Technology in Society 47 (2016) 129–139

Contents lists available at ScienceDirect

Technology in Society

journal homepage: www.elsevier.com/locate/techsoc

Leapfrog skills: Combining vertical and horizontal multi-skills to overcome skill trade-offs that limit prosperity growth

Stephen Fox

VTT, Technical Research Centre of Finland, Vuorimiehentie 3, Espoo 02044, Finland

ARTICLE INFO

Article history:
Received 20 May 2016
Received in revised form
26 September 2016
Accepted 15 October 2016
Available online 15 October 2016

Keywords:
Skills
Craft
Industrial
Knowledge
Multi-skills
Leapfrog

ABSTRACT

Leapfrog technologies, such as off-grid solar energy, overcome traditional trade-offs including widespread geographical distribution versus huge capital investment. The positive potential of leapfrog technologies is widely recognized. However, the need to overcome traditional skill trade-offs has received less consideration. Rather, skills continue to be considered in terms of the boundaries of crafts and professions, which evolved in the past within historical constraints. Yet, skills within established crafts and professions are limited by trade-offs, such as productivity versus versatility, which can limit prosperity growth. In this paper, findings are reported from a study investigating how limiting trade-offs can be overcome. The study encompassed craft skills, industrial skills, and knowledge skills. It is explained that trade-offs can be leapfrogged by combining hitherto separate skills within vertical multi-skills and horizontal multi-skills. Vertical multi-skills can enable increased productivity and consistency through increasing predictability by, for example, application of process design. At the same time, horizontal multi-skills can increase versatility through working across traditional skill boundaries. Methodologies and technologies available to facilitate the combination of vertical multi-skills and horizontal multi-skills are described. It is explained that facilitating their application requires thinking about skills less in terms of traditional crafts and professions, and more in terms of specialization, localization, rationalization, and democratization. Overall, it is argued that combining vertical multi-skills and horizontal multi-skills can leapfrog traditional skill trade-offs that limit prosperity growth.

1. Introduction

Studies from many different parts of the world indicate that increasing skills can increase prosperity growth across entire nations [1–5]. Previous studies have related skills development to craft work, industrial work and to knowledge work [6–14]. All these types of work have potential to contribute to prosperity growth. For example, craft skills are useful in the assembly and fixing of complicated components in-situ. Industrial skills are useful, for example, in production requiring clean environments such as those including micro-electronics. Knowledge skills are useful in the design and engineering of goods. Hence, all three types of skills can contribute to prosperity growth.

The focus of the study reported in this paper is production skills for enablers of prosperity growth including: sustainable energy generation (e.g. fabricating solar arrays); water capture, storage and supply (e.g. constructing water towers); facilitating soil health (e.g. erecting windbreaks); sanitation and waste management (e.g. constructing septic tanks); building construction (e.g. construction of dwellings); machine building (e.g. fabrication of packaging waste compressors); food processing (e.g. conversion of crops into foodstuffs); social goods (e.g. making prosthetics); and consumer goods (e.g. making apparel).

The research question addressed by the study is how can skills be restructured to leapfrog skills trade-offs, such as productivity versus versatility? The following researcher background over more than thirty years informed the study: completing a craft apprenticeship; instructing craft skills; carrying out manufacturing work; teaching manufacturing; carrying out design engineering; lecturing in design engineering. Research to inform the study included two years of investigation into the state-of-the-art in the communication and acquisition of skills with ten organizations providing skills training at training centers in the United States of America, and with seventeen companies providing some training at the workplace Finland (one), Italy (three), Japan (six), and South Korea (seven). This was followed by three years of survey research with

E-mail address: stephen.fox@vtt.fi.

http://dx.doi.org/10.1016/j.techsoc.2016.10.001

diaspora associations for the Horn of Africa and West Africa. Thirty-one interviews were carried out with an average duration of half an hour. The informant style of unstructured interview was used [15]. Questions were concerned with practice: in particular, the current provision of skills training and future needs. The interviewer did not seek to control the interviews. Rather, interviewees freely expressed their thoughts and took the interviews in the direction that they chose. This type of unstructured interview can be contrasted to the respondent style of unstructured interview where the interviewer seeks to follow a more defined agenda [15].

The remainder of the paper comprises five sections. In the following section, fundamental characteristics of skills are explained in terms of craft work, industrial work, and knowledge work. Then, criteria are defined for leapfrogging skills trade-offs. Next, resources available for leapfrogging skill trade-offs are described. Subsequently, a planning framework is introduced for leapfrog skills. In conclusion, principal contributions are summarized.

2. Fundamental characteristics of different skills

In this section, an analysis is presented of fundamental characteristics of skills in craft, industrial, and knowledge work. For each of these types of work, the following characteristics are considered: capital costs, acquisition speed, productivity, consistency, versatility, and longevity.

2.1. Craft work

Capital costs for craft skills can be relatively low, as they may require investment in only hand tools. However, a lengthy investment of time can be required, with craft skills taking years to acquire, for example, during an apprenticeship. This is because their acquisition involves trying to learn how to carry out a wide range of tasks, which involves many different materials and many different tools in many different situations to make many different types of goods with many different specifications. Some of these combinations of materials, tools, situations, and goods may occur once during an apprenticeship and then not again for many years. Conversely, many of these combinations of materials, tools, situations, and goods may never occur during an apprenticeship. Furthermore, there is unpredictable variation in the characteristics of materials, tools, situations, and specifications. Hence, while craft skills can be versatile in dealing with unpredictability, the same unpredictability can lead to low productivity and consistency at locations where craft skills are prevalent such as construction sites [16].

Here, consistency refers to conformance to specification. So, for example, what is produced always conforms to the specified height, width, depth, surface finish, functional performance etc. In other words, consistency refers to what is produced having exactly the specified qualities every time that it is produced [17].

The versatility of craft skills is not necessarily versatility that adds value, but rather versatility that has evolved ad hoc to try to cope with non-value adding unpredictable variations in work tasks and processes. As result, training for traditional craft skills can be challenging. This is because of the difficulty of providing instruction and feedback in how to deal with the wide range of unpredictable variations that may be encountered in traditional craft skills [18,19].

Low productivity and consistency of craft skills has led to many efforts to replace them with industrial practices. Where it is has not been possible to replace them fully in the production of large engineer-to-order capital goods, such as buildings and ships, craft skills are long lasting: with persistent demand for production practices that have remained much the same for decades. Thus, the versatility of traditional craft work may not be long-lasting because it is value adding versatility. Rather, it can be long-lasting because of the difficulty of replacement with value adding industrial practices, which are based on the standardization of work practices within factory environments [20].

2.2. Industrial work

Capital costs for industrial skills can be extremely high when they are applied in conjunction with industrial plant such as assembly lines. However, initial industrial skills can be acquired in a few hours. This is because industrial companies apply techniques such as task analysis and job design to minimize the unpredictability of work. Task analysis involves definition of mental and physical steps in performing a task [21]. Then, these steps are rationalized systematically to reduce their number and their variation. This is achieved through methods such as jigs, design for manufacture and assembly (DFMA), and visual control. Jigs and other forms of physical templates are used to ensure consistent positioning of work pieces, and/or motion of tools during production [22]. DFMA involves applying design principles to enable anybody to carry out assembly correctly and quickly [23]. Visual control involves pictorial instructions that do not rely on words for the communication of meaning [24]. Application of such techniques results in the replacement of task complexity with task simplicity. This, in turn, can enable industrial organizations to achieve high productivity and highly consistent conformance to specifications wherever they set-up production.

An individual's capacity to undertake an increasing number of tasks can be enabled through job design. This involves defining relationships of tasks in order to expand work range. Thus, a person can learn very quickly how to execute one designed task to a high standard. Then, that same person can learn quickly how to execute a second designed task to a high standard, and so build up a repertoire of skills while achieving high performance from the outset [25]. Nonetheless, compared to the broad versatility of craft skills, industrial skills are limited to the particular type of goods that jobs are designed for, such as particular stages of car assembly. Moreover, industrial skills can be useful for much less time than craft skills. If a car assembly plant shuts down, for example, in favor of relocating production to a lower cost country, then factory workers may find themselves with skills that are no longer useful.

2.3. Knowledge work

Capital costs for knowledge work are reduced through continual innovations in information and communication technologies (ICT). Yet, skills for knowledge work can take years to acquire [11]. Massive Open Online Courses (MOOCs) introduce the possibility of increasing access to, and accelerating, education for knowledge work. Yet, thus far, MOOCs have been used mostly by people in rich countries who already have a high level of education [26]. Long preparation may be worthwhile if knowledge work has more potential than craft work and industrial work to raise individuals' standard of living and lift countries out of the middle-income trap [5,8]. On the other hand, if individuals and countries are more in need of basic physical infrastructures for water supply, soil health, sanitation systems, energy generation, food production, etc., then skills for knowledge work in offices using computers may be of limited usefulness. As a result, graduates can find themselves "over educated" and unemployed [27].

An alternative to long years of study to prepare for knowledge work is for people to receive short training to undertake one type of computer task. Then, for the person's repertoire of task skills to be added to one task at a time. This approach, which is a similar to task