Envisioning an Advanced ICT-supported Build-up of Manufacturing Skills for the Factories of the Future

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Abstract: In this paper, we present the main concepts and the aim of the ManuSkills FoF project which is to study the use of enhanced ICT-based technologies and training methodologies to facilitate an increase of young talent interest in manufacturing and to support their training of new manufacturing skills. The project will experiment with a wide range of innovative delivery mechanisms such as serious games and teaching factory, supported by the use of social media augmented by gamification and leveraging the distribution channels preferred by young talent. In addition, the project will explore the pedagogical frameworks best suited to the personalization of individual learning needs taking into account the industrial demand. ManuSkills will address all three stages of the young talent pipeline (i.e. children, teenagers, young people), where in the early stages the focus will be to make manufacturing education more attractive to young talent, whilst in the later stages the focus will be to facilitate transformative deep learning of individuals, with reduced time-to-competence.

1 INTRODUCTION

When asking young talents, their understanding of what manufacturing of the future entails could not be further from the truth. In fact, with the shrinking of distances to create the global village coupled with the ever faster pace of advances in technology and process innovation, one can state clearly that manufacturing is in a state of constant innovation. The factory of the industrial revolution, where the shopfloor was unsafe and dirty, is being replaced by factories where lean and TQM have dramatically changed the work environment. A fundamental switch has taken place, where in the beginning the workers carried out repetitious tasks, now the focus is on cognitive interaction with the work environment through ICT. Consequently, higher education has become necessary. In addition to engineering, other competences such as sense making, dealing with complexity and soft skills, are also necessary.

Manufacturing goes digital and this is argued to amount to a third industrial revolution (Economist, 2012). Over the past few decades, manufacturing has evolved from a more labour-intensive set of mechanical processes (traditional manufacturing) to a sophisticated set of information-technology-based processes (advanced manufacturing). The dirty, noisy, unsafe workshops have given place to modern technologies and cleaner work environments. Everything in the factories of the future will be run by smarter software. Digitisation in manufacturing will have a disruptive effect every bit as big as in other industries that have gone digital, such as office equipment, telecoms, photography, music, publishing and films. And the effects will not be confined to large manufacturers; indeed, they will need to watch out because much of what is coming

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will empower small and medium-sized firms and individual entrepreneurs. Launching novel products will become easier and cheaper. Communities offering 3D printing and other production services that are a bit like Facebook are already forming online—a new phenomenon which might be called social manufacturing. Things will be made economically in much smaller numbers, more flexibly and with a much lower input of labour, thanks to new materials, completely new processes such as 3D printing, easy-to-use robots and new collaborative manufacturing services available online. The wheel is almost coming full circle, turning away from mass manufacturing and towards much more personalised production. According to the ActionPlanT project vision (ActionPlanT) for future manufacturing – 'Manufacturing 2.0', future ICT-enabled manufacturing will be:

1. **On-demand:** To sustain market share and create employment opportunities, Manufacturing 2.0 should accommodate changing demands from a new customer base and deliver customised products on-demand.
2. **Optimal:** European enterprises need to be able to produce products with superior quality, high security and durability and, at the same time, competitively priced compared to products from emerging markets.
3. **Innovative:** Faster introduction of collective innovation is one of the three key growth factors together with human capital and infrastructures. Innovative thinking, design and manufacturing will lead the way to sovereignty, independence and growth of European manufacturing.
4. **Green:** Manufacturing is responsible for significant energy use and consumption of natural resources. Manufacturing 2.0 needs focused initiatives to reduce energy footprints on shop floors and increase awareness of end-of-life (EoL) product use.
5. **Human-centric:** Manufacturing 2.0 will evolve from being perceived as production centred to human centred with greater emphasis on generating core value for human stakeholders. Future plants should be more accommodating towards the needs of the European workforce and consider them an integral stakeholder.

Moreover, since the manufacturing process, in a broad sense, becomes more and more complex, a big number of complementary roles will be necessary within the Factories of the Future, such as:

- **Virtual enterprise:** Supply chain engineers;
- **Forecasting:** Business analyst and data scientists;
- **Multi technology product:** Industrial engineers;
- **Quality:** Quality managers;
- **More complex manufacturing technologies:** Process engineers and planners;
- **Energy:** Energy managers.

In spite of the constant innovation pushing manufacturing forward, the lack of awareness by mainstream society implies that young talent does not choose a career in manufacturing contributing to a serious shortage of skilled labour. Reaching out to the young talent is the focus of the ManuSkills European project, studying the effectiveness of innovative delivery mechanisms such as serious games and teaching factory, supported by the use of social media augmented by gamification.

The paper is organised as follows: in section 2 the main concepts and project objectives are presented. In section 3 we present the approach we will follow to develop the concepts, implement them in an appropriate platform. In section 4 we present the expected impact to be created by the project actions, achievements and results.

2 CONCEPTS AND PROJECT OBJECTIVES

ManuSkills aims to study how best to reach the young talent using an ICT framework to address all three stages of the young talent pipeline (i.e. children, teenagers, young people), where in the early stages the focus will be to raise awareness about manufacturing to concerned stakeholders, then to make manufacturing education more attractive to young talent, whilst in the later stages the focus will be to facilitate transformative deep learning of individuals, with reduced time-to-competence. The resulting ManuSkills ICT framework is captured in Figure 1 where the triangle of parents, youth and teachers access the framework over their preferred device.

The learning content on the platform is packaged as learning objects provided by both educational institutions and industry, which are delivered using a wide range of mechanisms, such as teaching factory, serious games, webinar, video player and mobile apps. ManuSkills will benefit from existing pedagogical material from within the consortium and study the effectiveness along with the impact on

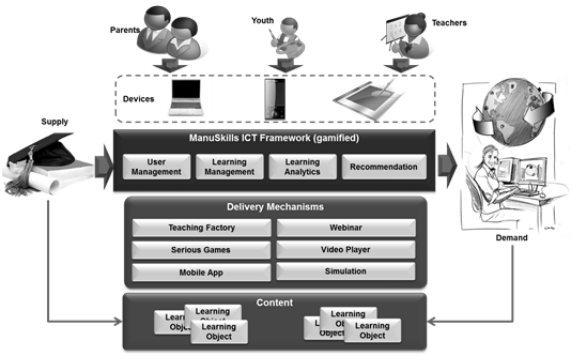

Figure 1: ManuSkills ICT Framework.

both raising the awareness and learning amongst young talent. In fulfilling its aims, ManuSkills will address the following objectives:

- **Objective 1:** Study the barriers and enablers towards raising the awareness of manufacturing and training along the entire young talent pipeline;
- **Objective 2:** Explore how to successfully engage young talent with ICT and increase their interest in manufacturing thus addressing the talent shortage for Europe to sustain its global competitiveness;
- **Objective 3:** Study innovative delivery education mechanisms and training methodologies to facilitate more effective and efficient competence development towards the rapid build-up of existing and emerging manufacturing skills;
- **Objective 4:** Mobilise stakeholders from business, government, academia, international organizations, civil society and nongovernmental organizations to develop action plans and influence policy for improving manufacturing education;
- **Objective 5:** Focus on strengthening manufacturing education at higher education levels and STEM related subjects with focus on engineering in secondary education, addressing the three target stakeholder groups: children, parents and educators.
- **Objective 6:** Achieve early impact based on the ManuSkills proof-of-concept platform and other project results, and facilitate wider impact through aggressive dissemination and networking activities supported by a **sustainable exploitation case.**

3 APPROACH

A framework capable of capturing the existing and future manufacturing skills, could be the basis of a, currently lacking, reference to professional needs, related to advanced manufacturing. These skills are essential to manufacturing companies in order to improve their innovativeness and competitiveness. Skilled young talent will strengthen the capacity to innovate and will give new incentive to industry in order to hinder the outflow of manufacturing activities to countries outside Europe. The synthesis of such a reference framework of manufacturing skills will be updateable in order to allow for new skills to be added that may result from new developments in advanced manufacturing. This framework will be used as a reference for manufacturing education and will enable capturing the main manufacturing skills, required by European companies for the promotion of innovation and creativity. The development of this reference framework will be based on a taxonomy of manufacturing skills with reference to existing relevant studies. This taxonomy will identify the main classes of manufacturing skills needed to compete in the evolving manufacturing ecosystem. It will comprise of mainly three categories, namely processes, equipment and systems. These main classes include manufacturing skills related to knowledge and optimization, control and human-machine interfaces, logistics and information flow, creativity and innovation.

On the basis of this framework, the project will define a vision on new approaches for awareness creation and training for the rapid build-up of manufacturing skills, using ICT enabling technologies. This vision will be reflected on a roadmap that will identify and give insight on the training technologies and approaches that will attract the young talent in manufacturing education and create engineers with manufacturing skills required by the factories of the future. The roadmap will be coordinated with both European SME ICT providers and users, for the development of future manufacturing skills, related to advanced manufacturing. This roadmap will have to drive the knowledge delivery mechanisms and the ICT technologies needed for assimilating the identified manufacturing skills, in the context of the future factories. In addition, the project will undertake an aggressive social awareness of the roadmap by European society, resorting to both traditional media (e.g. broadcast television, internet, press, etc.) and social media strategies with viral impact (i.e. social

networks, gamified apps, etc.). Existing ICT tools that can contribute to the rapid build-up of manufacturing skills will have to be enhanced and extended, while the need for new tools will be identified. The aim will be to boost competitiveness and innovation in European manufacturing that would be requiring a workforce with advanced manufacturing skills.

3.1 Additional Steps

Some of the required steps to bring about desired impact have been already mentioned in the previous paragraphs. Additional steps that ManuSkills will take are summarized as follows:

- ManuSkills project will involve relevant stakeholders as part of the development and deployment process, i.e. there will be meetings, seminars and other events with representatives from educational and research authorities and associations as well as for the relevant interest groups (e.g. primary/secondary school teachers, parents representatives, researchers, university professors) within the STEM education.
- Building on existing professional networks of teachers and teacher associations will provide opportunities to disseminate ManuSkills results and furthermore foster cooperation between schools, collaborative reflection, exchange of ideas and experiences and quality development.
- There will be constant communication of results and participation in discussions through relevant channels (such as newspaper, television, journals, conferences, web blogs etc.) through the whole duration of the project. The main results emerging from ManuSkills project are very likely to get a wide audience and a direct impact on debates in national and international contexts.
- Most of the project partners have already established networks with high schools, universities and industry in their countries and have been purposely chosen to participate and contribute to ManuSkills in order to build the community of stakeholders and reach the desired impact through established channels. The stakeholders within established networks all recognize the importance of STEM in a knowledge based society and the urgent need to enhance young people's interest towards STEM.

3.2 European Added Value

ManuSkills needs to take into the consideration the large European context as the TEL solutions to be implemented in schools, which are applicable within one context (i.e. within one country), could not simply be transferrable to other contexts (i.e. other countries). ManuSkills project is also following the initiative "*Science Education NOW*" (EU, 2007) which recommends that the articulation between isolated national activities in STEM education and those funded at the European level must be improved.

Several barriers can emerge in the deployment process of the ManuSkills ICT Framework (such as infrastructural barriers, accessibility barriers, legislative and education policy obstacles, lack of means to ensure long-term sustainability etc.) and in the European context; all these barriers strongly differ from country to country. ManuSkills will do the analysis of the present state of the different educational systems and corresponding institutional practices in the partners' countries to identify country specific drivers and barriers (e.g. related to curriculum and pedagogy, infrastructure, capacity-building, language and content, financing etc.) to ensure the wide implementation of the ManuSkills results in different European contexts.

4 EXPECTED IMPACT

The expected higher level impacts of the ManuSkills project are the following:

- Penetrate new application areas (e.g. high customisation, end-of-life product engineering and manufacturing), close to the market and opening new markets;
- Strengthen supply-side SMEs by enabling them to supply manufacturers with new equipment and components for improved manufacturing operations;
- Leveraging innovation capacity and competitiveness of European producers of laser manufacturing equipment and their suppliers, in particular SMEs, and of the users of such equipment;

ManuSkills will contribute only indirectly to the above impacts through the preparation of new generations to become eager for developing skills in advanced manufacturing and contribute in the increased competitiveness of European manufacturing industry.

We think that the main strategic impact generated by ManuSkills will be addressing the shortage of talented skills in manufacturing. The

World Economic Forum report "*The Future of Manufacturing. Opportunities to drive economic growth"* (WEF, 2012) is stated:

"An estimated 10 million jobs globally with manufacturing organizations cannot be filled today due to a growing skills gap. Despite the high unemployment rate in many developed economies, companies are struggling to fill manufacturing jobs with the right talent. Emerging nations cannot fuel their growth without more talent. Access to talent will become more important and more competitive. The skills gap that exists today will not close in the near future, which means companies and countries that can attract, develop and retain the highest skilled talent – from scientists, researchers and engineers to technicians and skilled production workers – will come out on top. In the race to future prosperity, nothing will matter more than talent."

We believe that ManuSkills main impact will be to contribute in reducing this gap, by increasing in the young talented people the awareness of a potential interesting professional career in the manufacturing sectors.

Anyhow more detailed direct impacts created by ManuSkills will be generated by the produced results in **medium-long term** and short, term as follows. Being medium-long term the quantification of the impact is vepry difficult to be done.

- To increase the competitiveness of the European companies by providing them the talented skilled workers;
- Innovation is more and more dependent on talented scientists and technicians. ManuSkills will help have an impact on the *Europe 2020 Flagship Initiative* on *Innovation Union*;
- To raise the awareness of publishers and learning content providers towards the growing demand of adapted manufacturing education taking into accounts the rapid evolution of technology and the inspirations of the young people. This will increase the quantity and the quality of the education content available in internet and easy to be reached;
- Systematic approach for continuous reinforcement of manufacturing by emerging technologies through developing strategies for providing appropriate training to acquire the related skills;
- Putting the humans at the centre of interest in manufacturing to remain competitive and innovative through institutionalisation of continuous and lifelong learning of the employees to improve their skills and increase their capabilities.

5 CONCLUSIONS

This envisaged evolution brings new needs for skills development. The adaptation of the educational content and its delivery mechanisms to the new requirements of knowledge-based manufacturing, the provision of integrated engineering competencies, including a variety of soft skills, the promotion of the innovation and entrepreneurship spirits, as well as an interdisciplinary thinking, reflecting the increasing integration of different areas of knowledge in manufacturing, are considered as major priorities.

The ActionPlanT project has delivered a validated set of recommendations and guidelines for an effective development of ICT for manufacturing skills. On top of that, the ManuSkills project will deliver an ICT framework and a roadmap for manufacturing awareness and skills development

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