대한경영정보학회
「경영과 정보연구」제34권 제3호 2015년 9월

HRD Implications of Robotic Technology in Organizations

Heo, Se-Jin*

<요 약>

This article examines the HRD implications of using robotic technology in the workplace. Because existing literature has been primarily about the technical engineering aspects of robotics, it is difficult to understand the socio-cultural perspective about the challenges and potentials of robotization in the workplace. Especially, in order to identify the best organizational support appropriate for working with robots, this article indicates alternative perspective for observing human-robot interaction in the workplace. In addition, this article points out four implications of robotic technology in organizations for practice and research development in HRD. These implications were identified as (1) defining the components of expertise in terms of human-robot interaction, (2) coping with organizational change process resulting from robotic technology, (3) designing appropriate interventions for an organization to effectively assist human-robot interaction, and (4) establishing the code of work ethics in the robotic age. The suggested implications can contribute to shaping conceptual frameworks for further empirical social science research.

Key Words: Robotic technology in workplace, HRD implications for robotization, Socio-cultural approach to robotic technology, Organizational support for new technology

논문접수일: 2015년 06월 05일 수정일: 2015년 09월 07일 게재확정일: 2015년 09월 24일
* Instructor, Dong-eui University, trinityh@naver.com

Ⅰ. Introduction

Since the 1990s, new organizational concepts and theories have begun to absorb and apply recent developments in quantum theory and chaos theory (Begun, 1994; Plsek, 2001; Stacey, 1995; Zimmerman, 1999). Classic theory in physics suggests that we can accurately predict the future state of a physical system if we have enough information about the current state (Capra, 1982; Wheatly, 1992), whereas quantum theory denies this possibility, noting that the very act of collecting the information for prediction alters the physical system we hope to understand (Begun, 1994). Quantum theory asserts that continuous change, activity, and interconnectedness add an element of unpredictability to any system. Therefore, planned, controlled, and orderly approaches to innovation or change are not likely to perfectly achieve their intended outcomes (Stacey, 1995).

Chaos theory also suggests that the future state of the world is unknowable because physical systems are highly sensitive to initial conditions. Given the sensitivity of systems to initial conditions, chaos theory warns that programs, processes, or practices that work well in one organization may work poorly even when faithfully implemented (Wheatley, 1992). It implies that small differences in initial conditions can lead to radically different outcomes even if two organizations look very much like.

These two theories suggest that organizations are more than simply open systems; they are complex adaptive systems (Shortell & Kaluzny, 2006). According to Plsek (2001), complex adaptive systems are composed of the individual agents who have the freedom to act in ways that are not always predictable and the actions of these agents. If we assume that future states of an organization are unknowable, as suggested by both quantum theory and chaos theory, is there still a possibility for planning, organizing, deciding, and controlling in complex adaptive systems?

Some scholars and practitioners argue that organizational survival depends on managers giving up their “obsession with control, knowing what is going on, and seeking stability” (Berquist, 1992; McDaniel, 1997; Vaill, 1989; Wheatley, 1992). On the other hand, others contend that classical management tasks still have a place in complex adaptive systems. For example, Stacey(1996) proposes that, in complex adaptive systems, selecting the appropriate management or leadership approaches depends on two factors: the amount of certainty about cause-effect linkages (e.g., “If we do X, then Y occurs.”) and the amount of agreement about an issue or decision (e.g., “What should we do?”). When high certainty and high agreement exist, classical management tasks work well. However, when uncertainty is high and disagreement reigns, chaos and anarchy often result. In such circumstances, few management or leadership approaches work. When only modest levels of certainty and agreement exist, organizations enter the “zone of complexity” or the “edge of chaos,” where high levels of creativity and innovation become possible. At this point, traditional management approaches lose their effectiveness.

Stacey's suggestion seems to be plausible because it elaborates the contexts and limits in which both quantum theory and chaos theory reside. Although it is clear that we cannot accurately predict the future, it is possible to expect more concrete boundaries to which our anticipations will be applied. In other words, when organizations are assumed to be complex adaptive systems, we can qualify our expectations about organizational change taking into consideration some factors such as the degree of certainty and agreement. In this respect, if we want to assess the innovation such as the use of a robot in the workplace, it is also important to understand the fact that we need to find reasonable standards and guidelines about the overall technology assessment, always bearing in mind that all organizations are different and unique. For instance, considering the degree of certainty and agreement will be a kind of option to decide the scope of using robots.

Although the researcher admits the assumption that organizations are complex adaptive systems, it is believed that traditional management tasks still play a role in some settings as Stacey(1996) suggested. However, as of now, we do not make a definite decision about the degree of certainty and agreement in the use of a robot because of the lack of previous research and the recent use of robots. Stacey's suggestion assigns us a question about identifying the degree of certainty and agreement. Therefore, if we want to make a rough prediction about organizational change, we are first required to have enough information about cause-effect linkages of the change and a variety of views on change. As I have mentioned previously, we do have little information about the influence of new technology represented by the use of robots. In other words, we have not thoroughly discussed the cause-effect linkages regarding the use of robot and have not deeply contemplated various views on the new technology.

At this stage, we need to concentrate on accumulating knowledge on how people perceive cause-effect linkages in the process of working with a robot and how people feel and think about the experience of working with a robot. This article is written to provide knowledge on people's recognition about working experience with a robot. Of course, this article is not looking for clear-cut "yes" or "no" answers. Rather, it is searching for the best fit between new technology and organizations.

Ⅱ. Studying Technology in Organizations

Certainly, working with robots is an unfamiliar experience for most people. For this reason, the robotic technology has made it possible for people to rethink the influence of new technology on organizational structures, processes, and outcomes. Because previous research on the robotic technology's influence on organizations is limited, this article focuses on critiquing existing theories checking its appropriateness to human-robot interaction in the workplace.

Over the years, different research perspectives on technology have developed in parallel with research perspectives on organizations (Orlikowski, 2000). These perspectives come from the need to explain the dynamics of organizational change. Here, this research deals with contingency theory and strategic choice theory because these theories clearly reveal the opposing viewpoints about the relationship between technology and organizations.

Proponents of contingency theory suggest that various subunits of the organization may be organized differently depending on the specific environments and technologies with which they are involved (Burns & Stalker, 1961; Lawrence & Lorsch, 1967; Perrow, 1967; Rundall, Starkweather & Cook, 1988; Thompson, 1967). Contingency theorists prioritized the importance of the environment, asserting that a specific organizational form is more effective according to the characteristics of the environment. For example, a more bureaucratic or mechanistic form of organization is more effective when the environment is relatively simple and stable, the tasks and technology are relatively routine, and a relatively high percentage of nonprofessional workers are employed. In contrast, a less bureaucratic or more organic form of organization is likely to be more effective when the environment is complex and dynamic, the tasks and technologies are non-routine, and a relatively high percentage of professionals are involved. Empirical support for contingency theory ideas is mixed depending on whether one is studying the organization as a whole, particular subgroups, or specific individuals (Schoonhoven, 1981).

Given the wide variety of organizations and different environments in which they operate, the contingency theory perspective has a wide application to many organizations. In addition, it seems reasonable to consider various aspects of the environment in order to create a bigger picture that may influence management style and organizational structure. However, if we just depend on contingency factors, it is possible to ignore the role of the intrinsic self-actualizing aspects of work. In addition, as the researcher mentioned in the previous section, if the organizations are assumed to be complex adaptive systems, we need to consider the importance of initial condition as well as contingency factors.

Strategic choice theory was advanced as a corrective to the view that the way in which organizations are designed and structured is determined by their operational contingencies (Child, 1972). In addition, strategic choice theory paid attention to the active role of leading groups who had the power to influence the structures of their organizations through an essentially political process (Child, 1997). ‘Strategic choice’ was defined as the process whereby power-holders within organizations decide upon courses of strategic action (Child, 1972). Strategic choice articulates a political process, which brings agency and structure into tension and locates them within a significant context. It recognizes that the evaluation of information, from within an organization and from its environment, can lead to the identification of opportunities and problems. This encourages a learning process which proceeds toward action through debate, negotiation, and the exercise of choice. In so doing, the strategic choice approach adopted a non-deterministic and, potentially, evolutionary position.

Strategic choice theory gave people an opportunity to think about the sense-making process within an organization. Even though the environment has been radically changing, the political power of leading groups strongly affects the organizational process and outcomes. If the leading groups stick to inappropriate unchangeable beliefs and values, changing contingent factors cannot help losing their influence on organizations. Strategic choice theory seems to be plausible because organizational decision-making is based on a set of values as well as an adaptation to the internal or external environment. However, just considering strategic choice theory is not useful in that we would ignore the interrelationship between organizations and the environment. Recognizing the strengths and weaknesses of each theory is more helpful to understand the whole organizational phenomena.

If so, what are the implications of these theories regarding the influence of using a robot in the workplace? Contingency theory implies that the use of a robot would transform the organizational structure, processes, and outcomes. In other words, just using new technology enables people to change their thinking and behavior, which lead to new organizational changes. On the other hand, strategic choice theory implies that organizations are mostly shaped by leading groups' choice despite the use of new technology. That is, organizations will not be changed if the leading group does not change their beliefs, even though the different environmental needs are so powerful that employees cannot help choosing different sets of behaviors.

These two theories are showing an example of extreme opposite views on the technology's influence on organizations. Rather than this kind of dichotomy, we need not assume that the use of new technology always triggers similar organizational changes among organizations. It happens or it does not happen. As of now, we do not exactly know what happens after working with robots and it is premature to determine its definite effects. It is possible that nothing happens after the use of robots in some organizations because they are well designed to working with robots. However, it is also possible that other organizations are required to wholly transform their system because they are not well designed to working with robots. It is necessary to clarify the best organizational support that is appropriate for working with robots. In order to identify the best fit, we need alternative perspective instead of contingency theory or strategic theory for observing human-robot interaction in the workplace.

Ⅲ. Practice-oriented Understanding about Human-Robot Interaction

Structurational model regards technology as embodying structures, which are then appropriated by users during their use of the technology (Orlikowski, 2000). Human action is a central aspect of this model. The actions are associated with embedding structures within a technology during its development and with appropriating those structures during use of technology. Orlikowski(2000) extended the structurational perspective on technology by proposing a practice-oriented understanding of the recursive interaction between people, technologies, and social action.

In fact, the structurational model of technology has been strongly influenced by the intellectual tradition of social constructivism (Woolgar, 1991; Bijker & Law, 1992). When it comes to the relationship between technology and an organization, social constructivists examine how interpretations, social interests, and disciplinary conflicts shape the production of a technology through shaping its cultural meanings and the social interactions among relevant social groups. Therefore, the structurational model posits that technology is developed through a social-political process which results in structures (rules and resources) being embedded within in the technology (Orlikowski, 2000).

Existing structurational models of technology examine what people do with technologies in use, positing such use as an appropriation of the "structures" inscribed in the technologies. While the notion of appropriation captures well the importance of human action in shaping the situated use of technology, it frames such human agency in terms of interaction with the structures embedded within technology. This view starts with the structures presumed to be embedded within technology, and then analyze how those structures are used, misused, or not used by people in various contexts.

However, Orlikowski(2000) suggested that we need to focus on emergent rather than embodied structures. Rather than starting with technology and examining how actors appropriate its embodied structures, this view starts with human action and examines how it enacts emergent structures through recurrent interaction with the technology at hand. The notions of emergent structure and enactment afford a practice-based extension to existing structurational models of technology. This practice lens regards human as constituting structures in their recurrent use of technology. Users repeatedly enact a set of rules and resources which structures their ongoing interactions with that technology through their regularized engagement with a particular technology in particular ways in particular conditions (Orlikowski, 2000).

In this practice lens, technology structures are not external or independent of human agency; they are not embodied in technologies simply waiting to be appropriated. Rather they are virtual, emerging from people's repeated and situated interaction with particular technologies. Orlikowski(2000) termed *technologies-in-practice* as the enacted structures of technology use, which means the sets of rules and resources that are reconstituted in people's recurrent engagement with the technologies at hand. In other words, *technology-in-practice* refers to the specific structure routinely enacted as we use the specific machine, technique, appliance, device, or gadget in recurrent ways in our everyday situated activities (Orlikowski, 2000). According to Orlikowski(2000), the *technology-in-practice* is a kind of behavioral and interpretive template for people's situated use of the technology. Continual habitual use of a technology will tend to reenact the same technology-in-practice, thus further reinforcing over time so that it becomes taken for granted. Besides, in Orlikowski's empirical research(2000), the empirical illustrations support that people enact different technologies-in-practice with the same type of technology across various contexts and practices.

Using the above practice lens is more effective to initiate the research on human-robot interaction in the workplace because it is observing the relationship between human agency and open-ended set of emergent structures. If we recognize the importance of emergent structures related to new technology, we need to pay attention to the particular instances and contexts through the technology-in-practice. As Orlikowski (2000) mentioned, we need to know whether and how people interact with technology in their day-to-day activities. It is not enough to appreciate the mere presence of the technology on the factory floor. In this respect, we need to be more sensitive about improvisation of new technology.

Orlikowski's framework can give us insights about how we will observe human-robot interaction in the workplace. The use of robot can lead to different technologies-in-practice across various contexts and practices. Through the practice lens, we have to try to understand when, where, how, and why people choose to reinforce, ignore, enhance, undermine, change, work around or replace their existing structures of technology use. For example, we can ask this kind of question: Which kinds of situations robots can help with and which ones they cannot? In order to answer this question, we need in-depth information about how an organization makes a variety of technologies-in-practice across various contexts. In other words, it requires us to make a preparation for various scenarios resulting from the improvisation of new technology represented by the use of a robot.

1. Examples of Practice-oriented Understanding about Human-Robot Interaction

In order to clearly apply Orlikowski's framework to human-robot interaction, I tried to search for empirical research examples of practice-oriented understanding in human-robot interaction. As of now, I was not able to find many examples because there is little research about the human-robot interaction in the workplace. Fortunately, two articles have been found and they will be reviewed to explain their connection to practice-oriented understanding. The chosen articles are worthwhile to review for the purpose of understanding the real research applications of practice-oriented understanding.

First, Forlizzi and Mutlu(2008) performed ethnographic research to examine how organizational factors affect the way its members respond to robots and the changes engendered by their use. In other words, they investigated the impact of technologies (e.g. professional service robots) on social dynamics and work practices of many groups. Throughout the research, they showed how aspects of work flow, and social/emotional, political, and environmental context intertwine the perceptions and interactions of hospital workers. They found that when different groups in an organization have different goals, their perceptions of the robot vary accordingly. For example, while hospital management perceived the use of the robot as an instrument for improved efficiency, medical units resisted the use of the robot because they perceived it as decreasing the quality of the healthcare they delivered. In addition, interestingly, medical staffs recognized the emotional tone of the interactions differently according to their job. For instance, nurses who treated cancer patients found the robot “annoying” while nurses at the birth units thought the robot was “delightful” (Forlizzi & Mutlu, 2008).

Their research is based on practice-oriented understanding because they intended to design their research to examine behavioral and interpretive templates for people’s situated use of robots. Besides, their research on the relationship between organizational structures and technology has focused on not only how interpretations, social interests, and disciplinary conflicts shape organizations’ use of technology but how people’s perceptions on technology affect cultural, structural, and workplace norms. For this reason, their research is a good example to show the usefulness of practice-oriented lens in terms of researching organizational implications of human-robot interaction.

Secondly, Siino and Hinds(2005) observed how sex segregation structures may shape how men and women workers make sense of professional service robots. Their ethnographic research is related to people’s sense making of robots in social environment. They found that male and female workers seemed to engage in sense making around the robot according to their position in the hospital (Sinno & Hinds, 2005). Engineers and male administrators generally saw it as a machine they control; female administrators and low-level female staff workers anthropomorphized it as a human male that acted with agency, and nurses regard it as a technology with no work utility and perhaps as further evidence of the low value placed on their jobs and work needs.

In their research, people’s different recognitions about robots resulted in their different preferred use of technology. For example, while engineers and male administrators enjoy working with the robot, female administrators, low-level female staff workers, and nurses are not favorable about the use of new technology. Although the authors did not specify the consequent organizational effect of their preference, we can guess that some rejections about the use of robots would lead to the organizational change such as the discouraged morale of nurses or their decreased productivity. On the other hand, those who are favorable about the use of robots will develop continual habitual use of a technology, which would result in new taken-for-granted organizational norms about the robots. For this reason, their research is also a good example to show new behavioral and interpretive templates for people's situated use of the robots.

Ⅳ. Robotic Technology Industry in the 21st century

Humans made robots, just as many people believe that God made humans. Certainly, robots are new creatures resulting from the human imagination. More surprisingly, not only in our imagination but also in everyday worlds can people meet robots as co-workers or friends.

According to a survey of the United Nations Economic Commission for Europe (UNECE) and the International Foundation of Robotics (IFR)(2005), robots will be more frequently used in the workplace, assisting elderly and disabled people by means of sophisticated interactive equipment, carrying out surgery, inspecting pipes and sites that are hazardous to people, fighting fire, and disabling bombs.

The United Nations, in its recent robotic survey(UNECE & IFR, 2002), categorized robots into three groups: industrial robots, professional service robots, and personal service robots. Industrial robots usually work for welding, machining, assembly, packaging, palletizing, transportation, and material handling (Thrun, 2004). Most industrial robots are used on assembly lines, chiefly in the auto industry (UNECE & IFR, 2005). Professional service robots assist people for achieving professional goals such as milking cows, handling toxic waste, ferrying medicine within hospitals, and assisting surgeons (UNECE & IFR, 2005). Lastly, the examples of personal service robots assisting or entertaining people are vacuum cleaners, lawn mowers, receptionists, assistants to elderly and people with disabilities, wheelchairs, and toys (Thrun, 2004).

The Robotic Industries Association estimates that North America uses 192,000 industrial robots, second only to Japan and roughly one-fifth of the world's robots (IFR Statistical Department, 2010). According to its latest report, *World robotics 2010: Industrial robots*, 2009 had a decline of 47% (60,000 units) compared to 2008, which was considered one of the most successful years. This is the lowest level reported since 1994. The worldwide economic and financial crisis caused a significant slump in the sales of industrial robots (IFR Statistical Department, 2010). According to Brown(2010), North American manufacturers ordered 30% fewer robots (worth 43% less money) during the first nine months of 2009 than they did in the same period in 2008. Orders fell to 7,172 robots worth $426 million compared with 10,279 robots valued at $743 million a year earlier. The downturn was distributed equally among the automotive industry (down 29% in units) and non-automotive customers (down 32%). Orders rose 14% in life sciences and 12% in food and consumer goods, which are small markets.

However, the Statistical Department of the International Federation of Robotics(2010) suggested that a strong recovery of worldwide robot installations in 2010 will result in an increase of about 27% to about 76,000 units and there is a continued growth between 2011 and 2013. According to the IFR Statistical Department (2010), the stock of professional service robots is forecast to increase to some 80,000 units for the period 2010-2013. Application areas with strong growth are defense, rescue and security applications, field robots, logistic systems, inspection robots, medical robots, and mobile robot platforms for multiple uses. In addition, it has been projected that sales of all types of domestic robots (vacuum cleaning, lawn-mowing, window cleaning, and other types) in the period 2010-2013 could reach 6.7 million units (IFR Statistical Department, 2010). The market for entertainment and leisure robots, which includes toy robots, is predicted to reach 4.6 million units (IFR Statistical Department, 2010).

Although traditional assembly lines had come under criticism from those concerned with their effects on workers, industrial robots perform many of the repetitive tasks. For this reason, recent variations on the assembly-line process have been believed to increase productivity and employee interest. According to Burnstein(2010), robots in factories are likely to save and to create more jobs than they eliminate. U.S. technology and business innovators recognize that robots help companies turn out higher-quality and lower-cost goods to compete with those made in China, Mexico, India, or other low-wage nations. They remove people from dangerous and boring jobs they should not have been doing in the first place, and put them in higher-skilled, higher-paying positions (Burnstein, 2010).

Burnstein(2010) pointed out that there is also a large ecosystem of robotics-related companies in America that employ thousands of people who design, build, program, and service robots and the equipment they work with. More surprisingly, General Motors, containing more than 1,100 robots, is now hiring back some laid-off workers to keep up with growing demand for stylish and high-quality new cars.

Industrial robotics also creates jobs at the companies that build and service the machines. Even though most of today's industrial robots are built in Japan and Europe, major robotics companies including ABB (ABB), Fanuc, Kuka Robotics, and Yaskawa Electric have U.S. divisions (Burnstein, 2010). Adept Technology (ADEP) is based in Pleasanton, California. Of course, if the robots working outside factories such as medicine, defense, and home maintenance are included, there are more than

8 million of the machines worldwide (Burnstein, 2010). Many leaders in those areas, including Intuitive Surgical Systems (ISRG) and iRobot (IRBT), have headquarters in the U.S.

It was around 1960 when industrial robots were first introduced in the production process, and until the 1990s, industrial robots dominated robotics research (Garcia, Jimenez, Santos, & Armada, 2007). For example, several researches written in the 1980s on the robotization's impact on the workplace have been found. At that time, researchers were questioning the result of the automation related to the use of robots. According to Hollon and Rogol (1985), people did not think that a high level of chronic unemployment among displaced workers will result from an increased usage of robots. Although the implementation of robotics will result in substantial displacement of workers from their current jobs, its introduction would be evolutionary rather than revolutionary (Hollon & Rogol, 1985). Given this slow-paced application, robotic adopters anticipate that displaced employees will have time to be retrained for robotic-related jobs or positions in an expanding service sector (Hollon & Rogol, 1985). Hollon and Rogol (1985) also pointed out that only those displaced personnel who are unwilling to undergo retraining will encounter prolonged unemployment.

Rather, in the case of Japan, the Japanese management concluded that the use of robots not only provides the user company with a competitive edge on the market but also plays a major role in stabilizing its labor situation (JMA Research Institute, 1983). In other words, at that time, companies using industrial robots could open new lines of businesses, including the development of new products, and could enter into new markets. Besides, industrial robots assured companies of stable labor power through the stabilization of production output and provided labor with improved benefits. In order to maximize the effect of robots, the JMA Research Institute(1983) advised that user companies need to consider the re-education and re-training of employees in line with the introduction of robots, the carrying out of robot engineering for the purpose of installing and effectively operating industrial robots, and the implementation of measures aimed at improving the work site and ensuring worker safety.

Since the introduction of industrial robots in the automotive industry, robotics research has evolved over time toward the development of robotic systems to help humans in dangerous, risky, or unpleasant tasks. As the tasks given to robots are more complicated, industrial robots have been designed to be more flexible, and robotics research has turned to adaptive and intelligent systems (Garcia et al., 2007).

According to Green, Billinghurst, Chen, and Chase(2008), there is growing interest in the field of human-robot collaboration as can be shown by the recent research of the Cogniron Project, MIT Media Lab, and the Mitsubishi Electric Research Laboratories. However, as a result of literature review, the researcher found that existing literature has been primarily about the technical engineering aspects of robotics. Minimal attention has been given to the anticipation and solution of problems on the human and organizational side of the robotics. Besides, most recent research about the social aspect of human-robot interaction has focused on autonomous and mobile robots (Forlizzi, DiSalvo, & Gemperle, 2004; Green, Billinghurst, Chen, & Chase, 2008; Kanda, Hirano, Eaton, & Ishiguro, 2004; Kuno, Sadazuka, Kawashima, Yamazaki, Yamazaki, & Kuzuoka, 2007; Shibata, 2004).

According to Kiesler and Hinds(2004), autonomous robots are distinctive from computers or other machines. First, people tend to perceive autonomous robots differently than they do most other computer technologies (Kiesler & Hinds, 2004). People's mental models of autonomous robots are often more anthropomorphic than their models of other systems (Friedman, Kahn, & Hagman, 2003). The tendency for people to anthropomorphize may be fed, in part, by science fiction and, in part, by the powerful impact of autonomous movement on perception (Scholl & Tremoulet, 2000).

Secondly, autonomous robots are more likely to be fully mobile, bringing them into physical proximity with other robots, people, and objects (Kiesler & Hinds, 2004). Because mobile robots will have to negotiate their interactions in a dynamic, sometimes physically challenging, environment (Kiesler & Hinds, 2004), one or more remote operators must help the robot negotiate its interactions in the remote place, creating a complex feedback system.

Lastly, autonomous robots are different from other machines because these robots make decisions to learn about themselves or their world and to exert some control over the information they process and actions they emit (Kiesler & Hinds, 2004). According to Kiesler and Hinds(2004), when compared to computer or other machines, an autonomous robotic system tends to add more complexity because it must adjust its decisions sensibly and safely to the robot's abilities and to the options available to the robot in a given environment.

As mentioned previously, because most existing research about autonomous robots have been based on the technical engineering perspective, it is still difficult to understand the human and organizational aspect of robotic technology. For this reason, I believe that subsequent empirical research will be able to contribute to the enlightenment from the socio-cultural perspective about the challenges and potentials of robotization in the workplace.

V. Implications for Practice and Research Development in HRD

In the future, HRD professionals are expected to deal with human-robot interaction issues in the workplace more frequently than before. Four specific agendas can be brought up in the future workplace: defining the components of expertise in terms of human-robot interaction, coping with the organizational change process, designing appropriate interventions for an organization, and establishing the work ethics in the robotic age.

1. Defining the Components of Expertise in terms of Human-Robot Interaction

In the future workplace, interacting with robots will bring about each organization's redefinition of expertise in terms of working with robots. According to Swanson and Holton III (2001), human expertise is composed of three elements: knowledge, experience, and problem solving. Interacting with robots will change the previous landscape of expertise, which leads to modifications or additions to knowledge, experience, and problem solving.

This agenda is closely related to contemplating the relationship between technological innovation and management of human expertise. Specifically, organizational culture positively influences product innovation (임재현·신진교·황수정, 2012). Creating innovation-friendly organizational culture can be posited as constructing competitive organizational R&D system to encourage continuous innovation.

For example, if employees are routinely working with robots, they are required to be familiar with the interaction with robots in addition to their domain-specific knowledge. In this case, people cannot help but face this inevitable question about working with robots: Are they colleagues or tools? This question will be an evolving issue for each organization using robots. Some organizations will promptly include the knowledge of human-robot interaction as more obvious kinds such as procedural or formal knowledge. On the other hand, other organizations tend to regard the knowledge of human-robot interaction as the less obvious kinds such as informal, impressionistic, and self-regulatory knowledge. Of course, determining which is the best fit for human-robot interaction depends on the organizational contexts and characteristics based on each unique R&D system.

Likewise, interacting with robots will influence the components of experience and problem solving within organizational R&D system. How smoothly employees interact with robots will be one of the important standards for measuring employee performance. In this respect, as time goes on, organizations will be likely to combine domain-specific experience or problem solving with effectiveness of working with robots even though these components were differentiated at the beginning of the robots' introduction.

2. Coping with Organizational Change Process

Using robots will be a kind of experiment for both organizations and employees. At the introduction of the robots, it is hard to always guarantee the success of working with robots. However, at least, it is possible to analyze the expected outcomes of using robots. How organizations will cope with organizational change represented by the use of robots must be taken into consideration.

Watkins and Marsick(1993) offered a definition of change that speaks to the means by which change occurs: "Change is a cyclical process of creating knowledge (the change or innovation), disseminating it, implementing the change, and then institutionalizing what is learned by making it part of the organization's routines" (p. 21). Likewise, Beckhard and Pritchard(1992) asserted that learning and change processes are part of each other. In other words, change is a learning process and learning is a change process. These definitions remind us that change always involves learning. Besides, this fundamental relationship points out why change is one of the core constructs for the discipline of human resource development (Swanson & Holton III, 2001).

On the other hand, previous research shows that environmental uncertainty has facilitated innovation (송경수·김혜정, 2005). In other words, organizations surrounded by stable environments are not likely to feel the need to take a risk for innovation. However, even though environmental uncertainty is helpful to motivate innovation, 'managing' environmental uncertainty is still important as establishing future strategies is critical to make decisions on organizational changes.

Before organizations begin to use robots, therefore, it is necessary to evaluate the readiness to change by collecting empirical data. In fact, experiencing the resistance to change is a natural phenomenon when organizations try to implement a new strategy. In order to make an effective change, recognizing the causes of resistance is a necessary step for understanding the organizational change. According to Piderit(2000), resistance to change consists of three dimensions: cognitive beliefs about the change; emotional (affective) feelings in response to change; and behavioral actions in response to change. Because this three-part view of resistance may not be consistent on all three dimensions, a person may experience the conflicts (Piderit, 2000). For example, a person may believe change is needed but may still fear it. Or, a person may not believe in it and fear it, but act as if in support of the change. According to Piderit(2000), this kind of ambivalence may be more widespread during change than is acknowledged. In this respect, conducting an organizational assessment is an effective way to more clearly recognize the ambivalence and complexities of organizational change.

Besides, empirical organizational assessment is a useful method to minutely observe and analyze various technologies-in-practice resulting from the use of robots. In fact, an assessment can confirm or reject the presenting problems (McLean, 2006). Namely, some work practices related to the technology can be proven to be critical to readiness or resistance to organizational change. Other practices can be proven to be trivial to the organizational change, although they may appear important to people. HRD professionals will be required to deal with evaluating the importance of each practice while conducting empirical organizational assessments. Collecting various practices and evaluating them will be a foundational task for understanding organizational implications of human-robot interaction.

3. Designing Appropriate Interventions for an Organization

The term *intervention* refers to a set of sequenced planned actions or events intended to help an organization increase its effectiveness (Cummings & Worley, 2005). According to Cummings and Worley(2005), three major criteria define an effective intervention: the extent to which it fits the needs of the organization; the degree to which it is based on causal knowledge of intended outcomes; and the extent to which it transfers change-management competence to organization members.

Generally, two major sets of contingencies that can affect intervention success have been discussed: those having to do with the change situation and those related to the target of change (Cummings & Worley, 2005). Both kinds of contingencies need to be considered in designing interventions. In fact, understanding the contingencies is strongly related to recognizing the priorities among various work practices related to the technology. Deciding on critical practices depends on how people are aware of the importance of a number of contingencies.

For example, HRD professionals need to consider both the change situation and the target of change. Several situation factors have to be examined and organizational issues also have to be analyzed. According to situational factors and organizational issues, the types of interventions will be selected differently. After the organizational assessment, HRD professionals should be able to decide which interventions are effective to improve their conditions. Of course, an assessment will be able to first allow the organization to prioritize areas that have the potential for improving the organization.

In order to design better organizational interventions, just containing lots of resources for innovation does not matter oftentimes. Rather, effectively combining physical, HR, financial, and organizational resources with each other is important although given resources are not abundant (정동섭, 2010). Therefore, suggested interventions should be able to start from the point where synergy effects among organizational resources can be maximized.

When it comes to working with robots, there are a lot of concerns related to job stability of human employees. If robots excel the capability of human employees, people might lose their jobs. It is true that anxiety toward job insecurity prevents employees concentrating on their work, which causes productivity loss. In this respect, organizational interventions first need to target transparent communication about job stability between employers and employees. Secondly, within an organization, job redesign and/or transfer avoiding the work repetition between robots and humans needs to be performed more frequently and more systematically than past and now. Thirdly, measuring the progress and the effects of practicing organizational interventions is important for potential empirical research.

4. Establishing the Code of Work Ethics in the Robotic Age

Professional service robots work for humans in the workplace. In the future, many people will commonly work with professional service robots. Besides, robots will intellectually and emotionally evolve as time goes on. It implies that people will be required to cooperate with robots and/or to compete with them. Regarding the identity of the robots, people might be confused or embarrassed because they would not exactly know how to define this kind of human-like creature.

According to Shibata and Tanie(2001), methods of human-robot interaction can be classified into two categories in terms of duration of interaction: short-term interactions and long-term interactions. When people interact with a robot at an exhibition or a similar event, the appearance of the robot has a large influence on the subjective interpretation of the behavior of the robot (Shibata, 2004). However, in a long-time interaction, it is important that the robot has some learning function to prevent the human from becoming bored with the interaction (Shibata, 2004). If the robot always displayed the same reaction or behavior during these interactions, the human would soon become bored with the robot.

Robots used in the workplace will usually involve long-term interaction. Unlike short-term interaction, people are required to continuously interact with the robot in order to achieve a professional purpose. Although the purpose of the interaction is not for fun, it is critical to consider how to stimulate people's motivation to interact with the robot. If the robot encourages people to make new patterns of thought or behavior, working with the robot will be more enjoyable to human workers.

On the other hand, long-term interaction, at the same time, would result in the serious abuse of robots and artificial agents by human. There is already empirical evidence that various forms of mistreatment of robots by humans will be common. This behavior can be aggravated by the provision of anthropomorphic interfaces (De Angeli, Brahnam, & Wallis, 2006) or by placing the robot into an intimate setting (Fogg & Tseng, 1999).

Regarding the ethical debate about the abuse of robots, Whitby(2008) raised interesting questions: "To what extent do we consider it acceptable to deliberately mistreat artifacts, particularly substantially human-like artifacts?"; "To the degree that we find deliberate mistreatment of robots morally unacceptable, what ethical limits can we justly place on such behavior?"; "Are these essentially a new set of ethics, or familiar ethics applied to this field?" (p. 329).

Of course, these ethical problems first need to be considered for the designers of robots and intelligent systems. However, governments, their appointed agents, legal opinion formers, and moral opinion formers also have responsibilities in this area because they are in charge of the real problem solving related to the ethical consequences of the use of robots.

At the same time, within an organization, HRD professionals need to be aware of the ethical issues arising from the use of robots. For example, working on the ethical questions Whitby(2008) suggested will be an important assignment for HRD professionals who are responsible for employee training and development. Besides, as robots will intelligently evolve, HRD professionals will be required to deal with equity issues between robotic workers and human ones. It implies that HRD professionals will need to contribute to creating an ethical business culture in the robotized workplace. Therefore, it is necessary to begin to contemplate the plausible ethical issues from now on in order to keep up with the speed of the robotic technology development.

Ⅳ. Conclusion

Throughout this article, I have discussed how organizations need to perceive the role of robots and what they should do to be ready for working with robots. Although it is true that current artificial intelligence does not excel human brain, it is plausible that robots equipped with more sophisticated and creative artificial intelligence will work with human workers in the future.

On the other hand, as one of new technologies, robots can be a daunting challenge to humans, particularly in case humans are not able to cope with the side-effects of working with robots. With regard to dealing with side-effects, the suggested HRD implications of human-robot interaction in this paper aims at preventing or minimizing the side-effects of robotization.

It is impossible to stop the progress of scientific technology as well as to go back to primeval age. If so, we need to persue the peaceful coexistence with technologies by understanding potential issues and problems human-robot interaction in workplace. Even though the recommended HRD implications given in this article is one of assignments for organizations, I believe this small step can contribute to the assistance for organizations to work with robots.

References

1. 송경수 · 김혜정(2005), “개인혁신과 조직혁신의 이슈에 관한 연구,” *경영정보연구*, 16, 59-76.
2. 임재현 · 신진교 · 황수정(2012), “대구지역 중소기업의 조직문화와 기술혁신: 고용안정성과 환경불확실성의 조절효과,” *경영정보연구*, 31(1), 183-203.
3. 정동섭(2010), “정보기술기업의 역량, 경쟁전략 및 성과의 관계,” *경영정보연구*, 29(4), 287-304.
4. Beckhard, R. & Pritchard, W.(1992), *Changing the essence: The art of creating*

and leading fundamental change in organizations. San Francisco: Jossey-Bass.

5. Begun, J. W.(1994), "Chaos and complexity: Frontiers of organization science," *Journal of Management Inquiry*, 5(1), 329-335.
6. Berquist, W. (1993), *The postmodern organization: Mastering the art of irreversible change*. San Francisco: Jossey- Bass.
7. Bijker, W. E. & Law, J. (1992), *Shaping technology/building society: Studies in socio technical change*. Cambridge, MA: MIT Press.
8. Brown, A. S.(2010), "Techfocus: Materials and assembly," *Mechanical Engineering*, 132(1), 16-18.
9. Burns, T. & Stalker, G. M.(1961), *The management of innovation*. London: Tavistock.
10. Burnstein, J.(2010, June 2), Robots can create jobs, *Business Week*, p.2.
11. Capra, F.(1982), *The turning point*, London: Flamingo.
12. Child, J.(1972), "Organizational structure, environment, and performance: The role of strategic choice," *Sociology*, 6, 1-22.
13. Child, J.(1997), "Strategic choice in the analysis of action, structure, organizations and environment: Retrospect and prospect," *Organization Studies*, 18(1), 43-76.
14. Cummings, T. & Worley, C.(2005), *Organization development and change*. Ohio: Thomson South-Western.
15. De Angeli, A., Brahnam, S., & Wallis, P. (2006), "Misuse and abuse of interactive technologies," *Proceedings of CHI'06*, Canada, 89, 1647-1650.
16. Fogg, B. J. & Tseng, H.(1999), "Theelements of computer credibility," *Proceedings of CHI'99*, 82, 80-87.
17. Friedman, B., Kahn, P. H., & Hagman, J. (2003), "Hardware companions? What online AIBO discussion forums reveal about the human-robot relationship," *Proceedings of the CHI 2003 Conference on Human Factors in Computing Systems*, New York, 273-280.
18. Garcia, E., Jimenez, M.A., Santos, P. G., & Armada, M.(2007, March 20), "The evolution of robotics research: From industrial robotics to field and service robotics," *IEEE Robotics. and Automation Magazine*, 14(1), 90-103.
19. Green, S., Billinghurst, M., Chen, X., & Chase, G.(2008), "Human-robot collaboration: literature review and augmented reality approach in design," *International Journal of Advanced Robotic Systems*, 5(1), 1-18.
20. Forlizzi, J., DiSalvo, C., & Gemperle, F. (2004), "Assistive robotics and anecology of elders living independently in their homes," *Human-Computer Interaction*, 19, 25-59.
21. Forlizzi, J. & Mutlu, B. (2008), "Robots in organizations: The role of workflow, social, and environmental factors in human-robot interaction," *Proceedings of the 3rd ACM/IEEE International conference on Human-Robot Interaction*, The Netherlands, 3, 287-294.
22. Hollon, C. & Rogol, G.(1985), "Howrobotization affects people," *Business Horizons*, 28(3), 74-80.

23. IFR Statistical Department(2010), *World robotics 2010: Industrial robots*. Frankfurt: International Federation of Robotics.

24. JMA Research Institute(1983), *Robotization: Its implications for management,* Tokyo: Fuji Corporation.

25.. Kanda, T., Hirano, T., Eaton, D., & Ishiguro, H.(2004), "Interactive robots as social partners and peer tutors for children: A field trial," *Human-Computer Interaction*, 19, 61-84.

26. Kiesler, S. & Hinds, P.(2004), "Introduction to this special issue on human-robot interaction," *Human-Computer Interaction*, 19, 1-8.

27. Kuno, U. Sadazuka, K., Kawashima, M., Yamazaki, K., Yamazaki, A., & Kuzuoka, H.(2007), "Museum guide robot based on sociological interaction analysis," *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, San Jose, 1191-1194.

28. Lawrence, P. & Lorsch, J.(1967), *Organization and environment,* Cambridge, MA: Harvard University Press.

29. McDaniel, R. R. Jr. & Ashmos, D. P.(1986), "Strategic directions within health care institutions: The role of the physician," *Journal of the National Medical Association*, 78(7), 633-641.

30. McLean, G.(2006*), Organization development,* San Francisco: Berrett-Koehler.

31. Orlikowski, W.(2000), "Using technology and constituting structures: A practice lens for studying technology in organizations," *Organization Science*, 11(4), 404-428.

32. Perrow, C.(1967), "A framework for the comparative analysis of organizations," *American Sociological Review,* 32, 194-208.

33. Piderit, S. K.(2000), "Rethinking resistance and recognizing ambivalence: A multi-dimensional view of attitudes toward an organizational change," *Academy of Management Review,* 25, 783-794.

34. Plsek, P. (2001), Redesigning health care with insights from the science of complex adaptive systems. In *Crossing the quality chasm: A new health system for the 21st century* (pp. 309-322). Washington, DC: National Academy Press.

35. Scholl, B. J.& Tremoulet, P.(2000), "Perceptual causality and animacy," *Trends in Cognitive Science*, 4, 299-309.

36. Schoonhoven, C. B.(1981), "Problems with contingency theory: Testing assumptions hidden within the language of contingency "theory." *Administrative Science Quarterly,* 26, 349-377.

37. Shibata, T.(2004), "An overview of human interactive robots for psychological enrichment," *Proceedings of the IEEE*, 92(11), 1749-1758.

38. Shortell, S. M., Gillies, R. R., Anderson, D. A., Mitchell, J. B., & Morgan, K. L.(1993), "Creating organized delivery systems: The barriers and facilitators," *Hospital and Health Services Administration*, 38(4), 447-466.

39. Siino, R. & Hinds, P. (2005), "Robots, gender & Sensemaking: Sex segregations's impact on workers making sense of a mobile autonomous robot." *Proceedings of*

International Conference on Robotics and Automation, Spain, 49, 2773-2778.

40. Stacy, R. D. (1996), *Complexity and creativity in organizations*. San Francisco: Barrett-Koehler.
41. Starkweather, D. & Cook, K. S. (1988), Organization - environment relations. In S.M. Shortell & A.D. Kaluzny (Eds.), *Health care management: A text in organization theory and behavior (2nd ed.)* (pp. 352). Washington, DC: Natural Academy Press.
42. Swanson, R. & Holton III, E. (2001), *Foundations of human resource development*. San Francisco: Berrett-Koehler.
43. Thompson, J. D. (1967), *Organization in action*. New York: McGraw-Hill.
44. Thrun, S. (2004), "Toward a framework for human-robot interaction," *Human-Computer Interaction*, 19, 9-24.
45. U.N. & I.F.R.R. (2002), *United Nations and the International Federation of Robotics: World robotics 2002*. New York and Geneva: United Nations.
46. U.N.E.C.E. & I.F.R. (2005), *World robotics 2004: Statistics, market analysis, forecasts, case studies and profitability of robot investment*. New York and Geneva: United Nations Publications.
47. Vaill, P. B. (1989), *Managing as a performing art: New ideas for a world of chaotic change*. San Francisco: Jossey-Bass.
48. Watkins, K. E. & Marsick, V. J. (1993), *Sculpting the learning organization: Lessons in the art and science of systematic change*. San Francisco: Jossey-Bass.
49. Wheatley, M. J. (1992), *Leadership and the new science: Learning about organization from an orderly universe*. San Francisco: Berrett-Koehler.
50. Whitby, B. (2008), "Sometimes it's hard to be a robot: A call for action on the ethics of abusing artificial agents," *Interacting with Computers*, 20(3), 326-333.
51. Woolgar, S. (1991), "The turn to technology in social studies of science," *Science Technology & Human Values*, 16(1), 20-50.
52. Zimmerman, B.J. (1992), The inherent drive toward chaos. In A. Van de Van, P. Lorange, B. Chakravarthy, J. Roos (Eds.), *Implementing strategic processes: Change, learning, and co-operation* (pp. 373-393). Oxford, UK: Blackwell.

Abstract

조직 내 로봇 기술의 사용에 관한 HRD 함의

허세진*

본 연구는 일터에서 사용되는 로봇의 HRD 정책적 함의에 대해 고찰하고 있다. 기존 연구들은 로봇의 기술적 측면을 주로 다루고 있기 때문에, 본 연구는 일터에서의 로봇 기술의 한계와 가능성을 사회문화적 측면에서 이해하기 위해 쓰여졌다. 특히 로봇과 함께 일하는 데 있어 가장 적합한 조직 차원의 지원 방안을 찾기 위해 일터에서의 로봇-인간 간의 상호작용을 관찰하는데 필요한 대안적인 관점을 제시하고 있다. 그와 함께 본 연구는 HRD 실천적 연구를 위한 로봇 기술의 함의를 다음과 같이 제안한다. (1) 인간-로봇 간 상호작용과 관련된 전문성의 요소들을 정의하는 것 (2) 기술 도입으로 인한 조직 변화 과정에 대처하는 것 (3) 로봇 기술에 적응하기 위한 조직 개입 방안을 계획하는 것 (4) 로봇과 인간이 함께 일할 때 필요한 직업윤리를 수립하는 것. 본 연구에서 제시된 로봇 기술의 함의들은 향후 일터에서의 로봇 기술 사용과 관련된 양적, 질적 사회과학 연구의 개념적 프레임워크를 수립하는 데 기여할 수 있을 것으로 기대된다.

핵심주제어: 일터에서의 로봇 기술, 로봇화의 HRD 함의, 로봇 기술에 대한 사회문화적 접근, 새로운 기술에 대한 조직의 지원

* 동의대학교 시간강사, trinityh@naver.com