Chapter 3

Human Capital in the Smart Manufacturing and Industry 4.0 Revolution

Joseph Evans Agolla

Additional information is available at the end of the chapter

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Abstract

The purpose of this chapter is to highlight the important role of human capital management in the Smart Manufacturing and Industry 4.0 revolution. Two hundred years ago, industrial revolution in the west has transformed or evolved from mechanical production driven or powered by water, and to date, we are in an era characterised by cyber physical systems. This transformation or industrial revolution has been driven by humans using creative minds to solve problems that were confronted. The Industrial 1.0 Revolution around 1700 AD, mass production was carried out by mechanical production powered by water (steam engines), which was labour intensive. The more manpower an industrial organisation has, the more goods and services would be produced, though this could take long to reach the market but that was the industrial system at that time. From mechanical production powered by steam engines between 1700s and 1800s to the second Industrial Revolution mass production powered by electricity between 1800s and 1900s to the third Industrial Revolution powered by electronic and IT automation and finally to Industry 4.0 Revolution cyber systems in 2000 and beyond, human capital has generated innovative solutions to human problems more than ever before. Today, human capital is not only creative, but rather a super human capital.

Keywords: human capital, cyber physical space, Industry 4.0 revolution, innovation, management, virtual organisations

1. Introduction

The chapter is structured as follows: first, an overview of Smart Manufacturing and Industry 4.0 revolution, which is followed by the future competencies required of human capital, conceptual framework for Smart Manufacturing and Industry 4.0 revolution, rewarding human capital in Smart Manufacturing and Industry 4.0 revolution and conclusion.

1.1. An overview of Smart Manufacturing and Industry 4.0 revolution

Ever since the origin of Industry 1.0 revolution in the seventeenth century till to date, the world has systematically gone through different phases of rapid industrial revolution with each marked with something totally different from the others. From Industry 1.0 revolution to Industry 2.0 and to Industry 3.0, countries have witnessed and experienced fast pace of technological changes. In Industry 1.0 revolution mass production was by powered steam powered or water engines that characterized it at that time. However, today no country or organisation can afford to take backseat and watch without being actively involved in Smart Manufacturing and Industry 4.0 revolution. The ingenuity of human beings in today's world has surpassed any human definitions of creativity, as human has transformed into super beings. Humans now possess great knowledge and how organisations will trade in such knowledge will make the difference in Smart Manufacturing and Industry 4.0 revolution.

Smart Manufacturing and Industry 4.0 revolution are characterised by Mobile, Cloud, Big Data analytics, Machine to Machine (M2M), Man to Machine Interactions (M2MI), 3D Printing, Robotics and many more that will require organisations with specific expertise. It is also said that Industry 4.0 revolution goes far beyond these. Digital networks to Cyber-Physical Systems (CPS) are simple physical objects with embedded software and computing power. In Smart Manufacturing and Industry 4.0 revolution, it is predicted that more manufactured products will be smart products and Cyber-Physical Systems (CPS). This is based on the connectivity and computing power, leading to self-management capabilities. Today, most of the manufacturing equipment transform into Cyber-Physical Production Systems (CPPS), which is software enhanced machinery. This equipment has its own computing power, capitalising on a wide range of embedded sensors and actuators, which is beyond connectivity and processing power. The CPPS act and know their state, capacity and different configuration options and are able to take decisions independently just like human beings. This gives way to a mass production, which in turn gives mass customisation, each product at the end of the supply chain. The mass customisation ensures unique characteristics as defined by the end customer. The characteristic of the Smart Manufacturing and Industry 4.0 revolution supply chain is extremely visible, integrated and the physical flows continuously mapped on digital platforms. This makes individual service provided by CPPS available to achieve the needed activities to make each tailored product. Therefore, characteristics of Smart Manufacturing and Industry 4.0 revolution are as follows:

- **Cyber-Physical Systems** (a fusion of the physical and the virtual worlds) CPS.
- **Internet of Things** (IoT) – comprises communicating smart systems using IP addresses. This communicates objects based on Internet technologies. Also, detect and identify using IPv6 addresses (128 bit address space). The advantage of this is that the detection, identification and location of physical objects and it communicates through connectivity.

- **Internet of Services** (IoS) – this is new approach to provide Internet-based services, concepts for product specific on demand, knowledge provision and services for controlling product behaviour. Interaction between people, machines and systems improve added value.
- **Internet of Data** (IoD) – in this scenario, data is managed and shared using Internet technologies. This is because Cyber-Physical Systems are producing big data. There is the development of a holistic security and safety culture.

The future of production is forecasted in Smart Manufacturing and Industry 4.0 revolution as one that is characterised by significant efficiency gains mainly through consequent digital integration and intelligentization of manufacturing processes [1]. This integration takes place on the horizontal axis across all participants in the entire value chain and on the vertical axis across all organisational levels [2]. In Smart Manufacturing and Industry 4.0 revolution, fully integrated and networked factories, machines and products act in an intelligent and partly autonomous way that requires minimal manual/human interventions [2]. Currently, Smart Manufacturing and Industry 4.0 revolution have introduced new concepts such as: Internet of Things (IoT), Industrial Internet (II), Cloud-based Manufacturing (C-BM) [3] and Smart Manufacturing addresses this vision of digitally enabled production and are commonly subsumed by the visionary concept of Industry 4.0 revolution [4]. In Smart Manufacturing and Industry 4.0 revolution, these concepts are related to recent technological progress where the Internet and supporting technologies (e.g. embedded systems) serve as the mainstay to integrate or create human-machine interface, materials, products, production lines and processes within and beyond organisational boundaries to form a new kind of intelligent, linked and agile value chain [2].

In Smart Manufacturing and Industry 4.0, learning organisations prove to be an indispensable means for educating students and professionals regarding practical application of production management principles and concepts. Lean management as a learning subject has clearly dominated the scene in the last decades. However, the current and future production scenarios in the sense of Smart Manufacturing and Industry 4.0 revolution also need other competencies to be addressed in order to enable today's managers and workers of organisations to deal with the challenges of an increasingly digitalised production system [5].

1.2. Future competencies for smart manufacturing

The Smart Manufacturing and Industry 4.0 is characterised by small decentralised, digitalised production networks, autonomously acting and capable of efficiently controlling their operations in response to changes in the environment and strategic goals [2]. The nodes of such a network are referred to as Smart Factories/Smart Manufacturing (SF/SM). This type of network is linked to a larger value chain network with the responsibility to fulfil a certain customer demand. In addition, assets such as machines and materials are situated at the underneath line of the whole automation pyramid, but are all well integrated through standardised interfaces. Last but not least, during manufacturing process, machines and products are inimitably identifiable and situated at all times in their entire lifecycles. These smart

materials and products are custom-built to a large extent at the costs of mass production in Smart Manufacturing and Industry 4.0 revolution.

1.2.1. Personal competencies

The question that one may want to ask is what type of personal competencies, skills and abilities is needed to fit well in Smart Manufacturing and Industry 4.0 revolution? Such competencies can be viewed as the ability of a person to act in a reflective and autonomous manner [2]. In nutshell, such competence comprises the ability to learn (develop cognitive abilities), to develop an own attitude and ethic value system that a person may possess. In addition, at the level of a worker, Smart Manufacturing and Industry 4.0 have created an increased automation of routine tasks never witnessed before. Today's workers have to face the fact that their present tasks no longer exist in the future, because the future promises uneven playground. The workers tasks keep on changing rapidly and there is a need to upkeep with the changes in the tasks. The rationale is that the digitals, Internet of Things and Networked Systems have eradicated some or most of the tasks, the worker currently performs [6]. This may require the ability to look at a person's own task perspective taking into account the bigger picture of the society as a whole (the challenges, resource scarcity, opportunities and wealth). In addition, opportunities for a person's own development and the commitment to lifelong learning should be the responsibility of both the individual and the organisation [3]. However, rather than developing naïve technology, devoutness as a critical attitude towards technological developments is a key asset for the future worker and organisation in Smart Manufacturing and Industry 4.0 revolution [2].

Personal flexibility with respect to work time, work contents, workplaces and mindsets are prerequisites competencies for an agile production, to respond quickly to market need and environmental situations. In addition, today and future managers need the ability to transform their management and leadership styles from power-driven to value-driven [7], as the teams of the Smart Manufacturing and Industry 4.0 are diverse both in culture, education and geographical location.

1.2.2. Social/interpersonal competencies

This is conceived as an individual who is embedded in a social setting, for example, like human beings and organisations also need the ability to communicate, cooperate and establish social connections, structures with other individuals and groups [6]. This is because organisations are social systems where interactions take place between different players (human-machines, human-human, etc.). The full digital integration and automation of the Smart Manufacturing processes in the vertical and horizontal dimension entails as well an automation of communication and collaboration mainly along standardised processes. Consequently, workers are responsible for a broader process scope and need the capability to comprehend the relations between processes, information flows, possible disturbances and potential solutions to such interfaces. The increase in scope and complexity of Smart Manufacturing and Industry 4.0 require a mindset geared towards building and maintaining networks of experts that are capable of cooperating in finding the ideal solutions to a particular problem. Currently, human work now concentrates at the edges of interfaces in which human flexibility in problem solving

and creativity is strategic. Therefore, allowing creative activities to be performed in distributed social settings, involving heterogeneous interdisciplinary and inter-organisational teams, require the ability to communicate complex problems in different languages as well [4].

Therefore today, managers must build or act as mediators that permit social processes such as mutual decision processes, which is not only within customary organisational borders but also for the whole network [8]. Social media play a key role as supporting technology in the Smart Manufacturing and Industry 4.0 revolution [2]. Managers, engineers and workers now have to show literacy, skills, knowledge and abilities with different tastes of technical communication and support systems [9].

1.2.3. Action-related competencies

Action-related competencies of a worker can be understood as 'the ability to take individual or socially constructed ideas to action' that transforms dreams into reality in Smart Manufacturing and Industry 4.0 revolution. It is the ability of an individual to integrate concepts into its own agenda, to successfully transfer plans into reality, not only on the individual but also on an organisational level [6]. It is worth noting that these concepts could be in their abstracts forms and therefore need to be reflected in their real sense of meanings.

Digitalisation production inevitably leads to high financial and technological efforts for the Smart Manufacturing and Industry 4.0 revolution. The inherent risk associated with such efforts needs pragmatic thinkers and actors to bring down the 'sky-high' vision of Industry 4.0 revolution to the shop floor, where majority of the workers are engaged [4]. Both managers and workers require strong analytical skills and ability to find domain-specific and practicable solutions without losing the overall goal, which is the key competencies. To accomplish this, therefore, managers must break down complex concepts into realistic work packages, to find and to assign appropriate people and teams [2]. Smart Manufacturing and Industry 4.0 are not a straightforward methodology or technology. Managers are required to encourage taking new routes but also take into account the risk of failures. For workers and managers alike a strong interdisciplinary "out-of-the box" orientation is likely to facilitate solutions finding in complex environments [2].

1.2.4. Domain-related competencies

This is referred to the ability to access and use domain knowledge for a job or a specific task [6]. The key elements of the domain knowledge are methodologies, languages and tools that are designed for problem solving or business domain and reaches beyond marginal. A core element of Smart Manufacturing and Industry 4.0 revolution is the full digitalisation of planning and the exploitation of data. The full digitalisation acts facilitates intelligent planning, control production processes and networks [2]. Production processes and networks (also those in the future) have domain peculiarities that require domain-specific competencies. Digitalised and intelligently managed production processes require works that are capable to understand the basics of network technologies and data processing [4]. Therefore, workers need to appraise whether the subsystems are performing as expected and must be able to interact with such

systems through suitable interfaces. In case of disruptions, workers and engineers must be able to analyse complex systems through specialised software [6]. Engineers are required to acquire skills, knowledge and abilities about state-of-the-art software architectures, modelling and programming techniques [4]. In addition, statistical methods and data mining techniques are key capabilities for future production engineers [10].

In summary, human-machine interfaces in the Smart Manufacturing and Industry 4.0 revolution have to be developed based on the user-centred approach with a task- and situation-orientation.

2. Human capital in Smart Manufacturing and Industry 4.0 revolution

Human capital is considered critical for the success of organisations in today's world, however in Smart Manufacturing and Industry 4.0 revolution, researchers and management practitioners are already predicting this scenario to take a different shape, given the characteristics of the changes anticipated. The characteristics of human capital that are key to success are education, experience and knowledge that organisations need to tap into to achieve success in the competitive world. Human capital theory considers that knowledge brings greater cognitive skills to individuals, thus impelling their productivity and efficiency potential to develop activities [5, 10]. From the national perspective, human capital can be defined as:

"*Human capital can be defined as a set of knowledge, abilities and skills, used in activities, processes and services that contribute to stimulate economic growth*" [9].

However, from this [9] definition, the author coins the definition that matches human capital in an organisation as:

A set of education, experience, knowledge and skills possessed by employees and that is used to create value for the success of the organisation. In these two foregoing definitions, we can see how experience, knowledge, skills and education are critical for human capital in the organisations, which in essence underscore the importance and role of human capital in the Smart Manufacturing and Industry 4.0 revolution.

Smart Manufacturing and Industry 4.0 requires not only just workforce, but also human capital nurtured in competitive education systems that is well prepared for creative work environments. No organisations require physical and tangible humans, as the present and future seems to offer a plethora of challenges to organisations and humanity. Therefore, as humans embrace to usher in Smart Manufacturing and Industry 4.0, it has become imperative for nations as well as organisations to embark on education systems that are more focused on knowledge beyond what the world currently preach. This may require teaching creativity to children at an early age (Early Childhood Education) right up to university levels. A move away from traditional education systems of writing, reading, cramming and memorising as mode of passing an examination that never produce thinkers, creators and ingenuity should be a thing of the past. Therefore, nations need to revolutionise their education systems that produce super humans capable of surviving in Smart Manufacturing and

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Industry 4.0 revolution. Education revolutions require a national culture that is supportive to such initiatives from government, where the citizens feel they have something to contribute towards achieving Smart Manufacturing and Industry 4.0 revolution goals. Hence, result in producing human capital that is capable to benefit Industry 4.0 revolution needs for Smart Manufacturing competitiveness.

3. Education in Smart Manufacturing and Industry 4.0 revolution

There is enough evidence that a country's education system plays an important role in its social, economic and political development. Most successful countries are successful because of their education system, for example, Japan education system requires that from class one to three, children are only taught Japanese moral values and nothing else. This is to ensure that they are imbibed with the Japanese's culture and education system that is supportive of Japanese's work environment ethics. Classrooms should foster quality environment capable of creative thinking and divergent views among children irrespective of their ages and stages of their education. Embracing technologies at an early age make such children more adaptable to the needs of Smart Manufacturing and Industry 4.0 revolution as opposed to adoptions and diffusions of such technologies at a later stage. Education for Smart Manufacturing and Industry 4.0 revolution is defined by technology literacy, information literacy, media creativity, social competence and responsibility, workplace skills and civic engagement. This is because the information made available dramatically increase, hence requiring people to have new skills to critically access and process content to ensure the best social communication and interaction. Smart Manufacturing and Industry 4.0 revolution present an opportunity as well as challenges to nations' education systems and only those nations whose education systems are anchored in inclusiveness and technologies imperatives will remain competitive. It is evident that, Smart Manufacturing and Industry 4.0 revolution rely more on the convergence of networks and devices to build bridges between people and countries. On the one hand, nations are already moving towards digital democracy to make their citizens productive and engaged participants in democracy. While on the other hand, in the workplace, more people are needed with technological skills to meet the demand of digital workplace worldwide. To meet all these demands for Smart Manufacturing and Industry 4.0 revolution, lifelong learning is necessary to ensure that everyone can stay informed. Universities have to lead research efforts not only to identify the skills but also to produce calibre of workforce that have the skills needed in the Smart Manufacturing and Industry 4.0 revolution. The questions that we need to address are: what sort of education systems is conducive for the Smart Manufacturing and Industry 4.0 revolution? How can we match education, knowledge and skills with that of Smart Manufacturing and Industry 4.0 revolution?

The evaluation of the competitiveness in the higher education sector should apply the approach that appraises the competitive advantage of the present systems with its legal, political, economic, social and technological factors [11]. The appropriateness of this method is based on the growth of a higher education environment that inspires, allows and safeguards a competitive higher education system. This takes an active part in increasing the standard of public (society) welfare and satiating the public interests through innovative approaches [11] as shown in

Figure 1. A model of human capital for Smart Manufacturing and Industry 4.0 revolution. Source: Author's own illustration.

Figure 1. Not only the competitiveness of higher education system that plays critical role, but also right from early childhood education (Pre-school), primary, secondary, vocational and tertiary education that ensures a country's competitiveness in its overall education system.

The effectiveness of higher education system stresses the element of human capital (scholars, higher education managers, educators, academics, students, etc.): the overall effectiveness evaluation system is based on the human competencies, ensuring the performance of higher education institutions, its evaluation, quality assurance frameworks, potential demand or final outcomes [11]. This is where most developing countries should focus to revolutionise their education for knowledge and innovative society that results in the national competitiveness. Good and competitive education system ensures a country of creative and knowledgeable population that contributes immensely at national innovation systems (NIS) as individual or organisation. In this study's conceptual (**Figure 1**), this relationship has been demonstrated.

Any education system or policy should focus learning outcomes that stimulate the three components of creativity (creative-thinking skills, expertise and cognitive) at any level of the education. When these people are nurtured under this type of education system, then that assures a country of not only creative, but also knowledgeable society [7].

Education systems that encourage and promote learners to question what they have been taught in formal as well as informal classrooms is an ideal for innovation-driven economy as it develops calibres of society where creative thinking is the norm of the day. This type of behaviour should be entrenched in the society as a whole, for example, early childhood education development level. When children are allowed to questioning, it leads to knowing, which develop their mental faculty to reason and analyse things from different perspectives. However, in most developing countries, particularly sub-Saharan-Africa countries, the cultural practices are that a child must not question anything coming from an adult person, as this is considered to be rude. In addition, it is viewed as a taboo and such children are seen as disrespectful to adult persons. But to create innovation-driven economy, any education policy should be such that it foster and nature creativity of the learners right from early childhood education development to higher education. This equips a country with creative and knowledgeable population that is capable for innovation imperatives. An attempt has been made to demonstrate three components of creativity that any education systems should focus on given creativity is a precursor to innovation. Education systems in the developing countries are products of colonialism that was developed without most of the developing countries people's participation, since then little has been done to reflect the changes that have taken place in the world.

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A country's capacity to absorb new technologies depends on upgrading the skills of the human capital, to produce goods and services that can reach standards of quality and performance acceptable in international markets. Such a country engages with the rest of the world in ways that create value. This requires the higher education system's collaboration with the labour market, private, public and secondary education among others. In order for higher education system to contribute successfully to a country's competitiveness, it needs to work hand in hand with all of them [12]. In particular, developing countries' national innovation policy should focus on an education system that is able to develop basic analytical and problem-solving skills, creativity, imagination, resourcefulness and flexibility of its people [8]. These skills and knowledge are critical and relevant to the Smart Manufacturing and Industry 4.0. Such countries and organisations that invest and reward their people effectively compete in Smart Manufacturing and Industry 4.0 revolution.

4. Organisation culture

Culture is the glue that glued a particular people together. In defining culture, several scholars have offered different definitions; however, of interest is that of [13] who defined culture as *"the shared ways in which groups of people understand and interpret the world"*. While on the one hand, Ref. [14] states that culture is something that is learned and therefore is entrenched in a society or nation. It is akin to a "mental programme" that is developed early in life and fortified through a widespread programme of socialisation. "The usual act of idea is greatly changed by culture" [15]. This is because of the effect, culture has on the lives of people; it provides a structured and highly consistent way of living that is not deliberately constructed [15]. Tse [13, 14] postulates a real-world application of culture to living, implying that culture can be perceived as an "onion" in which the central represents the value systems and the covers growing out of it denote customs and rites expected from values. The question that bog us are how does a national culture promotes and hinders a country's innovation capacity? Throughout history and civilisations, those involve in innovation are gifted people who take creativity and risk. Others work independently, while some with groups and organisations. But, in almost cases, these persons want support and infrastructure to transform their concepts and creative ideas into something concrete and marketable. While individual instinct, inventive ability and tendency are instrumental in moving innovation projects forward, the surrounding environment and culture serve as the incubator that aids or inhibits innovation [16]. It is common to see in developing countries' people laugh at innovators or inventors simply because they failed to make ingenuity materialise or their experiment could not see the light of the day. This is what I call "great killers of creativity and innovation". Such innovators, inventors or creators need moral support irrespective of the outcomes of their experiments. Otherwise, the would-be innovators will naturally shy away from such innovation endeavours in future fearing to be turned into a laughing stock by the society in which they live. The support from the society and the government naturally make these innovators, creators and inventors to aspire for more of innovative ventures. Therefore, supportive national culture irrespective of success or failure will motivate more innovators to come forward and offer something new, which in turn can be transformed into innovation imperatives.

Innovative culture is a tolerance of ambiguities, failures, divergent views and people are praised for trying out something new irrespective of the outcomes of such experiments. Much creativity has been killed due to the culture of intolerance to failures, as people are laughed at whenever they failed to achieve something they are experimenting with. Organisations as well as nations that want to be competitive in Smart Manufacturing and Industry 4.0 revolution must be at the forefront to encourage diverse ideas as a way to foster creativity.

5. Government

The role of government in innovation pervades all the sectors of the economy. As the sole regulator of the economy, government can either promote or hinder innovation. Government promotes innovation through the formulation of user-friendly legislation and policies that are supportive to both creative and innovative endeavours in the economy. At the national level, government is responsible for pulling all the sectors of the economy towards a common purpose to achieve economic development. But how does a government achieve this in the first place?

In other countries, Malaysia for example, the government is committed to a lower carbon footprint and reduction of air pollution in order to improve the health of its citizens and create a better environment [17]. To achieve this, the Malaysian government has established the Malaysia Green Technology Corporation (MGTC) to promote green technology under a national green technology policy [17]. This policy has encouraged Malaysian industries in the economy to explore innovative ways to improve development of new products, production processes, firm productivity and ecological improvements. This is a typical government promoting innovation through policy creation and implementation at a national level, which results in new start-ups/industries [18].

Innovation at a national level requires efforts from all the sectors of the economy to be spearheaded by a committed government and political will. Countries that have experienced rapid innovation have succeeded doing so because of the government taking the front lead in areas such as policy formulation, funding, openness to external ideas (open innovation) and joint-ventures in large undertakings of projects. For example, the Chinese government encourages firms to source external knowledge by acquiring foreign technology through the enactment of various legislations, policies and reforms [19]. Innovation policy at a national level that covers a broad spectrum of industrialisation and development needs of a country through financial, tax, industry, trade and Science and Technology (S&T) should serve as a link that connects all relevant players/actors at various levels of NIS [19].

The policy imperatives should define specific types of innovation at NIS such as inbound Open Innovation (OI), Outbound Open Innovation (OOI) and Closed Innovation (CI). This guides players/actors at different levels of the NIS as they engage in innovation endeavours at a national level. The innovation policy should also cater for how the resources of the NIS are shared among the actors, given that some innovation ventures require substantial resources that may not be within individual or organisational reach. Collaboration and engagement of government and citizens in NIS is paramount for an innovative nation [20].

To tap on the creativity of the entire population, outreach and other mechanisms need to be put in place that involves citizens. It is a bottom-up approach to problem solving. Governments should be ready to reward and incentivise innovators in the economy through appropriate legislations and policies as a way to promote innovation at a national level [21]. Such recognition of innovativeness strengthen and motivate innovators to come up with more creative approaches to solving real societal problems such as unemployment, poverty, infrastructure issues, health issues and other myriad problems facing a country.

It is unquestionable that the government plays a significant role in encouraging and stimulating innovation in the economy. This is achieved through various ways such as enactment of legislation that is pro-innovation as well as sustainable economic development. Government, too, can change the state of happiness, commitment and dedication in a society towards innovation [18].

6. National knowledge management

Since the beginning of Adam and Eve, knowledge has always existed and the co-existence of knowledge and humanity is shown in different human-made exploits [22]. Such exploits can be seen from Pyramids of Egypt, Taj Mahal in India and many others. Just like an organisation, a country's capability to innovate hangs on its domestic (within the boarder) competencies such as its own knowledge, organisational and technological base as well as its skills in discovery, embracing, developing and expanding knowledge generated within its boarders and collaborations with its proximate environment [23]. Knowledge-grounded development in today's global economy has become an arsenal and the ability of nations to generate, transfer and apply knowledge, but also to "tap external knowledge as well as adapt such knowledge for specific needs" locally [24]. For sustained (knowledge) development to take place, countries need to establish mechanisms that facilitate the circulation of data, information and knowledge across developing and developed nations [25].

In the twenty-first century, new organisations are emerging where knowledge is the primary production resource as opposed to capital and labour [26]. It is now believed that efficient utilisation of existing knowledge could create wealth for organisations. Knowledge management (KM) refers to the process of enhancing organisation performance by designing and implementing tools, processes, systems, structures and culture to improve the creation, sharing and the use of knowledge [27, 28]. Knowledge is increasingly becoming more valuable because management is taking into account the value of creativity, which allows for the transformation of one form of knowledge to the next. The perception of the existing relations among numerous systems elements leads to new interpretations and this means another knowledge level where a new perceived value is generated [29]. This relationship denotes that innovation highway hangs on the knowledge development [29, 30]. This relationship has well been captured in the proposed conceptual framework (**Figure 1**).

Previous studies [24] have shown that knowledge generation or acquisition, knowledge sharing and knowledge leverage or utilisation build employees' skills are relevant to the process of innovation. Knowledge management that facilitates collaboration between employees

and sectors enhances the knowledge sharing and utilisation, which in turn increase innovation (see **Figure 1**). Therefore, knowledge sharing plays an important role in innovation imperatives. Encouraging knowledge sharing between employees and incorporating KM into strategies lead to gain competitive advantage, customer focus and innovation [24, 31]. Organisations also could trigger off the sharing, application and the deployment of knowledge to facilitate innovation, because KM has a positive effect and contribution to transform tacit knowledge into innovative products, services and processes, which improve innovative performance as shown in **Figure 1**. Some studies showed that there is a relationship between organisational innovation and knowledge transfer as well as reverse knowledge transfer, but its effect depends heavily on learning orientations [24]. In gist, two key elements are important in the definition. From the review of the literature, there is evidence that knowledge is the core component of innovation – not technology or finances.

In a nutshell, strategic human capital practices are deployed in Smart Manufacturing and Industrial 4.0 revolution to ensure a competitive advantage by focusing extensively towards the human capital and build the knowledge base for a sustained growth. From the strategic human capital management perspective, a set of integrative human capital practices that support organisation's strategy produces a sustainable competitive advantage (**Figure 1**).

7. Rewarding human capital in Smart Manufacturing and Industry 4.0 revolution

Human capital management in the Smart Manufacturing and Industry 4.0 revolution provide workers with clearly defined and consistently communicated performance expectations. In Smart Manufacturing and Industry 4.0 revolution, managers are responsible for evaluating their employees' performance. This evaluation takes into account a fair rating, rewards and holds worker accountable for achieving specific business goals. The sole aims of such evaluation is crafting innovation and supporting continuous improvement). In Smart Manufacturing and Industry 4.0 revolution, human capital management is viewed as an approach to organisation staffing that values workers as assets. Such organisation perceives human capital as assets whose current value can be measured and future value can be enhanced through investment [32]. Human capital acts as a catalyst to increase productivity in Smart Manufacturing and Industry 4.0 revolution. Smart Manufacturing and Industry 4.0 revolution cannot survive if there are no human capital with the necessary skills, knowledge and abilities to transform concepts and abstracts thinking into reality that add value to the organisation. The success or failure of Smart Manufacturing and Industry 4.0 revolution depends entirely on how human capital contributes in his or her own way in its success and productivity. Human capital represents the collective value of Smart Manufacturing and Industry 4.0 revolution's competencies, knowledge and skills. This renewal is the source of creativity and innovation that imparts to Smart Manufacturing and Industry 4.0 revolution, the ability to change. Workers are the facilitators who stimulate the physical, inert forms of knowledgeable human capital and the docile forms of tangible capital, materials and equipment to improve Human capital as the most vital

asset in Smart Manufacturing and Industry 4.0 revolution and managing it is the greatest challenge facing modern managers and organisations [32]. For Smart Manufacturing and Industry 4.0 revolution to succeed, it is critical to map the workers centric approaches with that of Smart Manufacturing and Industry 4.0 revolution strategies.

In Smart Manufacturing and Industry 4.0 revolution, it is not possible to just get rid of them (employees). In fact, unless organisations learn to get the best out of their creative employees, they will sooner or later end up filing for bankruptcy. Similarly, if organisations just hire and elevate workers who are friendly and easy to manage, such organisations will be mediocre at best. This is because suppressed or stifled creativity is harmful organisational growth. While every organisation claims to care about innovation, very few are ready to do what it takes to keep their creative people happy or at least, productive. So what are the keys to engage and retain creative employees? In whatever form or structure, rewards must be seen to motivate and retain the creative human capital for the Smart Manufacturing and Industry 4.0 revolution.

7.1. Spoil them and let them fail

Like parents who rejoice their children's chaos: show your creative absolute encouragement and inspire them to do the illogical and flop. Innovation can originate from uncertainty, risk and experimentation if you know it will work, it is not creative. Creative people are the natural experimenters, so let them try and test and play. This is because there are costs associated with experimentation but these are lower than the cost of not innovating [32].

7.2. Surround them by semi-boring people

Managers must not find themselves doing the worst by forcing a creative employee to work with someone like them. Such action is likely to flop because employees will compete for ideas, brainstorm eternally or simply ignore one another at the end. That being said, managers should not surround creative worker with colleagues who are really boring or conventional, they would not understand them and fall out. In line with this, recent research suggests that teams consist of diverse members who are open to take each other's viewpoint and perform most creatively [32].

The response, then, is to support creative workers with their colleagues who are too conventional to challenge their ideas, but unconventional enough to collaborate with them. These colleagues will need to pay attention to details, mundane executional processes and do the dirty work.

7.3. Involve them in meaningful work

Innovators naturally tend to have more vision. They see the bigger picture and able to comprehend why things matter (even if they cannot explain it). The downside to this is that they simply will not involve in worthless work. This all or nothing approach to work reflects the bipolar character of creative artists, who perform well only when is fuelled by value. This approach can also apply to other employees because everyone is more creative when driven by their honest interests and a hungry mind.

At the same time, in any organisation there are employees who are less interested in, well, doing interesting work; they are satisfied with simply clocking in and out and are incentivized by external rewards. Organisations should ensure that frivolous or meaningless work is assigned to these employees [32].

7.4. Eliminate pressure from employees

Smart Manufacturing and Industry 4.0 revolution require that workers be given more freedom and flexibility at work as this usually enhances creativity, which is a precursor innovation. It cautions managers in Smart Manufacturing and Industry 4.0 revolution against leaning towards structure, order and predictability, terming such managers as probably not creative. This is because workers are more likely to perform more creatively in spontaneous and unpredictable situations. Managers should not constrain creative employees or force them to follow processes, rules, procedures or structures. Smart Manufacturing and Industry 4.0 revolution require workers to work remotely and outside normal hours; the emphasis is managers must not ask where employees are, what they are doing or how they do it. Workers left to decide what, when and how to perform a particular task is the calibre of employees needed in Smart Manufacturing and Industry 4.0 revolution.

7.5. Do not overpay employees

There is evidence suggesting a relationship between intrinsic and extrinsic motivation. Over the past two decades, psychologists have provided persuasive support for the so-called "over-justification" effect, namely the process whereby higher external rewards weaken performance by lowering a person's genuine or intrinsic interest [32]. Most notably, two large-scale meta-analyses reported that, when tasks are naturally meaningful (and creative tasks are certainly in this condition), external rewards weaken commitment. This is true in both adults and children, especially when people are rewarded merely for performing a task. However, providing positive feedback (praises) does not harm intrinsic motivation, so long as the feedback is perceived as honest. The moral of the story! The more you pay people to do what they love, the less they will love it. In the words of Czikszentmihalyi [33]:

"The most important quality, the one that is most reliably present in all creative individuals, is the ability to enjoy the process of invention for its own sake" [33].

More significantly, workers with talent for innovation are not motivated by money. Evidence suggests quite clearly that the more imaginative and inquisitive workers are, the more they are motivated by appreciation and absolute logical inquisitiveness rather than commercial needs.

7.6. Surprise employees

Few things are as frustrating to creative as tediousness. The characteristics of creative people are that they naturally seek persistent change, even when it is of less value. They take a different route to work every day, sometimes they get lost on the way and never repeat an order at a restaurant or hotel, even if they really loved it. Creativity is linked to higher tolerance of ambiguity [32, 34]. Creative and inventor love complexity and like making simple things

complex rather than vice-versa. Instead of searching for the solutions to a problem, they usually prefer to generate a thousand solutions or a thousand problems. It is therefore necessary that managers keep surprising their creative employees; failing that, managers should at least let them generate enough chaos to make their own lives less predictable.

7.7. Make employees feel important

"Most of the problem in this world is as a result of people seeking to be important" in organisation. And the reason is that others fail to appreciate their worth. Justice is not treating everyone the same, but like appreciating and giving them what they are worth. Every organisation has high and low potential employees, but only competent managers and leaders can identify such employees. If managers or leaders fail to recognise such employees' creative potential, employees will switch to other organisations where they feel more valued in terms of contributions [32]. Therefore, in Smart Manufacturing and Industry 4.0 revolution, organisations need to change their way of rewarding and managing these new generations of employees in order to successfully compete.

A final warning: Being able to manage your creative employees perhaps may not mean that managers should let creative employees manage others. Evidence suggests that natural innovators or inventors are hardly talented with leadership skills to warrant them handed leadership of other fellow employees. This is because the profile for good leaders and those of creative people are rather different. Example of such creative people who could not relate well with other people, but doing well with gadgets can be drawn from Steve Jobs. In addition, most Google engineers are completely not interested in the position of leadership or management. It is been proven that the orthodox view that corporate innovators or intrapreneurs demonstrate many of the psychopathic features that inhibit them from being successful leaders: they are uncontrollable, anti-social, self-seeking and often too low in responsiveness to other employees' welfare. But if these creative employees are managed well, motivated and incentivized, then their inventions will delight many [32, 34].

8. Conclusion

The chapter provides a strong evidence of the important role human capital plays in the Smart Manufacturing and Industry 4.0 revolution. In Smart Manufacturing and Industry 4.0 revolution, the success or failures of most organisations largely depend on how their human capital is managed. This is because Smart Manufacturing and Industry 4.0 revolution provides a space where employees to machines interactions are the order of the day. There is interconnectedness among various players and actors. The interfaces created become the connecting points between workers and machines. The features of Smart Manufacturing and Industry 4.0 revolution require creative and inventive workers. These are workers who are not creative but also knowledgeable and have techno how to work in such environments. Such workers are nurtured through an education system, where creativity, inventiveness, knowledge and technology flourish and entrenched in the national culture.

A concept concerning all activities regarding employing and managing people in Smart Manufacturing and Industry 4.0 revolution is considered human capital management or more in a narrower sense human resource management [34]. Developing a workforce to meet present and future market needs proposes the identification of required competencies [34]. Competencies such as skills, abilities, knowledge, attitudes and motivations an individual needs to cope with job-related tasks and challenges effectively as defined by Smart Manufacturing and Industry 4.0 revolution cutting edge. In addition, Smart Manufacturing and Industry 4.0 revolution require people who are well entrenched into Technology of Things (ToT), human-machine interactions, technology-technology interfaces, good understanding of networked systems, creativity and innovative.

Author details

Joseph Evans Agolla

Address all correspondence to: nyagonya2009@gmail.com

Botswana Open University, Gaborone, Botswana

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