Chapter 8

Renewing a University to Support Smart Manufacturing Within a Region

Heikki Ruohomaa, Mikko Mäntyneva and Vesa Salminen

Additional information is available at the end of the chapter

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Abstract

This chapter focuses on the topic of renewing a university in order to be able to support the adaptation of smart manufacturing and Industry 4.0 within a region. The chapter introduces Industry 4.0 as a framework for regional development. Factors related to Industry 4.0 related renewal in the region are identified and discussed further. An idea of how to apply Industry 4.0 as a framework for renewal of a multidisciplinary university's structure and curricula is introduced. Also, a case study for applying Industry 4.0 as a framework for increasing competitiveness in the region is introduced.

Keywords: Industry 4.0, smart manufacturing, regional development, university

1. Introduction

The chapter is closely linked to Industry 4.0 framework. The geographic focus, while developing this chapter further, is the region of Häme in the southern part of Finland. The various activities within the region are evaluated from the perspective of smartness and their ability to support Industry 4.0 framework, as well as the renewal of operations in the region.

The development of competitiveness of the region, while maintaining and developing it as an attractive location for companies requires, co-operation between various stakeholders. Industry 4.0 can be applied as a framework for regional development. Universities have a major task to support competence development of relevant topics in various fields. In the field of manufacturing industry, the Industry 4.0 is increasingly relevant topic and the universities should identify their role to support local industry in its adaptation.

2. Industry 4.0 as a framework for regional development

The term "Industrie 4.0" was initially originated in Germany [1]. Industry 4.0 is a policy framework that defines and describes how new technologies should be adopted to renew manufacturing. The renewal is expected to bring major boost in competitiveness. It provides the framework for different kinds of policy initiatives. From the regional development perspective it can also be used as a guideline for steering research and development activities [2].

Industry 4.0 describes how machines, and other technologies adapted in manufacturing communicate with each other. The major importance is on a networked perspective, i.e., how different companies within a value chain communicate each other. The intention is such that computerized systems control and monitor physical processes. Industry 4.0 takes manufacturing-related industries to the next level in adapting and utilizing digitization. In networked environment machines and physical objects are linked with each other. This allows decentralized production and real-time adaptation to the changes on the level of demand in the future [2].

The characteristics of Industry 4.0 is that it promotes computerization of manufacturing. Industry 4.0 is closely linked to Cyber-Physical Systems (CPS) [3]. They can be defined as transformative technologies which manage interconnected systems between its physical assets and computational capabilities [4]. We are increasingly using the concepts of the Internet of Things, the Internet of Everything and the Industrial Internet. The widespread adoption of information and communication technology (ICT) is increasingly accelerating and blurring the boundaries between the real physical world and the virtual one. The linkage is becoming increasingly smart [5].

Industry 4.0 is made possible through the development of the industrial Internet of Things [4]. New ICT-related technologies make Industry 4.0 development possible and give opportunities to re-engineer value chains and create new business models. Internet of Things (IoT) is one of the core technologies for Industry 4.0. The growth of connections brings the new possibilities and solutions for business. On the other hand, exponential growth brings also new challenges for education, R&D&I, and regional development activities. The exponential growth of IoT connections indicates the birth of new business models and new kind of business environments. This "smartness" requires greater connection and collaborations. This is where the "explosion" of platforms and ecosystems is occurring. An attempt to connect the Internet of Things, services, data, and people need radical redesigns within industries and the participants to connect up this all. Presently, Industry 4.0 is more industrial driven, but this will change and broaden out [6].

Industry 4.0 is about increasing productivity and competitiveness. One perspective how this increase in productivity takes place is increase in the efficiency and speed of processes within a company or a value network. Basically, utilization of Industrial Internet makes it possible to optimize the activities and resource utilization in entire value network. Also, material and energy efficiency can be improved, which is important from the perspective of sustainable operations. Large sets of accumulated and real-time data can be applied to forecast or process development purposes. In addition, digitization provides opportunities for new start-ups and may create further prosperity [1].

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Digitalization will bring new business opportunities and increasing competition. Companies are forced to renew their processes and activities, and at the same time restructure their business processes and models. Regions and areas are forced to plan and redesign services in their business environments as well. In order to see the development needs for attractiveness and welfare, but also to use the development resources in the best possible way, the key research questions related to this paper are:

1. How Industry 4.0 could be used as a framework for regional development?
2. What are issues affecting competitiveness of regions?
3. How structure and curricula of university could be renewed in order to support adaptation of Industry 4.0 in the region?
4. What issues to consider while applying Industry 4.0 to increase competitiveness of a region?

The changes created by Industry 4.0 are not only technological but also organizational [7]. More network-oriented operations are emphasized instead of a perspective of one single economic unit like one factory. The competence development activity, that is required to fully internalize Industry 4.0, is a major task. It should be implemented both on the societal level implemented for example by higher education institutions as well as on private enterprises. It is possible that productivity improvement perspective, which on the short to medium term, may lead to layoffs of workers regarding their current work positions is not necessarily welcomed by representatives of trade unions. However, on longer time frame, the competiveness of European manufacturing-related industries is beneficial for all members of the society [1].

3. Adaption of new technologies supporting Industry 4.0

It is assumed that European manufacturing industry has to radically renew itself. Industry 4.0 provides guidelines on how to make this renewal ambition a reality. The adaptation of new technologies that can be interconnected provides major opportunities. While large-scale utilization of sensors that are connected by wireless networks as well as further adapting robotics provide potential to gain major leaps in productivity. Analytical methods that can be utilized on big data provide further insights on managing a network of producers and suppliers. Mass customization becomes a reality. The overall productivity increase is due to increased speed, improved quality, better utilization of existing resources, and so on. However, the manufacturing firms should be prepared to make required investment on both hardware (equipment and computers) as well as on software (competence development and applications) [8].

Digitization is an increasingly relevant option while companies are trying to renew themselves and their operations to remain competitive. However, digitization is not only a short-term project; it is a long term transformation that should be lead. The leadership perspective is very important in this change management initiative. Such technologies like cloud computing, wireless networks, and big data can be adapted. However, the main question remains,

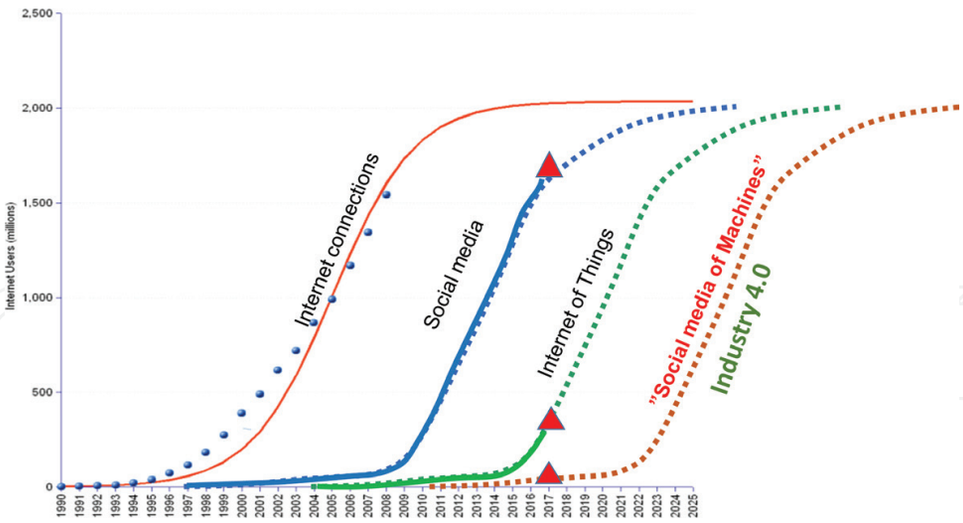

Figure 1. Rapid adaptation of new internet-related technologies.

what changes are about to happen in our industry or value network and how applying digitization makes it possible to remain competitive and even further increase competitiveness.

The development of new technologies not only causes major changes and transformations, but also provides plenty of opportunities for exploitation of sustainable, residential, and residential-oriented urban centers and environments. The subscriptions to the Internet (IoT) alone will rapidly multiply in the years to come. This development affects traffic, travel chains, housing for commerce, welfare, healthcare, tourism, services, industry, etc. This development of new Internet-related technologies described in **Figure 1** places urban development and development principles into a new perspective.

Training, development, innovation, and testing can no longer take place in a separate and closed laboratory environment, but to be able to create sustainable innovations education and development activities must be brought into an operating environment where residents, non-governmental organizations, political decision-making, civil servants, and students meet with regional development and different disciplines. The urban infrastructure is a part of the innovation-based ecosystems of different actors that produce new innovations at their interface.

4. Competitiveness of regions

Private organizations are doing their best to be more profitable and they are open to new ideas. That is why companies are actively starting to use new technologies and trying to find the most suitable business environment for their locations. At the government, region, and town level, the situation is quite different. Their task is not to make business, but to develop good and fruitful business environments for companies. Building infrastructure, providing a skilled labor force, etc., have been their main tasks.

By identifying the key factors for the Industry 4.0 related renewal, we will find different factors, i.e., "levels." These are described in **Figure 2**.

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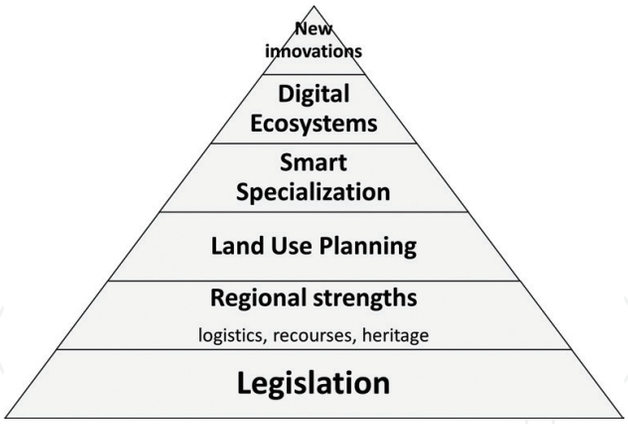

Figure 2. Factors affecting Industry 4.0 related renewal.

4.1. Legislation

Legislation is the very first level that we can see as the driver of development. At this level, we should understand that legislation should not be considered as an actor, which regulates/limits (actions), but legislation makes new kinds of business possible and supports business development. Generally, we can understand that legislation gives "the rules of the game" and this way makes business environments more predictable with less business risks. Legislation also gives the framework for operations like recycling, land use, and new business models, but also taxation decisions might encourage new businesses. EU legislation gives the framework for legislation but still there is national legislation, which steers local business and industry.

4.2. Land use

We have industrial/logistics areas where companies are located. Usually, the industrial areas have developed and profiled themselves based on the strengths in the local region like logistic connections, population, energy, raw materials, knowhow at universities, skilled labor force, and so on. The question will be: how should we plan land use (business/logistic areas) so that companies would be able to create a fruitful business ecosystem, efficient material use (circular economy), and minimize logistic expenses. This is usually a long process and the steps are not known accurately.

4.3. Regional strengths

We have industrial/logistics areas where companies are located. Usually, the industrial areas have developed and profiled themselves based on the strengths in the local region (like logistic connections, population, energy, raw materials, knowhow at universities, and skilled labor force).

4.4. Enterprise ecosystem

There are clear indicators that short distances will improve co-operation between companies. In the case of material and economic efficiency, short distances give savings in logistic expenses.

4.5. History

Every region and business has its own history and traditions, which makes it challenging to introduce new ideas makes it more difficult to manage change.

5. Renewal of university structure and curricula to support adaptation of Industry 4.0 in the region

One important role for universities is to support enterprises by applied research and creation of research and learning environments for continuous piloting of new technologies and preparation of new business models on Industry 4.0. It is not self-evident that representatives of government, enterprise, and universities collaborate with each other. It would be beneficial to support regional development while building up competence through shared projects and development activities. Digitization provides a large variety of opportunities. The question remains are we competent enough to utilize these opportunities. A close co-operation makes it possible to build a shared vision, which guides the further development work. This is important so that all the existing and available development resources could be aligned.

Quite often, it is expected that public sector organizations take care of the development of infrastructure and business environments. However, it is possible that the public sector organizations are not aligned with each other. Some of them may represent national perspective, while some are have a more local orientation. Also, there may still be other organizations, whose duty is to develop business environment. All the layers and activities should be along the same line, support each other, and be sustainable in order to get the co-operative environment to function efficiently. In a rapidly changing operational environment, a clear and commonly understood vision is required.

Industry 4.0 and Internet of Things are new topics; and both enterprises as well as universities have a little experience on what kind of real benefits they may bring. Co-operation between private enterprises and universities has potential, but still many universities as well as companies are just taking their initial steps on this arena. Various areas of collaboration do exist both on a national as well as on an international level. User-driven innovations show lots of promise, and therefore universities should try to identify the real market or real users for the potential innovations. Companies themselves could serve as field labs. One challenge is the confidentiality of information. This should be respected while promoting co-operational learning on various aspects related to Industry 4.0. To be able to reveal the full potential of enterprise-university partnerships, the interaction should take place on all levels. Being able to help the other partner to achieve their goals is beneficial for all. Longer-term development projects require high quality and in-depth roadmaps that should be developed collaboratively. This increases trust and commitment for long-term co-operation. Concrete co-operation project could emerge on various research projects, thesis work on both undergraduate and graduate studies and so on. Different kinds of experiments and measurements related to them could be started. It is important to succeed in benefiting multidisciplinary competence and sharing information sharing openly.

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The vision and approach are based on the need of regional clusters and the strengths of a region (e.g., logistic, university, natural resources, etc.). Industry 4.0 development can be seen as a smart utilization of digitization, which has European level comparability to European development in all key clusters.

Contents of education and training will be designed so that content will respond the future needs. Learning will take place in "real world" environments (field labs), which gives faster cycle time for development activities and implementation. This is the way, how to ensure the birth of new innovations and the renewing the businesses and organizations. In universities, engineering students among others should be prepared to meet the demands of Industry 4.0 in order to be able to operate in future employment domains [9]. However, Industry 4.0 should not be linked to the competence requirements of only engineering students and thus future engineers. It is probable that Industry 4.0 affects largely the whole society, and therefore all the university students should be somehow involved with various perspectives of Industry 4.0.

Most regions do not have a strategy or analysis on aligning regional development and digitization. Häme region of Finland is designing its new strategy "Smart Häme" to respond the challenges of digitization and to be the part of Digital Single Market (DSM). Based on that, the focus is to increase the know-how on how to successfully apply digitization on Häme region. After a Smart Specialization analysis, five key ecosystems (clusters) were identified. These were expected to be the most critical for the development and attractiveness of Häme region (see **Figure 3**). These are the ecosystems, which also should have special attention and resource allocation, in development: "Smart Agriculture," "Smart City," "Smart Factory," "Smart Well-being," and "Smart Defense." The evaluation criteria, which were used to select the ecosystems

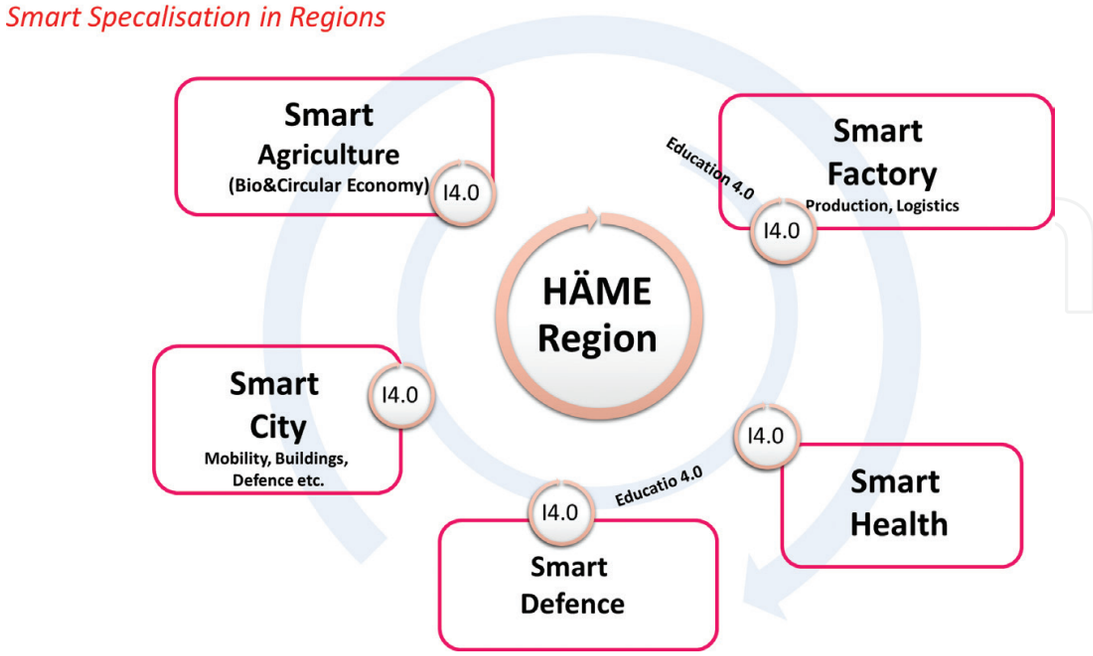

Figure 3. Häme region clusters/"Smarts."

in order to prioritize the development activities and resource allocation, were: size, know-how, importance, and versatility of the identified ecosystems.

"Smart Agriculture" was considered to be the strongest and most advanced, because of food processing industry, agribusiness, large education, and strong R&D activities in the region "Smart Agriculture" includes both BioEconomy and Circular Economy (bio) activities in the region.

"Smart Health" is the biggest expense in the cost structure of public services. Also, the amount of increasing elderly people and demand for better services emphasize a strong need to utilize the various opportunities of digital services. There are also many equipment and service providers in the region.

"Smart City" was also considered to be one of the key elements to improve the competitiveness of the region. There has been a clear understanding that digitization will change the planning of cities and the services in a city. The majority of services are probably in the densely populated urban areas in city centers. In Häme region "Smart City" includes also issues related to tourism, "Smart Mobility," "Smart Buildings," and "Smart Security."

"Smart Factory" has not been traditionally linked with services at all; but when we take a closer look at manufacturing industry, we will notice that lifecycle services might even play a bigger role than the production itself. Also, modern supply chains in the manufacturing industry have a strong and large service component. Regional development point of view is important to see that manufacturing itself creates new innovations and services.

The Smarts in the region and the ecosystemic choice to develop them are based on the region's own choices and intent. When defining the smarts, at least the following things should be taken into consideration: the strengths of the region, the competence (students and universities), the size, the intent, the development prospects, the history, the inheritance, the logistical position of skilled labor, prospects, and trends.

It is also important to understand the supporting nature of knowledge-intensive services in an increasingly digital world. This would better able the regional authorities and developers in co-operation with other actors to support the emergence of innovative ecosystems. Each smart must create its own "I4.0" renewal program, which creates a common vision, strategic steps forward and integration with the existing network organizations. **Figure 4** illustrates how the selected smarts are linked to university's faculties (schools) and research units.

Industry 4.0 focuses on the fourth major transition phase in an industrial partnership covering all industries and areas of life. The fourth stage of the transition is digitality and the development of information technology. Industry 4.0 provides a framework for development, development of architecture, and standardization, and hence functional compatibility. The development of Smarts (clusters) is based on a multi-disciplinary know-how, therefore universities must support development work in all the sectors they are implementing academic degree programs. The following topics ought to be taken into account while renewing university's structure and curricula.

5.1. Transdisciplinary approach

A transdisciplinary approach to research enables multidisciplinary outlook and understanding phenomena from various perspectives. This makes it possible to study complex systems and their interactions.

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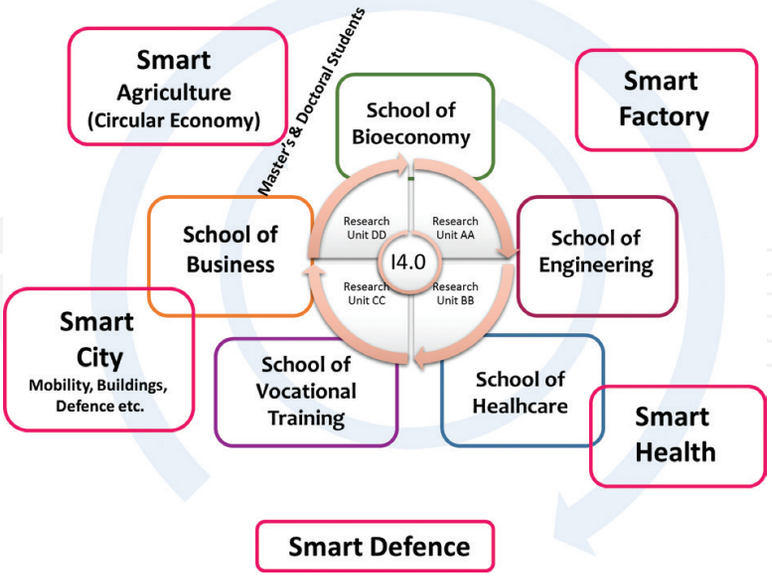

Figure 4. Integrating regional Smarts and university structure.

5.2. System design management

Digitality, multidisciplinarity, and the growing speed of change will result in increasing complexity, which is why the need for knowledge associated with managing complexity needs to be taken into account in education and development.

5.3. Smart specialization

Digitization provides the ability for data collection, rapid transfer, and processing. Various activities create new kinds of networks around them. For this reason, entities should be considered as digital ecosystems, which form efficient value chains and thus support creating new customer-focused products and services.

5.4. Field labs

The real-life learning environment is based on training, research, testing, and piloting environments. Multidisciplinary, complex, and fast changing things need "real-life" environments, where new things can be learned, adapt rapid methods for developing new products and services, and thus enable innovation to emerge.

5.5. Innovations

There are opportunities for new innovations that arise from different disciplines, customer interfaces, digital ecosystems, etc.

5.6. Organizational culture

The introduction of new approaches will also require the systematic development of a new organizational culture and a strong vision of the goals regarding the renewal.

6. Applying Industry 4.0 as a framework for increasing competitiveness in the region

Attractiveness from various perspectives is important so that region would be seen as an interesting and innovative environment. On the other hand, cities and public organizations (for example, hospitals, military bases, elderly houses, schools, parks, etc.) are using tax money for maintaining the welfare and provide services for people and organizations in the region. Based on that background, it would be justified that public organizations would be acting as "platforms" for different actors. This would allow testing their activities and products in "field labs" where education, research, and testing would take place in the same multidisciplinary environment.

We recommend that Industry 4.0 would be used as a transdisciplinary framework supporting a development of local service ecosystem. Since Industry 4.0 is a European concept and part of European platform, it is proposed that best practices will be benchmarked into European approach and experiences.

The key elements to designing the Local Service Ecosystem for Industry 4.0, are:

- "Smart development areas": to recognize the potential "smart" clusters on the region/area
- Vision: create the goal and vision for regional development based on "Smart" clusters
- "Field labs": make public sector organizations, cities, companies and universities to work together and create "real life learning" environment (field labs) in clusters.

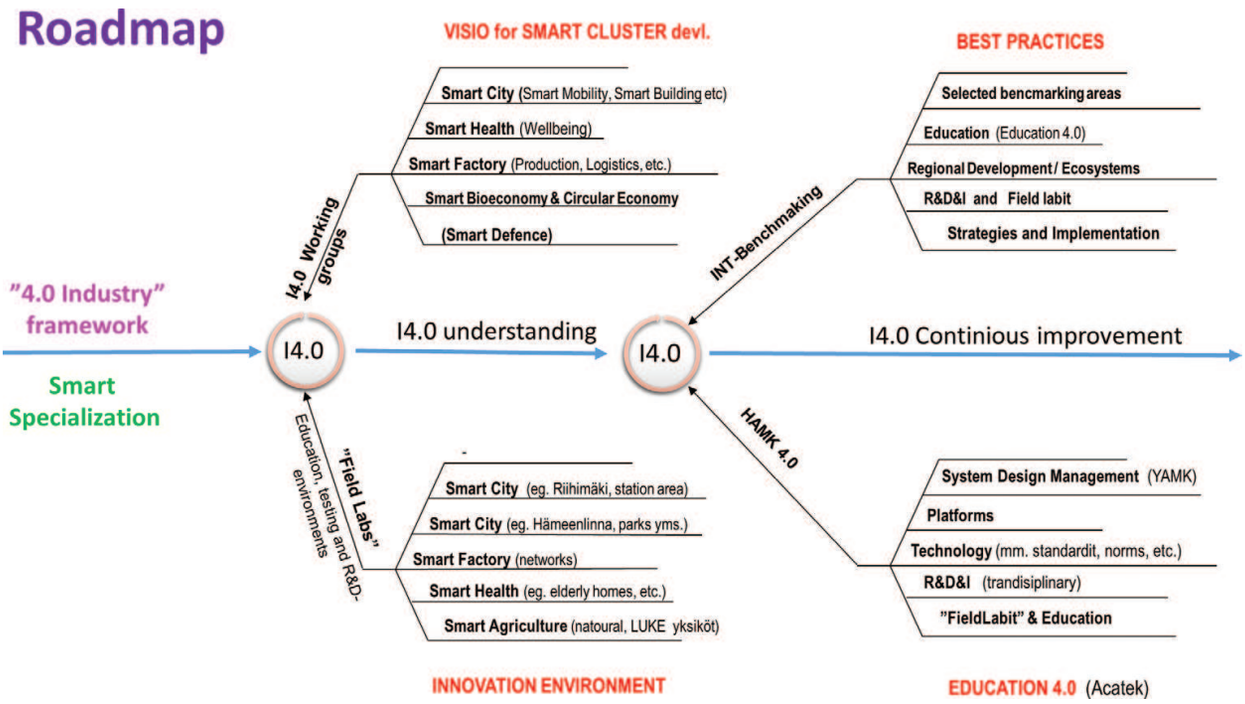

Figure 5. Steps to develop Industry 4.0 related services.

- Education: renew education content so that it response the new ICT-based technologies that are needed in Industry 4.0 and transdisciplinary approach.
- Benchmarking: make benchmarking for the regions, which are like "Häme" and have already taken the steps to adapt Industry 4.0 and to ensure compatibility.

These elements are further covered in **Figure 5**. The core idea of the figure is that Industry 4.0 framework should be understood in the existing innovation environment so that smart clusters could be established. International benchmarking could be applied to identify best practices, which could be adapted to educational programs and field labs. In order to be able to adapt Industry 4.0 framework to education so that it could be called Education 4.0 the following issues should be considered: system design management course should be introduced as a part of graduate studies. Technology platforms and implementation of transdisciplinary field labs should be introduced.

7. Discussion and conclusions

The principal idea behind this article has been to combine the principles of Industry 4.0 to value network thinking and digitization. Industry 4.0 is about creating significant impact and opportunities where business, technology, services, and innovation intersect. The aim has been to find a transdisciplinary concept supporting higher education, regional development, and business renewal in testing laboratories, while supporting and enabling new growth opportunities in the region.

That requires combining of various approaches. The main challenge is in the utilization of transdisciplinary knowledge and implementation work. The use of new technologies; including digitization and big data can capitalize on new opportunities. According to the experiences of conceptual development work, successful activity in Industry 4.0 is dependent on systematic long-term development on the public sector. The essential topic is preparing of up to date platforms, which enables, controls, and support the operations and creates a business environment to apply approaches. There are several contributing technologies related to Industry 4.0 framework. This implies that there is a major emphasis on competence development, and shared learning to apply these technologies to support transdisciplinary regional development.

The practical implications for renewing a university so that it could better support the adaptation of Industry 4.0 are as follows:

1. Higher education institutions should provide education and support for the adaptation of Industry 4.0

It is important to give a relevant role for the higher education institutions to provide and support a transdisciplinary approach to study services in a proper operating environment.

2. Research and learning environments in universities should be used to pilot new Industry 4.0 related technologies

One of the core roles for universities is to support enterprises by applied research and by creating of research and learning environments for continuous piloting of new technologies and

preparation of new business models on Industry 4.0. At the same time, a local higher education institution's future areas of focus, challenges related to digitization, as well as profiling among other higher education institutions are taken into account.

3. Enterprise-university partnerships should be established

To be successful on new challenges of Industry 4.0 development, enterprise-university partnerships have to be intense and main objective should be a shared learning. Long-term cooperation creates a background for new co-innovation and co-evolution.

Adapting Industry 4.0 framework as a basis for development activities is expected to provide not only an opportunity for remarkable competitive advantage for businesses, but also for regions.

Author details

Heikki Ruohomaa, Mikko Mäntyneva* and Vesa Salminen

*Address all correspondence to: mikko.mantyneva@hamk.fi

Häme University of Applied Sciences, Hämeenlinna, Finland

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