

The Growth of Industrial Revolution 4.0 and the Preparation of Software Engineers in Digital Transformation at Makers Institute Indonesia

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Abstract

The transformation of business models using increasingly big data analytics is one of the most significant changes in today's modern corporate culture. The emphasis in contemporary business has switched from a product to a platform. Human resources as Full Stack Engineers are required to respond to changes in business with the dimensions of the Internet of Things, Big Data, Augmented Reality, and Artificial Intelligence. Efforts to develop Full Stack Engineers are necessary since this is a worldwide and national stage for Software Engineers in the Industrial Revolution Era 4.0. The purpose of this research is to establish the hard skills of prospective Software Engineer graduates from an information technology institute of engineering and technology and the skills needs of the business world in the real world. Makers Institute Bandung's experience in managing Full Stack Engineers has revealed that there is a gap between what they learn in college and what is required. One of the gaps is that what is taught in the classroom does not apply to what is required in the workplace. There isn't truly a relationship. One of the issues that prospective Software Engineers confront is the lack of a robust model of thinking when it comes to constructing device integration.

Keywords: Industrial Revolution 4.0, Full-stack Engineer, Internet of Things (IoT).

Abstrak

Transformasi model bisnis menggunakan big data analytics adalah salah satu perubahan paling signifikan dalam budaya perusahaan modern saat ini. Penekanan dalam bisnis kontemporer telah beralih dari produk ke platform. Sumber daya manusia sebagai Full Stack Engineer dituntut untuk merespon perubahan bisnis pada dimensi Internet of Things, Big Data, Augmented Reality, dan Artificial Intelligence. Upaya pengembangan Full Stack Engineers diperlukan karena ini merupakan tahapan di seluruh dunia dan secara nasional bagi

Software Engineers di Era Revolusi Industri 4.0. Tujuan dari penelitian ini adalah untuk membentuk hard skill calon Software Engineer lulusan Institut Teknologi Informasi dan kebutuhan keterampilan dunia usaha di dunia nyata. Pengalaman Makers Institute Bandung dalam mengelola Full Stack Engineers mengungkapkan bahwa ada kesenjangan antara apa yang dipelajari di perguruan tinggi dan yang dibutuhkan. Salah satu kekurangannya adalah yang diajarkan di kelas tidak sesuai dengan yang dibutuhkan di tempat kerja. Hal tersebut benar-benar tidak berhubungan. Salah satu masalah yang dihadapi calon Insinyur Perangkat Lunak adalah kurangnya model pemikiran yang kuat dalam membangun integrasi perangkat.

Kata Kunci: *Revolusi Industri 4.0, Full-stack Engineer, Internet of Things (IoT).*

1. Introduction

One of the most interesting phenomena of the last decade is the digital transformation process that is taking place worldwide. Humans are the main driving factor of the major changes that occur in every era. Humans create technology, shifting human civilization from an all-physical civilization to an all-digital civilization. Information technology moves by shifting many things, causing disruption to move very quickly; suddenly, the technology we considered sophisticated a few years ago turned out obsolete and outdated (Kasali, 2019). Economic governance that is all-capital is suddenly disrupted by a group of creative humans brought from the future so that at this time, we are forced to accommodate three timeframes at once, past, present and future at one time (Govindarajan, 2016) this phenomenon is called by (Kasali, 2019) as tomorrow is today.

This technological innovation has begun to be discussed (Schumpeter, 1943) through the term Creative Destruction; in the view of neoclassical economics, technological change, innovation is the only way to increase the standard of living in a country (Henriques & Perry Sadorsky, 2005). Some recent research provides an overview of how the position of technological innovation capabilities can provide competitiveness for SMEs when in the process of developing new products (Handiwibowo et al, 2020). Then finally (Christensen, 1997) introduced the theory of Innovation Disruption theory which was then widely discussed to describe the new ways that startups used to disrupt established and large companies, even though technological innovations then shifted the current economic order throughout the World where the technology used by the industrial World must be shifted to the presence of digital devices which then become the basis for the existence of platform in the economy (Mellita & Noviardy, 2022).

This technological innovation is a new challenge that also opens up new job opportunities for software engineers and a supplier of new digital devices for today's industrial world, so this new job opportunity must be captured by educational institutions to prepare students to enter new professions as software engineer that is needed in the information technology-based business world. In reality, the World of education, especially the World of higher education, is

still unable to provide graduates who can compete in the field of technological innovation because Indonesia's competitiveness in this era of disruption is largely determined by the availability of adequate Indonesian digital talent (WANTIKNAS, 2020).

The unavailability of adequate human resources must be seen not only because of the quality of the Indonesian education system in general but also because there are gaps that originate from theory in business management, including the education system in Indonesia. Until now, the business world still uses an organizational model based on performance management, so our business world is moving linearly and within a framework (Kasali, 2019). Meanwhile, the education system in Indonesia still adopts performance management as a way to manage the education system in Indonesia (Wijaya & Murphy, 2017). The management of the national education system through standardization of the national education system is an inseparable part of the adoption of the national education management model with performance management that has been widely used in the industrial world.

Applying the KTSP education unit level curriculum in primary and secondary education in Indonesia is part of the education system in Indonesia using performance management (Stella & Wibisono, 2016). However, in the current era of disruption, according to (Kasali, 2019), the use of performance management to manage business institutions is not adequate because there is a possibility that we are trapped in linear growth, which is characterized by renovating, sustaining innovation and product-based. While in Innovation disruption, the model is not a renovative model from the past but comes from the future that is brought to the present, so because it comes from the future, the innovation disruption model becomes a new item for our education system. The Makers Institute, located in Bandung, Indonesia, seeks to develop a learning model to prepare software engineers ready to become the backbone of digital transformation in Indonesia. The Makers Institute is not a formal educational institution in Indonesia, but they are a business institution that goes directly to preparing software engineers ready to enter the digital World amidst the difficulty of finding software engineers ready to work from the formal education system in Indonesia.

In industrialized nations, there has been a lot of interest in the study of how the educational system matches the demands of the labour market. This debate began in 1928 when the Malcolm Report or 'The Report of the Committee on Education and Industry in England and Wales was presented. Then came the Labour government's Green Paper, published in 1977 (Beck, 1981). In the United States, in the 1980s, the commercialization of intellectual property was still not much attention, but since the Bayh-Dole Act by the US Congress, a collaboration between educational institutions and industry received a lot of attention widely (Demain, 2001).

The gap between universities' skills and what is needed from the start has emerged. In a study conducted by (Rosina et al., 2021), one of the main difficulties in educational institutions meeting the needs of the job market is the practicum infrastructure that exists in educational institutions, which is very limited, so there will always be gaps. Meanwhile, the study conducted (Bristot et al., 2012) emphasizes that there must be a distinction between competence and skill so that what is expected can be formed through an understanding of the pattern of the relationship between competence and skill, the gap between the world of education and industry

occurs because it has not been conceptualized in an integrative manner. The skills produced with the industry's desire have not been met.

Makers Institute As a place to learn and develop digital talent, recruiting university graduates from scientific backgrounds, both IT backgrounds and non-IT university graduates who are interested in developing their abilities in the digital field, especially in software engineering and data science. Is this research focused on knowing the background and exploring the main problems in developing Full Stack Engineers in digital transformation in Indonesia?

Literature Review

One theory that can explain the above phenomenon is the existence of a management theory gap which has been the mainstream management theory used in managing a productivity-based business model with the Innovation Disruption theory introduced by Christensen (1997) and Christensen et al. (2008b) in his book entitled *Innovator Dilemma*. Previously (Schumpeter, 1943) had introduced Creative Destruction, where in the business world, an entrepreneur needed creative innovation to destroy old products, which new products would then replace. In Schumpeter's opinion, a strong market structure will encourage rapid technological change so that through this process, there will be Creative Destruction (Nicholas, 2003), although at first, this thought was considered strange and difficult to verify. Then this thought began to appear true after (Christensen, 1997) wrote the book *Innovator Dilemma*, which later introduced the Innovation Disruption theory.

One of the problems faced by the business world today, especially large companies in Indonesia, which are still many who use Performance Management (Kasali, 2019). Management theory, which is still linear and product-based, then faces stuttering when the movement of the business world in this disruptive era is Performance not enough to deal with disruptive changes in business governance. Several managerial performance managements such as six sigma, financial ratios, service excellence, key performance indicators and balanced score cards are not enough. Changes in governance are completely new, so current business governance cannot be carried out in the old way. Conceptually, until now, Performance Management is still a very good concept because the complexity of the organization still requires a performance by paying attention to responsibilities and targets that have been made by the company (Franceschini et al., 2010).

Suppose Performance Management performs the current. Measurement and evaluation of targets are based on what has been done in the past (the past), but in this era of disruption, there are changes due to technological innovations from the future being brought to the present (Govindarajan, 2016) calls it the Three Box Solution where at this time (the present we must be able to fill it based on the perspective of the past and the future (the future with the Possibility gap. Disruption in the era, in the end, does not only occur in the business world; many sectors are then also experienced changes, one of which was the World of education (Christansen & Eyring, 2011) which touched on the World of education in the era of disruption. One of the important aspects of Innovation Disruption theory is how news organizations use simple, low-cost innovations to gain victory against old companies with large and strong capital (Christensen et al., 2004). At least at first, the presence of this startup started to target market

segments neglected by big companies, while they were more focused on improving the quality of their products and services, especially to serve the most profitable market segments for them. Meanwhile, startup companies are starting to target neglected market segments. They got attention because of their innovation until, finally, the business model they did began to disrupt the upper market segment owned by large companies. That's where the shifting process began (Larson, 2016).

2. Method

Data was gathered by conducting in-depth interviews with managers at Makers Institute, with several individuals, including the Chief Executive Officer, Chief Marketing Officer, and External Advisor at Makers Institute, as well as with instructors who are directly involved in the Makers Institute learning process. The process of qualitative data analysis, as conveyed by (Bogdan & Biklen, 2007), is an effort to work with data by organizing data, sorting it into something that can be managed, then synthesizing, looking for and finding patterns and getting something important to learn and conveyed to others.

3. Result and Discussion

Based on the results of research that has been carried out, several findings can be conveyed, including:

The Gap between Demand and Supply in Software Engineers

One of the fundamental and fundamental reasons for the Makers Institute to be directly involved in the development of digital talent in Indonesia by managing a Research and Development Institution originating from the corporation is in Indonesia. One of them is the urgency of the need for Software Engineers in Indonesia is very large. The technological disruption that is currently happening on the one hand, threatens to shift certain fields of work that are replaced by digital technology but also creates new job opportunities for Software Engineers who are desperately needed. Such front-end developers, back-end developers, full-stack developers, and software application developers are very much needed to develop digital transformation. The Republic of Indonesia's Ministry of Manpower reports that 1,232,666 ICT employees are currently needed, and that number is projected to rise to 1,979,418 by 2025. (Kemenakertrans, 2021), while the Technology Development Index in Indonesia continues to experience an extraordinary increase, growing by 5.08 percent, namely from 5.32 in 2019 to 5.59 in 2020 (BPS, 2021).

In Industrial Revolution 4.0, digitalization is at the core of fundamental changes in the industrial revolution. through digital devices based on the Internet of Things (IOT), big data, augmented reality (AR), artificial intelligence (AI), cyber security, additive manufacturing (3D printing), integrated systems, cloud computing, and connection to industrial machines. So, the need for new jobs is the key to improving Indonesia's competitiveness in the international workforce. According to the Ministry of Communication and Informatics, by 2030, it is estimated that there will be a shortage of 47 million digital talents. At the national level, Indonesia has at least 50,000 of our workforces, only basic and intermediate digital skills.

Meanwhile, people with advanced digital skills make up less than 1% of the workforce in Indonesia (Connected Indonesia, 2020).

Gaps in Higher Education and Industry

One of the interesting findings in the research conducted at Makers Institute participants Bootcamp who take part in the study program as software engineers are open, meaning that participants are not required to be graduates of Informatics Engineering. The Makers Institute Bootcamp also accepts participants from college graduates from various disciplines even; many participants come from social science disciplines, such as Economics, Politics, Tourism, religion and so on.

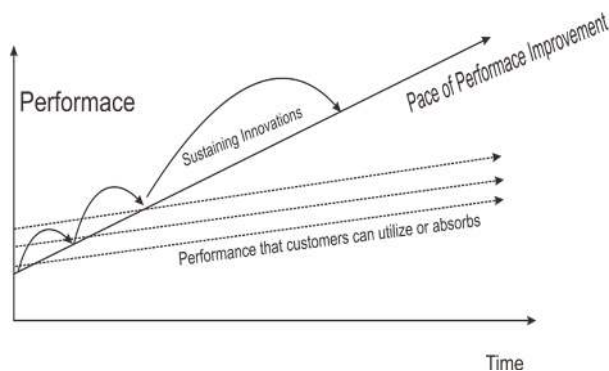
The Makers Institute developed its curriculum model, which was developed based on the Makers Institute's experience in managing technology-based industries. During the Bootcamp, participants were not only taught about how to become software engineers a practical the Makers Institute also emphasized how participants were able to think logically and systemically because the thinking process about how computer algorithms worked was needed to build design thinking and become problem solvers from various kinds of solutions to the desires of the industrial World.

An interesting finding there were some participants with a background in Informatics Engineering who did not have basic science or adequate basic exact sciences at all ended up being the best graduates. Based on the research's findings, it was noticed that one of the fundamental weaknesses is that many informatics engineering graduates lack the necessary basic science and computational thinking skills, in part because they commonly use programming templates created by others without considering the system's logic flow. Contrarily, one of a nation's fundamental criteria for technology development is basic science. The State, in this case, the World of education, should be able to invest in basic science. Large industrial countries that are good at basic science on average have good foundations in basic science multi-disciplinary because, through strong basic science, Indonesia will have its intellectual property to remain in Indonesia. Currently, Indonesia is in the engineering of basic science, whose research has been completed in developed countries. In the observations of the Makers Institute, Higher Education is a source that is considered to separate basic science from innovation. Universities with exact backgrounds are far from the industry, so basic science in the MIPA department is neglected and MIPA alumni in Indonesia do not have much room to take part in the industrial World; even now, they are not considered part of the Industrial revolution 4.0.

Based on the findings in research conducted at Makers Institute Bandung about the prospects for developing human resources, especially in developing digital talent in Indonesia. One of the most important issues is that in this era of disruption to innovation, there are changes in business governance, mainly when jobs are run by humans and then replaced by IT-based technology tools. Report (*Learning Generation Investing in Education for Changing World*, 2021) entitled Learning Generation conveys that two-thirds of jobs (jobs) that exist today will be lost because they will be replaced by technology. However, this era will also open new job

opportunities, especially the need for digital talent as a major factor in the Industrial 4.0 revolution. Several jobs that will play a very important role in changing business governance are mainly related to the availability of Software Engineering, such as front-end developers, back-end developers, full-stack developers, and software application developers. One of the problems in Indonesia is that there is a gap in what our industry needs and what Indonesian education can provide. This gap creates another gap, namely, the supply of digital talent that can still not enter the industry.

This shortage of digital talent supply does not only occur in quantity but there is a gap in quality. University graduates in Indonesia are not compatible with the country's industry needs. According to (the Ministry of Information and Communication of the Republic of Indonesia, 2021), IT college graduates should be at Advanced Digital skills and must master a programming language. Several analyses later became the findings in this study were the existence of gaps originating in the theory of business institutions in Indonesia and educational institutions in Indonesia.

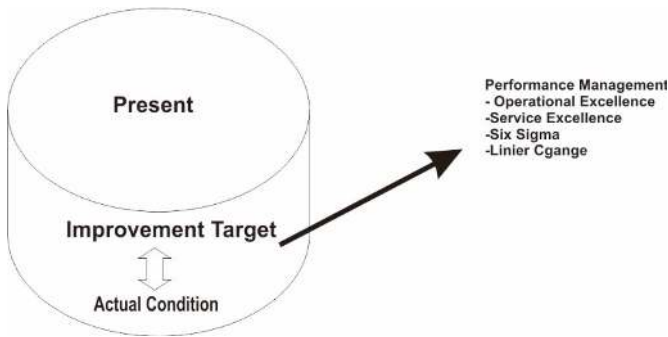


Source: Christensen et al., 2008b

Figure 1. A Gap in Quality

We can see this in Figure 1, the solid line depicts the innovation path carried out by the industry world, while the dotted line represents the ability of the customer to use the innovations carried out by the industry. Currently, the World of education in Indonesia is only in the early stages of transforming a public institution into an institution that carries out performance management recently adopted from a private corporation. Meanwhile, private corporate groups, which in this case include the industrial sector, have attempted to adopt a disruptive process against startup companies. Meanwhile, educational institutions that have just implemented performance management and that have not yet entered the mature performance management must be able to supply the power that must fight with future innovations. We can see this in (Govindarajan, 2016) regarding the three dimensions of time currently faced by the industrial World around the World.

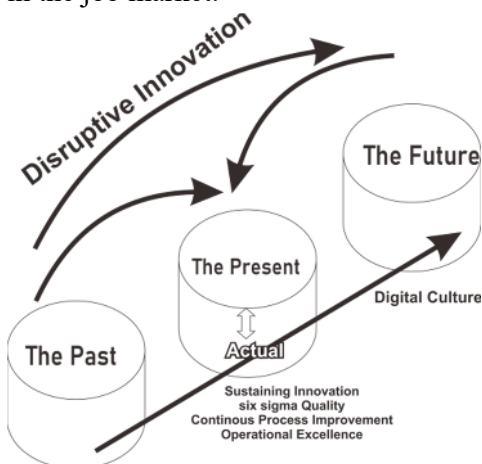
On the one hand, they must carry out sustainable innovations to ensure they can compete with similar industries. On the one hand, they must shift from product-oriented to platform-oriented (Kasali, 2017, 2019) for the innovations startups are making that continue to annoy them. Thus, the industrial sector innovates to compete with similar companies, and at the same time, they must innovate to face startup companies with disruptive innovations.



Source: Kasali, 2019

Figure 2. Sustainable Innovations

Meanwhile, educational institutions in Indonesia have only recently adopted performance management with uniform learning models throughout Indonesia. The innovations they carry out are still closely related to learning models, which cannot be as fast as what the industrial world does with sustaining innovation. The speed with which they innovate even exceeds what consumers need. With the speed of innovation carried out by industry, educational institutions in Indonesia cannot keep up with innovative developments in the industrial sector. So, when graduates from higher education in Indonesia want to enter the job market, what they learn on campus is not relevant to market needs. In contrast to educational institutions in developed countries, the industrial sector in developed countries comes to universities to look for what technological innovations are produced at universities to be carried out in the industrial sector (Christensen et al., 2008a). Whereas in Indonesia, universities often come to the industrial sector to ask what they will teach at the university so that university graduates can be absorbed in the job market.



Source: Kasali, 2019

Figure 3. Disruptive Innovation

The world of education in Indonesia is still in the present time dimension with the management model they have adopted from the business world, in this case using Performance Management with several managerial tools such as six sigma, financial ratios, service

excellence, operational excellence, linear change, key performance indicators and balances. Scorecards. While the business world, one of which is the industrial sector, besides still maintaining the Performance Management to face competition and using Sustaining Innovation, they have adopted a disruptive innovation model whose time dimension comes from the future so that they have entered Performance Management model.

4. Conclusion

One of the problems faced by universities in Indonesia in the era of technological innovation disruption is the lack of absorption of university graduates in Indonesia, especially to prepare digital talent, which is currently very much needed in the business world in the global market as well as in Indonesia. The existence of a shift in several fields in the field of life is an unavoidable part of the disruptive innovation that is currently happening.

Global digital innovation is altering not only economic governance but also lifestyles, which has a ripple effect on other spheres of human activity. It is this cross-sectoral change that causes the need for digital talent to occur, which is quite large, so the scale of this need must be responded to by higher education institutions in Indonesia to prepare students to have adequate computational thinking skills so that what educational institutions produce can match the scale the needs of the digital world on a global and national scale. To generate graduates with skills applicable to higher education, one possibility is to adapt the curriculum model utilized in higher education to the needs of industry. How can education develop critical thinking abilities and analytical thinking, which are fundamental abilities for innovation in technology, especially in higher education. Programs for teaching practitioners and providing internships are already in place for the short term, bringing industry and education together. Higher education institutions can also carry out research to create technological products required by industry, particularly those based on technology. University research is conducted, and industry is responsible for mass manufacturing the findings.

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