities are provided in a first-tier and third-tier education institution.

> *"Our internet infrastructure has been (established) a long time since 2007, and then (it was) developed again in the last 3 years (by adding) its bandwidth. Even the exams are conducted using it. The majority (of the exams) are already computer-based. Until today, there are approximately 1000 (computers)."*
>
> **A representative of a First-Tier, Private Higher Education Institution**

> *"Yes, but the problem is that electricity often goes out. So the WiFi (connection) is slow. We have fulfilled our obligation to pay, but we don't know the specific problem."*
>
> **A representative of a Third-Tier, Private Higher Education Institution**

5.2.2. Advanced

Advanced infrastructure and education facilities are defined as having basic infrastructure and facilities as well as an online education platform. This, however, can only be found in 4 out of 19 institutions interviewed. Online education platforms in these institutions are meant to provide a platform to disseminate academic materials in the form of live or pre-recorded videos. Some higher education institutions have established cooperation with online education platform providers such as Cisco, yet the rest make use of the free and open online education platform, such as Google Classroom or platforms that are built independently.

The following quotes illustrate how the more advanced infrastructure and facilities are being used by two first-tier education institutions.

> *"When lecturers (want to) share the content of their lectures for reference, (they can) use that (an online education platform built by the university). Also, if students want to have a discussion with the lecturer, they can use (it). Everything is recorded; there is a web record, so (the platform) can be one of the first alternatives for bridging online communication between lecturers and students because this was developed since a long time ago, since 2004."*
>
> **A representative of a First-Tier, Public Higher Education Institution**

> *"For online courses, we have (an online education platform built by the university). So the course is indeed recommended to be available online. So, we are headed there. We have not reached a complete transformation but at least "Okay, we have uploaded the materials." Or, at the very least, we held online tests there. In the technological and natural science faculties, it (the platform) is already around 70-80% (completed and utilized)."*
>
> **A representative of a First-Tier, Public Higher Education Institution**

5.3. THE CAPABILITY OF LECTURERS ON IR 4.0: A CHALLENGE

Third, we report the officials' perspectives on the capability or readiness of their lecturers in delivering academic materials related to IR 4.0. Interestingly, despite the rather rosy perspective on infrastructure and facilities, all of the 19 university officials interviewed perceived that most of their lecturers are yet to be ready. Furthermore, the interviews tend to conclude that most senior lecturers are not familiar with academic materials related to IR 4.0, as well as using technologies associated with

Photo by Uriel Soberanes on Unsplash

IR 4.0, such as cloud storage, virtual reality-based education, and so on.

The following quote illustrates concern on the capacity of some lectures in keeping up with the latest topics and skills required to teach IR 4.0, as told by a third-tier education institution official. Here age is mentioned as a concern, but the real issue is perhaps not age, but willingness and capacity to learn new things.

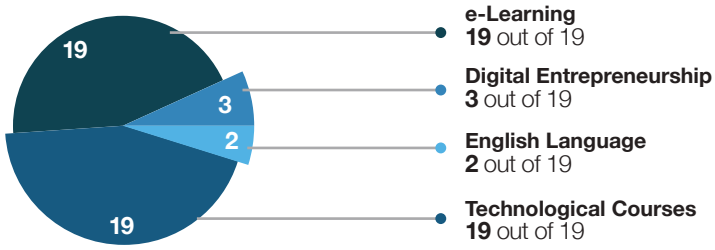
> *"Well, there is (still) a gap. This (year), our university is 36 years old, 80% of the lecturers are old, the seniors. So, if we ask what the policy is, it is difficult. They are too old if we (plan to) train (them). Maybe the effect will not be significant, or not in (the right) time because the gap between old and young is too high. Our regeneration is a bit late."*
>
> **A representative of a Third-Tier, Private Higher Education Institution**

To close the gap, some higher education institutions have provided training on the use of more advanced technologies, such as Google Classroom, Cisco WebEx, and Skype. These training are usually aimed at the more senior lecturers, considering that the younger lecturers have had less problem adapting to the technology due to being more exposed to technology. These are reflected in the statements below:

> *"In general, we provide training on this. We train all of our lecturers to at least implement Google Classroom in the learning process, at least for interaction between lecturers and students, (and then later, in the future) to deliver materials, reports and so on, so that records of the learning process can be stored in Google Classroom."*
>
> **A representative of a Third-Tier, Private Higher Education Institution**

> *"If you ask whether it's ready, it's actually not ready. This is our way: if any changes are needed in the curriculum (for example, related to IR 4.0), all the essential curriculum must be changed. If the curriculum changes, we will prepare it. One of them is actually being able to train the lecturers, upgrading (their skills) regularly to keep abreast of developments too. This can be done, possibly by holding training sessions or international exposure, when needed."*
>
> **A representative of a Third-Tier, Private Higher Education Institution**

5.4. THE IDEAL CURRICULUM TO RESPOND TO IR 4.0



Fourth, we report the university officials' perceptions of the ideal curriculum needed to respond to IR 4.0. Based on their answers, the ideal curriculum should cover four aspects: (1) an e-Learning platform, (2) courses and training on digital entrepreneurship, (3) English language courses, and (4) introductory courses on the technologies associated with IR 4.0.

5.4.1. e-Learning platform

The availability of the e-Learning platform is mentioned by all 19 higher education officials as part of the requirement of the new curriculum. These respondents envisaged the relevant curriculum as a set of subject materials delivered within an e-Learning platform. Interestingly, most representatives only stressed the availability of e-Learning platform without further explanation on what set of curriculum should be implemented within the platform.

> *"(We) moved the class to cyberspace. (It) can be interactive: (we) can ask questions, (we) can have discussions, (we) can form groups. And that is very relevant for today. We do not have to sit in one place together to transfer knowledge. No, it doesn't have to be that way. The principle is that this online class offers flexibility. Anywhere and anytime will do."*
>
> **A representative of a Second-Tier, Private Higher Education Institution**

> *"Every year we tried, and in 2010 we had assessments done by the National Accreditation Agency for Higher Education (BAN-PT). One of their (recommendations) is online learning; online courses have to be improved. Since 2010, it has been 9 years until now. We've done it (improve the online system) every year. "Come on, who hasn't been online yet?" So every study program will always invite their lecturers to do this (online study)."*
>
> **A representative of a First-Tier, Private Higher Education Institution**

5.4.2. Digital entrepreneurship

The availability of courses and training on digital entrepreneurship is highlighted by most of the higher education officials as part of their perceived ideal curriculum. However, only 3 out of 19 respondents mentioned tangible examples of the available courses, training or even local institutions which aim to develop students' digital entrepreneurship. Regarding the relevant local institutions, some higher education institutions have established various models, from ones that prepare students to possess digital entrepreneurship skills to ones that position themselves as incubation body to start-ups developed by the students.

> *"(Digital) entrepreneurship is a high priority, especially for us, here, at our (institution). Previously, the entrepreneurship course is not taught in every program (at this institution). But starting in 2017, with the change in the demand for information technology skills in the world of work, entrepreneurship courses are made compulsory for each program and every program level, ranging from D2, D3 (both vocational degrees), S1 (undergraduate degree), and up to the post-graduate level, there is entrepreneurship (courses) on offer. That's to anticipate the changing demands. Therefore, students will not always think that they will be looking for work after college."*
>
> **A representative of Second-Tier, Public Higher Education Institution**

> *"For those (students) who want to start a business, we try (to educate them). Since there are a few of them, we established an incubation (body) and that every year we recruit a number of groups, and we help build their business (so that) later it can stand a chance to be funded by investors."*
>
> **A representative of Second-Tier, Private Higher Education Institution**

5.4.3. English language

The availability of English language courses is mentioned by 2 out of 19 higher education representatives as part of the ideal curriculum. This aspect of the curriculum is relatively less-popular than other aspects because based on interviews, the importance of language courses is highly related to the geographical location of the higher education institution. Institutions located in or near major tourism sites tend to see English courses as a priority for most of their students, who either come from tourism-oriented areas or who would likely work in the tourism industry after graduation.

> *"A medical student, for example, may be an expert in the medical field, but if he is good in English, many hospitals will recruit him because of the need to interact with foreign patients... So, the (level of) competence often matters less. What is important is that it (the language fluency) can facilitate him to do his main task."*
>
> **A representative of First-Tier, Public Higher Education Institution**

> *"Next, English. Because the (future) of communication is English and that is also the case on the internet, correct? To provide English (proficiency), we are working with external institutions to train students (to be fluent in) conversations. In the curriculum, we also allocated 6 credits (for English)."*
>
> **A representative of First-Tier, Private Higher Education Institution**

5.4.4. Technological courses

Courses that introduce technologies associated with the advent of IR 4.0 were mentioned by most higher education representatives as part of what they perceive to be the ideal curriculum. They consider this as necessary due to the advent of new technologies such as big data, cloud computing, AI and IoT. However, only one higher education institution has established a course that introduces such technologies. This so-called *Digital Transformation course* consists of four sub-courses that aim to introduce the use of big data, AI, IoT and python in the present days. Currently this course is only limited to students in five faculties, namely Faculty of Biology, Mathematics and Natural Science, Medicine, Pharmacy, and Philosophy.

> *"We have a course called Digital Transformation. It is a new course that we offered since last semester. It is 100% online, there are no face-to-face meetings between lecturers and students. We used (the institution's online education platform), plus online interaction through Cisco WebEx. Last semester, we ran it in 5 faculties. The course explores big data analysis, IoT, python programming, and AI."*
>
> **A representative of First-Tier, Public Higher Education Institution**

5.5. CHALLENGES IN FORMULATING THE IDEAL CURRICULUM

Fifth, we report perceived challenges inhibiting the formulation of an ideal curriculum that answers the demands of the IR 4.0 era. Based on interviews with the 19 higher education institution officials, such challenges include the need to deal with more basic needs of the university, i.e. student recruitment. This challenge tends to be more pronounced in higher education institutions located outside of Java, where population density, and thus enrollment level is low. Another challenge is the need to adhere to the interests of the higher-level institution that runs the university (i.e. the owner of the university, or government agencies to whom the university must report). This is more pronounced in private education institutions that are owned by a foundation.

5.5.1. Higher priority on student recruitment

The disparity of conditions between higher education institutions located in Java and other areas adds a real issue towards the formulation of the ideal curriculum. Institutions located outside of Java – especially private ones - are less favored by many students in Indonesia, and therefore the number of students in these areas is arguably smaller than those in Java. Thus, the main focus of many educational institutions outside of Java is still gaining more applicants rather than reconfiguring its curriculum.

> *"The problem is, we are a private (institution). For us, (the growth of the institution) depends on the number of students. Alhamdulillah, for now, our institution is growing. Interest from the local community is growing, our facilities are decent, many of our students have also had achievements. With increasing interest and the number of students, our (the foundation's) income has increased."*
>
> **Representative Third-Tier, Private Higher Education Institution**

> *"Recruitment process requires data to be integrated on both sides. We want to track the alumni of madrasas and pesantrens (religious secondary schools) (who are likely to apply as students at this higher education institution). But we have difficulty in getting data on high school, madrasa, and pesantren graduates from the ministry."*
>
> **A representative of Third-Tier, Private Higher Education Institution**

5.5.2. Compliance to higher-level interests

Based on the interviews, the development of a higher education institution also depends on the interest of the higher-level organization that controls the education institution. In the case of public higher education institutions, the government through the Ministry of Education is in charge. Meanwhile, private, Islamic higher education institutions answer to both the Ministry of Education and the Ministry of Religious Affairs (Kemenag). Other (non-religious) private higher education institutions answer to both the Ministry Education and, mainly, the private foundations that own the institution and fund its operations.

With this configuration, each higher education institution must answer to the interests of the higher-level organization that they are responsible to. For some private higher education institutions, this would present another challenge since developing a curriculum that responds to the demands of the IR 4.0 era may not necessarily be in-line with the private foundations' or the Ministry of Religious Affairs' main objectives.

> *"We are a private (institution). We operate under a foundation. (Thus), our institution can't be separated from it because the foundation's (interest) is very influential. For them, as long as we do not adopt policies that diverge too far (from their interests), they certainly agree. But when talking about IR 4.0, we talk about a lot of things, especially human resources and facilities/infrastructure. But the foundation's priorities are not necessarily aimed in that direction."*
>
> **Representative Third-Tier, Private Higher Education Institution**

> *"Our institution is under two ministries, the Ministry of Religious Affairs (Kemenag) and the Ministry of Education. One of the mandates, when we switched from the previous institution model to current model, is that we have to make sure that we do not lose the Islamic aspects. That is our contract (with Kemenag). So, religious courses must be prioritized. We have more religious programs, at least 60% of the total number of programs on campus. This condition will later influence the philosophy of our curriculum because we cannot betray our mandate (given by Kemenag)."*
>
> **A representative of the Third-Tier, Private Higher Education Institution**

5.6. DECISION MAKING PROCESS

The decision-making process is considered as an aspect that is also affected by the coming of IR 4.0 era. This is largely due to the nature of the fast information flow enabled by technology. It is argued that the pace of information flow will force decision-makers to make faster decisions to respond to a specific issue. Moreover, this trend may drive decentralization of responsibilities since the flow of information is also becoming more dispersed.

Not only in the scope of decision making, but IR 4.0 is also considered to influence specific kinds of policies being made. The university's management is also expected to accommodate innovative practices, including the opening of a new program that caters to digitalization.

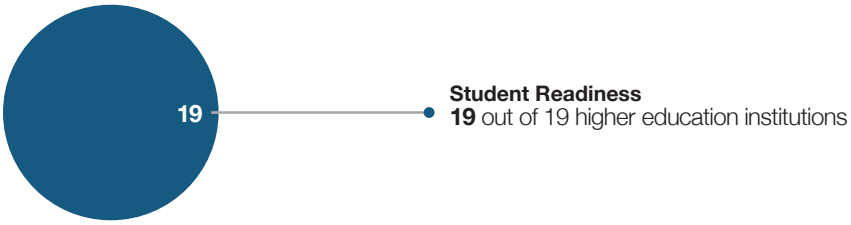
> *"It's true that now there is a sort of shift. For example, the Faculty of Economics and Business previously tend to lean more towards the study of management and accounting. But now, we think that these (studies) may be less relevant than they were before. This year, we want to propose a new department, Digital Business. Also, in the Engineering Faculty, before, we have the conventional, classic programs, like electrical engineering, industrial engineering, but now we also want to start opening biomedical engineering and advanced material engineering based on a high degree of computing."*
>
> **Representative Third-Tier, Private Higher Education Institution**

Similar policies of accommodating a more innovative approach to learning can also be seen in the making of a university's information system. For example, a move towards more collaborative learning approaches between faculties facilitated by a single information system in the university.

> *"The Faculty of Social and Political Sciences have their own system, so does the Faculty of Engineering. They can't see each other's systems (i.e., courses offered in each faculty). Through the new policy, every faculty needs to be integrated into one single system. Last semester, we started with five faculties in one server. It's not easy, not every dean wants to accommodate this integration. If we look at it from the perspective of profits, the information system (of each faculty) is not made by ourselves, but by third parties. So, our goal for next semester is to have all faculties join this one single information system so that the interconnectivity of students' data, for example, is no longer a problem."*
>
> **Representative Third-Tier, Private Higher Education Institution**

Hence, we conclude that IR 4.0 may not, per se, have influence in the technical decision-making process among the management--in the sense of fast-paced decision. However, the decision that is being made is highly affected by the pace of development of technologies and the need for "riding the wave" of digitalization.

5.7. STUDENTS' READINESS TOWARDS IR 4.0



Fifth, we found that all university representatives were confident of their students' readiness towards IR 4.0. This is reflected in the interviews where they were asked about the readiness of the university's alumni to compete with other universities' graduates in the IR 4.0 era. The following statements show such confidence, which is quite common throughout the respondents.

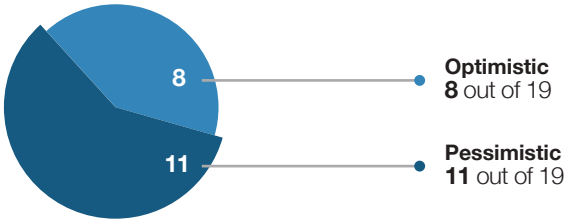
> *"Of course, I believe they are ready. They, the younger generation, whenever it comes to things related to digital, they are more 'aggressive', and they always want to step forward. However, in the past, this is hard to accommodate because it isn't in the curriculum, yet. Now, we have a specific digitalization course that we put into our curriculum. For example, if they want to start a business, they can sell their products on the internet, which is actually very easy. Not all of our graduates can become civil servants, so we hope they can become entrepreneurs, so that they can create jobs, for example."*
>
> **A representative from First-Tier, Private Higher Education Institutions**

A similar narrative is also stated by the representative from a Polytechnic representative, where he/she states that the readiness to face the IR 4.0 era is not even a question, but a must for every graduate.

> *"It is actually a must (they must be ready to compete in the IR 4.0 era). When there's a workshop or training that utilizes information technology, we always ask them to join so that they will be updated with the latest information and knowledge. We don't want students to only sit as audiences… it is the duty of polytechnic education to equip its students (with skills and abilities) so that they will be able to adapt to the environment of IR 4.0. If we fail to do so, then we are no different than the normal academic universities."*
>
> **A representative from First-Tier, Private Higher Education Institutions**

> *"We still have many things to improve. However, we hope that in the near future, our graduates can be more 'recognized' and get certifications from external institutions that serve as proof."*
>
> **A representative from First-Tier, Private Higher Education Institutions**

5.8. THE NATIONAL EDUCATION SYSTEM'S READINESS TOWARDS IR 4.0



Sixth, we found that perceptions on the readiness of the national education system varied among the university officials. In general, eight out of nineteen universities were more optimistic, while the rest were more pessimistic in seeing the readiness of the government to face the era of IR 4.0 through its national education system. The university officials' perspectives regarding this specific issue are important to understand the level of government support (or lack thereof) that the university received.

5.8.1. Negative sentiments

There are several aspects that trigger negative sentiments towards the government and its national education system. These encompass issues such as (i) budget allocation, (ii) human resources, and (iii) bureaucracy, as can be seen from the statements below.

> *"Government contributions are only at the stage of persuading and suggesting ideas. For budget, maybe there is a control mechanism in place, but it is still seen to be inadequate. Because the laboratory and multimedia facilities need to be well-equipped. For bigger universities, maybe there is a kind of support in place, however, it is not supported by the government with adequate funding. They should add more funding for research, infrastructure, and facilities. If not, then it is just talk; speaking, not action."*
>
> **A representative from First-Tier, Public Higher Education Institution**

> *... If I may give a critic (to the government), they do not understand that there's a human resource issue in the education sector. This human resource crisis is, for example, about the number and quality of people. We have a very big problem. For example, Ministerial Regulation Number 2 of 2016 states that a Professor can teach up to 70 years old. This is an indication that we have a crisis.*

A representative from First-Tier, Private Higher Education Institution

> *We see that policy (reform) is rather slow, while the changes are very fast. Policies and regulations sometimes do not correspond to the pace of the changes that are occurring. Sometimes there is a fast response, but what we need here is a policy that is also detailed. Sometimes the regulation exists, but there is no clear direction on implementation. I hope that the Ministry of Education can give a prompt response whenever there is a change in the industry. If the objectives are to have them (the graduates) work in the industrial sector, they need to have more detailed regulations… so that the regulations will not become dormant, not being implemented, or changed again.*

A representative from Third-Tier, Private Higher Education Institution

> *I think the regulations need to be monitored and developed so that it is not always very 'political.' If it is always very 'political, then the ministries and the ones who replace it should maintain a strategic plan …*

A representative from Second-Tier, Private Higher Education Institution

5.8.2. Positive Sentiments

Positive sentiments towards the government's national education system in response to IR 4.0 are also present in several other university officials' statements. Such positive sentiments are portrayed when the respondents stated that (i) they know that a government's regulation is already in place to respond to a specific issue, and (ii) the way the university supports the government's regulation. Examples of such positive sentiments are presented below.

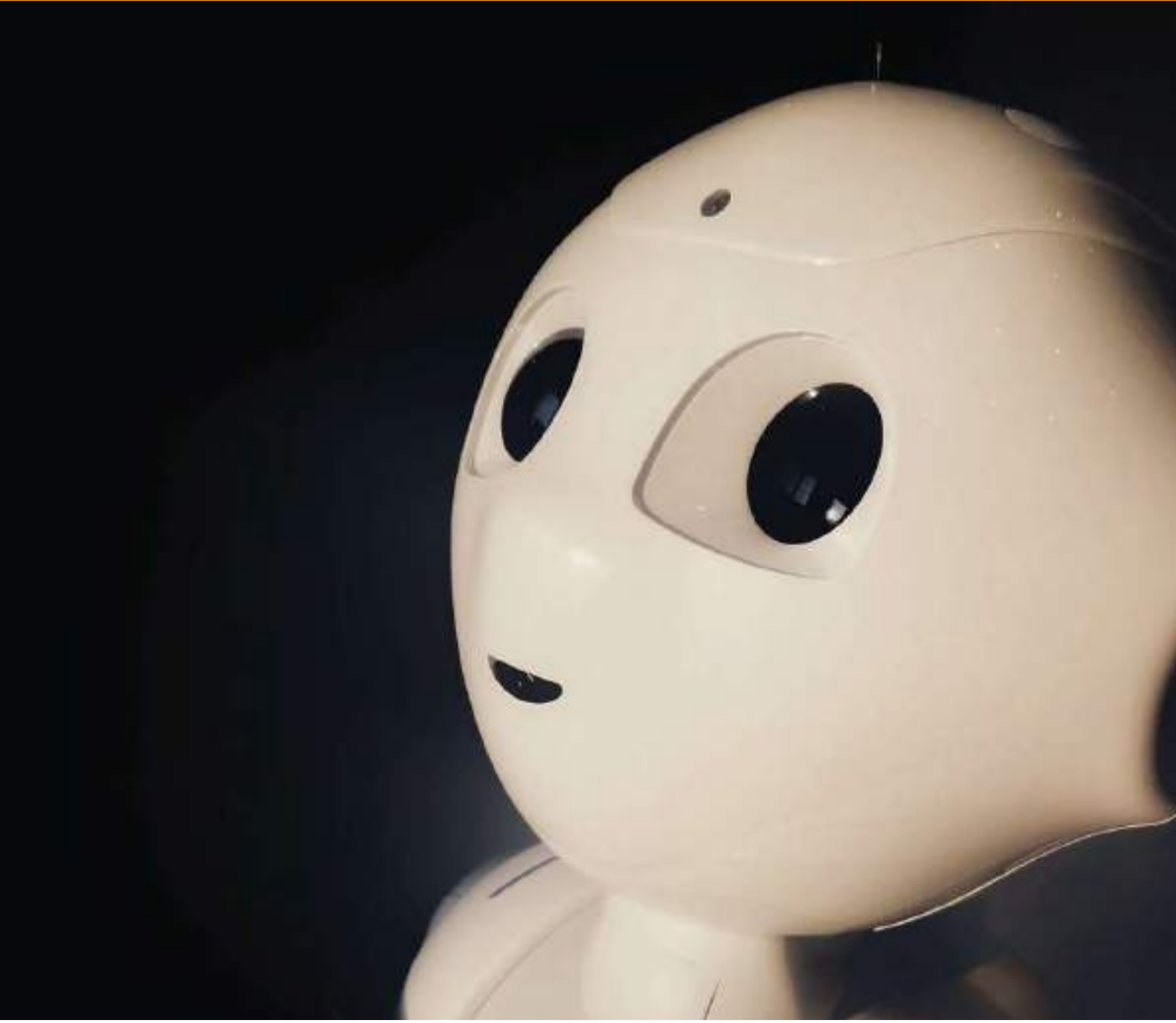
> *Yes, I think the Ministry of Education has done some research (to support its policy regarding IR 4.0). Based on such research, there is a need to improve three kinds of literacy: technology, data science, and human literacy … The ministry provides a specific platform, and (our university) is also actively involved in that platform. I think the presence of Indieline (the Ministry's online platform) shows their commitment and seriousness, although, there may be more things to be prepared.*

A representative from Second-Tier, Private Higher Education Institution

> *"Whatever regulation we issue (later), we have to follow the development of IR 4.0. Although what we have now may not have any impact on IR 4.0, in the future, we must do it."*
>
> **A representative from Third-Tier, Private Higher Education Institution**

> *"We have a cooperation with the Ministry of Communication and Informatics, that there will be 100 lecturers in 2019 who will get scholarships and training. We welcome the initiative. It is easy to put it in the curriculum but to implement it, that is the difficult part …"*
>
> **A representative from a Second-Tier, Public Higher Education Institution**

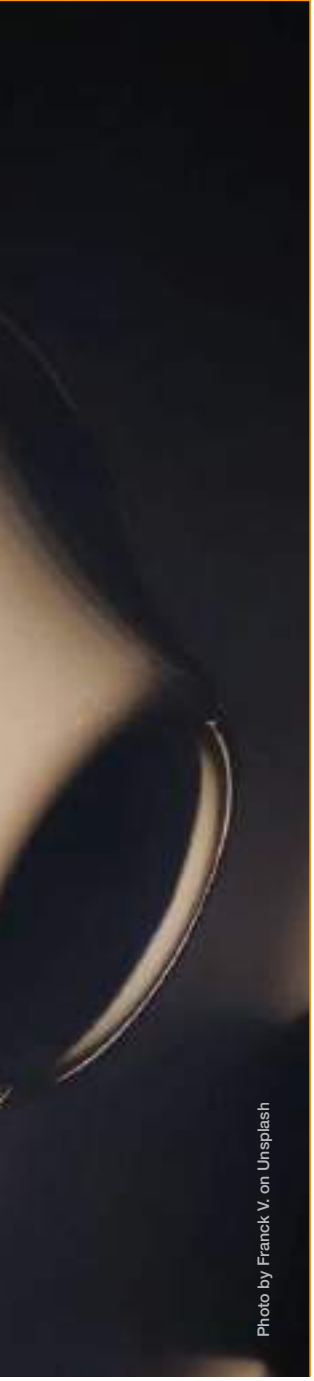
Photo by Green Chameleon on Unsplash



6. CONCLUSION

The rapid advancement of digital and internet technologies, also known as IR 4.0, presents new challenges and opportunities for the workforce all over the world. Existing jobs may be displaced, but new jobs will be created. The skills needed to thrive in the workplace are also changing. Efforts are needed to prepare the current and future workforce for this shift so they can thrive in the era of IR 4.0.

How is Indonesia's higher education system preparing itself for this new trend? This report has presented the findings of a major study on the readiness of Indonesia's higher education students, as well as higher education institutions, for IR 4.0. It was based on surveys with 1,162 students all over the country, and interviews with formal representatives of 19 private and public higher education institutions. Efforts were made to ensure representation of first-tier, second-tier, and third-tier universities, and within them, STEM and non-STEM faculties.



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6.1. SUMMARY OF FINDINGS

Through this study, we were able to identify Indonesian university students' access to ICT, and their strengths and weaknesses in terms of digital and cross-functional competencies. We also gained a better understanding of how university officials perceive their readiness for IR 4.0, in terms of infrastructure, the capability of lecturers, as well as their concerns on curriculum, the national education system, and university governance.

6.1.1. Readiness of students

University students obtained a composite score of 60.62 out of 100 for their overall readiness towards IR 4.0. This means that they admitted to having more than half of the skills required to thrive in IR 4.0, but they still have a long way to go until they acquire most of those skills. The score of 60.62 is derived by taking the average of the score for digital competency ("hard skills"), which was 57.92, and the score for cross-functional competency ("soft skills"), which was 63.33. From these scores, we see that Indonesian students seem to have a slightly higher level of soft skills than hard skills.

The aggregate score of 57.92 for digital competency is derived by taking the average of the scores for basic digital competency (72.89), intermediate digital competency (56.35), and advanced digital competency (44.53). These scores seem to indicate that most students have already acquired the basic skills, while only slightly more than half have acquired intermediate skills, and slightly less than half have acquired advanced skills.

The students' level of digital competency can be further analyzed through their key demographic variables: we disaggregated these scores based on several demographic variables, namely gender of student (male or female), type of faculty (STEM or non-STEM), university tier (first-, second-, third-tier), and geographic location of university (Java or outside Java).

The following describes differences in students' IR 4.0 readiness based on their characteristics. Based on gender, we found that men tend to obtain higher scores than women for intermediate and advanced digital skills, but at the basic level, both genders performed equally. Based on faculty type, we see that STEM students tend to obtain higher scores, and this disparity is seen consistently throughout the basic, intermediate, and advanced levels competencies. Based on university tier, we also see differences in digital competency, with first-tier university students consistently scoring higher than those in second-tier universities, and the latter performed better than those in third-tier universities. Based on university location, we see a digital

divide between universities based in Java and those located outside of Java, with the former doing better than the latter.

Going deeper into the types of skills, we find that students did much better in *information processing* and *communications* than in content creation and safety. Information processing was the highest-scoring skillset at the basic and intermediate levels of digital competency, but at the advanced level, the highest-scoring skillset was communications. There was a high percentage of students who could use multiple communication tools (79.4%), and a similarly high percentage who could save information from the internet in various formats (72.46%).

At the other end of the spectrum, *content creation* and *safety* were the lowest-scoring skillsets at all levels of digital competency. This indicates that the ability to use already established platforms or applications is still more pronounced than having more technical, back-end skills. There was a low percentage of students who could create websites using a programming language (21.5%), a low percentage (31.58%) who checked safety features and software configurations regularly.

The aggregate score of 63.33 for cross-functional competency is derived by taking the average of the specific skillset scores. Here we found that *coordinating with others* and *cognitive flexibility* were relatively more pronounced among the Indonesian students than *negotiation* and *service-orientation*. This finding was consistent across gender, faculty type, university tier, and university location.

Finally, from the student surveys, we found a sense of overconfidence in their perceived readiness to face IR 4.0. Based on their specific digital and cross-functional skills, the students' obtained an aggregate readiness score of 60.62, as we have discussed above. However, based on their own readiness perception, they rated themselves with an aggregate score of 72.84.

6.1.2. The readiness of higher education institutions

From interviews with 19 higher education officials, we obtained a rich account on the extent of universities' readiness, covering their perspective towards IR 4.0, infrastructure and facilities, lecturer's capability, the ideal curriculum, the national education system, challenges faced, and governance structure.

On infrastructure, all of the 19 higher education institutions interviewed seemed to have acquired a basic level of infrastructure and facilities, covering a WiFi connection, laboratory, online library, and online information system. However, the

quality and extent of such infrastructure differed across the institutions. When we asked about the presence of an online education platform (to distinguish between basic and advanced level of infrastructure), only four institutions admitted to having this, indicating a need to further develop higher education infrastructure and facilities to improve their readiness towards IR 4.0.

On teaching staff, interestingly, all of the 19 higher education institutions admitted to having problems with the capability of their lecturers. They saw that many of their senior lecturers were not familiar with materials and technologies related to IR 4.0, which indicated a dire need for retraining and upgrading for many university lecturers.

On the ideal curriculum, the interviews concluded the importance of at least four aspects: (1) an e-Learning platform, (2) courses and training on digital entrepreneurship, (3) English language courses, and (4) introductory courses on the technologies associated with IR 4.0. The university officials also explained several challenges in formulating this ideal curriculum, which included the need to place a higher priority on student recruitment (especially for smaller, private institutions), and the need to comply with higher-level interests (especially for religious educational institutions under the auspices of the Ministry of Religious Affairs).

On the national education system, there was a mixed review. There were concerns about a lack of adequate funding for labs and multimedia facilities, a lack of qualified teaching staff, and slow progress of policy reform. But there were also positive sentiments on the presence of proper policies and regulations, and relevant initiatives from different ministries that they supported.

On the preparedness of their students for IR 4.0, eight out of nineteen university officials were quite confident that their students will excel. They use words such as “of course” and “it is a must.” It remains to be seen whether this confidence has a strong basis. But this finding echoes the students’ confidence in their own readiness when they were asked to rate themselves.

6.2. CONTRIBUTION, LIMITATION, AND FUTURE RESEARCH OPPORTUNITIES

This research has contributed to building knowledge on the readiness of Indonesia’s higher education students and institutions for IR 4.0. It fills a gap in the literature where comprehensive and empirical studies on the topic are lacking. It does so by covering a large number of student respondents from STEM and non-STEM faculties across multiple university tiers in Indonesia.

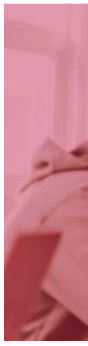
Even though the study has generated a rich dataset on the topic, it has primarily been a descriptive study, not an analytical one. Where relevant, we have presented cross-tabulations and breakdown of various dimensions of IR 4.0 readiness by gender, faculty type, university tier, and university location. However, we have not done more analytical studies using the data to find patterns, correlations, and causations.

There are still plenty of opportunities to analyze the data in more detail. For example, the data could be explored to identify indicators that correlate with and, perhaps, determine students' or universities' readiness. We could also, perhaps, identify if students that were more proficient in certain skillsets also tend to be proficient in other skillsets. These types of analyses could perhaps be conducted as follow-up analytical work aimed for academic publications.

Another aspect that could be further explored in subsequent or future studies is the extent to which the students' skills are deemed relevant for industries or the workplace. In this study, we used benchmarks from the EU and WEF to identify digital and cross-functional competencies, but industries in different countries may have more specific requirements or comments towards the quality of the local graduates. We have yet to understand how Indonesian companies and institutions view the quality and readiness of university fresh graduates to work in their workplace. Linking a study on graduates' competencies and industry requirements would further expand the immediate and practical relevance of this research.

Finally, the results of this study could be further analyzed to identify policy recommendations. The early part of this chapter has presented some of the key conclusions from the research. But what policy recommendations would be appropriate to respond to these findings? For example, in terms of digital skillsets, we found that students tend to score low for content creation and safety. Should there be more efforts geared at teaching programming skills and awareness of cybersecurity? Also, this study found major concerns on the readiness of teaching faculty in higher education institutions. What factors contribute to the seemingly low readiness of teaching staff? Should there be more programs to teach the teachers so that they can better prepare students for IR 4.0?

These are some of the questions that could be further explored as a follow-up to this research. In the meantime, we hope the findings of this study had been informative and useful in preparing Indonesia to enter IR 4.0.



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