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# Innovation in education and re-industrialisation in Europe

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**Abstract.** In this paper we discuss innovations in education, with a focus on those oriented towards knowledge-driven re-industrialisation in Europe. We first introduce the specific education needs for re-industrialisation with regard (a) to young people's knowledge and skills in science, technology, engineering and mathematics (STEM), and (b) to specific training needs of mid-level technicians. Then we propose the adoption of a context-based approach to place science and technology within young people's daily lives and to promote links between science, technology and society. In particular, we propose the use of robotics labs to improve context-based approach to technology education. We suggest action-research as a feasible practice to boost bottom-up changes in teaching and learning activities, and we focus on the university initiative Officina Emilia as an exemplar of such actions, as the initiative involves university researchers, manufacturing and services companies, education agencies, civil society. The paper offers some concluding remarks on two main ingredients that can support a more appropriate set of education and training activities to enhance knowledge-driven re-industrialisation: first, the need to allow the emergence of hybrid places fostering innovation, with the involvement of different agents; second, the robotics labs, among others, as a means to foster a multidisciplinary perspective, crucial for the new challenges that education faces in supporting re-industrialization.

**Keywords:** innovation in education; knowledge driven reindustrialization in Europe; technology context-based education; robotics and innovation in education.

**JEL**: I21; J24; I28; R1

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## 1 Introduction

A re-industrialization of Europe is becoming an imperative to support a path of sustainable development characterized by social inclusion and innovation, as remarked also by the Report on EU competiveness [1]. The main rationale for strengthening the manufacturing sector in Europe is rooted in evidence that the sector is the locus of significant innovation, which in turn also provide opportunities for growth in the service sector as well (in particular business services). Although it constitutes a decreasing share of Europe's Gross Domestic Product (GDP), the manufacturing sector is still the engine of modern economies. Because of backward and forward linkages [2], development in manufacturing has a multiplier effect on the growth of the economy [3]: a general increase in productivity of the manufacturing sector makes a contribution to the growth of GDP that is four times higher than that of other inputs.

The re-industrialization process requires new skills (in quantitative and qualitative terms) to support changes in technology and organizational models (within the companies and in their networks). These new skills can be nurtured in workplaces. But there is strong evidence that it is more effective to incorporate their development already in the educational pathway (particularly in the upper secondary level). New skills are also needed by the labor force already employed or seeking employment, and both the companies and training organizations, until now devoted to the adult training, can be better integrated with the general education system.

The capacity of the actual education system in Italy to create and develop adequate skills does not meet current needs. Indeed, international comparisons clearly show that Italian students have lower scores in the standardized tests and a longer school to work transition [4]. There are substantial differences in performance across the national territory. There is evidence of some worsening of an already weak vocational education and training field. And, as a remedy to overcome the present crisis, in order to reduce the high rate of unemployment among the young people, it is crucial to foster the acceleration of innovation in education. A similar situation arises in other European education systems, and this is why the European Commission has pushed on innovation in education toward new skills for new jobs [5].

In this paper we argue that, in order to strengthen re-industrialization, it is necessary to boost innovation in the whole education system, from pre-school to university. In particular, the education and training system must take on the challenge to provide or to increase the provision of the ability to (1) apply in different environments what has been learned, (2) understand the social, economic, historical and cultural heritage of the context in which people live and work, (3) master knowledge of the core work processes. To reach these goals, the education system should allow students to have experiences in several different environments and to be aware of the concreteness of the material conditions of life and work [6][7].

Innovation processes in education need to address contents and methodologies, the required structures, resources, materials and competences, as well as institutional settings. It is well known that such innovation processes call for systemic reforms in education and when they coming from the center and spreading in the periphery could take a long time to be defined and implemented. In this paper we argue that, even though reform initiatives in education are crucially important, there are more feasible, faster and more incisive changes which can be started involving local actors in action-research practices.

An example of such interventions is the one realized through "Officina Emilia", an action-research supported by the University of Modena and Reggio Emilia. It has produced workshop laboratories, such those with micro-robotics, that have produced significant

changes into contents and methods of teaching–learning, by linking science, technology, engineering and mathematics in a more effective way [8][9]. At the same time, Officina Emilia's laboratories allow students to develop soft skills – such as time management, proper allocation of resources, efficient team working, problem solving, communication, use of feedbacks from processes. Officina Emilia has many common features with several initiatives carried out over time in Italy and in Europe (as highlighted recently in [10]). Its special contribution is on three related domains: (1) to combine micro-robotic education with other educational activities; (2) to promote knowledge and understanding of the characteristics of the industrial structure typical of the territories with a strong vocation in manufacturing (with a focus on mechanical industry, that has in Emilia-Romagna, the Italian region where Officina Emilia is based, some leading productions at world level); (3) to involve all young people, not only students enrolled in technical and vocational training pathways. Moreover, Officina Emilia addresses teachers involvement as a crucial issue for innovation processes in education. Lastly, Officina Emilia has sought to support bottom up changes in education through multi-agent and multi-level actions: this is why, an open public hybrid space has been designed to allow students, educators, production and technology experts, policy makers to open their mindset and improve the understanding and practices on the issue of regeneration of competence networks. Public hybrid spaces are increasingly recognized as loci fostering innovation processes, since they provide a venue in which new ideas and insights can emerge by allowing interactions and interpretative ambiguity. As Lester and Piore have stressed [11], often, these are the missing dimensions in innovation processes, which are nurtured not by only analysis and problem solving, but also by generative relationships which are based on heterogeneity, aligned and mutual directedness of the relevant agents, and appropriate permissions to support agents' opportunities of action [12].

In the remainder of this paper we first introduce the interdependencies between economic system and education system, by pointing out that new skills require new learning processes, the need to support citizenship and social inclusion, the specific training needs of mid-level technicians. We discuss a new approach to technology education in context, and the specific characters of robotics labs to improve such context-based technology education. Then, after remarking on the potential and the limits of innovation in education, we present the Officina Emilia initiatives and its robotics labs. The paper concludes by identifying two main ingredients that can support a more appropriate approach to education and training to enhance knowledge-driven reindustrialization.

## 2 The interdependencies between economic system and education system

### 2.1 New skills requiring new learning processes

Among other goals, education should foster skills to enter the labor market. The close relationship between participation in the education system and economic development has been established in a literature rooted first in the work of Becker [13] on human capital, but that has since found confirmation in multiple sources [14][15][16][17]. Often, education policies are identified as strategic actions for the promotion of innovation and seek connections with both the employment and the development policies [18].

Investigations on skills of young people entering the labour market at EU level [18][19][20], but also interviews with employers (such as those carried out in an industrial district in Italy [21]) highlight a gap between what the educational system is able to create and the needs for knowledge in technologies, computer science and organizational models. Moreover, recent research has focused on the analysis of the demand and the use of new skills, and has explored how educational environments (both in the education system and in the workplace) can either perpetuate or eliminate skills imbalances and low-skills traps [22][23].

So far, initiatives to improve education in science and technology have not been able to support the creation of adequate knowledge, skills and competences of young people leaving the education system [24]. Only a minority of young people have capacity to appreciate the contribution of technology to enhance products and processes, as well as the contribution of technology to determine the character of professional skills and work environments.

The capacities that young people (and adults) would need to support the re-generation of the manufacturing sector are different from those described in the labour studies [25] and in the classical management theories [26]. Those studies have historically been focused on the technologies and the organization of work inside the companies organized according to a Tayloristic and Fordistic production model. Due to broad sectoral, institutional and technological changes rooted in the crises of the 1970s, however, jobs in many manufacturing industries are no longer broken down into routines and well-defined tasks, with the implication that workers can no longer focus on a particular subset of tasks. Moreover, written rules and procedures are consequently less effective in facilitating coordination and ensuring uniformity. Lastly, work specialisation is no longer the only element producing efficient performance both in technical and managerial functions. New skills are needed. To cope with the changing and unpredictable situations inside the organisations, these new skills must be grounded on the interweaving of knowledge in different fields, technical skills and interpersonal communicative abilities.

Recent research, as a result, has begun to show how and why this demand for new skills requires new learning processes and has, in particular, made special reference changes in training for cohorts of young people (with, for instance, CEDEFOP [6] discussing the new competences to be created.). A related issue is the specific need for training the new intermediate professional groups [27].

Before addressing these issues in the following section 2.2 and 2.3, it is useful to recall that significant support in designing new learning processes derives from Vygotsky [28][29], Dewey [30][31][32], Papert [33] and Hutchins [34] who focus on contextualized knowledge, open learning environments with multiple opportunities and cooperative ways of working. Those are exactly the learning environments in which it would be possible to create skills for workers who have to face the current manufacturing technologies and organizational models, taking full advantage of ICT.

### 2.2 New basic knowledge to be generalized

Skills to be promoted in the education system must address not only employability, but also social cohesion, inclusion and active citizenship [35]. The inability of young people to understand the context in which they live may be one of the reasons why social cohesion of several local communities is too often threatened [36]. A considerable amount of evidence lead to believe that these skills are dramatically poor among too many young people [37].

If skills and knowledge are to be used to deal with problems of everyday and working life, the curriculum (i) must cope with the realm of technology; and (ii) to build countless connections with economics, sociology and the study of institutions. It must, moreover, find ways to enhance the capacity of those trained to understand the social, economic, historical and cultural heritage of the different contexts, and the concreteness of the actual conditions of life and work. It follows, therefore, that there may be a need for new educational methodologies.

To help identify some such methodologies, in this paper we highlight two issues. The first is the separation (particularly critical in the Italian educational system) between the teaching of the humanities and of science-technology and between theoretical and practical abilities. The second refers to inadequacies in the access of young people to essential and useful knowledge on: (i) material properties and their use in industrial products; (ii) techniques of production and quality of the industrial products; (iii) computer programming as computational literacy [38]; (iv) skills and work experiences of employers and employees; (v) environmental quality and living conditions at local and regional level.

Let us briefly deal with technology education. Separate and distinct courses are the most common approach to this type of education, at least in primary and lower secondary education. From the 1990s onwards, technology education has been promoted as a key element in all curricula, as well as an element permeating every discipline. Although a certain confusion remains about what is to recognized as "technology," most attention to date has been focused on information and communication technologies. In fact, however, others are relevant as well, including especially technologies of industrial production and technologies embedded in everyday products. Incorporating attention to these last so that they are familiar to all young people would support their need to acquire information, not only when they have to choose their education and vocational pathways, and to select their careers, but it would also help them to become aware consumers and active citizens.

How should education pathways in technology be designed? It is almost impossible to imagine that they would be carried out only in labs separated from actual workplaces, thus separating machines, procedures and the work tasks from the context in which they are embedded. Technology and the social, institutional, economic and political context, as well as physical and natural environment, have been shown, especially in the Italian context, to be linked. And we thus propose "context-based technology education"[39].

Two crucial elements have to be addressed when adopting this perspective: the interdisciplinary nature of learning in context-based technology education and the need to introduce active learning methods to develop effective learning. Context-based technology education needs to address the labour and entrepreneurship culture, and the knowledge of human work in different places and times. This must not be confused with traditional apprenticeship pathways. In particular, a closer relationship with the workplaces does not necessarily mean to train in a specific task, but calls into question the teaching methods and several other complex learning objectives, if all the young people have to be involved, and not only those who want to enter the labour market early.

### 2.3 The new training needs of mid-level technicians

Vocational courses, at secondary, post-secondary and tertiary level, should be redesigned to cope with the new training needs of mid-level technicians, especially in industry, and in the light mechanical industry in particular.

The education system in Italy, and in other European countries such as France and Germany, includes a dedicated path for the training of mid-level technicians in the various economic sectors. Thanks also to the proper functioning of this segment of education,

many industrial, construction, agricultural and service sectors developed in Italy after World War II at a rapid pace and with great success in the global market. Given the present state of technology, organizational settings and new international division of labour, not all education systems seem able to keep the pace of innovation required; the training of mid-level technicians sometimes suffers as a result, and they and lose the opportunity to effectively contribute to innovation processes, particularly in the manufacturing sector.

The training of technicians in Italy has long sought to create a mastery of long lasting concepts, techniques and methods. The organization of curricula was composed of sequences of contents, repertoires of skill-based procedures, and standard solutions. Interactions with companies have long been mediated by interpersonal relationships and family. Over the years, the teaching of theoretical knowledge has increasingly replaced the hands-on labs, to take account of the increasing body of available topics. This type of training is still partly useful, but the training for innovation now requires different actions. Technicians need to empower themselves to deal with the complexity and the variability of dynamic organizations. During their training, at school and even in the workplace, they have also to cope with analysis, interpretation and non-standards solutions to changing problems. They must be able to meet situations involving several variables in conditions of uncertainty, relying on strong knowledge of manufacturing processes, not only on the knowledge of design or production of individual phases. In short, there is a growing demand for allowing mid-level technicians to have a greater capacity to integrate multiple knowledge, not only technological, but also economic and cultural, and what schools (and universities too) are doing is not enough.

Interviews with entrepreneurs of small and medium-size businesses [21] highlighted this as a critical aspect that limited their businesses' potential growth. Even if university courses have increased their supply of BA courses, and other post upper secondary coursed have been experimented to support those needs, even if the crisis has made available many mid-level technicians with experience, a shortage of mid-level technicians with the skills listed above is likely to occur.

## 3 Context-based technology education and education using micro-robots in Officina Emilia's experience

As introduced in Section 1, not only STEM disciplines must be in the agenda of innovation in education, but a context-based technology education has to link together science, technology, engineering and mathematics with the knowledge of the functioning of the society. The use of micro-robotic equipment in education makes it easier to learn a number of fundamental concepts which link those disciplines together. At the same time, teaching with micro-robotics allows the development of soft skills such as time management, the proper allocation of resources, an efficient team work, problem solving, effective communication and use of feedbacks from processes. For all these effects, micro robotics labs are generally considered a useful strategy to improve effective technology education, also with references to actual production. Officina Emilia has, in this regard, introduced robotics labs as a subset of the laboratories designed to promote the understanding of the mechanisms, the machines, the know-how and procedures that are widespread in industrial enterprises. Moreover, in these labs we implement specific stimuli to teach and learn how enterprises work, with reference to a specific territory, and which are the actual job positions of the people working in the industry.

The Officina Emilia initiative, supported by the University of Modena and Reggio Emilia since in 2000, builds on comparative analyses of education systems and into in-

dustrial districts and local development policies. It addresses multiple social, economic and technological needs of the region in which the university operates. When it started, the manufacturing sector was considered by many to have lost relevance to economic development, particularly in the more advanced and rich western societies. The Officina Emilia initiative pointed out that not only this sector, and the local mechanical industry in particular, continued to support the growth of the local economy, but that it would cease to do so unless special competences generated and nurtured inside their enterprises were re-generated and supported. The Officina Emilia initiative therefore began a program of action-research aiming at improving the context-based technological education, that could answer the problems of re-generation of technical skills, whose shortage was becoming critical in areas with a strong engineering manufacturing vocation, as in the industrial districts of North-East Italy.

Since 2006, Officina Emilia has carried out a coordinated package of educational activities, which includes educational robotics, to be placed in a regional curriculum. The educational activities are realised in collaboration with teachers, schools, training agencies, a significant number of small and medium enterprises (in the engineering sector and providing industrial services), as well as the representatives of multinational companies, trade unions and business associations. A special Museum-workshop (Museolaboratorio) in Modena opened in 2009 to carry out the activities involving students, the initial and in-service teacher training, the networking activities at local, regional and national level. The Officina Emilia initiative shares hypotheses, methodologies, activities and results with academic and practitioner communities in Italy, as discussed during the national workshop held in Modena in 2013 [40] and in other European countries [10] and worldwide.

The methodologies adopted to facilitate the diffusion of innovative teaching-learning practices include hands-on activities with significant artefacts, objects, products, tools and machine tools used in small and medium engineering companies. The educational activities combine knowledge of production technologies with direct knowledge of workers and employers, inside their workplaces. Hands-on activities, using and producing multimedia contents are as important as the meeting and the interviews with professionals. Guided visits, periods of internship are complemented by activities in the Museolaboratorio and in the school classrooms.

Officina Emilia's robotics and other labs started in 2005. Cooperation with teachers, as well as the dynamics of the learning process of the students involved, made it possible to modify and refine the protocols and the materials to be used in the robotic labs. Until 2008, the labs were carried out in primary and secondary school classes in Modena, Reggio Emilia and Bologna districts, in the Emilia-Romagna region. Several other initiatives involved adult people and five editions were carried out to train educators and teachers. When they opened in 2009, the labs were conducted in the Museolaboratorio and were accompanied by action-research (a) to explore the conditions to disseminate the tested educational practices in the pre-university education system at regional level, and (b) to identify ICT tools to support hands-on activities complemented with multimedia contents[1]

Between 2009 until 2012, the laboratories have involved approximately 5,000 students from pre-school to upper secondary education. Nearly 170 teachers have been involved in in-service training to promote changes into their everyday work, 12 schools signed a permanent agreement of collaboration on innovative education to be developed with the

[1] In relation to this issue, it is worth mentioning the use of MOVIO [41], an open source web application to implement the on line version of the multimedia contents and procedure of the labs; and the production of a specific web application, Homm-sw [42] to create, and share on the web, transmedia narratives co-created by students, teachers, and experts.

support of the university, and 3 schools introduced Officina Emilia labs in their official curriculum.

The following table shows the involvement of students and teachers in different types of educational activities.

**Table 1. Number of students and teachers involved in the action-research of Officina Emilia, by type of activity and grade of school. September 2009 - June 2013**

| | *Primary* | *Lower secondary* | *Upper secondary°* | *Total students* | *Total teach-ers* |
|---|---|---|---|---|---|
| Age of the students | 6-10 y | 11-13 y | 14-19 y | | |
| Educational robotics labs | 952 | 1.295 | 530 | 2.777 | 78 |
| Labs on machines and industrial processes | 1.533 | 67 | 141 | 1.741 | 80 |
| Guided visits to industrial plants | - | - | 214 | 214 | 9 |
| Guided visits to the exhibits of the Museum-workshop | - | - | 36 | 6 | 2 |
| Total students | 2.485 | 1.362 | 921 | 4.768 | |
| Total teachers | 112 | 36 | 21 | | 169 |

Source: Officina Emilia database. Modena and Reggio Emilia University. 2014.

The Officina Emilia educational robotics labs are just one part of the action-research program. They are the largest, in terms of number of students and teachers, especially because Officina Emilia began its activity in local schools at a time when there was neither a widespread knowledge of materials (such as LEGO Mindstorm® or Arduino) nor an awareness of the appropriate teaching methodologies.

The Officina Emilia robotics labs usually last four hours and belong to the two following groups.

"A robot that follows a line" is a laboratory for young people from 12 to 19 years old, where teams of 3-4 students build a robot with LEGO® bricks, following instructions without verbal directions. Then, each team writes the software program to make the robot follow a black line on a white background. Teams test their robots and compete to assess the performances and the strategies adopted in programming. This lab does not require specific prior knowledge, nor practical or computer science knowledge. During the lab, students watch videos and/or meet one technician or one entrepreneur working in a local company producing or using robots. The objective of the videos and of the interview is to connect what the students have experimented, through the hands-on laboratory, to the concreteness of the workplace and the market-related issues faced by the local/regional enterprises. A more complex version of the same lab was tested inspired by the "Roberta" international program [43][44]. This lab is dedicated to girls between 15 and 19 years and includes the construction of four different robots, using different sensors. “Roberta” lab requires more complex programming to take account of the performances of different sensors.

"Robot-Cocco-Drillo" is a robotics lab for children aged between 8 and 11 years old. Students construct an automatism, in the form of animal, able to move. They learn to use a sensor in connection with a computer. The languages of verbal description, iconography, the flowchart and the programming software WeDo® are compared. During this lab,

children listen to stories about workers and robots helping them to do hard work, or robots used to do surgical operations and to explore distant and dangerous lands. The last part of the laboratory involves direct observation of machine tools and industrial artifacts. The age of participants allows to draw attention to quality and weight of the materials.

The activities of educational robotics extensively involve students enrolled at middle schools (11-13 year olds). Teachers used the labs to support the pursuit of two objectives. The first is the enhancement of technology education, which they believe was adversely affected by the Italian reforms of the education system of the 2000s. The second relates to the need to help students and their families to make informed choices, at the end of their middle school period. Teachers expressed a strong need for data and tools to effectively introduce the students to the industrial structure of the area where they live, and which influences their educational, training and professional opportunities.

The experience of Officina Emilia with the schools shows that the hands-on activities, and the opportunity to be guided to observe a workplace, widen the horizons of thinking, help the imagination, support self-esteem in confronting technological challenges (in particular with regard to girls approaching technologies they consider as largely out of their interest), and open students to new domains (e.g. reconnecting what students do in the labs with their parents' or relatives' jobs, which they generally do not consider of any importance and they learn to appreciate in different perspectives).

These same experience highlight, moreover, a remarkable gender issue. 63% of the students who attended the Officina Emilia workshops are boys. This is in part simply due to a disproportionate engagement with of technical and vocational schools, which are themselves disproportionately male. But it is also due to a tendency of girls to skip class on the days they are to attend workshops. Vice versa, the proportion of men among teachers is clearly a distinct minority (9%). Even if the participation of girls to the laboratories of educational robotics was slightly higher than that recorded on average, the large distance that girls experience, with respect to the themes dealt in those labs, challenges any general process of innovation in the education system. Even the massive prevalence of women among teachers with an initial education in humanities, particularly strong among teachers of primary and lower secondary schools, gives reason to re-address preconceptions that women's education has settled in the behavior of the younger generation.

A key issue for programs of innovation in schools sits in the training of teachers, as changes are required to support new knowledge and methodological skills. Officina Emilia organised specific training activities before the teachers choose the labs for their students. During these activities, teachers themselves acquire the basic knowledge to understand the essential elements of production technologies. Moreover, the opportunity to implement their ability to innovate is carried out during the laboratories, where the teachers are charged to specific tasks of observation and evaluation of the students' performances and of the workshop setting.

With regard to Italy, beyond the institutional and organizational context of education, reform is needed in the treatment teachers themselves. Teachers have different personal and professional goals in relation to age and conditions of their contract. They are trained to teach one subject (except for the primary school teachers) and they often feel inadequate when they are asked to move away from their specific traditional subjects. Research has also pointed out that teachers' commitment and openness to change decreases with the progress of their careers [45][46][47]. In Officina Emilia's experience, teachers that were trained through programs of high quality level action-research in schools and in the classrooms, often directed by the university, acquired the habit to change, to work cooperatively, as well as to assess their results collectively. Other teachers, without this training experience, are looking for methods to improve their work. They are especially

stressed by their powerlessness to cope, in a more effective way, with the excessively varied backgrounds and situations of the students they teach. Generally speaking, the teachers involved by the Officina Emilia action-research, demonstrated a strong commitment to participate in innovation processes, but they do not belong to the younger age groups. On the contrary, the experience carried out shows an important share (large majority) of teachers with more than two decades of career. This calls for some urgent action on training the new generations of teachers.

## 4 Some concluding remarks

Paradoxically, standard tests of learning can serve as a barrier to the development of innovative learning experiences, due to the phenomenon of "teaching to the test" and the need to perpetuate the teaching practices with known effects on learning. This situation is also evident in the schools participating in the Officina Emilia action-research program.

Teachers are resources within the education system, and must be involved in innovation programs. Often, unfortunately, they do not find effective programs and additional resources to reward the necessary extra-work to implement innovative processes. In this situation, even processes of innovation spontaneously budding within individual schools are compromised, as is the capacity of schools to accommodate the best practices that can be learned by peer exchanges.

Based on the considerations made earlier in this paper, including especially claims regarding changes needed to prepare the younger generation for the economy that seems to emerging from the current crisis, we need to identify which actors are best positioned to generate the requisite reforms.

Universities and regional authorities can play an important role in supporting the innovation of the education system and improve its effectiveness. Universities have the institutional task of training teaching staff (either before the selection at the entrance, or in the first phase of their training) and they may extend their support toward multidisciplinary research, as in some cases already do, by interacting with the design of curricula and the support of the educational planning, or the creation of materials. Innovative actions call for evaluation and dissemination of experiences and these competences risk to be scarcely available inside the schools.

Only some Italian regional governments have taken seriously their role and proposed guidelines for a curriculum to support the needs of a more-knowledge based economy and that might therefore produce a more appropriate mix of skills in the workforce. Other regions left their schools free to organize themselves as they wished. In the absence of support and guidance available to schools in need, a low rate of innovation can be expected.

To pave the way of reform initiatives in education, feasible, faster and incisive changes can be undertaken involving local and regional actors in action-research practices. Two main ingredients can support more appropriate education and training initiatives to enhance knowledge-driven re-industrialization: first, the need to allow the emergence of hybrid places (fostering innovations) where relevant agents (from university researchers to manufacturing and services companies, education agencies, civil society) may practice action-researchers to support school teachers in producing effective education changes; and secondly robotics labs, among others, are a means to foster a multidisciplinary perspective, crucial for the new challenges that education faces in supporting re-industrialization [48].

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